Table 1. Ancillary examinations and laboratory tests for the infant

Test / date	8-7	8-8	8-10	8-13	8-15	8-17	8-22	8-27	9-1
White blood cell ($\times 10^9$/L)	5.24	13.10	7.76	11.89	19.71	29.8	17.2	13.26	8.63
Neutrophils (%)	21.9	34.6	39.7	22.6	46.1	65.2	71.5	62.7	42.5
CRP	< 0.20	< 5	28.34	26.2	< 5	< 5	10.08	< 5	< 5
Hypersensitive C-reactive protein	< 0.20	2.24	> 5	-	-	-	> 5	< 0.50	< 0.50
Specimen culture		Blood culture (-), Urine mycoplasma culture (-)			Endotracheal tube tip culture: *R. mannitolilytica*	Sputum culture: *R. mannitolilytica*	Sputum culture: *R. mannitolilytica*	Sputum culture: *R. mannitolilytica*	Sputum culture (Normal flora)
Bedside chest X-ray	-	Decreased transradiancy in both lungs compared to previous; Pulmonary infiltrates worsened compared to previous	Pulmonary infiltrates showed absorption and improvement	Pulmonary infiltrates increased compared to previous	Pulmonary infiltrates showed absorption and improvement compared to previous	Pulmonary infiltrates showed absorption and improvement compared to previous	Pulmonary infiltrates slightly worsened compared to previous	Partial absorption of infiltrates in the left upper lobe compared to previous; No significant change in infiltrates in the remaining lung fields	No significant absorption of pulmonary infiltrates compared to previous

2.2. Sample collection and processing

2.2.1. Patient samples

Patient Specimens: The tip of the endotracheal tube was collected at the time of extubation on day 8 after admission. Sputum specimens were collected on the day of onset of fever (day 14 post-admission). Bacterial culture and identification of both samples showed the presence of *R. mannitolilytica* in the extubated tube tip and sputum cultures. Antimicrobial susceptibility test results on day 15 indicated that the isolate was sensitive to levofloxacin and cefepime but resistant to ampicillin and ceftriaxone. Following positive results from both the sputum and the tube tip cultures, more specimens including sputum, blood, urine and stool were taken for bacterial and fungal cultures.

2.2.2. Ventilator circuit samples

Following the second sputum culture that was positive for *R. mannitolilytica*, the Hospital Infection Control Department immediately restricted access to the intensive care unit (ICU) with the infant (who had already been isolated in a single room after the initial detection). Samples were collected from the ventilator's internal circuits, humidifier water tank and connection ports.

2.2.3. Environmental samples

Air samples were taken from the NICU ward and swabs from healthcare worker's hands and surfaces of frequently touched items.

2.3. Bacterial culture and identification

All samples were labeled with collection time, location and identity of the collector before being sent to the clinical laboratory. Isolation and culture were performed using standard bacteriological protocols. Bacterial identification was performed by matrix-assisted laser desorption ionization-time of flight mass spectrometry and by 16S rRNA gene sequencing.

2.4. Epidemiological investigation

The Hospital Infection Control Department, in association with the head of the Neonatology Department, the attending physician, and the primary nurse, made a retrospective analysis of all the diagnostic and treatment procedures during the hospitalization of the infant. The investigation was concentrated on specific time points, looking at personnel who had contact with the infant, the use of medical equipment and the management of the ward environment.

The sampling by the Hospital Infection Control Department showed that the *R. mannitolilytica* was isolated from the sputum of the infant and also from the endotracheal tube tip cultures. The isolated bacteria showed resistance to antibiotics such as ceftriaxone and amoxicillin/clavulanic acid. Meanwhile, blood, urine and stool cultures taken from the infant were negative.

3. Results

3.1. Sample test results of the ventilator circuit

Clinical laboratory results showed the presence of *R. mannitolilytica* in the humidifier water tank and internal

circuits of the ventilator.

3.2. Environmental sampling tests results

The clinical laboratory findings revealed that the *R. mannitolilytica* could not be found in the environmental samples of the NICU ward or on the hands of medical personnel or on the surfaces of the most touched objects.

4. Discussion

4.1. Analysis of the source of infection

In this study, which used environmental hygiene sampling and bacterial culture, *R. mannitolilytica* infection of the infant was identified to have been caused by the ventilator circuit. These results suggest that the ventilator circuits may be colonized and grow bacteria in the long-term of their use, especially in a humidifier water tank, which is most likely to be contaminated by bacteria.

4.2. Discussion of the route of transmission

The colonization of the ventilator circuit by *R. mannitolilytica* and the subsequent transmission of the infection to the respiratory tract of the infant through the ventilator was identified to be the greatest cause of infection. The current studies have classified risk factors that lead to development of VAP into two broad categories. The former is the first category, which includes patient-related variables like age, severity of underlying conditions and comorbidities. The second category is the iatrogenic ones, including medical interventions, treatment modalities, and drug interventions. Some of the factors that predisposed the infant to VAP in this instance were extremely low birth weight, gestational age < 32 weeks, a number of intubations, coexistent neonatal sepsis, and the use of acid-reducing agents. Together, long-term mechanical ventilation, and the immunocompromised condition of the infant were all important risk factors of infection. Also, the conditions in the NICU ward were most likely favourable to the growth of bacteria due to the high humidity of the environment.

4.3. Characteristics of R. mannitolilytica

R. mannitolilytica is an opportunistic pathogen and its biological properties enable them to survive and proliferate in a hospital over an extended period of time. Its incidence in healthcare facilities has been increasing annually particularly in high-risk units of the healthcare facility like ICUs, burn wards and respiratory units [7].

It has also been demonstrated that these bacteria may be spread using contaminated medical equipment, including ventilators and catheters, or by hand contact with healthcare providers, leading to nosocomial cross-infections. Patients with long-term broad-spectrum antibiotic or immunosuppressive therapy are more frequently reported to have infections. *R. mannitolilytica* is regarded as a mostly pathogenic bacterium due to its virulence factors that are secreted [8]. It has been found to release cytotoxins and invasive enzymes that have the potential to interfere with the host cell barriers. Over the last few years, there has been a significant rise in the number of isolates containing MDR and the expression of extended spectrum β-lactamases, complicating clinical management. Although antibiotic treatment is the primary mode of treating *R. mannitolilytica* infections, it is important to choose the appropriate agents due to the resistance trends. Research indicates that some strains are sensitive to carbapenems (e.g. imipenem) and combination therapy (cefoperazone/sulbactam). At the same time, the enhancement of the environmental cleaning of the hospital and the strict hand hygiene of the healthcare

workers is one of the key steps to prevent and control the spread of this pathogen.

4.4. Preventive interventions

In the light of this VAP case, the following bundled intervention plan is suggested:

(1) Strengthen disinfection management of ventilator circuits
Change ventilator circuits and humidifier water tanks regularly to prevent the use of one and the same equipment.

(2) Maximize humidifier control
Inject sterile distilled water or sterile water as humidification fluids, and do not store humidification water long.

(3) Standardize hand hygiene and aseptic techniques
Enhance hand hygiene awareness and compliance levels among medical personnel to minimize the chance of cross-infection.

(4) Strengthen environmental surveillance
Conduct regular microbiological surveillance of the NICU environment and equipment to aid in the rapid identification and correction of possible contamination sources.

5. Conclusion

This research could determine the origin of *R. mannitolilytica* infection in a neonatal VAP case as the ventilator circuit through the use of case investigation, laboratory bacterial culture and antimicrobial susceptibility analysis. This is a critical finding on which the improvement of hospital infection prevention and control strategies is based. The next step in preventing neonatal VAP should be put on enhancing disinfection and control of ventilator-related equipment to lower the rate of the disease.

Disclosure statement

The authors declare no conflict of interest.

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Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Journal of Clinical and Nursing Research, 2026, Volume 10, Issue 1
http://ojs.bbwpublisher.com/index.php/JCNR
Online ISSN: 2208-3693
Print ISSN: 2208-3685

A Case Report of Familial Episodic Pain Syndrome Type 3 in a 5-Year-Old Boy

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Abstract: Medical history summary: The child has suffered from episodic joint pain in the lower extremities since childhood, with occurrences ranging from 1 to 3 times daily, predominantly during rainy, cold, and humid weather, as well as in the afternoons and evenings. Symptoms and signs: The primary manifestation is episodic pain in the distal extremities, predominantly in the lower limbs, knees, and ankles. Occasionally, the pain may ascend to the elbows, wrists, and palms, and may occasionally affect the proximal extremities and waist. Diagnostic methods: Nerve biopsy and related pathological examinations, along with whole exome sequencing, are helpful for diagnosis, particularly the detection of variants in the SCN11A gene. Treatment approaches: (1) Pharmacotherapy: Sodium channel blockers and nonsteroidal anti-inflammatory drugs such as ibuprofen and naproxen can alleviate pain. (2) Neuromodulation techniques: Techniques such as transcranial magnetic stimulation (TMS) and spinal cord stimulation (SCS) can be employed to improve symptoms. (3) Psychotherapy: Cognitive-behavioral therapy (CBT), relaxation training, or psychological counseling can enhance the patient's coping abilities. Clinical outcome: Pain relief can be achieved with analgesic medication in children, and pain symptoms generally persist until adulthood, gradually diminishing or even disappearing. Patients can reduce the frequency of episodes by staying warm and avoiding cold and damp conditions.

Keywords: SCN11A; Paroxysmal pain; Autosomal dominant inheritance

Online publication: Feb 9, 2026

1. Introduction

Familial episodic pain syndrome (FEPS) is a rare autosomal dominant genetic disorder characterized primarily by severe, episodic, and relatively localized paroxysmal pain. This pain typically occurs in the distal lower extremities and joints. Patients usually develop symptoms in early childhood, but due to their young age and inability to articulate their discomfort, the condition is often overlooked by parents. Symptoms tend to gradually alleviate or even disappear upon reaching adulthood. Familial episodic pain syndrome can be classified into three types based on different gene mutations, with this case being classified as FEPS type 3. Given the rarity of this condition,

clinical awareness is relatively low, and it is prone to being missed or misdiagnosed. This study aims to contribute to the establishment of more comprehensive diagnostic methods and treatment strategies.

2. Clinical data

2.1. General information

(1) Chief complaint

A 5-year-old male child presented to our outpatient clinic on December 2, 2024, with a history of "joint pain since birth".

(2) Symptoms

The child has exhibited paroxysmal crying without obvious precipitating factors since infancy, predominantly occurring in the afternoons, nights, and during rainy or cold weather, with a frequency of 1 to 3 episodes per day, each lasting for tens of minutes. During these crying episodes, the child kicks their lower limbs and experiences excessive sweating. After being able to speak at the age of one and a half, the child self-reported intermittent and periodic pain in the lower limb joints. During pain episodes, there is no limitation in joint movement, no rash, redness, bruising, or other color changes, and no skin breakdown. Since the onset of the condition, the child's growth and development have been generally normal, with no limb numbness, satisfactory appetite, and no dysfunction in urination or defecation.

(3) Past medical history

The child has been generally healthy, with no history of infectious diseases such as hepatitis, tuberculosis, or typhoid fever, nor close contact with such cases. There is no history of significant psychological trauma, traumatic surgery, or blood transfusion. The child has received all scheduled vaccinations on time and has no history of exposure to special medications or toxins.

(4) Personal history

G1P1 (first pregnancy, first delivery), full-term spontaneous vaginal delivery, with unremarkable conditions at birth. The child was fed with a combination of breast milk and formula after birth and was weaned at one year old. Growth and development have been comparable to peers, with a regular daily routine.

(5) Family history

The child's mother reports experiencing paroxysmal pain in the lower limb joints since childhood, with the intensity of pain increasing with each episode. She was previously misdiagnosed with growing pains in children and was treated with oral traditional Chinese medicine preparations, which were ineffective. The symptoms could be alleviated by immediately taking pain relievers such as paracetamol tablets after an episode. However, if medication was delayed, the effect was poor, and the paroxysmal pain would recur. Paying attention to keeping warm and avoiding cold and dampness can reduce the frequency of attacks. The symptoms of the child's mother gradually alleviated with age until the pain almost disappeared in adulthood. In the family, a total of 12 family members across four consecutive generations, including the child's mother, exhibited similar symptoms, all of whom experienced gradual relief or even complete disappearance of symptoms after reaching adulthood.

3. Examination

(1) Physical examination

The patient's body temperature was 36.5 °C, pulse rate was 68 beats/min, respiratory rate was 16 breaths/min, and blood pressure was 115/70 mmHg. The patient was conscious, in good spirits, with normal respiration, strong heart sounds, regular rhythm, and a normal heart border upon percussion. No murmurs were heard in any valve area. Breath sounds in both lungs were clear, superficial lymph nodes were of normal size, and there were no petechiae or ecchymoses on the skin. No significant muscle atrophy was observed in the limbs.

(2) Auxiliary examination

Blood routine examination showed no significant abnormalities in white blood cells, neutrophils, eosinophils, or C-reactive protein ("0.10 mg/L", reference range: 0–10 mg/L). Trace elements, vitamin D, rheumatoid factor ("8.3 IU/mL", reference range: 0.0–20.0 IU/mL), antistreptolysin O ("8 IU/mL", reference range: 0–200 IU/mL), immunoglobulin M ("1.29 g/L", reference range: 0.43–1.93 g/L), immunoglobulin G ("5.60 mg/L", reference range: 5.4–13.4 mg/L), immunoglobulin A ("0.88 g/L", reference range: 0.3–1.88 g/L), and complement C3 ("0.98 g/L", reference range: 0.78–2.1 g/L) showed no significant abnormalities, while C4 ("0.10 g/L") was slightly lower than the normal range (reference range: 0.17–0.48 g/L). Folic acid, at "13.80 ng/mL" (reference range: 5.21–24 ng/mL), is normal, while vitamin B12, at "1188 pg/mL", is higher than the normal range (reference range: 180–916 pg/mL).

(3) Genetic testing

Next-generation sequencing revealed a heterozygous mutation c.665G > A in the SCN11A gene, and family verification indicated that the child's mother also carries this mutation. This variant is a single nucleotide variation located on chromosome 5 at chr3:38966953, resulting in the substitution of arginine (Arg) with histidine (His) at position 3P22 in the protein. This locus (p.R222H) has been reported in the literature as familial episodic pain syndrome type 3. The inheritance pattern of familial episodic pain syndrome type 3 associated with this gene is autosomal dominant. Other related diseases of this gene include hereditary sensory and autonomic neuropathy type 7, which also follows an autosomal dominant inheritance pattern (**Figure 1**).

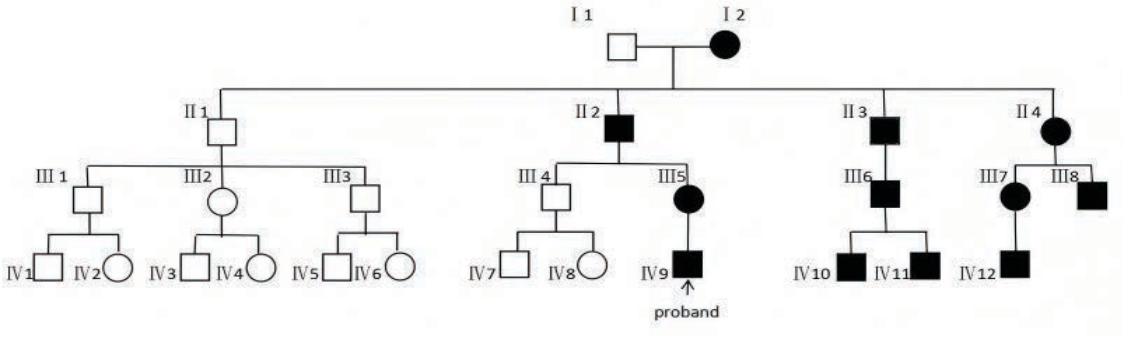

Figure 1. Patient's pedigree chart.

4. Diagnosis and differential diagnosis

(1) Differentiating from growing pains

Growing pains typically present without other accompanying symptoms, whereas familial episodic pain syndrome type 3 may be accompanied by other neurological symptoms. Genetic testing can aid in differentiation.

(2) Differentiating from rheumatism

Rheumatism often manifests as migratory soreness and pain in joints and muscles, with significantly elevated erythrocyte sedimentation rate and antistreptolysin O levels. In contrast, familial episodic pain syndrome type 3 is a hereditary neuralgia characterized by paroxysmal pain without the joint and muscle symptoms and laboratory abnormalities associated with rheumatism.

(3) Differential diagnosis of orthopedic diseases

Osteoarthritis, gouty arthritis, and other orthopedic diseases often present with symptoms such as joint pain, stiffness, and deformation, and joint lesions can be observed on X-ray or CT scans. In contrast, the pain in familial episodic pain syndrome type 3 is unrelated to joint lesions, and no abnormalities are detected on imaging examinations.

(4) Differential diagnosis of FEPS1 and FEPS2

The pain symptoms of FEPS1 primarily occur in the upper body, such as the arms, shoulders, and chest. The pain symptoms of FEPS2 mainly occur in the feet. In contrast, the pain in familial episodic pain syndrome type 3 primarily occurs in the distal joints of the limbs.

In summary, the child was diagnosed with familial episodic pain syndrome type 3.

5. Treatment

The child did not receive oral medications or other treatments at our hospital. The child's mother had previously self-administered pain relievers such as paracetamol tablets and traditional Chinese medicine preparations.

6. Treatment outcomes, follow-up, and prognosis

The child still experiences episodic pain in the distal extremities of both lower limbs several times a day, but keeping warm and avoiding damp and cold conditions can reduce the frequency of episodes.

7. Discussion

Familial episodic pain syndrome (FEPS) is a rare autosomal dominant genetic disorder characterized by severe episodic pain that manifests in early childhood, primarily affecting the distal extremities. The symptoms of FEPS gradually alleviate and may even completely disappear as the patient ages [1]. The underlying mechanism may be related to the gradual decline in the physiological expression levels of voltage-gated sodium channels (VGSCs) with age. Due to the relatively limited clinical awareness of FEPS, misdiagnosis or missed diagnosis frequently occurs. Therefore, when encountering patients with similar symptoms, after excluding secondary limb pain disorders such as rheumatism, hematological diseases, and orthopedic conditions, it is advisable to consider the possibility of FEPS. Genetic screening of patients and their family members can facilitate a definitive diagnosis, thereby preventing secondary harm caused by the misuse or abuse of medications. Some patients may develop

psychological abnormalities; in this case, the patient's family members attributed the symptoms to superstitious beliefs due to the presence of similar symptoms in multiple family members. Early diagnosis can significantly alleviate the psychological and financial burdens on the patient's family.

The clinical features of FEPS primarily manifest as episodic limb pain and numbness, with the pain predominantly concentrated in the lower extremities, knees, and ankles. Occasionally, the pain may ascend to the elbows, wrists, and palms, and may even affect the proximal extremities and waist. The pain is intense and paroxysmal, often occurring in the afternoon or evening, and exhibits a periodic pattern. The precipitating factors include weather changes, cold, and stressful events, among others, while heat application or the use of nonsteroidal anti-inflammatory drugs (NSAIDs) can partially alleviate the pain. FEPS can be classified into three types based on different gene mutations: FEPS1, FEPS2, and FEPS3 [2].

(1) FEPS1

It is caused by heterozygous variations in the transient receptor potential ankyrin 1 gene (TRPA1) located on chromosome 8q21. The pain primarily occurs in the upper body, such as the arms, shoulders, and chest, and is often triggered by factors such as eating, fatigue, and cold. A warm environment can alleviate the pain, while NSAIDs have no significant effect [3].

(2) FEPS2

It is caused by variations in the sodium voltage-gated channel alpha subunit 10 gene (SCN10A) located on chromosome 3p22. The pain mainly occurs in the feet and is unrelated to cold or other triggering factors, although warmth can sometimes alleviate the pain. Skin biopsies reveal partial or complete loss of intraepidermal nerve fiber density [4].

(3) FEPS3

Caused by variations in the sodium voltage-gated channel alpha subunit 11 gene (SCN11A) located on chromosome 3p22. The pain primarily occurs in the distal joints of the limbs, particularly the knees and ankles. Some patients show a certain therapeutic response to NSAIDs, and the frequency of pain episodes decreases with age [5].

This case is classified as FEPS3.

Familial episodic pain syndrome type 3 (FEPS3) is an autosomal dominant genetic disorder. The phenotypic details of this disease are as follows: During pain episodes, patients experience hyperhidrosis, abnormal physiological functions of the autonomic nervous system, and pain, while other sensory modalities may remain normal or diminished. The onset of the disease occurs in early childhood, with patients perceiving pain as cold. Episodes are triggered by fatigue, illness, or strenuous exercise [6]. Nonsteroidal anti-inflammatory drugs (NSAIDs) can alleviate pain, which often occurs later in the day. There is a tendency for episodes to decrease with age, and some patients may develop adult-onset small fiber neuropathy [7].

Neuroelectrophysiological tests and nerve biopsies lack specificity in diagnosing FEPS during the onset period. However, as clinical symptoms resolve, some patients may develop lesions in unmyelinated nerve fibers. These lesions aid clinicians in differentiating FEPS from other types of peripheral neuropathies. Exome sequencing has revealed that FEPS patients carry SCN11A gene variants, including known mutations and newly discovered heterozygous mutations.

Currently, the treatment strategy for FEPS primarily relies on symptom relief, such as using hot compresses and NSAIDs like ibuprofen and naproxen to alleviate mild to moderate pain. However, long-term use of NSAIDs requires attention to potential side effects. For patients who do not respond well to pharmacological treatment,

neuromodulation techniques, such as transcranial magnetic stimulation (TMS) and spinal cord stimulation (SCS), may be effective treatment options. Additionally, psychotherapy, such as cognitive-behavioral therapy (CBT), can help improve patients' coping abilities and reduce psychological stress caused by pain.

As a rare autosomal dominant inherited neuropathic pain syndrome, the treatment of FEPS may focus on the following aspects in the future.

(1) Pharmacotherapy

Develop novel drugs targeting specific ion channels or receptors to more precisely regulate pain signal transduction. For instance, drugs targeting sodium ion channels such as Nav1.7, Nav1.8, and Nav1.9, or drugs targeting transient receptor potential (TRP) channels, may become new treatment options for FEPS in the future.

(2) Physical therapy and neuromodulation

Explore more effective physical therapy methods, such as electrical stimulation and magnetic stimulation, as well as neuromodulation techniques, such as spinal cord stimulation and deep brain stimulation, to alleviate or eliminate pain symptoms.

(3) Gene therapy

With the continuous advancement of gene editing technologies, such as CRISPR-Cas9, it may be possible in the future to precisely repair or replace the disease-causing genes of FEPS, thereby fundamentally addressing the pain issue.

At present, due to the genetic heterogeneity and diverse clinical manifestations of FEPS, establishing unified treatment standards still poses challenges. Additionally, for FEPS patients with negative genetic tests or unknown pathogenic mechanisms, diagnosis and treatment become even more complex.

8. Conclusion

Pediatric limb pain is a symptom that encompasses a wide range of diseases. When encountering such cases, clinicians need to carefully differentiate and diagnose them, rather than simply categorizing them as growing pains or arthritis. It is also necessary to consider the possibility of some uncommon or rare diseases. Additionally, genetic screening can be performed on children when necessary to clarify the cause of the disease and avoid unnecessary secondary harm caused by the misuse of medications.

Disclosure statement

The authors declare no conflict of interest.

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Journal of Clinical and Nursing Research, 2026, Volume 10, Issue 1
http://ojs.bbwpublisher.com/index.php/JCNR
Online ISSN: 2208-3693
Print ISSN: 2208-3685

Interventional Room Nursing for Patients with Ischemic Stroke Treated with Tirofiban Combined with Direct Thrombectomy

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Abstract: *Objective*: To explore the interventional room nursing and its application effects in patients with ischemic stroke treated with tirofiban combined with direct thrombectomy. *Methods*: A total of 61 patients with ischemic stroke admitted to our hospital from June 2024 to June 2025 were selected and divided into two groups using the red and blue ball method: the control group (n = 30, receiving routine interventional room nursing) and the observation group (n = 31, receiving additional tirofiban medication-specific nursing + individualized interventional nursing on the basis of routine nursing). The cerebral hemodynamic indicators, adverse reactions, effectiveness of complication nursing, and nursing satisfaction were compared between the two groups. *Results:* After 7 days of treatment, the observation group had lower cerebrovascular peripheral resistance and higher mean blood flow velocity and mean blood flow volume compared to the control group (all $p < 0.05$). The observation group had a higher effectiveness rate of complication nursing than the control group, with a statistically significant difference ($p < 0.05$). The nursing satisfaction in the observation group (96.77%) was higher than that in the control group (80.00%), with a statistically significant difference ($\chi 2 = 4.223$, $p = 0.040 < 0.05$). *Conclusion:* Tirofiban combined with direct thrombectomy can significantly improve cerebral hemodynamics, enhance the effectiveness of complication nursing, and increase patient satisfaction in patients with ischemic stroke.

Keywords: Tirofiban; Direct thrombectomy; Ischemic stroke; Interventional room nursing; Nursing coordination

Online publication: Feb 11, 2026

1. Introduction

Ischemic stroke is caused by narrowing or occlusion of cerebral blood vessels, leading to ischemia, hypoxia, and necrosis of brain tissue, subsequently resulting in neurological deficits. It primarily manifests as limb hemiplegia, speech dysfunction, impaired consciousness, etc., and is characterized by high morbidity, disability, mortality, and recurrence rates, posing a severe threat to patients' lives and health [1]. Currently, direct thrombectomy is the primary clinical treatment method, which rapidly opens occluded blood vessels through mechanical means, restores cerebral blood perfusion, and reduces brain tissue damage. According to relevant reports, some patients

still experience issues such as vascular re-occlusion and insufficient cerebral perfusion after direct thrombectomy treatment [2]. As a highly selective non-peptide platelet aggregation inhibitor, tirofiban inhibits platelet aggregation by blocking the platelet glycoprotein IIb/IIIa receptor, thereby preventing thrombus formation. The quality of interventional room nursing directly affects the safety and effectiveness of treatment, especially in combined medication therapy, where scientific nursing interventions can ensure medication safety and improve surgical coordination efficiency. Based on this, this article further explores the clinical effects of tirofiban combined with direct thrombectomy in treating patients with ischemic stroke and the targeted interventional room nursing measures. The report is as follows.

2. Materials and methods

2.1. General information

A total of 61 patients with ischemic stroke admitted to our hospital from June 2024 to June 2025 were selected and divided into two groups using the red and blue ball method: the control group (n = 30) and the observation group (n = 31). In the control group, there were 19 males and 11 females, aged between 40 and 78 years old, with an average age of (62.35 ± 3.32) years old; the onset time ranged from 1 to 6 hours, with an average of (3.65 ± 0.15) hours. In the observation group, there were 18 males and 12 females, aged between 41 and 78 years old, with an average age of (62.39 ± 3.36) years old; the onset time ranged from 1 to 5 hours, with an average of (3.57 ± 0.12) hours. There was no statistically significant difference in the information between the two groups ($p > 0.05$).

2.2. Diagnostic criteria

Reference was made to the "2018 Chinese Guidelines for the Diagnosis and Treatment of Acute Ischemic Stroke": presence of any neurological deficit such as sudden limb weakness, speech impairment, visual abnormalities, dizziness, or unsteady gait; exclusion of cerebral hemorrhage by head CT; diagnosis can be made if symptoms persist for more than 24 hours without imaging evidence; laboratory tests (complete blood count, coagulation function, blood glucose, etc.) should be completed to exclude stroke mimics and other etiologies [3].

2.3. Inclusion and exclusion criteria

2.3.1. Inclusion criteria

(1) Patients meeting the above diagnostic criteria;
(2) Time from onset to hospital admission not exceeding 6 hours, meeting the indications for direct thrombectomy treatment;
(3) Informed consent obtained from patients and their families;
(4) Approval obtained from the Ethics Committee of our hospital.

2.3.2. Exclusion criteria

(1) Patients with mental or cognitive abnormalities;
(2) Patients with a history of intracranial hemorrhage or brain trauma;
(3) Patients with cardiac, hepatic, or renal insufficiency;
(4) Patients allergic to the methods or medications used in the trial.

2.4. Methods

2.4.1. Control group

The control group received routine interventional room care: Assisting patients in completing preoperative routine examinations before surgery, preparing interventional surgical instruments and medications; preparing the skin at the puncture site, informing them of the basic surgical procedure and precautions; assisting the surgeon in positioning the patient during surgery; accurately passing surgical instruments and closely monitoring vital signs; after surgery, assisting patients in returning to the ward, observing for bleeding or hematoma at the puncture site, and instructing patients to rest in bed.

2.4.2. Observation group

In addition to routine interventional room care, the observation group received specialized care for tirofiban administration and individualized interventional care, with the following measures:

(1) Preoperative care

① Comprehensive assessment: Conduct examinations to evaluate the patient's coagulation function and vascular condition, with a focus on assessing the risk of bleeding. For patients at high risk of bleeding, develop targeted preventive measures in advance; ② Medication instruction: Provide detailed explanations to patients and their families about the mechanism of action, administration method, potential adverse reactions, and corresponding measures of tirofiban to enhance medication compliance; ③ Preparation of items: In addition to routine surgical items, specifically prepare tirofiban injection, intravenous pumps, and hemostatic emergency items (hemostatic forceps, hemostatic gauze, etc.); ④ Psychological counseling: Share successful treatment cases with patients, answer their questions, and enhance their confidence in treatment.

(2) Intraoperative nursing care

① Precise medication administration: Strictly adhere to the intravenous pump parameters set by the doctor's orders to ensure accurate dosage and speed of tirofiban infusion. During the infusion process, monitor the patency of the infusion tubing to prevent drug extravasation; ② Close monitoring: Enhance monitoring of the patient's vital signs and watch for signs of bleeding (increased bleeding at the puncture site, gingival bleeding, nosebleeds, etc.). If abnormalities occur, immediately report to the doctor and assist in handling them; ③ Optimization of surgical coordination: Flexibly adjust the patient's position according to the needs of the thrombectomy procedure; accurately and quickly pass surgical instruments.

(3) Postoperative nursing care

① Enhanced observation of the puncture site: Check the puncture site every 0.5 hours for bleeding or hematoma, and monitor the temperature, color, and sensation of the lower limb skin. If hematoma enlargement or persistent bleeding occurs, promptly apply pressure to stop the bleeding; ② Coagulation function monitoring: Regularly assist the patient in reviewing coagulation function indicators after surgery and adjust nursing measures promptly based on the results; ③ Diet and activity guidance: During bed rest, instruct the patient to choose bland, easily digestible, and protein-rich foods, and avoid spicy and irritating foods. Assist the patient in performing passive limb movements to prevent deep vein thrombosis in the lower limbs, and advise them to avoid strenuous activities to prevent bleeding at the puncture site; ④ Nursing care for adverse reactions: In case of adverse reactions such as skin rash and vascular reocclusion, promptly report to the doctor, assist in management, and comfort the patient and their family members.

2.5. Observation indicators

(1) Compare the cerebral hemodynamics indicators of the two groups before treatment and after 7 days of treatment. Utilize a cerebrovascular function detector (manufacturer: Beijing Gushanfeng Biotechnology Co., Ltd., model: GT-300) with a probe frequency set at 5 MHz. Assist the patient in assuming a supine position and proceed with the operation after their breathing and heart rate have stabilized. Measure the cerebrovascular peripheral resistance, mean blood flow velocity, and mean blood flow volume.

(2) Compare the adverse reactions (rash, vascular reocclusion, vascular injury) between the two groups.

(3) Compare the effectiveness rate of complication nursing between the two groups (the proportion of patients whose symptoms of complications such as bleeding and vascular reocclusion are controlled or alleviated after nursing care, out of the total number of patients with such complications).

(4) Compare nursing satisfaction between the two groups, assessed using a self-designed nursing satisfaction questionnaire (Cronbach's α coefficient of 0.88, demonstrating good reliability and validity) from our hospital. The questionnaire covers aspects such as nursing attitude, proficiency in nursing operations, and effectiveness of health guidance, with a total score of 100 points. It is divided into three levels: very satisfied (≥ 90 points), satisfied (70–89 points), and dissatisfied (< 69 points). Nursing satisfaction is calculated as the sum of the very satisfied rate and the satisfied rate.

2.6. Statistical methods

The cerebral hemodynamic indicators, incidence of adverse reactions, effectiveness rate of complication nursing, and nursing satisfaction were input into SPSS 20.0 software. The first indicator is a measurement variable (conforming to a normal distribution), expressed as ($\overline{x} \pm$ s), and analyzed using the *t*-test. The latter three indicators are categorical variables, expressed as "%". A statistically significant difference is considered when $p < 0.05$.

3. Results

3.1. Cerebral hemodynamic indicators

According to **Table 1**, after 7 days of treatment, the observation group had lower cerebrovascular peripheral resistance and higher mean blood flow velocity and mean blood flow volume compared to the control group (all $p < 0.05$).

Table 1. Changes in cerebral hemodynamic indicators between groups ($\overline{x} \pm$ s)

Group	Cerebrovascular peripheral resistance [kPa/(s·m)]		Mean blood flow velocity (cm/s)		Mean blood flow (mL/s)	
	Before treatment	After 7 days	Before treatment	After 7 days	Before treatment	After 7 days
Observation group (n = 31)	90.54 ± 12.29	73.88 ± 5.42[a]	13.69 ± 3.28	20.66 ± 6.45[a]	5.45 ± 1.23	8.78 ± 2.66[a]
Control group (n = 30)	91.51 ± 13.31	80.67 ± 8.40[a]	13.71 ± 3.29	17.01 ± 5.35[a]	5.43 ± 1.25	7.34 ± 1.53[a]
t-value	0.296	3.764	0.024	2.401	0.063	2.580
p-value	0.768	< 0.001	0.981	0.016	0.950	0.012

Note: Compared with before treatment in the same group, [a]$p < 0.05$.

3.2. Incidence of adverse reactions

According to **Table 2**, there was no statistically significant difference in the incidence of adverse reactions between the two groups ($p > 0.05$).

Table 2. Incidence of adverse reactions between groups [n (%)]

Group	Rash	Vascular re-occlusion	Vascular injury	Total incidence (%)
Observation group (n = 31)	1 (3.23)	1 (3.23)	0 (0.00)	2 (6.45)
Control group (n = 30)	1 (3.23)	2 (6.67)	1 (3.33)	4 (13.33)
χ^2-value	-	-	-	0.814
p-value	-	-	-	0.367

3.3. Effectiveness rate of complication nursing

In the observation group, one case of rash and one case of vascular reocclusion occurred, both of which were rapidly controlled after targeted nursing interventions, resulting in a 100.00% effectiveness rate in complication nursing.

In the control group, there was one case of rash, two cases of vascular reocclusion, and one case of vascular injury. Symptoms were alleviated in two cases after nursing care, while two patients with vascular reocclusion required further treatment, yielding a 75.00% effectiveness rate in complication nursing. The observation group demonstrated a significantly higher effectiveness rate in complication nursing compared to the control group, with a statistically significant difference ($p < 0.05$).

3.4. Nursing satisfaction

Table 3 indicates that the observation group exhibited higher nursing satisfaction compared to the control group, with a statistically significant difference ($p < 0.05$).

Table 3. Incidence of adverse reactions between groups [n (%)]

Group	Very satisfied	Satisfied	Dissatisfied	Overall satisfaction rate (%)
Observation group (n = 31)	20 (64.52)	10 (32.26)	1 (3.23)	30 (96.77)
Control group (n = 30)	12 (40.00)	12 (40.00)	6 (20.00)	24 (80.00)
χ^2-value	-	-	-	4.223
p-value	-	-	-	0.040

4. Discussion

The core pathological mechanism of ischemic stroke involves thrombus formation leading to cerebral vessel occlusion, subsequently causing ischemic-hypoxic damage to brain tissue. Direct thrombectomy can swiftly and directly remove intracranial thrombi, restoring vascular patency. However, some patients may experience vascular reocclusion due to platelet reaggregation or residual thrombus enlargement [4]. Tirofiban, a highly selective platelet aggregation inhibitor, effectively blocks the platelet aggregation process and reduces the risk of thrombus formation. Combining direct thrombectomy with tirofiban is expected to further enhance therapeutic outcomes.

Interventional room nursing, as a crucial component of the treatment process, directly influences the safety and effectiveness of therapy. Especially when combined with tirofiban treatment, implementing scientific nursing measures is essential to ensure medication safety, optimize surgical collaboration, and improve patient prognosis.

The above findings indicate that, after seven days of treatment, the improvement in cerebral hemodynamic indicators was more significant in the observation group compared to the control group. This can be attributed to the crucial role played by the specialized nursing care for tirofiban administration and individualized interventional nursing provided to the observation group in addition to routine care. A comprehensive preoperative assessment of the patient's bleeding risk and thorough preparation laid a solid foundation for the smooth implementation of treatment and nursing. During surgery, precise medication administration ensured the accuracy of tirofiban dosage and infusion rate, while close monitoring of the patient's vital signs and signs of bleeding enabled timely detection and management of abnormalities, thereby ensuring treatment safety. Postoperatively, enhanced observation of the puncture site and regular monitoring of coagulation function facilitated the early detection and management of complications, while dietary and activity guidance helped prevent secondary issues such as deep vein thrombosis in the lower extremities, thereby improving patient prognosis [5]. These results align with clinical reports [6]. There was no significant difference in the incidence of adverse reactions between the two groups, but the observation group demonstrated higher rates of effective complication management and nursing satisfaction compared to the control group. This suggests that targeted interventional room nursing can enhance the effectiveness of complication intervention and improve the patient's nursing experience without increasing the risk of adverse reactions. The reason for this is that the nursing interventions in the observation group were more targeted and individualized. Preoperative psychological counseling effectively reduced patient anxiety, precise intraoperative coordination improved surgical efficiency, and meticulous postoperative complication nursing and health guidance enhanced the patient's sense of security and trust.

In addition, this study also found a close connection between nursing interventions and patient prognosis. Postoperative bleeding monitoring and nursing care enable the timely detection and management of issues such as bleeding and hematoma at the puncture site, thereby reducing the impact of adverse reactions on patient prognosis. Medication nursing ensures the standardized use of tirofiban, assists in optimizing the patient's blood coagulation function, and reduces the risk of recurrent thrombosis [7]. Furthermore, individualized surgical cooperation enhances the efficiency of thrombectomy procedures, reduces the duration of cerebral ischemia and hypoxia, mitigates cerebral tissue damage, and improves the neurological prognosis of patients [8]. However, this trial was a single-center, small-sample study, which may affect the reliability and generalizability of the results; moreover, long-term follow-up of patients was not conducted.

5. Conclusion

In summary, for patients with ischemic stroke treated with a combination of tirofiban and direct thrombectomy, implementing comprehensive interventional room nursing that includes specialized nursing for tirofiban medication and individualized interventional nursing can effectively improve cerebral hemodynamics, enhance the effectiveness of complication nursing, and increase patient satisfaction with nursing care. Future research could involve multi-center, large-sample, long-term follow-up studies to further demonstrate the long-term effectiveness and safety of the combined treatment regimen and targeted interventional room nursing.

Disclosure statement

The author declares no conflict of interest.

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Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Journal of Clinical and Nursing Research, 2026, Volume 10, Issue 1
http://ojs.bbwpublisher.com/index.php/JCNR
Online ISSN: 2208-3693
Print ISSN: 2208-3685

Observation on the Effect of Combined Exercise Intervention Based on the Hospital-Community-Family Model on Intrinsic Capacity in Elderly Patients with Diabetes Mellitus Complicated by Chronic Kidney Disease

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Abstract: *Objective*: To explore the application effect of combined exercise intervention based on the hospital-community-family model on intrinsic capacity in elderly patients with diabetes mellitus complicated by chronic kidney disease. *Methods*: Using convenience sampling, 100 elderly patients with diabetes mellitus complicated by chronic kidney disease who received treatment in the endocrinology department of a tertiary A-level hospital from May 2024 to May 2025 were selected as the study subjects. They were randomly divided into an experimental group (50 cases) and a control group (50 cases) using a random number table method. The control group received routine health education and telephone follow-up, while the experimental group, in addition to the control group's interventions, underwent combined exercise intervention based on the hospital-community-family model. Remote medical guidance was utilized to monitor and study the application effect of exercise intervention on intrinsic capacity in elderly patients with diabetes mellitus complicated by chronic kidney disease. Fasting blood glucose, 2-hour postprandial blood glucose, glomerular filtration rate, 6-minute walk distance, and scores in five dimensions of intrinsic capacity (exercise, cognition, psychology, vitality, and sensation) were measured before the intervention, at 4 weeks of intervention, and at 12 weeks of intervention for both groups. *Results:* Before the exercise intervention, there were no statistically significant differences ($p > 0.05$) between the two groups in terms of fasting blood glucose, 2-hour postprandial blood glucose, glomerular filtration rate, 6-minute walk distance, and scores across five dimensions of intrinsic capacity: mobility, cognition, psychology, vitality, and sensation. After 12 weeks of intervention, the experimental group demonstrated significantly higher scores than the control group in glomerular filtration rate, 6-minute walk distance, and the dimensions of mobility, cognition, and vitality within intrinsic capacity, with all differences being statistically significant ($p < 0.05$). Conversely, the experimental group showed significantly lower scores than the control group in fasting blood glucose, 2-hour postprandial blood glucose, and the psychological dimension

of intrinsic capacity, with these differences also being statistically significant ($p < 0.05$). *Conclusion:* Continuous nursing care utilizing telemedicine based on a hospital-community-family model combined with exercise intervention can effectively enhance exercise tolerance and intrinsic capacity in elderly patients with diabetes mellitus complicated by chronic kidney disease, thereby improving their quality of life. The effectiveness of the intervention is positively correlated with the duration of the intervention.

Keywords: Hospital-community-family model; Telemedicine; Elderly; Diabetes mellitus complicated by chronic kidney disease; Intrinsic capacity

Online publication: Feb 11, 2026

1. Introduction

As the process of population aging accelerates, the co-occurrence of chronic diseases in the elderly has become a major concern in the field of public health [1]. Both diabetes mellitus (DM) and chronic kidney disease (CKD) are prevalent chronic conditions among the elderly population, often interacting and progressing in tandem. This not only exacerbates renal function impairment and elevates the risk of end-stage renal disease (ESRD), but also triggers a series of issues such as physical function decline and cognitive impairment [2]. Approximately 30–50% of patients with concurrent DM and CKD eventually develop ESRD, posing a severe threat to their quality of life [3]. The concept of intrinsic capacity (IC), introduced by the WHO in 2015 as a core indicator for assessing the health status of the elderly, encompasses multiple dimensions including physical capacity, cognition, psychology, and social adaptation. The level of IC directly determines the elderly's ability to live independently and their health prognosis, serving as an important metric for evaluating the effectiveness of chronic disease management [4]. It aims to reflect the overall state of the elderly from a holistic perspective and can be used as an independent predictor of disability in the elderly [5]. Current exercise intervention models are mostly confined to short-term guidance within hospitals, lacking continuous supervision at the community level and long-term cooperation at the family level, making it difficult to meet the personalized and long-term intervention needs of elderly patients with comorbidities [6,7]. The hospital-community-family integrated intervention model breaks down the barriers of healthcare service settings. Through telemedicine service platforms, it integrates tertiary healthcare resources, achieving full-process coverage from standardized in-hospital diagnosis and treatment to continuous community management and then to daily home care, providing new approaches for the comprehensive management of elderly patients with chronic diseases [8–11]. Therefore, this study aims to explore the implementation of exercise intervention guidance and monitoring for elderly patients with diabetes mellitus (DM) complicated by chronic kidney disease (CKD) based on a hospital-community-family model, and subsequently evaluate its application effect on patients' intrinsic capacity, with the goal of providing a reference basis for further improving the quality of life of elderly patients with DM complicated by CKD.

2. Subjects and methods

2.1. Subjects

This study consecutively enrolled 100 elderly patients with DM complicated by CKD who received treatment in the Endocrinology Department of a tertiary-level hospital from May 2024 to May 2025. Using a random number

table method, the enrolled patients were divided into an experimental group and a control group, with 50 cases in each group.

2.1.1. Inclusion criteria

Participants meeting the diagnostic criteria for DM with a disease duration of ≥ 3 months; conforming to the definition of CKD proposed by the Kidney Disease Outcomes Quality Initiative (KDOQI) guidelines, with clinically confirmed stable CKD stages 1–4, and not undergoing maintenance dialysis treatment; elderly patients aged ≥ 60 years; individuals capable of independent walking and able to complete individualized exercise prescriptions for this study as instructed; long-term residence after discharge within the community covered by the hospital's telemedicine platform; able to communicate without barriers with researchers, willing to participate throughout the study, and having signed an informed consent form [12,13].

2.1.2. Exclusion criteria

Individuals with severe osteoarticular diseases, such as ankylosing spondylitis; those with mental disorders combined with severe heart, liver, brain, lung, or other serious renal diseases; and those currently participating in clinical trials. There were no statistically significant differences in general data between the two groups ($p > 0.05$).

2.2. Intervention methods

Exercise intervention involves the formulation of individualized exercise prescriptions. The exercise prescriptions are developed with reference to the "Chinese Guidelines for Exercise in Type 2 Diabetes" and the "Clinical Practice Guidelines for Exercise Rehabilitation in Chronic Kidney Disease" [14,15]. Specific guidance is provided on exercise form, intensity, frequency, and duration.

2.2.1. Control group

The control group receives conventional care for DM combined with CKD.

2.2.2. Experimental group

In addition to conventional treatment and care, the experimental group undergoes a joint exercise intervention based on a hospital-community-family model utilizing a telemedicine platform. The specific measures are as follows:

(1) Establish a remote platform and an exercise intervention team

The team members include: 1 endocrinologist, 1 nephrologist, 1 exercise rehabilitation therapist, 1 endocrine specialist nurse, 1 nephrology specialist nurse, 2 community nurses, and 1 remote platform engineer.

(2) Remote exercise and health management content

Remote exercise supervision and follow-up will be conducted twice a week, including: ① Online exercise supervision and guidance: a. Warm-up exercises for 10 minutes each time; b. Aerobic exercises; c. Resistance exercises; e. Flexibility exercises; f. Stretching exercises. ② Online medical consultations: Patients can consult hospital or community healthcare professionals online through the remote platform using text, voice, images, or video. ③ Online health education: Monthly online educational lectures will be conducted by endocrine or nephrology specialist nursing experts.

(3) Remote platform patient-side operations

Researchers will release videos related to rehabilitation exercises for diabetes mellitus (DM) and chronic kidney disease (CKD) on the hospital's telemedicine platform every Tuesday and Thursday for patients, community healthcare professionals, and caregivers to learn from, thereby enhancing patients' enthusiasm for participating in exercise rehabilitation.

2.3. Observation indicators

Data will be collected during patient follow-up visits, with observation indicators including: fasting blood glucose, 2-hour postprandial blood glucose, glomerular filtration rate, 6-Minute Walk Test (6MWT), and intrinsic capacity scores for the elderly. Intrinsic capacity encompasses five dimensions: exercise, cognition, psychology, vitality, and sensation.

(1) Short physical performance battery (SPPB)

The SPPB comprises four major tests: balance ability test, walking speed test, and sit-to-stand test. A score of 1 is assigned for a performance time ranging from 16.7 to 60 seconds, 2 points for a time between 13.70 and 16.69 seconds, 3 points for a time between 11.20 and 13.69 seconds, and 4 points for a time of ≤ 11.19 seconds. If the task cannot be completed or the time exceeds 60 seconds, a score of 0 is given. Each test component is scored from 0 to 4, resulting in a total SPPB score of 12 points. An SPPB score of ≤ 8 indicates decreased physical performance [16].

(2) Mini mental state examination (MMSE)

The MMSE is currently one of the preferred screening tools for cognitive impairment, developed by Folstein [17]. The scale includes assessments of orientation, memory, attention and calculation, recall ability, and language skills. The total score is 30 points, with higher scores indicating better cognitive function. It demonstrates high reliability and validity when used to evaluate dementia in various populations.

(3) Mini nutritional assessment (MNA)

The MNA scale, developed by Guigoz et al., includes six items: ① weight loss in the last three months; ② body mass index; ③ psychological stress or acute illness in the last three months; ④ mobility; ⑤ psychological problems; and ⑥ appetite in the last three months. The total score is 14 points, and a score of ≤ 11 points suggest a decline in the vitality dimension [18].

(4) Short-form geriatric depression scale (geriatric depression scale 5 items, GDS-15)

The GDS-15 was developed by foreign scholar Sheikh in 1986 and consists of 15 items, with a total score of 15 points. Each item answered as indicative of depression is scored as 1 point, and a final score of ≥ 8 points indicates the presence of depressive symptoms [19].

(5) Sensory dimension scoring

The sensory dimension includes vision and hearing. Vision and hearing are assessed using a visual acuity chart and a whisper test, respectively. Normal vision and hearing are scored as 1 point, while any impairment is scored as 0 points.

2.4. Statistical methods

Data were analyzed using SPSS 25.0 statistical software. Normally distributed measurement data are presented as mean ± standard deviation ($\overline{x} \pm s$). Comparisons between groups were conducted using paired *t*-tests, while comparisons within three different time groups were performed using repeated measures analysis of variance. A p-value < 0.05 was considered statistically significant.

3. Results

3.1. Comparison of fasting blood glucose level between two groups of patients

A comparison of fasting blood glucose levels between the two groups before intervention, at 4 weeks of intervention, and at 12 weeks of intervention is presented in **Table 1**.

Table 1. Comparison of fasting blood glucose level between two groups before and after intervention (mol/L, $\overline{x} \pm s$)

Time point	Before treatment	4 Weeks of treatment	12 Weeks of treatment
Experimental group (n = 50)	10.2 ± 2.7	8.6 ± 2.4	7.9 ± 2.3
Control group (n = 50)	10.7 ± 1.3	10.2 ± 1.2	10.0 ± 2.2
F-value (ANOVA)	F_{Group}4.045	F_{Time}35.484	$F_{Interaction}$82.679
t-value (vs. Baseline)	-0.523	-0.152	12.115
p-value	0.609	< 0.001	< 0.001

3.2. Comparison of 2-hour postprandial blood glucose levels between the two groups

A comparison of 2-hour postprandial blood glucose levels between the two groups before intervention, at 4 weeks of intervention, and at 12 weeks of intervention is shown in **Table 2**.

Table 2. Comparison of 2-hour postprandial blood glucose levels between the two groups before and after intervention (mol/L, $\overline{x} \pm s$)

Time point	Before treatment	4 Weeks of treatment	12 Weeks of treatment
Experimental group (n = 50)	11.8 ± 2.2	9.8 ± 2.6	8.8 ± 2.1
Control group (n = 50)	10.7 ± 2.1	10.5 ± 1.2	10.3 ± 2.6
F-value (ANOVA)	F_{Group}4.127	F_{Time}30.258	$F_{Interaction}$81.367
t-value (vs. Baseline)	-0.520	-0.137	13.109
p-value	0.341	< 0.001	< 0.001

3.3. Comparison of glomerular filtration rates between the two groups

A comparison of glomerular filtration rates between the two groups before intervention, at 4 weeks of intervention, and at 12 weeks of intervention is shown in **Table 3**.

Table 3. Comparison of glomerular filtration rates between the two groups before and after intervention (mL/min, $\overline{x} \pm s$)

Time point	Before treatment	4 Weeks of treatment	12 Weeks of treatment
Experimental group (n = 50)	86.867 ± 12.775	87.003 ± 12.342	99.367 ± 8.349
Control group (n = 50)	87.172 ± 12.710	87.097 ± 12.548	84.007 ± 9.286
F-value (ANOVA)	F_{Group}4.112	F_{Time}32.243	$F_{Interaction}$84.637
t-value (vs. Baseline)	-0.417	-0.118	12.284
p-value	0.609	< 0.001	< 0.001

3.4. Comparison of the six-minute walk distance (6MWD) between the two groups

A comparison of the 6MWD between the two groups before intervention, at 4 weeks of intervention, and at 12 weeks of intervention is shown in **Table 4**.

Table 4. Comparison of the 6MWD between the two groups before and after intervention (m, $\overline{x} \pm s$)

Time point	Before treatment	4 Weeks of treatment	12 Weeks of treatment
Experimental group (n = 50)	306.245 ± 27.218	325.295 ± 27.296	369.570 ± 24.635
Control group (n = 50)	301.185 ± 23.652	319.920 ± 24.878	322.820 ± 26.423
F-value (ANOVA)	F_{Group}22.287	F_{Time}318.572	$F_{Interaction}$148.529
t-value (vs. Baseline)	1.283	5.647	14.193
p-value	0.685	< 0.001	< 0.001

3.5. Comparison of intrinsic capacities between the two groups

A comparison of scores across five dimensions of intrinsic capacity between the two groups before intervention, at 4 weeks of intervention, and at 12 weeks of intervention is shown in **Table 5**.

Table 5. Comparison of intrinsic capacities between the two groups before and after intervention (points, $\overline{x} \pm s$)

Dimension	Time point	Experimental group (n = 50)	Control group (n = 50)	*F*-value	*t*-value	*p*-value (Group difference)
Motor	Before Intervention	5.05 ± 2.82	4.83 ± 1.86	F_{Group}23.856	-0.463	0.629
	4 Weeks	5.32 ± 2.42	4.75 ± 1.79	F_{Time}50.672	-3.582	0.061
	12 Weeks	7.54 ± 2.16	4.82 ± 1.61	$F_{Interaction}$28.652	-8.792	< 0.001
Cognitive	Before Intervention	18.27 ± 2.61	18.62 ± 2.34	F_{Group}15.445	-1.639	0.106
	4 Weeks	21.24 ± 1.92	18.97 ± 1.69	F_{Time}82.315	-4.085	0.087
	12 Weeks	25.37 ± 1.54	19.68 ± 1.28	$F_{Interaction}$41.285	-9.257	< 0.001
Psychological	Before Intervention	6.44 ± 2.83	6.52 ± 1.92	F_{Group}20.526	-2.023	0.171
	4 Weeks	4.21 ± 1.56	6.32 ± 1.27	F_{Time}121.284	-0.761	0.227
	12 Weeks	3.19 ± 1.84	5.86 ± 1.53	$F_{Interaction}$106.251	-12.568	<0.001
Vitality	Before Intervention	10.12 ± 1.42	9.89 ± 1.86	F_{Group}4.564	-0.582	0.489
	4 Weeks	10.29 ± 1.29	10.12 ± 1.39	F_{Time}20.128	-1.752	0.864
	12 Weeks	11.86 ± 1.81	10.19 ± 1.56	$F_{Interaction}$18.812	-5.127	< 0.001
Sensory	Before Intervention	0.32 ± 0.71	0.31 ± 0.89	F_{Group}56.261	-1.728	0.161
	4 Weeks	0.33 ± 0.76	0.32 ± 0.23	F_{Time}72.729	-1.453	0.121
	12 Weeks	0.34 ± 0.68	0.35 ± 0.38	$F_{Interaction}$73.592	-1.039	0.258

4. Discussion

4.1. Hospital-community-family exercise intervention improves glycemic control in elderly DM-CKD patients

Joint exercise intervention based on the hospital-community-family model can effectively improve fasting blood glucose and 2-hour postprandial blood glucose levels in elderly patients with diabetes mellitus (DM) complicated by chronic kidney disease (CKD). The study results indicate that after 4 and 12 weeks of intervention, both fasting blood glucose and 2-hour postprandial blood glucose levels in the experimental group were significantly lower than those in the control group, with statistically significant differences ($p < 0.05$). This suggests that the intervention can effectively reduce blood glucose levels in patients, and the effect of reducing blood glucose is positively correlated with the duration of the intervention, with longer durations yielding more pronounced effects. The analysis suggests that the intervention may leverage remote monitoring and guidance models in telemedicine to ensure the safety and scientific validity of patient exercise, while providing continuous supervision and motivation from family members or peers, leading to higher adherence, incorporation into daily habits, and long-term maintenance, thereby effectively achieving blood glucose control goals.

4.2. Hospital-community-family exercise intervention improves renal function in elderly DM-CKD patients

Joint exercise intervention based on the hospital-community-family model can effectively improve renal function in elderly patients with DM complicated by CKD. The results of this study indicate that after 12 weeks of intervention, the glomerular filtration rate (GFR) in the experimental group was higher than that in the control group, with a statistically significant difference ($p < 0.05$). This suggests that the intervention can effectively improve renal function in patients. The analysis suggests that the intervention may leverage both remote monitoring and remote rehabilitation in telemedicine to enhance patient exercise adherence, boost confidence, and increase the completion rate of designated exercise intervention programs.

4.3. A hospital-community-family rehabilitation exercise model improves exercise capacity in elderly DM-CKD patients

Joint rehabilitation exercise intervention based on the hospital-community-family model can effectively improve exercise capacity in elderly patients with DM complicated by CKD. Studies have shown that appropriate aerobic exercise combined with resistance training can effectively improve patients' mobility and quality of life, while low physical activity can effectively delay the further progression of diabetes mellitus (DM) and chronic kidney disease (CKD) [20–22]. However, excessive physical activity can also increase the burden on the kidneys. The lack of professional exercise guidance and examination after discharge can lead to impaired exercise capacity and a decline in physical function levels among elderly patients with DM complicated by CKD, resulting in periodic reductions in physical activity levels and ultimately functional disorders [23]. The results of this study indicate that the 6-minute walk distance of patients in the experimental group was higher than that in the control group, suggesting that patients' exercise capacity was effectively improved, consistent with the findings of studies by Chen Jiale and others [24].

4.4. A multi-level rehabilitation exercise intervention improves intrinsic capacity in elderly patients with diabetic kidney disease

Rehabilitation exercise intervention based on a hospital-community-family model can effectively improve the

intrinsic capacity of elderly patients with DM complicated by CKD. Intrinsic capacity serves as an independent predictor of disability in the elderly [25]. Studies have shown that a decline in intrinsic capacity affects the daily living abilities of the elderly [26]. Improving patients' intrinsic capacity can effectively delay disease progression, reduce the risk of complications, and enhance their quality of life. The results of repeated measures analysis of variance in this study showed no statistically significant difference in the scores of the sensory dimension of intrinsic capacity between the two groups after 4 and 12 weeks of intervention ($p > 0.05$). However, statistically significant differences were observed in the scores of the motor, cognitive, psychological, and vitality dimensions of intrinsic capacity between the two groups after 4 and 12 weeks of intervention ($p < 0.05$). It is proven that this intervention can significantly improve the levels of patients' intrinsic abilities in terms of exercise, cognition, psychology, and vitality. The analysis suggests that the reason may be that the combination of telemedicine platforms and exercise interventions can promote the effective participation of patients' family members in the entire process of patients' exercise rehabilitation treatment, enabling patients to receive more encouragement and assistance from family members, community staff, and medical personnel.

5. Conclusion

In summary, this study employed a hospital-community-family model combined with exercise interventions and utilized telemedicine platforms to provide exercise guidance for elderly patients with diabetes mellitus (DM) complicated by chronic kidney disease (CKD). This approach aimed to deliver comprehensive nursing care throughout the entire process for these patients, improve their blood glucose levels, enhance renal function, boost their intrinsic abilities, and ultimately improve their quality of life. However, given that telemedicine and digital smart nursing technologies are not yet fully widespread, and the scope of hospital-community-family collaboration is relatively limited, the results may be subject to bias. Therefore, future multi-center studies could be conducted to enhance the scientific rigor of the findings.

Funding

2024 Medical Science Research Project Plan of Hebei Province: Research on the Rehabilitation Effect of Combined Exercise Intervention Based on a Hospital-Community-Family Model for Elderly Patients with Chronic Diseases (Project No.: 20240083); Youth Science and Technology Project of the Hebei Provincial Health Department: Research on the Standardization Level of Self-Management in Patients with Diabetic Foot and Related Factors Affecting Wound Healing (Project No.: 20190002)

Disclosure statement

The authors declare no conflict of interest.

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Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Journal of Clinical and Nursing Research, 2026, Volume 10, Issue 1
http://ojs.bbwpublisher.com/index.php/JCNR
Online ISSN: 2208-3693
Print ISSN: 2208-3685

A Cross-sectional Analysis of Prenatal Bisphenol an Exposure and Pregnancy Characteristics in Northeastern Yunnan, China

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Abstract: *Objective*: To assess prenatal Bisphenol A (BPA) exposure levels and explore their preliminary associations with maternal and fetal characteristics in a population from Northeastern Yunnan. *Methods*: A cross-sectional analysis was performed using data and urine samples from 70 pregnant women in their third trimester recruited at Qujing Central Hospital. Urinary BPA was measured by HPLC-MS/MS. Participants were stratified into high and low BPA exposure groups based on the median concentration. *Results:* BPA was detected in all samples (100%) with a median concentration of 2.41 μg/L (IQR: 0.68–4.96). The high BPA exposure group (≥ 2.41 μg/L) had a significantly higher proportion of gestational diabetes mellitus (GDM) (42.9% vs. 17.1%, $p = 0.021$) and a lower median fetal birth weight (3250 g vs. 3450 g, $p = 0.048$) compared to the low exposure group. *Conclusion:* This pilot study reveals ubiquitous BPA exposure in pregnant women from Northeastern Yunnan. The observed preliminary associations with GDM and reduced fetal birth weight warrant further investigation in larger, longitudinal studies.

Keywords: Bisphenol A; Pregnancy; Exposure assessment; Cross-sectional study; China

Online publication: Feb 11, 2026

1. Introduction

Bisphenol A (BPA) is a widespread endocrine-disrupting chemical, and pregnant women and fetuses are vulnerable to its effects [1]. Studies have linked prenatal BPA exposure to adverse pregnancy outcomes (APOs) like gestational diabetes mellitus (GDM) and fetal growth restriction [2–5]. However, data on exposure levels and their potential health implications in specific Chinese industrializing regions like Northeastern Yunnan are scarce. Therefore, this study aimed to conduct a preliminary assessment of urinary BPA concentrations in late pregnancy and explore their associations with key maternal and fetal characteristics in this understudied population.

2. Materials and methods

2.1. Study population and design

A cross-sectional analysis was conducted using data from the first 70 pregnant women who completed urine sample collection and BPA measurement in an ongoing prospective cohort at Qujing Central Hospital in Northeastern Yunnan (Data collected between Jan 2022 and Dec 2023). Spot urine samples were collected during the third-trimester prenatal visit. This study represents the initial laboratory analysis from the parent cohort.

2.2. Measurement of BPA exposure

Urinary BPA concentrations were analyzed using HPLC-MS/MS (Agilent 1290/6470), a highly sensitive and specific method recommended for human biomonitoring [3]. The limit of detection (LOD) was 0.1 ng/mL. Values below the LOD were replaced by LOD/√2. For this initial analysis, raw urinary concentrations (μg/L) are reported to present the direct measurement results.

2.3. Statistical analysis

Participants were divided into two groups based on the median urinary BPA concentration (High Exposure ≥ median; Low Exposure < median). Descriptive statistics were presented as median (interquartile range, IQR) for continuous variables and number (percentage) for categorical variables. Differences between groups were tested using the Mann-Whitney U test for continuous variables and the Chi-square or Fisher's exact test for categorical variables. All analyses were performed using SPSS (Version 26.0), and a two-tailed p-value < 0.05 was considered statistically significant.

3. Results

BPA was detected in all 70 urine samples (100%). The median urinary BPA concentration was 2.41 μg/L (IQR: 0.68–4.96; range: 0.06–54.54). As shown in Table 1, women in the high BPA exposure group had a significantly higher prevalence of GDM (42.9% vs. 17.1%, p = 0.021) and gave birth to infants with a lower median birth weight (3250 g vs. 3450 g, p = 0.048) compared to those in the low exposure group. No significant differences were observed in maternal age, gestational age at sampling, weight gain, delivery mode, or low Apgar score proportion.

Table 1. Characteristics of the study population stratified by median BPA exposure level

Characteristic	Total (n = 70)	Low BPA exposure (< 2.41 μg/L) (n = 35)	High BPA exposure (≥ 2.41μg/L) (n = 35)	*p*-value
Maternal Age (years), median (IQR)	30 (27–34)	31 (28–35)	29 (26–32)	0.104
Gestational Age at Sampling (weeks), median (IQR)	38 (37–39)	38 (37–39)	38 (37–39)	0.789
Gestational Weight Gain (kg), median (IQR)	14 (12–16)	114 (11-6)	14 (12–15)	0.665
Delivery Mode (Cesarean), n (%)	49 (70.0%)	23 (65.7%)	26 (74.3%)	0.438
Gestational Diabetes Mellitus (GDM), n (%)	21 (30.0%)	6 (17.1%)	5 (42.9%)	0.021
Fetal Birth Weight (g), median (IQR)	3300(2930–3600)	3450(3210–3700)	3250(2750–3540)	0.048
Apgar Score at 1 min < 8, n (%)	8 (11.4%)	3 (8.6%)	5 (14.3%)	0.456
Urinary BPA (μg/L), median (IQR)	2.41 (0.68–4.96)	0.86 (0.32–1.51)	4.49 (3.25–7.66)	< 0.001

4. Discussion

In this pilot cross-sectional analysis of 70 pregnant women from Northeastern Yunnan, we found universal detection of BPA in urine during the third trimester [1]. The median concentration observed here provides the first preliminary exposure data for this region. Notably, higher BPA exposure was preliminarily associated with an increased likelihood of GDM and lower fetal birth weight [2,4–6]. These findings are consistent with the known endocrine-disrupting properties of BPA, which may interfere with glucose metabolism and fetal growth pathways [1,2].

The primary strength of this study is the presentation of first-hand, objectively measured exposure data from an understudied population. However, several important limitations must be emphasized. First, the cross-sectional design and small sample size preclude causal inference and limit statistical power. Second, the use of a single spot urine sample and reporting of uncorrected concentrations may introduce exposure misclassification bias, although it provides a direct snapshot of exposure. Third, despite observing some significant associations, residual confounding by unmeasured factors (e.g., detailed diet, socioeconomic status) cannot be ruled out [6]. Therefore, these results should be interpreted as preliminary and hypothesis-generating.

5. Conclusion

This initial analysis confirms widespread prenatal BPA exposure in Northeastern Yunnan and suggests potential associations with maternal GDM and fetal growth that merit further scrutiny. The findings underscore the need for larger, longitudinal studies in this region employing repeated exposure assessments and creatinine-adjusted concentrations to accurately characterize the health risks of BPA exposure during pregnancy.

Disclosure statement

The authors declare no conflict of interest.

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Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Journal of Clinical and Nursing Research, 2026, Volume 10, Issue 1
http://ojs.bbwpublisher.com/index.php/JCNR
Online ISSN: 2208-3693
Print ISSN: 2208-3685

Analysis of Management Strategies for Chronic Diseases in the Elderly with Cognitive Impairment

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Abstract: With the intensification of population aging in China, the problem of cognitive impairment in the elderly has become increasingly prominent, attracting widespread attention from all sectors of society. Geriatric cognitive impairment is characterized by chronicity, which not only seriously threatens the health of the elderly and reduces their quality of life, but also imposes a heavy burden on families and society due to its long course. Attaching importance to and strengthening the chronic disease management of elderly cognitive impairment has profound significance for delaying disease progression, improving patients' quality of life, and reducing the burden of family care. Therefore, this paper first comprehensively understands elderly cognitive impairment by briefly elaborating on its definition and characteristics; on this basis, it focuses on exploring effective strategies for the chronic disease management of elderly cognitive impairment, hoping to provide new ideas and methods for the management of this condition and offer useful references for relevant clinical research and practice.

Keywords: The elderly; Cognitive impairment; Chronic disease management; Strategies

Online publication: Feb 11, 2026

1. Introduction

Elderly health has always been a key issue of social concern. Geriatric chronic diseases refer to chronic illnesses specifically affecting the elderly, characterized by chronicity and progression. In recent years, with the continuous increase in the number of elderly patients with chronic diseases, their management has attracted growing attention. Among various chronic diseases, the prevalence of cognitive impairment in the elderly has been on the rise year by year, which poses a serious threat to the quality of life of the elderly. Considering the characteristics of elderly cognitive impairment, its management model should not focus solely on treatment, but gradually shift to a model suitable for chronic disease management. Through the organic combination of long-term care, symptom control, and quality of life maintenance, efforts should be made to significantly improve patients' quality of life.

2. Comprehensive analysis of elderly cognitive impairment

2.1. Definition

Cognitive impairment refers to a syndrome caused by various etiologies, characterized by clinical damage in one or more cognitive domains (such as attention, memory, and language ability) of varying degrees. Clinically, it is believed that elderly cognitive impairment generally goes through two stages, basically progressing from mild cognitive impairment to dementia [1,2]. Among them, Alzheimer's disease is the most common cause of senile dementia, followed by vascular dementia, Lewy body dementia, frontotemporal dementia, Parkinson's disease dementia, and other types. This profoundly reflects the complexity and diversity of the etiologies of elderly cognitive impairment.

As China gradually enters an aging society, studies have shown that the number of elderly people with cognitive impairment is increasing year by year, which has become a major public health issue of global concern. Data show that there are approximately 15.07 million dementia patients among the elderly aged 60 and above in China. The World Health Organization predicts that the global total number of dementia patients will surge from the current 55 million to 153 million by 2050. This set of data directly reflects the extremely severe prevention and control situation of elderly cognitive impairment [3].

2.2. Characteristics

2.2.1. Complexity of symptoms and individual differences

The complexity of symptoms and individual differences in elderly cognitive impairment bring many challenges to disease management and clinical treatment. Studies have shown that due to individual differences, the symptoms of elderly cognitive impairment vary. More specifically, if multiple patients are diagnosed with the same type of cognitive impairment (such as Alzheimer's disease), their symptom manifestations and progression rates may still differ significantly depending on the severity of the condition. Some Alzheimer's disease patients may present with language dysfunction in the early stage, such as word-finding difficulties, empty speech, and disorganized language organization; in contrast, other patients may present with spatial orientation impairment in the early stage, meaning they may get lost or have difficulty recognizing directions even in familiar environments [4]. Additionally, elderly patients often have multiple chronic diseases, and their cognitive impairment symptoms are easily intertwined with and masked by the clinical manifestations of other diseases. Taking "Parkinson's disease" as an example, some patients will exhibit typical motor symptoms such as stiffness and tremor, along with varying degrees of cognitive impairment. Common cognitive problems include inattention and decreased executive function. However, sometimes cognitive issues are overshadowed by more prominent motor disorders, which may increase the difficulty of diagnosis and identification, and in severe cases, delay the golden treatment period.

2.2.2. Distinction from normal aging

Accurately distinguishing between normal physiological aging and pathological cognitive impairment is a core link in early screening and intervention. Although elderly people with normal physiological aging will also experience a certain degree of cognitive function changes (such as memory loss and decreased reaction speed), these changes are usually gradual and mild, and more importantly, they basically do not affect daily life. For a simple example, some elderly people may occasionally forget something or the name of a familiar person, but they can recall it when reminded. In contrast, the degree and frequency of forgetting in patients with cognitive impairment will gradually increase; even with prompts, they basically cannot recall, and in more severe cases, they

may slowly forget the names of their family members and certain people or events with profound memories. It is worth noting that compared with elderly people with normal aging, patients with cognitive impairment usually face comprehensive damage in multiple cognitive domains, such as language ability, executive function, visuospatial ability, and memory ability [5,6]. For this reason, patients' quality of life is seriously affected. Some patients may gradually lose their ability to live independently, which provides an important basis for clinical differentiation.

3. Effective strategies for chronic disease management of elderly cognitive impairment

3.1. Improve public awareness

In the entire non-pharmacological intervention system, health education is in a fundamental position and is an important prerequisite for improving management compliance and enhancing intervention effects. The first step in implementing health education is to comprehensively assess the basic situation of elderly patients, including their basic information, educational background, medical history, comorbidities, cognitive level, and the availability of social support from caregivers. This enables the development of personalized education plans, improving the pertinence and effectiveness of education. Some elderly patients with cognitive impairment have significantly reduced or even completely lost their self-management abilities. For these patients, the target audience of health education should extend from the patients themselves to their families and caregivers. The content of health education should cover various aspects such as disease etiology, risk factors, clinical manifestations, intervention strategies, treatment goal setting, lifestyle adjustments, professional care skills, and pharmacological and non-pharmacological treatment methods. The aim is to help educated individuals construct a systematic knowledge system to provide solid theoretical support for subsequent care and intervention [7]. Regarding educational forms, in addition to traditional face-to-face education, diverse educational approaches such as group education, peer experience sharing, community health promotion, online thematic lectures, and new media platform pushes should be actively introduced. This ensures convenient and timely access to information and enhances the interest and interactivity of health education.

It is worth noting that health education for elderly people with cognitive impairment is not a one-time event but a long-term and systematic process. Systematic and standardized health education can not only help patients and their families fully and correctly understand the corresponding disease and master various disease management skills but also effectively improve patients' self-management abilities and treatment compliance. While reducing the burden on families and society, it can further delay disease progression, improve quality of life, and benefit patients [8].

3.2. Construct a healthy lifestyle

Physical exercise and rehabilitation exercises, as important links in lifestyle interventions for chronic diseases in the elderly with cognitive impairment, can strengthen the body and significantly promote the improvement of patients' cognitive functions. Among them, physical exercise such as standardized aerobic exercise plays a positive role in preventing cognitive decline caused by inflammatory reactions; on the one hand, it can improve overall cognitive function, and on the other hand, it can greatly reduce the incidence of senile dementia. It is worth emphasizing that physical exercise should be moderate and appropriate. Excessively high or low exercise intensity may be counterproductive. In the early stage of the disease, patients can choose regular and moderate

physical activities to stimulate the release of neurotrophic factors and optimize cerebral blood circulation, thereby achieving the goal of improving cognitive function in the early stage. With the progression of the disease, after professional evaluation, the exercise load can be appropriately increased to help patients successfully break through the rehabilitation bottleneck period. The prominent advantage of cognitive rehabilitation training lies in repeated training of cognitive functions to maintain the excitability of residual nerve cells in patients and promote the functional reconstruction of damaged parts of the brain [9,10]. Common forms include speech training, memory training, puzzle activities, short-term memory training, daily living ability training, and executive function training. For example, nursing homes can regularly carry out a variety of puzzle activities such as tangram puzzles, poker games, and chess. Under the demonstration of caregivers, patients are guided to piece together patterns or improve their language abilities through word association training. In addition to physical training, nursing homes should also pay attention to sleep management and weight management of elderly patients with cognitive impairment. On the one hand, ensure that patients get adequate sleep, with a recommended daily sleep duration of 6–8 hours; on the other hand, for overweight or obese patients, on the basis of routine management, it is recommended to add no less than six months of lifestyle interventions. Through diet optimization and increased exercise, patients' weight can be controlled within a reasonable range, which can also invisibly reduce the risk of cognitive impairment deterioration [11].

3.3. Strengthen psychological support

With the progression of cognitive impairment, psychological problems have gradually become an important issue plaguing patient. Patients' psychological problems and cognitive functions interact with each other, which reflects the importance of paying attention to the prevention and resolution of patients' psychological problems. In the early stage of the disease, some patients often experience a strong sense of helplessness, anxiety, or depression due to the awareness of their declining cognitive abilities and social functions. As the disease progresses to the middle and late stages, trapped by unexpressed physical pain, adverse drug reactions, unmet care needs, or the impact of comorbidities, patients' emotional and behavioral problems may further worsen, manifesting as depression, anxiety, emotional fragility, etc., and some may even experience neuropsychiatric symptoms such as hallucinations, delusions, or delirium [12]. At any stage, what patients need most is systematic psychological support, which can free them from negative emotions, stabilize their behavioral performance, thereby delaying the decline of their overall functions to a certain extent, and ultimately improving the quality of life of patients and their caregiving families.

To this end, nursing homes should make the following adjustments:

Firstly, construct a patient-centered multidisciplinary collaborative psychological support system, with the joint participation of professionals such as psychiatrists, clinical psychologists, and cognitive rehabilitation therapists. Based on a comprehensive assessment of patients' cognitive and psychological status, personalized intervention plans are tailored for them. Of course, intervention plans are not static; they should be dynamically adjusted and optimized in real time according to patients' actual conditions. Secondly, integrate various intervention methods such as supportive psychotherapy, cognitive-behavioral therapy, reminiscence therapy, music therapy, and family system intervention to provide comprehensive and personalized psychological support for patients, helping them maintain normal mental health [13,14].

3.4. Improve self-management

The core goal of improving self-management is to help patients maintain functional independence as much as possible and enhance their ability to take care of themselves. Firstly, in the early stage of the disease, nursing homes should focus on helping patients establish good self-management habits and invisibly improve their self-management abilities. For example, introduce external memory aids such as medication calendars, smart pill boxes, and electronic reminders to compensate for patients' lost cognitive functions; at the same time, simplify daily task processes, ensure patients get adequate sleep, and help them develop regular work and rest habits, which are also crucial for improving their ability to take care of themselves. Secondly, attach importance to personalized management. Nursing homes should establish exclusive electronic files for each patient, recording key points that should be focused on during care, especially the corresponding symptoms of each patient (such as getting lost when going out and emotional fluctuations). This can provide a scientific data basis for formulating personalized intervention plans. Of course, the management process is inseparable from strong technical and professional support. Nursing homes should actively introduce medication reminder apps, positioning devices, smart home equipment, etc., to provide effective assistance for patients' self-management; regularly arrange medical staff to provide professional training and on-site guidance for patients to improve their self-management level [15].

4. Conclusion

In summary, based on the characteristics of elderly cognitive impairment and the actual needs of patients, nursing homes should actively try diversified management strategies. Through comprehensive interventions such as improving public awareness, constructing a healthy lifestyle, strengthening psychological support, and improving self-management, they can promote patients' health and effectively provide a more scientific and professional solution for healthy aging.

Disclosure statement

The author declares no conflict of interest.

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Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Journal of Clinical and Nursing Research, 2026, Volume 10, Issue 1
http://ojs.bbwpublisher.com/index.php/JCNR
Online ISSN: 2208-3693
Print ISSN: 2208-3685

Research on the Optimal Allocation of Community Elderly Care Service Resources Based on Big Data Technology

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Abstract: With the accelerating aging process of China's population, the demand for community elderly care services has shown diversified and personalized characteristics. However, problems such as insufficient total care service resources, uneven distribution, and prominent supply-demand contradictions have seriously affected service quality. Big data technology, with core advantages including data collection, analysis and mining, and accurate prediction, provides a new solution for the allocation of community elderly care service resources. This paper systematically studies the application value of big data technology in the allocation of community elderly care service resources from three aspects: resource allocation efficiency, service accuracy, and management intelligence. Combined with practical needs, it proposes optimal allocation strategies such as building a big data analysis platform and accurately grasping the elderly's care needs, striving to provide operable path references for the construction of community elderly care service systems, promoting the early realization of the elderly care service goal of "adequate support and proper care for the elderly", and boosting the high-quality development of China's elderly care service industry.

Keywords: Big data technology; Community; Elderly care; Service resources

Online publication: Feb 11, 2026

1. Introduction

The "14th Five-Year Plan for National Aging Career Development and Elderly Care Service System" clearly points out that "promote the digital transformation of elderly care services and use big data, artificial intelligence and other technologies to optimize the allocation of elderly care service resources", which points out the direction for the reform of community elderly care service resource allocation. Big data technology can integrate the health data, demand data, and resource data of community elderly, analyze the problems of "accurate demand identification, dynamic resource allocation, and personalized service supply" from multiple perspectives, and break the limitations of traditional allocation models. At present, some cities are striving to apply big data technology to community elderly care services, but they are still exploring in terms of data integration, analysis and application,

and talents. In view of this, this paper carefully analyzes the application value of big data technology and comprehensively constructs resource optimal allocation countermeasures, so as to provide theoretical basis and practical examples for promoting the efficient utilization and accurate supply of community elderly care service resources.

2. Application value of big data technology in the allocation of community elderly care service resources

2.1. Improve resource allocation efficiency and alleviate supply-demand contradictions

On the one hand, big data technology can realize dynamic monitoring and efficient scheduling of resources. By installing intelligent terminals in the community to real-time obtain data on the usage status, idle status, and number of unused equipment of care resources, and using the big data platform for visual display [1]. Community managers can flexibly adjust resources based on this information: when the number of disabled elderly in a community surge leading to a shortage of nurses, the big data platform can automatically dispatch idle care personnel from surrounding communities to support. On the other hand, big data technology can achieve accurate prediction of resource demand [2]. By analyzing historical data such as the age, health status, and living habits of community elderly, combined with regional population change trends, the big data platform can predict the demand for care resources in the next period of time. Communities can reserve relevant resources in advance according to the prediction results, recruit temporary care personnel or increase investment in rehabilitation equipment before the arrival of demand peaks, avoiding the problem of "temporary shortage".

2.2. Improve service accuracy and meet personalized needs

Firstly, big data technology can form a "holographic demand portrait" of the elderly. By integrating multi-source information such as community health records, intelligent device data, questionnaire survey data, and family feedback data, the big data platform can construct a demand portrait including dimensions such as "health status, care needs, service preferences, and payment capacity" [3]. Secondly, big data technology can realize personalized recommendation of service items. Based on the demand portrait, the big data platform uses algorithms to match the most suitable care service items and resources: for the above-mentioned slightly disabled elderly living alone, it can provide a service combination of "3 home-based rehabilitation care sessions per week (including blood pressure monitoring) + 1 intelligent safety monitoring session per day (such as fall alarm) + 1 psychological companionship session per week", and match caregivers with hypertension care experience and portable intelligent monitoring equipment, etc.; this personalized service recommendation improves service satisfaction and avoids unnecessary waste [4].

2.3. Improve management intelligence and optimize service quality

Traditional community elderly care service management mostly relies on manual records and paper files, resulting in slow data updates, difficult information exchange, and lack of quality supervision, making it difficult to control the entire service process. Through data integration and intelligent analysis, big data technology can promote the management model from "manual extensive" to "intelligent refined", thereby improving service quality [5].

On the one hand, big data technology can realize full-process traceability and supervision of services. Caregivers upload service information in real-time through a mobile APP during service provision, and intelligent

devices automatically record service data, which are synchronized to the big data platform. Managers can check the service status of each link on the platform, and promptly intervene and correct if a caregiver has insufficient service time, irregular operations, etc.; family members can also query the elderly's service status through the platform to improve service transparency [6]. On the other hand, big data technology can achieve dynamic evaluation and improvement of service quality. By analyzing service data, the big data platform can automatically generate evaluation reports on service quality, and identify existing problems and corresponding improvement suggestions. Communities continuously improve service processes and resource allocation according to these evaluation reports, forming a cycle of "evaluation–improvement–re-evaluation".

3. Countermeasures for the optimal allocation of community elderly care service resources based on big data technology

3.1. Integrate multi-source data and build a unified data resource library

Communities need to cooperate with departments such as health and wellness, civil affairs, and medical insurance, as well as medical institutions, elderly care enterprises, and intelligent device manufacturers to integrate various data and establish a unified data resource library for community elderly care services [7]. This database should cover three types of data: the first is basic information of the elderly, such as age, gender, family composition, housing conditions, and economic status, to analyze service accessibility and payment capacity. The second is health and demand data, including health records, physical function status, and care needs, to accurately identify those in need of help [8]. The third is data on the supply of various resources, including information on caregivers, equipment materials, and service items, so that they can be dispatched and used at any time. For example, communities can connect to the electronic medical record systems of local hospitals to obtain the elderly's medical history data, collect daily health data through smart bracelets, and obtain resource supply data through nursing institution management systems, achieving "one-network sharing" of data. It is necessary to establish a data update mechanism, clarify the data update responsibilities of various departments and institutions, and ensure data freshness.

3.2. Build core functional modules to realize data value transformation

The big data analysis platform needs to develop four core functional modules: "data collection–analysis and mining–decision support–service connection", transforming data into resource allocation decisions and service supply actions [9]. Firstly, the data collection module can access data from multiple terminals and has a cleaning function to ensure data quality. Secondly, the analysis and mining module uses big data algorithms to conduct multi-dimensional analysis including demand analysis, resource analysis, and matching analysis [10]. Thirdly, the decision support module presents the above results in the form of visual reports to provide managers with resource allocation suggestions. Fourthly, the service connection module realizes automatic matching from demand to resources to services. For example, after the elderly submit care needs through the platform, the system will automatically recommend suitable caregivers and required service items, generate a service order, and notify relevant personnel, realizing the automatic completion of the entire process from demand submission to final execution.

3.3. Strengthen data security assurance and protect the elderly's privacy

The elderly's health data and personal information are sensitive data, so a strict data security assurance system must be established to prevent data leakage and abuse. Firstly, improve data security management systems, clarify the permissions and processes for data collection, storage, use, and sharing. Caregivers can only access the data of their own service objects, and must obtain the consent of the elderly or their guardians if they want to share the data with others [11]. Secondly, use technical means for protection, such as encrypting data, implementing access control, adopting strong authentication methods such as facial recognition and dynamic passwords, and conducting security monitoring. Thirdly, strengthen the publicity of laws and regulations and carry out personnel training. Organize platform managers and caregivers to study the Data Security Law and the Personal Information Protection Law, clarify their respective data security responsibilities, and prevent illegal operations. For example, communities can cooperate with professional network security companies to conduct regular data security assessments and vulnerability testing to ensure the safe and stable operation of the platform and safeguard the privacy rights of the elderly [12].

3.4. Collect care needs through multiple channels to ensure no omissions

Communities should form an "online + offline" multi-channel demand collection system covering different types of elderly to ensure comprehensive and non-missing demand collection. For online channels, develop user-friendly online demand submission platforms for the elderly, including WeChat mini-programs, telephone hotlines, and intelligent terminals, allowing the elderly to easily submit their needs; for elderly friends who are not familiar with intelligent devices, their families or community grid workers can help submit on their behalf; the platform should have clear demand classification and a demand description field where the elderly can add more detailed information [13]. For offline channels, arrange community grid workers and caregivers to conduct regular home visits, focusing on disabled, elderly living alone, and advanced-age groups, to understand their daily care problems and service experiences through face-to-face communication [14]. In addition, set up special demand collection points in community activity centers or elderly canteens, and assign staff to help the elderly fill out relevant questionnaires. It is also possible to cooperate with hospitals and community health centers to collect care needs when the elderly seek medical treatment or undergo physical examinations. For example, doctors can propose necessary rehabilitation care items based on the elderly's health status and help submit them.

3.5. Respond to care needs personally and provide customized services

According to the results of demand stratification and classification, provide customized care service plans for the elderly and match appropriate resources to achieve precise "one-person-one-policy" services. Firstly, formulate personalized service plans. Combine the elderly's needs, health status, and service preferences to formulate detailed personalized service plans, specifying service items, service frequency, service duration, and service supervisors. For example, arrange a service plan of "twice-daily home care + three rehabilitation training sessions per week + 24-hour intelligent monitoring" for disabled elderly [15]. Secondly, match professional resources. Based on the requirements of the service plan, find and assign qualified caregivers and suitable service equipment. Thirdly, dynamically adjust service plans. Use the big data platform to monitor service effects in real-time and promptly adjust service plans and resource allocation according to changes in needs. For example, after 2 months of rehabilitation care, the functional status of a community elderly has improved significantly. Through analyzing the elderly's rehabilitation data, the big data platform will automatically change the service plan from "three rehabilitation training sessions per week" to "one rehabilitation guidance session per week", and allocate these idle

rehabilitation resources to other elderly in need.

4. Conclusion

In summary, big data technology has significant application value in the optimal allocation of community elderly care service resources. It not only improves the efficiency of resource allocation and effectively alleviates supply-demand contradictions but also greatly enhances service accuracy and meets the personalized needs of the elderly. At the same time, the introduction of big data technology has also promoted the development of management intelligence and further optimized service quality.

Disclosure statement

The author declares no conflict of interest.

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Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Journal of Clinical and Nursing Research, 2026, Volume 10, Issue 1
http://ojs.bbwpublisher.com/index.php/JCNR
Online ISSN: 2208-3693
Print ISSN: 2208-3685

Research on the Correlation Between Anesthetic Depth and Surgical Stress Response in Minimally Invasive Cardiothoracic Surgery Anesthesia

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Abstract: Objective: To explore the relationship between anesthetic depth and surgical stress response in minimally invasive cardiothoracic surgery. Methods: A total of 89 patients who underwent thoracoscopic minimally invasive cardiothoracic surgery in our hospital from June 2024 to December 2024 were selected as the research objects. They were divided into the light anesthesia group (n = 45) and the deep anesthesia group (n = 44). The vital signs at different intraoperative nodes and perioperative stress status of the two groups were compared. *Results:* Before lesion resection and after surgery, the mean arterial pressure and heart rate of the deep anesthesia group were lower than those of the light anesthesia group, with statistically significant differences. *Conclusion:* In thoracoscopic minimally invasive cardiothoracic surgery, deep anesthesia can effectively control the patient's surgical stress response, but the postoperative awakening time is longer; patients under light anesthesia have a shorter awakening time, but the intraoperative stress response is obvious.

Keywords: Cardiothoracic surgery; Anesthetic depth; Surgical stress response; Thoracoscopic surgery

Online publication: Feb 11, 2026

1. Introduction

Cardiothoracic surgery is a medical specialty focusing on the diagnosis, treatment and prevention of heart and lung diseases, covering a wide range of surgical and non-surgical treatment methods, including coronary artery bypass grafting, heart valve replacement, cardiac pacemaker implantation, heart transplantation, lung tumor resection, lung transplantation, etc. Thoracoscopy is a minimally invasive surgical method with the advantages of small wound and rapid recovery, and is widely used in clinical treatment of cardiothoracic surgery. However, minimally invasive surgery may still induce intraoperative stress response in patients, increasing the risk of postoperative complications [1]. Therefore, in minimally invasive cardiothoracic surgery, it is necessary to control the intraoperative anesthetic depth to reduce damage to the patient's body, thereby reducing the stress response, further lowering the risk of minimally invasive surgery, and helping patients recover as soon as possible after surgery.

2. Materials and methods

2.1. General information

A total of 89 patients who underwent thoracoscopic minimally invasive cardiothoracic surgery in our hospital from June 2024 to December 2024 were selected as the research objects.

2.1.1. Inclusion criteria

(1) Clinically diagnosed with lung cancer and meeting the indications for thoracoscopic minimally invasive surgery [2];
(2) Aged over 18 years old;
(3) American Society of Anesthesiologists (ASA) grade I-III, stable vital signs, no allergy to anesthetics, and tolerance to surgery;
(4) Complete clinical data and voluntary participation in this study [3].

2.2. Research methods

The 89 patients scheduled for minimally invasive cardiothoracic surgery fasted and abstained from drinking before surgery. After entering the operating room, venous access was established, various monitoring instruments were connected to monitor changes in the patient's intraoperative vital signs. In addition, the operating room nurse disinfected the patient's face, accurately placed electrodes 5 cm above the nasal root, parallel to the right eyebrow arch, and at the right temple, correctly connected the BIS electrodes, and debugged the equipment parameters. Both groups of patients received mask oxygen inhalation. Midazolam, sufentanil and propofol were used as anesthetic induction drugs, and cisatracurium besylate was used as a muscle relaxant [4]. After the patient's eyelash reflex disappeared, the patient's position was changed to a lateral position with the surgical site facing up, the lung ventilation mode was switched, and one-lung ventilation was started. All patients received propofol 6–12 mg/(kg·h) combined with remifentanil 0.1–0.3 μg/(kg·min) for intraoperative anesthesia, and cisatracurium besylate was injected intermittently to maintain muscle relaxation in patients, facilitating subsequent thoracoscopic lobectomy [5]. During the operation, the patient's BIS changes were continuously monitored to ensure that the value was maintained within the range of 40–60; the patient's mean arterial pressure (MAP) was monitored. Once the arterial pressure was less than 65 mmHg, crystalloid fluid was infused rapidly. If the blood pressure still did not recover, norepinephrine was injected in a timely manner, and the dosage of norepinephrine was adjusted according to changes in blood pressure until the blood pressure was greater than 65 mmHg. After surgery, both groups of patients used patient-controlled intravenous analgesia (PCIA) pumps for analgesia, and sufentanil was used as the analgesic drug until 48 hours after surgery. The patients were asked about wound pain, breathing smoothness, etc., and postoperative indicators were monitored [6].

2.3. Observation indicators

(1) Monitor the mean arterial pressure, heart rate and blood oxygen saturation of the two groups of patients before anesthesia induction, at intubation, before lesion resection and after surgery.
(2) Compare the postoperative awakening time and extubating time of the two groups of patients, and observe the patient's consciousness, such as the ability to move the eyes and shake hands.
(3) Compare the preoperative, intraoperative and postoperative norepinephrine dosage, postoperative pain degree and postoperative analgesic drug dosage of the two groups of patients to scientifically evaluate the

impact of anesthetic depth on the patient's surgical stress response [7].

(4) Compare anesthesia-related complications between the two groups of patients, such as restlessness after awakening and postoperative delirium.

Postoperative delirium assessment includes the following indicators:

(1) Fluctuating mental state;

(2) Inattention;

(3) Confused and unclear consciousness;

(4) Disordered language expression and thinking [8].

2.4. Statistical analysis

SPSS24.0 software was used for data analysis. Independent sample *t*-test or repeated measures analysis of variance was used for intergroup comparison. Data were expressed as [n(%)], and χ^2 test was used for intergroup comparison. $p < 0.05$ was considered statistically significant.

3. Results

3.1. Comparison of vital signs of patients

There were no statistically significant differences in MAP, heart rate and blood oxygen saturation between the two groups before anesthesia induction and immediately after intubation ($p > 0.05$). Before lesion resection and at the end of surgery, the MAP and heart rate of the deep anesthesia group were lower than those of the light anesthesia group, with statistically significant differences ($p < 0.05$). See **Table 1**.

Table 1. Comparison of vital signs of patients

Indicators	Groups	n	Before anesthesia induction	Immediately after intubation	Before lesion resection	At the end of surgery
MAP/mmHg	Deep anesthesia group	45	89.23±5.29	89.15±6.73	79.32±5.24	85.34±3.16
	Light anesthesia group	44	88.63±4.36	91.32±7.25	88.35±7.21	87.34±5.62
Heart rate (beats/min)	Deep anesthesia group	45	75.21±5.84	87.03±7.25	84.30±6.12	79.35±6.16
	Light anesthesia group	44	77.61±6.21	89.33±8.74	92.15±8.34	82.30±7.69
Blood Oxygen saturation/%	Deep anesthesia group	45	98.96±2.06	95.72±2.23	94.76±3.12	95.86±2.47
	Light anesthesia group	44	98.32±1.60	98.28±2.16	95.13±2.38	96.02±2.20

3.2. Comparison of stress status of patients

Before surgery, the levels of prostaglandin E2 (PGE2), nerve growth factor (NGF) and substance P (SP) in the blood of the two groups were balanced, with no statistically significant differences ($p > 0.05$). At the end of surgery and 1 day after surgery, the levels of PGE2, NGF and SP in the deep anesthesia group were lower than those in the light anesthesia group, with statistically significant differences ($p < 0.05$). See **Table 2**.

Table 2. Comparison of stress status of patients

Indicators	Groups	n	Before surgery	At the end of surgery	1 day after surgery
MAP/mmHg	Deep anesthesia group	45	172.34 ± 19.14	219.84 ± 32.05	200.05 ± 27.38
	Light anesthesia group	44	174.43 ± 20.20	261.40 ± 35.36	240.15 ± 29.61
Heart rate (beats/min)	Deep anesthesia group	45	316.45 ± 31.64	362.10 ± 36.36	347.95 ± 33.64
	Light anesthesia group	44	322.61 ± 35.80	402.39 ± 40.15	395.78 ± 32.41
Blood Oxygen saturation/%	Deep anesthesia group	45	10.21 ± 1.34	23.72 ± 2.73	17.54 ± 3.24
	Light anesthesia group	44	10.05 ± 1.66	26.90 ± 4.21	21.25 ± 2.39

4. Discussion

4.1. Correlation between anesthetic depth and surgical stress response in minimally invasive cardiothoracic surgery

With the wide application of minimally invasive surgery in cardiothoracic surgery treatment, the treatment methods of cardiothoracic surgery have become more diversified, which has gradually reduced the trauma caused by surgery to patients' bodies, and provided treatment opportunities for many patients with poor physical function who cannot accept conventional surgery, thereby helping them alleviate pain and recover health. Anesthesia is an important part of minimally invasive cardiothoracic surgery and an important factor affecting the patient's surgical stress response [9]. Therefore, cardiothoracic surgeons should strengthen cooperation with anesthesiologists to determine the anesthetic depth and anesthetic dosage according to the patient's physical condition, surgical time and difficulty, laying a good foundation for minimally invasive surgery. This study showed that the blood pressure of the deep anesthesia group was significantly lower than that of the light anesthesia group during and after thoracoscopic minimally invasive surgery, and the hemodynamics was relatively stable. Under deep anesthesia, the patient's myocardial activity is inhibited, the heart rate gradually slows down, and the blood pressure decreases, which is conducive to alleviating the patient's intraoperative stress response. However, if the patient's blood pressure is lower than 65 mmHg, the anesthetic risk will increase, threatening the patient's life safety. Under light anesthesia, the patient's cerebral cortex is relatively active, and the inhibition of myocardial activity is not obvious, so the heart rate and blood pressure are higher than those of patients under deep anesthesia, which may lead to postoperative pain [10]. In addition, this study believes that elderly patients face higher anesthetic risks in minimally invasive cardiothoracic surgery. Deep anesthesia should be used with caution, the dosage and administration rate of propofol should be strictly controlled, and the blood pressure and heart rate of elderly patients should be closely monitored during the operation to reduce the patient's surgical stress response.

4.2. Impact of surgical stress response on the prognosis of minimally invasive cardiothoracic surgery

This study believes that reducing the patient's surgical stress response can not only help the patient's postoperative rehabilitation, but also improve the long-term prognosis [11]. Under the surgical stress state, the synthesis and release of prostaglandin E2 (PGE2), nerve growth factor (NGF) and substance P (SP) in the blood of the two groups of patients will increase, which will promote the growth and differentiation of neurons, and invisibly aggravate the growth of inflammatory factors in the patient's body after surgery. At the same time, this study

showed that the levels of PGE2, NGF and SP in the deep anesthesia group were significantly lower than those in the light anesthesia group at the end of surgery and 1 day after surgery, indicating that deep anesthesia can effectively inhibit the patient's surgical stress response and avoid postoperative inflammatory response. In addition, this study selected remifentanil combined with propofol as the anesthesia maintenance plan. Remifentanil has a better analgesic effect, which can effectively inhibit the patient's myocardial activity, thereby reducing the patient's surgical stress response; the combination of remifentanil and propofol can improve the sedative and hypnotic effect and effectively inhibit the patient's surgical stress response [12].

4.3. Deep anesthesia effectively controls patients' stress levels

This study found that the level of inflammatory factors in the deep anesthesia group was higher than that in the light anesthesia group, indicating that light anesthesia has a relatively low impact on the patient's body's inflammatory level. This study used propofol combined with remifentanil for deep anesthesia, which can effectively reduce the inflammatory damage caused by stress response, while light anesthesia can effectively reduce the risk of postoperative delirium in patients [13].

4.4. Suggestions for improving patients' comfort during anesthesia in minimally invasive cardiothoracic surgery

First, anesthesiologists can use antibacterial dressings to cover the deep vein puncture site, reduce the entry of sweat and blood into the puncture site during minimally invasive surgery, minimize the production of bacteria at the puncture site, reduce the probability of puncture site infection, and help the healing of the patient's wound. At the same time, anesthesiologists should do a good job in disinfection before deep vein puncture and antibacterial protection of the puncture site, laying a good foundation for subsequent surgery. Second, postoperative pain is one of the important problems to be solved in minimally invasive cardiothoracic surgery, and it is also an important factor affecting the patient's postoperative recovery [14]. After surgery, anesthesiologists can take measures such as paravertebral nerve block and analgesic pumps to block nerve transmission by local injection of anesthetic drugs, thereby reducing postoperative pain in patients. For example, in thoracoscopically guided minimally invasive surgery, anesthesiologists can carry out postoperative pain management according to the patient's consciousness and vital sign monitoring data after surgery, reduce the patient's dependence on general anesthetics, and help the patient recover as soon as possible.

5. Conclusion

In conclusion, minimally invasive surgery provides more treatment options for patients and promotes the development of clinical treatment of cardiothoracic surgery. In minimally invasive cardiothoracic surgery, anesthetic depth is an important factor affecting the patient's surgical stress response, which will affect the patient's intraoperative blood pressure, heart rate, postoperative inflammatory level and postoperative rehabilitation effect. Therefore, cardiothoracic surgeons should attach importance to the anesthesia management of minimally invasive surgery, strengthen cooperation with anesthesiologists, formulate anesthesia plans according to preoperative evaluation and surgical plans, clarify the anesthetic depth, and strictly control the dosage and administration rate of anesthetic drugs. Patients under light anesthesia can wake up as soon as possible after surgery, with mild inflammatory response in the body, but obvious postoperative pain and stress response [15]. Patients under deep

anesthesia have relatively slow intraoperative hemodynamics and obvious surgical stress response, but abnormal changes in postoperative blood pressure and heart rate, delayed awakening time, and obvious inflammatory response. Therefore, in the clinical work of minimally invasive cardiothoracic surgery, attending physicians and anesthesiologists should comprehensively evaluate the patient's physical state and surgical plan, select an appropriate anesthetic depth; optimize the combined use of anesthetic drugs and administration rate, reduce the role of analgesic drugs in surgical inflammatory stress, improve the anesthetic effect, and help patients recover as soon as possible.

Disclosure statement

The authors declare no conflict of interest.

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Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Journal of Clinical and Nursing Research, 2026, Volume 10, Issue 1
http://ojs.bbwpublisher.com/index.php/JCNR
Online ISSN: 2208-3693
Print ISSN: 2208-3685

An Analysis of the Role of Integrated Medical and Elderly Care in the Management of Chronic Diseases among the Elderly

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Abstract: In recent years, with the accelerating aging process of the population, China has entered an aging society, and the number of elderly patients with chronic diseases has been increasing. The traditional medical and elderly care service models can no longer fully meet their needs. The integrated medical and elderly care model has emerged as the times require. It organically combines medical resources with elderly care resources to provide comprehensive and continuous health management services for the elderly, becoming an important approach to solving the problems of chronic disease management among the elderly. In this regard, this paper first elaborates on the role of integrated medical and elderly care in the management of chronic diseases among the elderly, and then puts forward application strategies of integrated medical and elderly care in the management of chronic diseases among the elderly, in order to provide certain reference for relevant researchers.

Keywords: Integrated medical and elderly care; The elderly; Chronic disease management; Role

Online publication: Feb 11, 2026

1. Introduction

China's rapidly aging population has led to a growing number of older adults with chronic diseases, challenging the capacity of traditional healthcare and elderly care models. In response, the integrated medical and elderly care model has emerged as a critical approach. By combining medical and eldercare resources, it aims to provide continuous, comprehensive health management for the elderly. This paper examines the role of this integrated model in managing chronic diseases among the elderly and proposes practical application strategies, offering insights and references for researchers and practitioners in the field.

2. The role of integrated medical and elderly care in the management of chronic diseases among the elderly

2.1. Helps break down the barriers between medical and elderly care services

Under the traditional model, medical and elderly care services are not closely integrated. After elderly patients receive treatment in medical institutions and their conditions stabilize, they need to be followed up with care and rehabilitation training in elderly care institutions. However, this process faces shortcomings such as poor connection and information occlusion [1]. Integrated medical and elderly care can effectively make up for these shortcomings, promote the close integration of medical and elderly care services, and realize real-time sharing of various data through building an information sharing platform. Not only can doctors grasp the specific situation of the elderly in elderly care institutions in a timely manner, but elderly care institutions can also formulate professional care plans based on the elderly's past treatment records. For example, when caregivers in elderly care institutions find abnormalities in the elderly's health, they promptly feedback the abnormal data to doctors in medical institutions. Doctors provide professional suggestions, and caregivers conduct preliminary treatment in accordance with the suggestions, striving for time for further medical treatment [2].

2.2. Helps build a full-cycle health management system

In the management of chronic diseases among the elderly, building a full-cycle health management system is crucial, and integrated medical and elderly care plays a unique role in this regard. The integrated medical and elderly care model can provide the elderly with full-process services from disease prevention, diagnosis, treatment to rehabilitation and long-term care [3]. For example, in the disease prevention stage, integrated medical and elderly care institutions can use medical resources to conduct regular health check-ups and health assessments for the elderly, and formulate personalized health intervention plans such as dietary guidance and exercise suggestions based on the elderly's physical conditions and living habits, helping the elderly develop good living styles and reduce the risk of chronic diseases. In the links of disease diagnosis and treatment, relying on professional medical teams and advanced medical equipment, integrated medical and elderly care institutions can timely and accurately diagnose the elderly's diseases and provide scientific and effective treatment plans. At the same time, the close cooperation between elderly care institutions and medical institutions enables the elderly to be quickly transferred to higher-level hospitals when further specialist treatment is needed, ensuring timely medical treatment [4].

2.3. Helps improve service accuracy and efficiency

In the integrated medical and elderly care model, medical staff can collect and sort out comprehensive health information of the elderly with the help of information technology, including disease diagnosis and treatment records, periodic inspections and daily health management information, establish systematic and real-time health files, and conduct in-depth analysis of these data. This helps medical staff accurately grasp the elderly's health status and disease development changes, and provide more accurate and suitable diagnosis, treatment and care plans for the elderly [5]. At the same time, service efficiency will be further improved by effectively connecting medical treatment with elderly care services. Elderly care institutions are equipped with basic medical equipment and caregivers to timely address the elderly's basic diseases or emergency incidents, reducing the time and energy consumed in visiting hospitals. In addition, through cooperation with external medical institutions, timely referral can be made in case of intractable diseases, allowing the elderly to receive targeted treatment in the shortest possible time, further improving service levels and ensuring that the elderly obtain high-quality health

management services [6].

3. Application strategies of integrated medical and elderly care in the management of chronic diseases among the elderly

3.1. Attach importance to policy support and build a multi-level security system

Firstly, introduce corresponding policies. To promote the effective application of the integrated medical and elderly care model in the management of chronic diseases among the elderly, the government should introduce relevant policy measures, clarify the functional division of labor among various departments, and strengthen communication and contact between relevant departments. For example, the National Health Commission is responsible for formulating and supervising the implementation of service standards for integrated medical and elderly care, the civil affairs department is mainly responsible for the establishment and operation management of nursing homes, and the medical insurance department is mainly responsible for the formulation and implementation of medical insurance plans. Through policy guidance, medical and elderly care resources are integrated to promote the sustainable development of integrated medical and elderly care institutions [7].

Secondly, build a multi-level security system. Appropriately expand the scope of medical insurance reimbursement, include the medical services provided by integrated medical and elderly care institutions into the scope of medical insurance reimbursement, thereby reducing the elderly's expenditure on chronic disease management. Establish a long-term care insurance mechanism to provide long-term care security for disabled and semi-disabled elderly. At the same time, launch commercial insurance for the management of chronic diseases among the elderly to meet the special management needs of different elderly people, set up a fund specifically to support the construction and development of integrated medical and elderly care institutions, and provide certain subsidies for eligible elderly people.

Thirdly, strengthen supervision and evaluation. Regularly assess and evaluate the service quality of integrated medical and elderly care institutions and the expenditure of medical insurance funds to ensure the implementation of policies and the stable operation of the system. In addition, strengthen publicity and guidance, popularize the integrated medical and elderly care model and security policies among the elderly and their family members, and continuously improve the level of chronic disease management among the elderly [8].

3.2. Innovate service models to meet diversified needs

Firstly, implement home-based integrated medical and elderly care services. Establish specialized family doctor contract service teams to regularly provide medication guidance, home medical care and other services for elderly patients with chronic diseases. Through wearable intelligent devices and telemedicine technology, real-time obtain the elderly's physical data such as heart rate, blood pressure and blood glucose, and immediately transmit them to medical staff to adjust treatment and care plans. At the same time, provide rehabilitation care and daily care services for the elderly, enabling them to receive professional medical and nursing services in a familiar home environment [9].

Secondly, build an integrated medical and elderly care alliance. Integrate the resources of medical institutions and elderly care institutions in the region to establish a close-knit integrated medical and elderly care alliance. Medical institutions provide medical support for elderly care institutions, including regular ward rounds, consultations, emergency first aid and other services; elderly care institutions provide rehabilitation care and daily

care services for medical institutions. In this way, the sharing and optimal allocation of medical resources and elderly care resources are realized, and service efficiency and quality are improved.

Thirdly, carry out personalized services. Provide personalized integrated medical and elderly care plans according to the health status, economic level and personal needs of elderly patients with chronic diseases. For example, provide comprehensive daily care and health care services for elderly people with poor economic conditions, multiple chronic diseases and inability to take care of themselves; provide high-end professional health management and rehabilitation treatment services for elderly people with better economic conditions. In addition, pay attention to the psychological and cultural needs of the elderly, organize a variety of cultural and recreational activities to meet their spiritual needs and effectively improve their quality of life [10].

3.3. Apply cutting-edge technologies to improve the intelligent level of services

Firstly, use intelligent monitoring equipment to realize real-time health management. Through various wearable intelligent devices such as smart mattresses and smart bracelets, real-time monitor the elderly's sleep quality, heart rate, blood pressure, exercise and other data, and transmit these data to the cloud. Medical staff conduct dynamic health management of the elderly through mobile phones and computers. Once abnormal data is detected, the system issues an early warning immediately, and medical staff quickly formulate and adopt corresponding strategies [11].

Secondly, use artificial intelligence-assisted diagnosis to improve diagnostic accuracy. Use artificial intelligence technology to analyze medical images, test reports, etc., helping doctors diagnose diseases more accurately. Artificial intelligence algorithms can quickly identify lesion features in images and provide diagnostic references for doctors. For example, when diagnosing lung CT images of the elderly, artificial intelligence can quickly detect lung nodules, inflammation and other lesions, and provide information such as the size, location and nature of the lesions, assisting doctors in making more accurate diagnoses [12].

Thirdly, build an intelligent elderly care service platform to realize one-stop management. Adopt cutting-edge technologies to build a smart elderly care service platform, which includes modules such as service evaluation, information management, service appointment and health files. Medical staff can timely grasp the basic situation of elderly patients with chronic diseases, such as service needs and health status, by logging into the platform, and provide targeted medical and elderly care services for them. Family members can also use the platform to apply for medical care, elderly care, service history, service fees, etc., and give evaluations. In addition, the smart elderly care service platform can also promote information sharing and collaborative cooperation among various medical institutions and elderly care institutions, improving the overall quality of integrated medical and elderly care services [13].

3.4. Focus on talent training and strengthen professional service teams

Firstly, start from the source of education. Institutions of higher learning and vocational colleges can jointly offer relevant courses and majors, such as geriatrics, geriatric rehabilitation and geriatric nursing, to cultivate a group of excellent integrated medical and elderly care service talents. In addition, attach importance to the combination of theory and practice, focus on increasing the proportion of practical courses, and allow more students to obtain rich internship and training opportunities in medical institutions and elderly care service institutions, improving their problem-solving ability and practical ability [14].

Secondly, regularly carry out continuing education and training. The content of continuing education and

training needs to include cutting-edge integrated medical and elderly care service concepts, doctor-patient communication skills and medical and nursing technologies. Through a combination of online and offline training, expert seminars and experience sharing meetings, effectively improve the professional level and service ability of on-the-job medical staff [15].

Thirdly, build a sound incentive mechanism. To attract excellent integrated medical and elderly care service talents, scientifically build a salary system, open up channels for post promotion and career development, continuously enhance the sense of achievement of medical staff, and broaden their career prospects. Establish relevant reward mechanisms to commend outstanding medical staff in the post from material and spiritual aspects, and fully stimulate their work enthusiasm. In this way, by gradually cultivating professional integrated medical and elderly care service talents, better services can be provided for the management of chronic diseases among the elderly.

3.5. Strengthen cultural construction and enrich the spiritual life of the elderly

Firstly, set up special cultural activity areas. Integrated medical and elderly care institutions should set up activity areas such as libraries, chess and card rooms, and calligraphy and painting rooms according to actual conditions, allowing the elderly to choose appropriate cultural and recreational activities based on their own interests. At the same time, integrated medical and elderly care institutions regularly organize a series of cultural and entertainment activities, such as intangible cultural heritage craft experience, knowledge lectures and art performances, to enrich the spiritual world of the elderly and further improve their sense of happiness.

Secondly, pay attention to the psychological care of the elderly. Integrated medical and elderly care institutions should set up psychological counseling teams to provide psychological support for the elderly. Elderly patients with chronic diseases are particularly prone to negative emotions such as depression and anxiety due to long-term illness, which is not conducive to their rehabilitation and may even further affect their health. Through face-to-face communication with the elderly, psychological counseling teams can accurately grasp and understand their mental health status and specific needs, and take effective measures to relieve negative emotions, enabling them to face diseases and life positively.

Thirdly, deepen the exchange and interaction activities of the elderly. Integrated medical and elderly care institutions can organize various social activities, such as elderly clubs and interest groups, allowing the elderly to share life experiences and enhance mutual affection through communication. This not only contributes to the mental health of the elderly, but also creates a warm and harmonious elderly care environment.

4. Conclusion

In summary, the integrated medical and elderly care model has shown significant roles and great application value in the management of chronic diseases among the elderly. It breaks down the barriers between medical and elderly care services, builds a full-cycle health management system, and effectively improves service accuracy and efficiency. In this regard, this study can further promote the in-depth development of integrated medical and elderly care in the management of chronic diseases among the elderly by attaching importance to policy support and building a multi-level security system; innovating service models to meet diversified needs; applying cutting-edge technologies to improve the intelligent level of services; and focusing on talent training and strengthening professional service teams. In the future, it is necessary to continuously pay attention to and study the integrated

medical and elderly care model, and constantly explore and improve relevant policies, services, technologies and talent systems. Only in this way can we better meet the needs of elderly patients with chronic diseases, improve their quality of life and health level, and allow every elderly person to enjoy a happy and healthy old age.

Disclosure statement

The author declares no conflict of interest.

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Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Journal of Clinical and Nursing Research, 2026, Volume 10, Issue 1
http://ojs.bbwpublisher.com/index.php/JCNR
Online ISSN: 2208-3693
Print ISSN: 2208-3685

Comparative Study of *Auricularia auricula* Polysaccharide-Iron Complex, Heme Iron, and Ferrous Glycinate in Iron-Deficient Adults: A Randomized Clinical Trial

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Abstract: Iron deficiency anemia affects approximately 1.62 billion people worldwide, yet traditional iron supplements present bioavailability limitations and gastrointestinal side effects. This randomized, double-blind clinical trial investigated a novel Auricularia auricula polysaccharide-iron complex (AAPIC) compared with heme iron and ferrous glycinate in 180 iron-deficient adults receiving 30 mg elemental iron daily for 12 weeks. AAPIC achieved comparable hemoglobin improvements (from 98.3 ± 8.7 to 126.5 ± 9.2 g/L) to heme iron (from 97.8 ± 9.1 to 128.3 ± 8.6 g/L) and was significantly superior to ferrous glycinate (from 98.6 ± 8.9 to 119.7 ± 10.3 g/L; $p < 0.001$). Iron absorption efficiency showed AAPIC at 23.7 ± 4.2%, heme iron at 25.1 ± 3.8%, and ferrous glycinate at 18.4 ± 5.1%. Toxicological assessments revealed no hepatotoxicity, nephrotoxicity, or mutagenicity. Gastrointestinal adverse events occurred in 8.3% of AAPIC recipients versus 15.0% with ferrous glycinate and 10.0% with heme iron. The polysaccharide component facilitates iron transport through enhanced intestinal uptake mechanisms. AAPIC represents a promising, well-tolerated alternative with clinical efficacy comparable to established iron formulations.

Keywords: Auricularia auricula polysaccharide; Iron complex; Heme iron; Ferrous glycinate; Bioavailability; Iron deficiency anemia; Clinical trial; Toxicology

Online publication: Feb 11, 2026

1. Introduction

Iron deficiency represents the most prevalent nutritional disorder globally, with the World Health Organization estimating that 30% of the world's population experiences some form of anemia, predominantly attributable to insufficient iron intake or absorption [1]. Iron plays indispensable roles in oxygen transport, cellular respiration, DNA synthesis, and immune function, with inadequate status resulting in decreased hemoglobin production,

impaired cognitive development, reduced work capacity, and compromised immune responses [2–4].

Current iron supplementation strategies utilize inorganic iron salts (ferrous sulfate, ferrous fumarate, ferrous gluconate) or organic forms (heme iron polypeptide, ferrous glycinate). Despite widespread application, conventional supplements present significant limitations [5,6]. Inorganic iron salts demonstrate poor bioavailability (10–20% absorption) and commonly induce gastrointestinal disturbances including nausea, constipation, and diarrhea, resulting in poor patient compliance [7]. Heme iron exhibits superior absorption (25–30% bioavailability) through direct enterocyte heme transporter uptake but presents challenges including higher production costs, animal-source restrictions, and potential oxidative stress concerns. Ferrous glycinate shows enhanced gastrointestinal stability, though absorption efficiency remains variable [8–10].

Auricularia auricula (black fungus) has been utilized in traditional Chinese medicine for centuries due to its blood-nourishing properties [11]. Recent investigations identified abundant polysaccharides comprising primarily β-glucans (molecular weights 10–500 kDa) demonstrating immunomodulation, antioxidant capacity, hypolipidemic effects, and potential mineral absorption enhancement [12]. This study aims to investigate whether complexation of iron with these polysaccharides creates a stable and bioavailable transport system, potentially combining the absorption advantage of organic iron with the functional benefits of bioactive polysaccharides [13–15]. The polysaccharide matrix may protect iron from precipitation and oxidation while facilitating transcellular transport through specific polysaccharide receptors or enhanced paracellular permeability [16–18].

This study addresses the knowledge gap through rigorous clinical trial design incorporating parallel assessment of three iron formulations. Study objectives encompassed:

(1) Quantitative determination of iron absorption efficiency through pharmacokinetic analysis;
(2) Comprehensive toxicological evaluation including hepatic, renal, and genotoxic assessment;
(3) Comparative efficacy analysis based on hematological parameters;
(4) Safety and tolerability profiling through adverse event monitoring.

2. Methodology

2.1. Study design, participants, and intervention

2.1.1. Inclusion criteria

Adults aged 18–55 years with serum ferritin < 30 μg/L (females) or < 40 μg/L (males), hemoglobin 80–110 g/L, BMI 18.5–28.0 kg/m^2.

2.1.2. Exclusion criteria

Pregnancy, bleeding, malabsorption, hepatic/renal dysfunction, hypersensitivity.

2.1.3. Study design

Based on sample size calculation, 180 participants (60 per group) were enrolled [19]. Random allocation (1:1:1), stratified by gender and baseline hemoglobin. Participants were instructed to take one capsule daily before breakfast for 12 weeks. Each capsule contained 30 mg of elemental iron, provided as either:

(1) 600 mg of *Auricularia auricula* polysaccharide-iron complex (AAPIC),
(2) 600 mg of heme iron, or
(3) 150 mg of ferrous glycinate plus 450 mg of maltodextrin (as filler to match capsule weight). Visits:

baseline, weeks 2, 4, 8, 12, 16.

Complete blinding was maintained.

2.2. Laboratory assessments and statistical analysis

Absorption Kinetics: 60 participants per group underwent single-dose absorption evaluation at week 2. Blood samples were collected at 0, 1, 2, 3, 4, 6, and 8 hours post-administration. Serum iron was measured by colorimetric assay (Roche Cobas 8000), with absorption efficiency calculated as [20, 21].

$$\text{Absorption Efficiency}(\%)=\frac{\Delta\text{Serum Iron}_{(0\text{-}4h)}\times\text{Plasma Volume}}{\text{Elemental Iron Dose}}\times 100 \quad (1)$$

Where plasma volume = 0.04 L/kg body weight.

Complete blood counts (Sysmex XN-9000) measured hemoglobin, hematocrit, red blood cell count, MCV, MCH, MCHC, RDW, reticulocyte count, and CHr by flow cytometry.

Serum ferritin (chemiluminescent immunoassay, Roche Elecsys 2010), serum iron and TIBC (colorimetric methods, Roche Cobas c501), transferrin saturation [(serum iron/TIBC) × 100], and soluble transferrin receptor (ELISA, R&D Systems) were measured.

Metabolic panels at baseline and weeks 4, 8, 12 included hepatic function (ALT, AST, ALP, GGT, bilirubin, albumin), renal function (creatinine, BUN, eGFR), lipid profile, and oxidative stress markers (MDA, SOD, GPx). Genotoxicity evaluation (baseline, week 12) included micronucleus assay (1000 binucleated cells), chromosomal aberration test (100 metaphases), and comet assay.

Participants completed standardized gastrointestinal symptom questionnaires at each visit, rating severity (0–3) for nausea, vomiting, abdominal pain, constipation, diarrhea, dyspepsia, and metallic taste. Events were graded using CTCAE version 5.0.

Intention-to-treat analysis with data presented as mean ± SD. Between-group comparisons used one-way ANOVA and chi-square tests. Primary efficacy analyses utilized repeated-measures ANOVA adjusting for baseline values. Post-hoc comparisons used Tukey's HSD test. Non-inferiority was evaluated using two-sided 95% CI against -5 g/L margin. Missing data were handled by multiple imputation (50 datasets). Significance: two-sided $p < 0.05$ (R version 4.2.1, SAS version 9.4).

3. Results

3.1. Participant characteristics and study flow

Of 267 screened individuals, 87 were excluded (42 not meeting criteria, 28 declining, 17 other reasons), with 180 randomly allocated to AAPIC (n = 60), heme iron (n = 60), or ferrous glycinate (n = 60). Multiple participants withdrew within 12 weeks of intervention (3 in the AAPIC group, 2 in the heme iron group, and 4 in the ferrous glycinate group), with completion rates of 95.0% (57/60), 96.7% (58/60), and 93.3% (56/60), respectively. Withdrawal reasons included loss to follow-up, adverse events, and personal reasons. The intention-to-treat population comprised all 180 randomized participants. The per-protocol population, which included participants with > 80% adherence to the study medication and without major protocol deviations, consisted of 171 participants (57, 58, and 56 in the AAPIC, heme iron, and ferrous glycinate groups, respectively). Baseline characteristics were well-balanced across groups (**Table 1**). Mean age: 34.2–35.8 years; female predominance: 68–72%. Baseline hemoglobin (AAPIC 98.3 ± 8.7 g/L, heme iron 97.8 ± 9.1 g/L, ferrous glycinate 98.6 ± 8.9 g/L, $p = 0.92$) and

serum ferritin ($p = 0.88$) showed no significant differences.

3.2. Iron absorption kinetics

Pharmacokinetic analysis of serum iron concentrations following single-dose administration revealed distinct absorption profiles (**Table 1**, **Table 2**). Baseline fasting serum iron levels were comparable across groups (45–48 μg/dL, $p = 0.76$). Peak serum iron concentrations (Cmax) occurred at 3–4 hours post-administration for all formulations.

Table 1. Baseline characteristics of study participants

Characteristic	AAPIC (n = 60)	Heme iron (n = 60)	Ferrous glycinate (n = 60)	*p* value
Age (years)	34.2 ± 9.8	35.8 ± 10.3	34.9 ± 9.5	0.67
Female sex, n (%)	41 (68.3)	43 (71.7)	41 (68.3)	0.89
Body mass index (kg/m²)	22.4 ± 2.9	22.8 ± 3.1	22.6 ± 2.7	0.79
Hemoglobin (g/L)	98.3 ± 8.7	97.8 ± 9.1	98.6 ± 8.9	0.92
Hematocrit (%)	30.8 ± 2.9	30.5 ± 3.1	30.9 ± 2.8	0.85
Serum ferritin (μg/L)	14.7 ± 8.3	15.2 ± 8.9	14.9 ± 8.1	0.88
Serum iron (μg/dL)	46.3 ± 12.8	45.7 ± 13.5	47.1 ± 12.3	0.84
TIBC (μg/dL)	428.6 ± 38.7	432.1 ± 41.2	426.3 ± 39.8	0.72
Transferrin saturation (%)	10.9 ± 3.2	10.6 ± 3.4	11.1 ± 3.1	0.77
MCV (fL)	78.4 ± 6.3	77.9 ± 6.7	78.7 ± 6.1	0.81
MCH (pg)	25.2 ± 3.1	24.9 ± 3.3	25.4 ± 2.9	0.74
Reticulocyte count (×10⁹/L)	48.3 ± 14.6	49.7 ± 15.2	47.9 ± 14.9	0.83
CHr (pg)	23.7 ± 3.8	23.4 ± 4.1	23.9 ± 3.6	0.79
Dietary iron intake (mg/day)	11.8 ± 3.2	12.1 ± 3.5	11.6 ± 3.1	0.75

Table 2. Pharmacokinetic parameters of iron absorption

Parameter	AAPIC (n=30)	Heme iron (n = 30)	Ferrous glycinate (n = 30)	*p* value
Baseline serum iron (μg/dL)	46.8 ± 11.7	45.3 ± 12.4	47.5 ± 11.9	0.76
Cmax (μg/dL)	178.4 ± 28.6	187.3 ± 26.8*	156.2 ± 31.5	0.001
Tmax (hours)	3.2 ± 0.8	3.5 ± 0.7	3.1 ± 0.9	0.18
AUC0–8h (μg·h/dL)	893.7 ± 142.3	947.2 ± 128.6*	731.5 ± 156.8	< 0.001
ΔSerum iron (μg/dL)	131.6 ± 24.9	142.0 ± 23.2*	108.7 ± 28.3	< 0.001
Absorption efficiency (%)	23.7 ± 4.2	25.1 ± 3.8*	18.4 ± 5.1	< 0.001

Heme iron demonstrated the highest peak concentration (187.3 ± 26.8 μg/dL), followed closely by AAPIC (178.4 ± 28.6 μg/dL), both significantly exceeding ferrous glycinate (156.2 ± 31.5 μg/dL, $p = 0.001$). The incremental area under the curve (AUC0–8h) showed similar patterns: heme iron 947.2 ± 128.6 μg·h/dL, AAPIC 893.7 ± 142.3 μg·h/dL, ferrous glycinate 731.5 ± 156.8 μg·h/dL ($p < 0.001$).

Calculated absorption efficiency revealed heme iron achieving 25.1 ± 3.8%, AAPIC 23.7 ± 4.2%, and ferrous

glycinate 18.4 ± 5.1%. The difference between heme iron and AAPIC was not statistically significant ($p = 0.21$), indicating comparable absorption characteristics. Both demonstrated significantly superior absorption compared to ferrous glycinate ($p < 0.001$ for both comparisons). The 95% confidence interval for the AAPIC-heme iron difference (-2.8 to 0.6%) fell entirely within the pre-specified non-inferiority margin, establishing AAPIC as non-inferior to heme iron.

3.3. Primary efficacy outcomes

Hemoglobin concentrations increased progressively in all treatment groups throughout the 12-week intervention (**Table 3**). Repeated-measures ANOVA demonstrated significant effects of time ($p < 0.001$), treatment ($p = 0.003$), and treatment-by-time interaction ($p = 0.04$), indicating differential response patterns among formulations.

Table 3. Changes in hemoglobin concentration over 12 weeks (g/L)

Time point	AAPIC	Heme iron	Ferrous glycinate
Baseline	98.3 ± 8.7	97.8 ± 9.1	98.6 ± 8.9
Week 2	104.7 ± 8.9*	105.3 ± 9.2*	102.8 ± 9.4*
Week 4	112.4 ± 9.3*	114.1 ± 8.7*	108.6 ± 10.1*
Week 8	120.8 ± 9.6*	122.9 ± 8.9*	114.9 ± 10.8*
Week 12	126.5 ± 9.2*	128.3 ± 8.6*	119.7 ± 10.3*
Change from baseline	28.2 ± 7.8	30.5 ± 7.3	21.1 ± 8.6

At week 12, mean hemoglobin reached 126.5 ± 9.2 g/L with AAPIC, 128.3 ± 8.6 g/L with heme iron, and 119.7 ± 10.3 g/L with ferrous glycinate, representing increases of 28.2 ± 7.8 g/L, 30.5 ± 7.3 g/L, and 21.1 ± 8.6 g/L, respectively. The hemoglobin increment with AAPIC was non-inferior to heme iron (difference -2.3 g/L, 95% CI: -4.9 to 1.1 g/L, p for non-inferiority < 0.001). Both AAPIC and heme iron demonstrated significantly greater hemoglobin increases compared to ferrous glycinate ($p = 0.001$ and $p < 0.001$, respectively).

Anemia correction, defined as achieving hemoglobin ≥ 120 g/L, occurred in 78.3% of AAPIC recipients, 81.7% of heme iron recipients, and 63.3% of ferrous glycinate recipients by week 12 ($p = 0.04$). Time to anemia correction analysis using Kaplan-Meier methods revealed median times of 8.1 weeks (95% CI: 7.2–9.3), 7.8 weeks (95% CI: 6.9–8.9), and 10.2 weeks (95% CI: 9.1–11.6) for AAPIC, heme iron, and ferrous glycinate groups, respectively (log-rank $p = 0.008$).

Response velocity, calculated as hemoglobin increment per week during the first 4 weeks, demonstrated comparable rates between AAPIC (3.53 ± 0.97 g/L/week) and heme iron (4.08 ± 0.89 g/L/week, $p = 0.16$), both exceeding ferrous glycinate (2.50 ± 1.12 g/L/week, $p < 0.001$ vs both).

3.4. Secondary efficacy outcomes

Serum ferritin, the primary indicator of iron stores, increased substantially in all groups (**Table 4**). Week 12 levels reached 58.4 ± 18.7 μg/L with AAPIC, 62.1 ± 19.3 μg/L with heme iron, and 47.3 ± 16.8 μg/L with ferrous glycinate, representing fold-increases of 4.0, 4.1, and 3.2, respectively. The AAPIC group demonstrated non-inferiority to heme iron (difference -3.7 μg/L, 95% CI: -9.2 to 1.8 μg/L) and significant superiority over ferrous glycinate (difference 11.1 μg/L, 95% CI: 4.8 to 17.4 μg/L, $p = 0.001$).

Table 4. Iron metabolism parameters at baseline and week 12

Parameter	AAPIC	Heme iron	Ferrous glycinate
Serum ferritin (μg/L)			
Baseline	14.7 ± 8.3	15.2 ± 8.9	14.9 ± 8.1
Week 12	58.4 ± 18.7*	62.1 ± 19.3*	47.3 ± 16.8*†
Change	43.7 ± 16.2	46.9 ± 17.1	32.4 ± 14.7†
Serum iron (μg/dL)			
Baseline	46.3 ± 12.8	45.7 ± 13.5	47.1 ± 12.3
Week 12	92.7 ± 21.4*	96.3 ± 19.8*	81.5 ± 23.6*†
Change	46.4 ± 18.3	50.6 ± 17.2	34.4 ± 19.8†
TIBC (μg/dL)			
Baseline	428.6 ± 38.7	432.1 ± 41.2	426.3 ± 39.8
Week 12	358.2 ± 34.6*	352.8 ± 36.1*	371.9 ± 38.7*†
Change	-70.4 ± 28.3	-79.3 ± 31.2	-54.4 ± 29.6†
Transferrin saturation (%)			
Baseline	10.9 ± 3.2	10.6 ± 3.4	11.1 ± 3.1
Week 12	26.2 ± 6.8*	27.6 ± 6.3*	22.1 ± 7.2*†
Change	15.3 ± 5.7	17.0 ± 5.4	11.0 ± 6.1†
sTfR (nmol/L)			
Baseline	42.8 ± 11.7	43.5 ± 12.3	42.3 ± 11.9
Week 12	28.3 ± 8.4*	27.1 ± 7.9*	32.6 ± 9.7*†
Change	-14.5 ± 7.2	-16.4 ± 7.8	-9.7 ± 6.8†

Transferrin saturation, reflecting immediately available iron for erythropoiesis, improved from baseline values of approximately 11% to 26.2 ± 6.8% with AAPIC, 27.6 ± 6.3% with heme iron, and 22.1 ± 7.2% with ferrous glycinate. The increments (15.3 ± 5.7%, 17.0 ± 5.4%, and 11.0 ± 6.1%, respectively) demonstrated comparable efficacy between AAPIC and heme iron ($p = 0.28$) with both superior to ferrous glycinate ($p < 0.01$).

Soluble transferrin receptor concentrations, which increase in iron deficiency, declined significantly in all groups. Week 12 levels of 28.3 ± 8.4 nmol/L (AAPIC), 27.1 ± 7.9 nmol/L (heme iron), and 32.6 ± 9.7 nmol/L (ferrous glycinate) represented reductions of 34%, 38%, and 23% from baseline, respectively. Greater decreases with AAPIC and heme iron ($p = 0.003$ vs ferrous glycinate) indicated superior tissue iron delivery.

Mean corpuscular volume increased progressively, reflecting the shift from iron-deficient to iron-replete erythropoiesis (**Table 5**). Week 12 values reached 87.3 ± 5.8 fL with AAPIC, 88.1 ± 5.6 fL with heme iron, and 84.7 ± 6.4 fL with ferrous glycinate, representing increases of 8.9, 10.2, and 6.0 fL, respectively. The AAPIC group demonstrated non-inferiority to heme iron while both showed superiority to ferrous glycinate.

Table 5. Red blood cell parameters at baseline and week 12

Parameter	AAPIC	Heme Iron	Ferrous Glycinate
MCV (fL)			
Baseline	78.4 ± 6.3	77.9 ± 6.7	78.7 ± 6.1
Week 12	87.3 ± 5.8*	88.1 ± 5.6*	84.7 ± 6.4*†
MCH (pg)			
Baseline	25.2 ± 3.1	24.9 ± 3.3	25.4 ± 2.9
Week 12	29.8 ± 2.9*	30.2 ± 2.7*	28.4 ± 3.2*†
MCHC (g/L)			
Baseline	321.4 ± 18.7	319.8 ± 19.3	322.6 ± 18.2
Week 12	341.7 ± 16.8*	343.2 ± 16.1*	335.4 ± 17.9*†
RDW (%)			
Baseline	16.8 ± 2.4	17.1 ± 2.6	16.7 ± 2.3
Week 12	13.9 ± 1.8*	13.6 ± 1.7*	14.7 ± 2.1*†
Reticulocyte count ($\times 10^9$/L)			
Baseline	48.3 ± 14.6	49.7 ± 15.2	47.9 ± 14.9
Week 2	87.6 ± 23.4*	92.3 ± 25.1*	73.8 ± 21.7*†
Week 12	62.4 ± 18.7*	64.8 ± 19.3*	58.3 ± 17.9*
CHr (pg)			
Baseline	23.7 ± 3.8	23.4 ± 4.1	23.9 ± 3.6
Week 2	27.9 ± 3.6*	28.4 ± 3.4*	26.2 ± 3.9*†
Week 12	29.3 ± 3.2*	29.7 ± 3.1*	27.8 ± 3.7*†

Mean corpuscular hemoglobin exhibited parallel improvements, increasing from approximately 25 pg to 29.8 ± 2.9 pg (AAPIC), 30.2 ± 2.7 pg (heme iron), and 28.4 ± 3.2 pg (ferrous glycinate). Red blood cell distribution width, a marker of anisocytosis that increases in iron deficiency, declined significantly in all groups, with more pronounced reductions in AAPIC (from 16.8 ± 2.4% to 13.9 ± 1.8%) and heme iron (from 17.1 ± 2.6% to 13.6 ± 1.7%) compared to ferrous glycinate (from 16.7 ± 2.3% to 14.7 ± 2.1%, $p = 0.03$).

Reticulocyte hemoglobin content, representing the iron status of nascent red blood cells, showed rapid response to supplementation. By week 2, CHr increased to 27.9 ± 3.6 pg (AAPIC), 28.4 ± 3.4 pg (heme iron), and 26.2 ± 3.9 pg (ferrous glycinate), with sustained elevation through week 12. This early response (within 1–2 weeks) preceded hemoglobin changes (4–8 weeks), confirming CHr as a sensitive early indicator of iron delivery to erythropoiesis.

Reticulocyte counts demonstrated biphasic patterns, with initial elevation at week 2 (reflecting erythropoietic stimulation) followed by normalization by week 12 as anemia corrected. Peak reticulocyte responses occurred in AAPIC (87.6 ± 23.4 × 10^9/L) and heme iron (92.3 ± 25.1 × 10^9/L) groups, both exceeding ferrous glycinate (73.8 ± 21.7 × 10^9/L, $p = 0.006$).

3.5. Safety and toxicology assessments

Comprehensive safety monitoring revealed no clinically significant hepatotoxicity or nephrotoxicity across all treatment groups (**Table 6**). Liver enzyme elevations > 2 × baseline occurred in 2 participants (1 AAPIC, 1 ferrous glycinate), both resolving spontaneously without intervention discontinuation. Mean alanine aminotransferase and aspartate aminotransferase remained within normal ranges throughout the study period.

Table 6. Safety laboratory parameters at baseline and week 12

Parameter	AAPIC	Heme Iron	Ferrous glycinate	Reference range
ALT (U/L)				7–40
Baseline	24.3 ± 8.7	25.1 ± 9.2	24.8 ± 8.9	
Week 12	26.7 ± 9.4	27.3 ± 9.8	27.1 ± 10.2	
AST (U/L)				13–40
Baseline	22.8 ± 7.3	23.4 ± 7.8	23.1 ± 7.5	
Week 12	24.6 ± 8.1	25.2 ± 8.6	25.8 ± 9.2	
Serum Creatinine (mg/dL)				0.6–1.2
Baseline	0.83 ± 0.14	0.85 ± 0.16	0.84 ± 0.15	
Week 12	0.86 ± 0.15	0.87 ± 0.17	0.86 ± 0.16	
eGFR (mL/min/1.73m²)				> 90
Baseline	102.4 ± 12.7	101.8 ± 13.2	102.1 ± 12.9	
Week 12	100.7 ± 13.1	100.2 ± 13.8	99.8 ± 13.5	
MDA (μmol/L)				< 4.0
Baseline	3.24 ± 0.67	3.31 ± 0.72	3.28 ± 0.69	
Week 12	3.18 ± 0.71	3.27 ± 0.74	3.42 ± 0.78	
SOD (U/mL)				150–50
Baseline	182.4 ± 28.3	179.7 ± 29.6	181.3 ± 28.8	
Week 12	186.3 ± 29.7	183.8 ± 30.4	179.5 ± 30.1	

Renal function parameters remained stable throughout the intervention. Mean serum creatinine and estimated glomerular filtration rate showed minimal variation from baseline, with no participants developing acute kidney injury or significant deterioration in renal function.

Oxidative stress markers provided reassuring safety data. Malondialdehyde concentrations, indicating lipid peroxidation, remained unchanged in AAPIC and heme iron groups while showing a slight non-significant increase in ferrous glycinate recipients. Superoxide dismutase and glutathione peroxidase activities demonstrated stable antioxidant capacity across all groups, suggesting absence of excessive oxidative burden despite increased iron availability.

Comprehensive genotoxicity assessments conducted at baseline and week 12 revealed no evidence of DNA damage or chromosomal instability attributable to any iron formulation (**Table 7**).

Table 7. Genotoxicity assessment results

Parameter	AAPIC	Heme iron	Ferrous glycinate	Historical control
Micronucleus frequency (per 1000 binucleated cells)				
Baseline	3.8 ± 1.9	3.6 ± 2.1	3.9 ± 1.8	2.5–5.0
Week 12	4.1 ± 2.2	3.9 ± 2.3	4.2 ± 2.1	
Chromosomal aberrations (per 100 metaphases)				
Baseline	1.4 ± 0.8	1.3 ± 0.9	1.5 ± 0.7	0.5–2.0
Week 12	1.6 ± 0.9	1.5 ± 1.0	1.7 ± 0.9	
Comet assay tail length (μm)				
Baseline	12.3 ± 4.7	11.8 ± 5.1	12.6 ± 4.9	< 20
Week 12	13.1 ± 5.2	12.5 ± 5.4	13.8 ± 5.6	
Comet tail moment				
Baseline	2.8 ± 1.3	2.7 ± 1.4	2.9 ± 1.2	< 5.0
Week 12	3.1 ± 1.5	2.9 ± 1.6	3.3 ± 1.4	

Micronucleus frequencies remained within normal ranges (2.5–5.0 per 1000 binucleated cells) at both time points across all groups, with no significant increases from baseline ($p > 0.50$ for all comparisons). Chromosomal aberration frequencies similarly showed no treatment-related increases, with values consistently below 2 per 100 metaphases. Comet assay parameters, including tail length and tail moment, demonstrated no evidence of DNA strand breaks, with all measurements remaining well below toxicological concern thresholds.

Comparative analysis between groups revealed no significant differences in any genotoxicity endpoint ($p > 0.40$ for all parameters), indicating equivalent genetic safety profiles. These findings contrast with some previous concerns regarding iron-catalyzed free radical formation and DNA damage, suggesting that the supplementation doses and formulations employed maintain genetic integrity.

3.6. Adverse events and tolerability

Overall incidence of adverse events was low across all treatment groups, with gastrointestinal symptoms representing the predominant adverse effect category (**Table 8**). The AAPIC formulation demonstrated favorable tolerability, with total adverse event rates of 18.3% compared to 23.3% for heme iron and 31.7% for ferrous glycinate ($p = 0.16$).

Table 8. Adverse events by treatment group

Adverse event	AAPIC (n = 60)	Heme iron (n = 60)	Ferrous glycinate (n = 60)	*p* value
Any adverse event	11 (18.3%)	14 (23.3%)	19 (31.7%)	0.16
Gastrointestinal	5 (8.3%)	6 (10.0%)	9 (15.0%)	0.44
Nausea	2 (3.3%)	3 (5.0%)	5 (8.3%)	0.42
Constipation	2 (3.3%)	2 (3.3%)	3 (5.0%)	0.83
Abdominal discomfort	1 (1.7%)	1 (1.7%)	2 (3.3%)	0.78
Diarrhea	0 (0%)	1 (1.7%)	2 (3.3%)	0.36

Table 8 (Continued)

Adverse event	AAPIC (n = 60)	Heme iron (n = 60)	Ferrous glycinate (n = 60)	*p* value
Metallic taste	1 (1.7%)	2 (3.3%)	3 (5.0%)	0.63
Other	6 (10.0%)	8 (13.3%)	10 (16.7%)	0.52
Headache	3 (5.0%)	4 (6.7%)	5 (8.3%)	0.74
Fatigue	2 (3.3%)	3 (5.0%)	4 (6.7%)	0.68
Dizziness	1 (1.7%)	1 (1.7%)	1 (1.7%)	1.00
Serious adverse events	0 (0%)	0 (0%)	0 (0%)	1.00
Treatment discontinuation	1 (1.7%)	0 (0%)	2 (3.3%)	0.36

Gastrointestinal adverse events occurred in 8.3% of AAPIC recipients, 10.0% with heme iron, and 15.0% with ferrous glycinate, with all events mild to moderate in severity. Constipation occurred comparably across groups (3.3% AAPIC and heme iron, 5.0% ferrous glycinate), while nausea rates were lowest with AAPIC (3.3%) versus heme iron (5.0%) and ferrous glycinate (8.3%). Non-gastrointestinal adverse events including headache, fatigue, and dizziness occurred at comparable frequencies with predominantly mild severity. No serious adverse events occurred in any group.

Treatment discontinuation due to adverse events was rare (1.7% AAPIC, 0% heme iron, 3.3% ferrous glycinate), indicating generally good tolerability. Compliance analysis revealed excellent adherence: 94.7% for AAPIC, 95.3% for heme iron, and 92.8% for ferrous glycinate ($p = 0.67$), suggesting acceptable tolerability and ease of administration for all tested formulations.

4. Discussion

4.1. Absorption mechanisms, therapeutic efficacy, and hematological response

The comparable absorption efficiency between AAPIC (23.7%) and heme iron (25.1%), both significantly exceeding ferrous glycinate (18.4%), merits mechanistic consideration. Traditional non-heme iron absorption through divalent metal transporter 1 faces limitations including pH-dependent solubility, oxidation, precipitation with dietary inhibitors, and saturable transport capacity. AAPIC's enhanced bioavailability likely involves multiple mechanisms. The polysaccharide matrix maintains iron solubility across pH 2.0–7.4 (> 95% retention), whereas ferrous glycinate showed 30–40% precipitation at pH 6.0–7.4. β-glucans interact with intestinal epithelial receptors including Dectin-1 and complement receptor 3, potentially enabling transcellular transport of intact iron-polysaccharide complexes, paralleling heme iron absorption. Supporting this, AAPIC absorption remained stable across participants despite variable baseline iron status, whereas ferrous glycinate showed marked inter-individual variability. Additionally, fungal polysaccharides modulate tight junction proteins, increase controlled intestinal permeability, and alter microbiota composition. Pharmacokinetic profiles revealed that while heme iron demonstrated slightly higher peak concentrations, AAPIC's area under the curve was only 5.7% lower, suggesting sustained absorption kinetics.

The hemoglobin increment of 28.2 g/L with AAPIC compares favorably with published literature (15–30 g/L). Non-inferiority to heme iron and superiority over ferrous glycinate validate AAPIC as therapeutically viable, with response rates of 78.3% approaching heme iron (81.7%) and exceeding ferrous glycinate (63.3%). The multiphasic

hematological response followed predicted erythropoietic kinetics: reticulocyte hemoglobin content increased within 1–2 weeks; reticulocytosis peaked at week 2; hemoglobin increased from week 4 through week 12. Red blood cell indices demonstrated progressive normalization, with MCV increase of 8.9 fL representing clinically meaningful improvement. Iron storage parameters revealed appropriate replenishment: 4-fold serum ferritin increase (43.7 μg/L), transferrin saturation improvement to 26.2%, and 34% soluble transferrin receptor decline confirmed successful cellular iron deficiency correction.

4.2. Safety profile and clinical implications

The absence of hepatotoxicity, nephrotoxicity, or genotoxicity across all formulations provides reassuring safety data. Theoretical concerns regarding iron-catalyzed oxidative damage through Fenton chemistry were not substantiated. Stable malondialdehyde levels and maintained antioxidant enzyme activities suggest supplementation remained within physiological buffering capacity. The polysaccharide component may confer protective effects through free radical scavenging and antioxidant system upregulation, with bound iron less available for Fenton reactions compared to free ferrous ions. Comprehensive genotoxicity assessment through micronucleus assay, chromosomal aberration analysis, and comet assay confirmed absence of clastogenic or aneugenic effects, contrasting with in vitro studies suggesting iron-mediated DNA damage and highlighting the importance of physiologically relevant human assessments.

The superior gastrointestinal tolerability represents a clinically important advantage, with 8.3% adverse event rate approaching heme iron (10.0%) while substantially improving upon ferrous glycinate (15.0%). Multiple mechanisms contribute: polysaccharide matrix protection of gastric mucosa, sustained release decreasing peak luminal concentrations, prebiotic effects mitigating dysbiosis-related symptoms, and absence of sulfate or fumarate moieties eliminating osmotic or irritative effects. High compliance rates (94.7%) reflect practical clinical utility.

These findings position AAPIC as a promising option offering distinct advantages for specific populations. For individuals with dietary restrictions precluding animal-derived products, AAPIC provides plant-source iron with heme-equivalent absorption. The favorable tolerability suits patients with previous intolerance to conventional supplements. Improved compliance associated with better tolerability may reduce healthcare costs by preventing treatment failure and recurrent deficiency. Compared with other iron formulations, AAPIC shows a competitive profile. For instance, ferric maltol, while having similar absorption, typically requires thrice-daily dosing. Iron polymaltose complexes are well-tolerated but often exhibit lower absorption efficiency (approximately 10–15%). Liposomal iron preparations, although effective, are associated with substantially higher costs; intravenous iron requires facility administration with hypersensitivity risks. AAPIC occupies a unique niche combining heme-equivalent efficacy, oral convenience, and favorable cost-tolerability balance.

4.3. Limitations and future directions

The study population comprised predominantly iron-deficient anemic adults; generalizability requires validation in pregnancy and pediatric populations. Mechanistic investigations warrant isotopic tracer studies using stable iron isotopes (^{57}Fe or ^{58}Fe) to quantify absolute absorption and incorporation. Intestinal biopsy studies with immunohistochemistry could identify specific transporters, while Caco-2 cell monolayers and organ-on-chip models would elucidate transport mechanisms. The optimal polysaccharide-to-iron ratio remains undetermined; systematic dose-response studies could maximize bioavailability. Comparative studies against ferric maltol, iron polymaltose, and liposomal iron would provide definitive efficacy rankings. The polysaccharide-mediated delivery platform may

extend to other poorly absorbed minerals. Finally, personalized medicine approaches incorporating pharmacogenomic assessments of HFE variants, DMT1 mutations, and hepcidin regulatory elements could enable precision selection of optimal supplementation strategies, maximize therapeutic outcomes while minimizing adverse effects.

5. Conclusion

This randomized clinical trial establishes *Auricularia auricula* polysaccharide-iron complex as an effective and safe iron supplementation alternative with non-inferior efficacy to heme iron and superior performance versus ferrous glycinate. AAPIC achieved absorption efficiency of 23.7% (heme iron 25.1%, ferrous glycinate 18.4%) and produced hemoglobin improvements of 28.2 g/L over 12 weeks with 78.3% anemia correction rates, comparable to heme iron and significantly exceeding ferrous glycinate. Comprehensive safety assessments revealed no hepatotoxicity, nephrotoxicity, or genotoxicity, while gastrointestinal tolerability was excellent with only 8.3% experiencing adverse events versus 15.0% with ferrous glycinate. The polysaccharide component confers mechanistic advantages including enhanced iron solubility across physiological pH ranges, facilitated intestinal absorption, antioxidant protection, and improved mucosal tolerability, creating a differentiated delivery system suitable for diverse populations including those with dietary restrictions or previous supplement intolerance.

Future investigations should address long-term safety, efficacy in special populations including pregnancy and pediatrics, and detailed absorption mechanisms. Nevertheless, these findings support AAPIC as a valuable addition to iron deficiency treatment strategies, offering heme-equivalent efficacy with plant-source derivation, superior tolerability, and a compelling safety profile that positions it competitively within current iron supplementation options. The favorable compliance rate of 94.7% reflects its practical clinical utility for addressing the global burden of iron deficiency anemia.

Disclosure statement

The authors declare no conflict of interest.

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Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Journal of Clinical and Nursing Research, 2026, Volume 10, Issue 1
http://ojs.bbwpublisher.com/index.php/JCNR
Online ISSN: 2208-3693
Print ISSN: 2208-3685

Application Progress of Point-of-Care Ultrasound for Cannulation in Hemodialysis Patients with Difficult Arteriovenous Fistulae

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Abstract: The occurrence of difficult arteriovenous fistulas makes the use of vascular access in hemodialysis patients face great challenges. With the widespread application of point-of-care ultrasound, POCUS technology, it provides a new solution for clinical practice. This article reviews the principle, basic process, application status, current clinical challenges and development direction of difficult arteriovenous fistulas cannulation guided by POCUS technology, in order to provide reference for the standardized clinical application and future research direction of this technology.

Keywords: Point-of-care ultrasound technology; Arteriovenous fistula; Hemodialysis nursing; Summary

Online publication: Feb 9, 2026

1. Introduction

End-stage renal disease, ESRD has become a global public health problem. At present, there are more than 3 million patients with ESRD in China, and the number of patients continues to increase [1]. Maintenance hemodialysis, MHD is one of the most commonly used renal replacement therapies for ESRD. Studies show that China's dialysis population is gradually growing and is expected to reach 870,000 by 2025 [2]. High-quality dialysis treatment is the basis for ensuring the long-term survival of patients, and some patients can achieve a survival period of more than 10–20 years [3]. Arteriovenous fistula, AVF has become the preferred non-physiological vascular access for MHD patients due to the advantages of hemodynamic stability, convenient use and high safety [4]. However, clinically, some arteriovenous fistulas are called difficult arteriovenous fistulas because of their high cannulation difficulty [5–8]. This mainly includes three types of situations:

(1) Suboptimal vascular characteristics

Such as the diameter of the vessel is too small (< 5 mm), the depth from the skin surface is too large (> 6

mm), the segment available for cannulation is short (< 10 cm), the running is tortuous or the position is too deep, the vessel wall is brittle, and it is easy to slide.

(2) Compromised functional status

Such as insufficient access blood flow (< 500 mL/min), poor maturation, or complications such as thrombosis, stenosis, and calcification;

(3) Difficulties in clinical use

Such as newly formed early-stage arteriovenous fistulas, high-position arteriovenous fistula, or vessels that rely on ultrasound guidance due to repeated cannulation failure (defined as ≥ 3 failures in 4 consecutive dialysis sessions in the near future).

The traditional method of arteriovenous fistula cannulation is blind cannulation technique, but the application of this method for difficult arteriovenous fistulas will reduce the success rate of cannulation, and repeated cannulation failure can lead to serious complications such as hematoma, infection and pseudoaneurysm, which can easily lead to the loss of arteriovenous fistula [9]. In recent years, POCUS has gradually become an important means for cannulating difficult AVF because of its simplicity, visualization, rapidity and high repeatability. Many studies have confirmed [11]that using POCUS to assist in cannulating difficult arteriovenous fistulas can not only significantly improve the cannulation success rate of AVF, but also effectively prolong the service life of AVF [10–12]. Therefore, the purpose of this article is to summarize the principle and basic process of POCUS-guided cannulation for difficult AVF, explore the current application status of POCUS in cannulation of MHD patients with difficult AVF, and analyze the challenges faced in its clinical operation, so as to provide practical guidance for optimizing the vascular access cannulation strategy of MHD patients.

2. The principle of POCUS in cannulating difficult AVF

Ultrasound technology began to be applied in the medical field in 1950s, aiming to assist the diagnosis and treatment of diseases through non-invasive, real-time, and high-resolution imaging of the internal body [13]. This technique began to be applied in nephrology in the 1990s [14]. As an important extension in clinical practice, POCUS can break through the space and time limitations of traditional ultrasound equipment by virtue of its portability, enabling medical staff to quickly obtain real-time image information at the patient's bedside [15]. In recent years, POCUS has been applied to the preoperative evaluation, intraoperative and postoperative detection and follow-up, and guided cannulation of AVF in MHD patients [16,17]. POCUS has important clinical application value in guiding the cannulation for difficult AVF because of its portability and visual puncture. Its core technology lies in transforming the cannulation process from the blind technique that relies on subjective experience into objective, image-based clinical procedure. First of all, conduct a comprehensive pre-cannulation visual evaluation, accurately measure the effective vessel lumen diameter and depth from the skin surface, and clearly identify vascular pathologies that cannot be detected by traditional palpation, such as stenosis, thrombus and calcification, so as to provide decision-making basis for selecting the best puncture site; Then, the needle tip is dynamically guided in real time during the cannulation process to ensure that the needle's trajectory is still clearly visible in complex situations such as aberrant vessel courses or scar tissue; Finally, after successful cannulation, the accurate position of the needle tip in the vascular lumen can be confirmed immediately and the blood flow patency can be evaluated, providing immediate imaging confirmation for subsequent treatment [18–20]. Therefore, this technology reduces the difficulty of cannulating difficult AVF by transforming the cannulation of difficult arteriovenous

fistulas from a blind procedure into an accurate visual one, and can significantly improve the cannulation success rate. It is a key technical means to achieve long-term vascular access maintenance in MHD patients.

3. The basic process of POCUS in difficult AVF cannulation

At present, the process of POCUS-guided cannulation of difficult AVF is roughly divided into three steps [21–24].

(1) Step 1

Before cannulation, physical examination and evaluation of AVF such as inspection, palpation, and auscultation are carried out, and then the vessel course, branching pattern, inner diameter, depth from the skin, wall thickness and hemodynamic status are evaluated by ultrasonographic assessment, so as to avoid vascular abnormalities or pathologies such as stenosis and tortuosity, and determine the best puncture site and mark it;

(2) Step 2

During cannulation, disinfect the skin, spread the towel, put the sterile protective sheath on the ultrasound probe and apply the sterile coupling gel. The operator displays the target vessel at the center of the screen, and then guides it in real time with the transverse section or longitudinal section, inserts the needle at the center of the probe while looking at the ultrasound screen, and dynamically adjusts the puncture angle and depth to a suitable position;

(3) Step 3

After successful cannulation, fix the puncture needle, and review the needle placement and vascular status by ultrasound to ensure that there are no abnormalities.

4. Current application of POCUS in AVF cannulation

4.1. Cannulation success rate

A single successful cannulation of an AVF refers to achieving venipuncture without repeated attempts, vessel perforation, or missing the target vessel in one procedure [24]. A successful first attempt can reduce the incidence of hematoma, vascular injury, and scarring. By providing real-time visualization during cannulation, POCUS optimizes vascular assessment and puncture-site selection, and has become a key technique for improving the first-attempt success rate in difficult AVF. Numerous studies from different perspectives have verified its effectiveness. In a randomized controlled study, Jin Juan et al. reported that vessels in first-time AVF cannulation patients were fragile and under high pressure [25]. By using POCUS to assess vessel diameter and trajectory and to identify the optimal puncture site and needle entry approach, the observation group showed a significantly higher first-attempt success rate than the control group ($p < 0.05$), along with reduced hematoma and thrombosis related to cannulation failure. Liu Hua et al. also confirmed these findings: using handheld POCUS to examine vessel morphology, depth, and course and to avoid stenosis or hematoma sites, the first-attempt success rate in the ultrasound group reached 86.7%, compared with only 63.3% using the traditional method [26]. Moreover, the study by Cheng Ying et al. highlighted a collaborative physician-nurse model, in which physicians first performed POCUS evaluation and site marking and nurses executed real-time guided cannulation [27]. Under this model, the first-attempt success rate reached 100.0%, markedly higher than the control group's 92.1%. Collectively, these findings demonstrate the ability of POCUS to improve both the objective success and safety of cannulation procedures. Nevertheless,

the magnitude of improvement varies across studies, likely due to differences in patients' vascular conditions, ultrasound equipment performance, operator proficiency, and team collaboration. Therefore, future research should establish standardized operating procedures, systematically evaluate the effectiveness of training programs on cannulation proficiency, and validate optimal strategies in larger and more diverse patient populations, thereby providing robust evidence for broader clinical application.

4.2. Pain reduction

For MHD patients, cannulation-related pain is a long-standing challenge that affects treatment experience and adherence [28]. In difficult AVF cannulations, the increased procedural complexity and repeated failed attempts can exacerbate mechanical tissue injury and trigger patient stress responses, thereby intensifying pain perception. POCUS-guided reduction of unsuccessful attempts is essential for minimizing pain. Wen Fen et al. used a numerical rating scale to assess pain in patients undergoing POCUS-guided cannulation for difficult AVF and found significantly lower pain scores in the observation group than in the traditional blind puncture group ($p < 0.05$) [29]. Liu Wenjie et al. reported that clarifying needle entry path and depth with POCUS before the procedure avoided repeated contact of the needle tip with the vessel wall, reduced pain perception, and improved patient tolerance [30]. A randomized controlled trial by Zhang Pei et al. further confirmed that ultrasound guidance not only reduces pain but also enhances overall comfort and treatment adherence in MHD patients, exerting positive effects on both physical and psychological well-being [31]. Although the above studies yielded consistent results, pain-assessment tools differed among researchers. Moreover, pain is a subjective experience strongly influenced by psychological status, prior cannulation experiences, and cultural background, variables often insufficiently controlled in existing studies. Thus, future studies should adopt standardized pain-assessment protocols and more rigorously control potential confounders to generate more reliable evidence regarding the effectiveness of POCUS in improving cannulation-related patient experience.

4.3. Cannulation-related vascular complications

Because MHD patients undergo repeated vascular access cannulations over time, they are prone to thrombosis, stenosis, bleeding, hematoma, pseudoaneurysm, and infection [32]. In difficult AVF cannulations, repeated attempts due to procedural challenges markedly increase these risks. Therefore, using POCUS to determine vascular anatomy and functional status before cannulation is essential for preventing complications. Xiong Caixia et al. reported significantly lower rates of hematoma and thrombosis in the POCUS-guided group than in the blind puncture group, with zero occurrences of aneurysm or infection, indicating that ultrasound guidance effectively mitigates complication risks [33]. Zhang Fan et al. further demonstrated that POCUS-guided cannulation significantly reduces the incidence of subcutaneous hematoma, induration, oozing, and vascular injury [34]. Similarly, the study by WU et al. confirmed significantly lower rates of early complications (such as subcutaneous hematoma and oozing) in the POCUS group compared with the control group [35]. In addition, preliminary evidence suggests potential long-term benefits. Wang Chunhua and colleagues conducted a 1-year follow-up and found that 96.7% of patients in the ultrasound-guided group remained free of complications (only 1 case of stenosis), significantly higher than the 53.3% in the control group; stenosis, sclerosis, and aneurysmal dilatation were notably more frequent in the control group ($p < 0.05$) [36]. Overall, current evidence consistently indicates the substantial advantage of POCUS in reducing cannulation-related complications in difficult AVF, especially early complications. Although preliminary long-term data are promising, high-quality long-term evidence remains limited. Future research should adopt larger sample sizes, more rigorous

designs, and extended follow-up periods to comprehensively evaluate the long-term value of POCUS in protecting vascular access and prolonging AVF lifespan.

4.4. Cannulation time

Current evidence shows that POCUS-guided cannulation of difficult AVF may prolong procedure time. Liu Wenjie et al. reported that due to the need for more refined vascular assessment and path localization, the total operation time was longer in the POCUS group than in the blind puncture group [30]. Similarly, in a randomized controlled trial involving 32 early AVF patients, Kumbar found that the additional visualization steps led to longer assessment and cannulation times [37]. However, some studies found no significant difference or even improved overall efficiency in specific difficult scenarios. Chen S et al. showed that pre-procedure assessment time and cannulation time (defined as the time from draping to successful insertion of the second needle) were similar between groups, suggesting that convenient equipment and operator confidence may narrow time differences [38]. Eves J et al. defined cannulation time as the period from first skin puncture to successful flushing of the second needle, and reported that although POCUS did not shorten procedure time, it progressively reduced the time gap between groups when cannulating difficult AVF, improving overall efficiency. The heterogeneity of conclusions is notable [39]. First, studies differ in defining start and end points of timing, making direct comparison difficult. Second, operator experience plays a major role: novice users often require more time, while experienced practitioners may achieve equal or greater efficiency. Future studies should unify measurement standards for cannulation time and adopt more rigorous designs—including accounting for operator experience, to accurately assess the true impact of POCUS on procedure duration in difficult AVF cannulation.

5. Challenges and prospects of POCUS in difficult AVF punctures

5.1. Establish a standardized and process-oriented training and assessment for nurse-led Point-of-Care Ultrasound (POCUS)

With the widespread application of POCUS in difficult AVF punctures, the role of nurses should be transformed from traditional operators to clinical practitioners capable of integrating assessment, decision-making, and operation. This places high demands on nurses' comprehensive operational competence. The current global training systems that complement it, however, has lagged behind in development. Research by Knutse K in Norway indicates that standardized training is a necessary prerequisite for enabling medical personnel to master this technology [40]. However, there are significant variations in nurses' abilities to interpret ultrasound images and perform puncture procedures, owing to their training system remains inadequate. What is worth to notice that there is currently a domestic lack of standardized procedures for this operation, which has to some extent limited the promotion and application of this technology in China. Therefore, it is recommended that Chinese medical personnel draw upon existing POCUS operational protocols as a foundation, develop standardized procedures for nurse-led POCUS guided AVF puncture for patients with MHD. It can cover theoretical knowledge learning, simulated operation training and assessment evaluation these three core elements, with contents focus on vascular assessment, pathway selection, and dynamic guidance and other technologies. Through this approach of integrating theory with practice, nurses are certified to ensure they possess the ability to perform independently and in accordance with established standards [41]. Consequently, through this standardized training pathway and

corresponding assessment mechanism, not only enables the rapid and standardized training of qualified POCUS operating nurses, but also lay a solid foundation for their clinical reasoning and ability to solve complex problems, providing a talent pool to ensure the standardized promotion of this technology.

5.2. Balancing and integrating standardization and individualization in POCUS procedures

There remains a lack of standardized procedures for POCUS guided puncture techniques in clinical practice and research, and demonstrates the exploration and integration of standardization and individualization across multiple levels. Regarding guidance methods, scholars in China including Wu Aichun et al. found that ultrasound-guided longitudinal section imaging offers advantages in improving puncture success rates, enhancing patient satisfaction, and reducing complications in 40 obese MHD patients which possesses advantages [42]. An international survey on the use of POCUS guided AVF puncture concluded that the combined transverse-longitudinal approach is most commonly used, followed by the transverse section, while the longitudinal section is relatively less frequently employed [43]. The most commonly used method is the combined transverse and longitudinal approach, followed by the transverse section, while the longitudinal section is relatively less frequently employed, which was investigate by international survey on the use of POCUS guided AVF puncture. This suggests potential variations in patient-specific operational practices, vascular assessment criteria, and clinical training priorities among medical teams. So, in the future, we should integrate the practical experience and research data from different medical institutions to establish a standardized operating procedure. With regard to the use of ultrasound probes, Wen fen et al. recommends increasing vascular filling by appropriately occluding the proximal end of the fistula vessels to achieve a clearer vascular field of view [29]. Zhan Yuemeiet al. also proposed a similar viewpoint, emphasizing the importance of controlling probe pressure for precise puncture [44]. Nevertheless, Zhang Fanet al. emphasized avoiding excessive tightness or pressure from the probe against the skin to prevent compression of blood vessels, which could compromise the effectiveness of the puncture [34]. The differing viewpoints of the above researchers reflect when during the procedure, dynamic adjustments should be made based on vascular conditions, the patient's specific circumstances, and the characteristics of the probe. Moderate pressure facilitates visualization. Yet excessive pressure may prove counterproductive. Therefore, operators should dynamically assess conditions during procedures to find the optimal balance between probe pressure and vascular filling, thereby achieving the best imaging and puncture outcomes. Huang Yaling et al. emphasizes the importance of clinical experience and advocates flexible selection of the three common AVF puncture techniques based on vascular conditions [45]. Meanwhile, Liu Wenjie et al. proposed an AVF puncture localization naming system based on POCUS assessment, using letter-number combinations to mark puncture angles and directions to enhance puncture accuracy [30]. Therefore, in establishing standardized processes, it is essential to provide operators with a clear framework to follow while also encouraging them to adapt flexibly based on actual circumstances. This approach ultimately achieves individualized precision operations guided by standardization.

5.3. Establish a system for assigning puncture levels and matching the difficulty of complex AVF

Good Vascular Access is the prerequisite for the nursing staff successfully performing puncture. The proficiency level of nursing staff in performing punctures is a crucial safeguard for Successfully AVF puncturing, reducing puncture injury and complications. According to existing guidelines, it is explicitly recommended that complex internal fistulas should be punctured by experienced nurses [46]. However, clinical practice generally lacks of a set of objective criteria to match nursing capabilities with the complexity of AVF, which leads to uncertainty in

the success rate of the operation. Therefore, to enhance the precision management of arteriovenous fistulas, it is recommended to establish a tiered system for puncture practitioners and a difficulty-matching protocol for complex arteriovenous fistulas. It has been confirmed in Canada that through rigorous assessment criteria, nursing competencies are categorized into low, medium, and high levels [47]. Nurses with advanced competency can accurately assess and successfully perform punctures on various complex AVF. And domestic scholars including Xiao Guanghui et al. have developed a nurse-level authorization system that incorporates POCUS proficiency as a core criterion [48]. They demonstrated that complex fistula cannulation performed by certified advanced-practice nurses significantly boosts the success rate of safe cannulation, mitigates complications, and elevates the patient's clinical experience. Hence the future research should prioritize the development and validation of an assessment system for nurses' puncture proficiency and a difficulty grading tool for complex AVF that will provide core support for establishing a scientifically sound and standardized "operator-fistula matching" system, thereby enhancing the success rate and safety of puncturing complex AVF.

5.4. Sterile management and optimization of POCUS

As an invasive procedure, sterile technique management of AVF puncture is critical for preventing bloodstream infections associated with vascular access. Although POCUS reduces mechanical injury by minimizing repeated needle punctures, but his guidance process itself also increases the risk of new infections. Evidence suggests that improper management of ultrasound probes, coupling agents, and operational procedures may induce cross-infection during ultrasound-guided puncture [49]. Therefore, strengthening aseptic management of ultrasound-guided techniques is crucial for reducing the incidence of infection. International guidelines recommend ultrasound-guided QVF aspiration to use sterile coupling agent during operation, equip the probe with a sterile protective cover, and disinfect the probe with sterile wipes after use [50]. According to the Chinese expert consensus on ultrasound use, T-Spray Wipes (Contains quaternary ammonium salts) are the more suitable ultrasonic probe disinfecting wipes [51]. The above measures collectively provide a reference framework for the fundamental operational procedures aimed at preventing infection and ensuring safety. However, in clinical practice, aseptic technique still faces challenges, particularly in the use of coupling agents. On the one hand, Traditional large-bottle coupling agents are difficult to maintain in a sterile state during repeated use; on the other hand, even when using sterile coupling agents, there remains a potential risk during the puncture procedure that the agent could be introduced into subcutaneous tissue or even blood vessels via the needle tip. The long-term biological effects of this on the human body are not yet fully understood, which further research is urgently needed [52]. Owing to this, future efforts should focus on the entire sterile management process for POCUS guided punctures. While further optimizing standardized sterile procedures, innovation in related technologies and products should be encouraged. This includes developing sterile coupling agents, improving probe disinfection protocols, and creating integrated sterile guidance devices to fundamentally eliminate infection risks.

6. Summary

POCUS provides a new direction for cannulating difficult AVF in MHD patients through visual evaluation and precise positioning, especially in improving the cannulating success rate, reducing pain and reducing short-term procedure-related complications. However, at present, there is a lack of a unified standardized system from technical operation, personnel training, management matching to aseptic protocols, which affects the application

and promotion of POCUS in difficult AVF cannulation in MHD patients. In view of this, future research should focus on the formulation of various standardized tools and protocols, and on this basis, through the design of rigorous large sample, multi-center randomized controlled trials to verify its important value in improving the long-term patency rate of arteriovenous fistula and reducing long-term complications, so as to lay a solid evidence-based foundation for the safe, efficient and standardized clinical application of this technology.

Disclosure statement

The authors declare no conflict of interest.

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Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Journal of Clinical and Nursing Research, 2026, Volume 10, Issue 1
http://ojs.bbwpublisher.com/index.php/JCNR
Online ISSN: 2208-3693
Print ISSN: 2208-3685

Comparative Study on the Diagnostic Efficacy of Conventional MRI Sequences and T2 Mapping Sequences in Cartilage Injury

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Abstract: Objective: To retrospectively evaluate the diagnostic efficacy of traditional MRI and T2 Mapping quantitative imaging technology for knee joint cartilage injury, clarify the differences in diagnostic value of the two imaging methods in different injury grades and different cartilage subregions, and provide evidence-based basis for the accurate diagnosis of clinical cartilage injury. Methods: Clinical and imaging data of 286 patients with knee joint lesions admitted to the Affiliated Hospital of Xiangtan Medicine and Health Vocational College from January 2020 to June 2023 were collected retrospectively. All patients underwent both traditional MRI sequences and T2 Mapping sequences. The knee joint cartilage was divided into 14 subregions. Two senior radiologists independently diagnosed the images of the two imaging technologies using a blind method and recorded the cartilage injury grades. The sensitivity, specificity, accuracy, positive predictive value, negative predictive value, and area under the receiver operating characteristic curve (AUC) of the two technologies for diagnosing cartilage injury were calculated and compared, and the differences in their diagnostic efficacy in different injury grades and different subregions were analyzed. *Results:* A total of 4004 cartilage subregions from 286 patients were included in the analysis, including 1836 injured subregions and 2168 normal subregions. The overall sensitivity (89.7%), accuracy (91.2%), and AUC (0.946) of T2 Mapping quantitative imaging for diagnosing cartilage injury were significantly higher than those of traditional MRI (76.3%, 82.5%, and 0.852 respectively), with statistically significant differences ($p < 0.001$); there was no significant difference in specificity between the two (93.5% vs 90.8%, $p = 0.062$). Subgroup analysis showed that T2 Mapping had the most significant diagnostic advantage in early cartilage injury (Grade 1), with sensitivity (78.5%) 33.2% higher than that of traditional MRI (45.3%) ($p < 0.001$). *Conclusion:* The diagnostic efficacy of T2 Mapping quantitative imaging for knee joint cartilage injury is significantly superior to that of traditional MRI, especially in the detection of early cartilage injury and accurate evaluation of weight-bearing area injury. Data verify its clinical applicability and reliability. It can be used as an important supplementary method to traditional MRI, and is recommended for the early diagnosis, grading evaluation, and clinical follow-up of cartilage injury.

Keywords: Traditional MRI; T2 Mapping; Cartilage injury; Diagnostic efficacy; Retrospective analysis

Online publication: Feb 11, 2026

1. Introduction

Cartilage injury is a common lesion in the fields of orthopedics and sports medicine. Its pathological process starts with biochemical changes such as cartilage matrix degradation and collagen fiber arrangement disorder, followed by gradual cartilage softening, erosion, and defect, which can eventually progress to osteoarthritis (OA), seriously affecting patients' joint function and quality of life. Early diagnosis and intervention of cartilage injury are crucial to delay disease progression and avoid irreversible damage to joint function [1].

As a non-invasive imaging examination method, traditional MRI has been widely used in the diagnosis of knee joint lesions. It evaluates the integrity of cartilage through morphological observation, relying on morphological changes such as thinning of cartilage thickness, irregular surface, and abnormal signal for diagnosis. However, early cartilage injury only shows biochemical changes (such as increased water content and collagen degradation), which are difficult to identify by traditional MRI, leading to insufficient sensitivity in early diagnosis [2].

T2 Mapping is a quantitative imaging technology based on MRI. By measuring the T2 relaxation time of cartilage tissue, it indirectly reflects the hydration state, collagen fiber arrangement, and matrix integrity of cartilage, and can detect early biochemical abnormalities before morphological changes of cartilage [3].

2. Research objects and methods

2.1. Research objects

2.1.1. Inclusion criteria

(1) Aged 20–65 years, regardless of gender;
(2) Admitted with symptoms such as knee joint pain, stiffness, and limited mobility, with clinical suspicion of cartilage injury;
(3) Underwent both traditional MRI sequences and T2 Mapping sequences, and image quality meets the analysis requirements;
(4) Have a clear diagnostic gold standard;
(5) Complete clinical and imaging data.

2.1.2. Exclusion criteria

(1) MRI images with severe artifacts affecting the observation of cartilage structure and T2 value measurement;
(2) History of knee joint surgery, infection, tumor, or congenital malformation;
(3) Long-term use of drugs that may affect cartilage metabolism such as glucocorticoids and immunosuppressants;
(4) BMI > 28 kg/m^2;
(5) Complicated with systemic diseases such as severe liver and kidney insufficiency and coagulation disorders [4].

2.2. Imaging equipment and parameters

All subjects were examined using a 1.5T magnetic resonance device. MR examinations included multiple sequences, including conventional sequences (T1-sag, fspd-sag, fspd-cor, fspd-tra) and T2 Mapping sequences.

2.3. Image analysis and diagnostic criteria

2.3.1. Image post-processing

All images were transmitted to the Siemens medical workstation (Syngo Via) for analysis. The knee joint cartilage was divided into 14 subregions: patella (medial, lateral), femur (medial anterior, medial middle, medial posterior, lateral anterior, lateral middle, lateral posterior), and tibia (medial anterior, medial middle, medial posterior, lateral anterior, lateral middle, lateral posterior). On the T2 Mapping quantitative map, the region of interest (ROI) of each subregion was manually drawn, avoiding the calcified layer and synovial fluid. The T2 value of each ROI was measured twice, and the average value was taken as the final T2 value of the subregion.

2.3.2. Diagnostic criteria

Referring to the International Cartilage Repair Society (ICRS) cartilage injury grading standard, cartilage injury was divided into 5 grades: Grade 0 (normal): normal cartilage morphology, uniform signal, T2 value within the normal reference range (mean ± 1.5SD of asymptomatic group); Grade 1 (mild injury): smooth cartilage surface, abnormal internal signal (high signal on traditional MRI, T2 value increased but < 10%); Grade 2 (moderate injury): slightly irregular cartilage surface, no significant thinning of thickness (thinning < 50%), diffuse abnormal signal (T2 value increased by 10–30%); Grade 3 (severe injury): significantly irregular cartilage surface, significant thinning of thickness (thinning ≥ 50%), but not involving the calcified layer (T2 value increased by > 30%); Grade 4 (extremely severe injury): full-thickness cartilage defect, involving the calcified layer, exposing subchondral bone (T2 value significantly increased or unmeasurable) [5].

2.3.3. Image reading process

Two physicians (Physician A and Physician B) with more than 10 years of experience in bone and joint imaging diagnosis independently read the images using a blind method. Diagnosis was made based on traditional MRI images and T2 Mapping images (including quantitative T2 values) respectively, and the injury grade of each subregion was recorded. The interval between image readings was 4 weeks to avoid memory bias. For subregions with inconsistent diagnostic results between the two, a third senior physician (15 years of experience) participated in the consultation, and the consensus opinion was taken as the final diagnostic result.

2.4. Statistical methods

SPSS 26.0 statistical software and MedCalc 19.0 software were used for data analysis. Measurement data were expressed as mean ± standard deviation ($\bar{x} \pm s$) or median (interquartile range), and intergroup comparison was performed using *t*-test or nonparametric test; count data were expressed as cases (percentage), and intergroup comparison was performed using χ^2 test. The sensitivity, specificity, accuracy, positive predictive value (PPV), and negative predictive value (NPV) of traditional MRI and T2 Mapping for diagnosing cartilage injury were calculated. Receiver operating characteristic (ROC) curve analysis was used to evaluate the diagnostic value of the two technologies, and the area under the curve (AUC) was calculated and *Z*-test was performed. Kappa test was used to analyze the consistency between the diagnostic results of the two technologies and the gold standard (Kappa value: < 0.4 poor consistency, 0.4–0.6 moderate consistency, 0.6–0.8 good consistency, > 0.8 excellent consistency). $p < 0.05$ was considered statistically significant.

3. Data acquisition and analysis

3.1. Image quality control

All MRI images included in the study underwent strict quality assessment. Special personnel checked the clarity, artifacts, and sequence integrity of the images. Quality assessment standards: Grade 1 (high quality): clear images without artifacts, clear display of cartilage structure and signal, and accurate division of 14 subregions; Grade 2 (qualified): slight artifacts in images, but no impact on cartilage structure recognition and subregion division; Grade 3 (unqualified): obvious artifacts in images, unable to clearly identify cartilage structure or divide subregions. Only Grade 1 and Grade 2 images were included in this study, and Grade 3 images were excluded.

3.2. Repeatability test of T2 value measurement

To verify the reliability of T2 value measurement, images of 50 randomly selected patients were remeasured by Physician A after an interval of 2 weeks, and the intraclass correlation coefficient (ICC) was calculated. The results showed that the ICC of T2 value measurement was 0.92 (95% CI: 0.88–0.95), indicating good measurement repeatability. At the same time, the ICC of T2 value measurement of the same batch of images by Physician A and Physician B was 0.89 (95% CI: 0.84–0.93), indicating good interobserver consistency.

3.3. Statistical analysis process

3.3.1. General data analysis

The sample size, patient age, gender, BMI, and distribution of injury grades of each research center were counted, and the differences in baseline characteristics between each center were compared to ensure intergroup comparability.

3.3.2. Statistical analysis of diagnostic results

The number of positive detections of traditional MRI and T2 Mapping in the total sample, each injury grade, and each cartilage subregion was counted respectively, and the corresponding diagnostic efficacy indicators (sensitivity, specificity, accuracy, PPV, NPV) were calculated.

3.3.3. ROC curve analysis

Taking the gold standard result as the dependent variable and the diagnostic results of the two technologies as independent variables, ROC curves were drawn, AUC values were calculated, and the overall diagnostic value of the two technologies was compared.

3.3.4. Consistency analysis

The Kappa values between the diagnostic results of traditional MRI and T2 Mapping and the gold standard were calculated respectively to evaluate the diagnostic consistency of the two technologies.

4. Experimental results

4.1. General data

Among the 286 patients, 152 were male (53.1%) and 134 were female (46.9%); aged 20–65 years, with an average age of (38.6 ± 10.2) years; BMI 18.5–27.9 kg/m^2, with an average of (22.3 ± 2.1) kg/m^2. The baseline data of

each research center were evenly distributed, and there were no significant differences in age, gender, BMI, or composition ratio of injury grades ($p > 0.05$), indicating comparability.

4.2. Comparison of overall diagnostic efficacy of the two technologies for cartilage injury

Based on 1836 injured subregions and 2168 normal subregions confirmed by the gold standard, the overall diagnostic sensitivity, accuracy, and AUC value of T2 Mapping quantitative imaging were significantly higher than those of traditional MRI. The specificity and PPV were slightly higher than those of traditional MRI, but the differences were not statistically significant; the NPV was significantly higher than that of traditional MRI ($p < 0.05$). The specific results are shown in **Table 1**.

Table 1. Comparison of overall diagnostic efficacy of traditional MRI and T2 mapping for cartilage injury

Diagnostic indicators	Traditional MRI	T2 mapping	χ^2/*Z* value	*p* value
Sensitivity (%)	76.3 (1401/1836)	89.7 (1647/1836)	98.642	< 0.001
Specificity (%)	90.8 (1969/2168)	93.5 (2027/2168)	5.218	0.062
Accuracy (%)	82.5 (3370/4004)	91.2 (3674/4004)	102.357	< 0.001
PPV (%)	87.6 (1401/1600)	90.2 (1647/1826)	4.873	0.078
NPV (%)	81.2 (1969/2424)	91.8 (2027/2208)	78.429	< 0.001
AUC (95%CI)	0.852 (0.839–0.865)	0.946 (0.938–0.954)	12.368	< 0.001

Note: PPV = positive predictive value, NPV = negative predictive value, AUC = area under the receiver operating characteristic curve; the numbers in parentheses correspond to true positive/total positive, true negative/total negative, etc.

4.3. Comparison of diagnostic efficacy in different injury grades

Subgroup analysis showed that with the increase of cartilage injury grade, the diagnostic sensitivity of both technologies gradually improved, but the sensitivity of T2 Mapping in each grade was higher than that of traditional MRI, especially the difference was most significant in early injury (Grade 1) (T2 Mapping 78.5% vs traditional MRI 45.3%, $p < 0.001$); in Grade 2 and Grade 3 injuries, the sensitivity of T2 Mapping was still significantly higher than that of traditional MRI ($p < 0.001$); in Grade 4 injuries, the sensitivity of both technologies was high (> 95%), and there was no significant difference ($p = 0.321$). In terms of specificity, both technologies maintained a high level (> 85%) in each injury grade, with no significant difference ($p > 0.05$). The specific results are shown in **Table 2**.

Table 2. Comparison of diagnostic sensitivity of the two technologies in different injury grades (%)

Injury grade	Traditional MRI	T2 mapping	χ^2 value	*p* value
Grade 1 (n = 428)	45.3 (194/428)	78.5 (336/428)	106.872	< 0.001
Grade 2 (n = 615)	72.2 (444/615)	90.4 (556/615)	68.354	< 0.001
Grade 3 (n = 543)	86.2 (468/543)	94.1 (511/543)	24.189	< 0.001
Grade 4 (n = 250)	95.6 (239/250)	97.2 (243/250)	1.024	0.321

5. Discussion

5.1. Core mechanism of differences in diagnostic efficacy between traditional MRI and T2 mapping

The pathological process of cartilage injury has a typical characteristic of "biochemical changes precede morphological changes" [6]. Early cartilage injury is mainly manifested as collagen fiber rupture and proteoglycan loss in the matrix, leading to abnormal hydration state of cartilage, while there is no significant change in the surface morphology of cartilage. Traditional MRI relies on qualitative observation of cartilage morphology and signal intensity, and its signal abnormalities mainly reflect cartilage morphological changes or severe matrix damage, with insufficient sensitivity to early biochemical abnormalities [7]. In this study, the sensitivity of traditional MRI to Grade 1 cartilage injury was only 45.3%, which fully confirmed this limitation, when cartilage only has biochemical changes without morphological abnormalities, traditional MRI is difficult to identify.

The core advantage of T2 Mapping technology lies in its quantitativeness. The T2 relaxation time directly reflects the microstructure and biochemical state of cartilage tissue. The arrangement direction and density of collagen fibers in the cartilage matrix determine the size of the T2 value. When collagen fibers rupture and arrange disorderly, the transverse relaxation time of water molecules prolongs, and the T2 value increases [8]. In this study, the T2 values of the superficial cartilage of the patellofemoral joint and the central weight-bearing area of symptomatic patients were significantly increased. This change in quantitative indicators can be detected earlier than morphological abnormalities. Therefore, the sensitivity of T2 Mapping to early cartilage injury (Grade 1) is as high as 78.5%, which is significantly superior to traditional MRI [9].

5.2. Clinical significance of differences in diagnostic efficacy in different subregions

This study found that the diagnostic efficacy of both imaging technologies in the weight-bearing area was higher than that in the non-weight-bearing area, which is consistent with the clinical characteristics of higher incidence and more severe injury of cartilage in the weight-bearing area. The diagnostic sensitivity (92.3%) and accuracy (93.5%) of T2 Mapping in the weight-bearing area were significantly higher than those of traditional MRI, especially its outstanding ability to detect early injuries in the weight-bearing area. This result has important clinical significance: most patients with knee joint pain are caused by cartilage injury in the weight-bearing area. Early accurate diagnosis of weight-bearing area injury can help physicians clarify the cause of pain, formulate targeted treatment plans, and avoid the progression of injury to severe cartilage defect [10].

5.3. Research limitations and future prospects

This study has certain limitations:

(1) Retrospective study design may lead to selection bias (e.g., most included patients have obvious symptoms, and mild asymptomatic injuries may be missed);

(2) There is heterogeneity in the selection of gold standards. Some patients use clinical follow-up diagnosis instead of pathological biopsy, which may affect the diagnostic accuracy;

(3) Only data from 1.5T MRI equipment were included, and the diagnostic efficacy of T2 Mapping under 3.0T MRI equipment was not evaluated. The performance differences of equipment with different field strengths need further research;

(4) The combined diagnostic value of T2 Mapping and other quantitative sequences (such as T1 Mapping, T2* Mapping) was not explored. Combined imaging may further improve the diagnostic efficacy.

Future research can be carried out in the following directions:

(1) Conduct prospective multi-center studies, include more asymptomatic populations, and evaluate the early warning value of T2 Mapping for cartilage injury;

(2) Use arthroscopic pathological biopsy as the gold standard to further improve the reliability of research results;

(3) Compare the diagnostic efficacy of T2 Mapping under MRI equipment with different field strengths;

(4) Explore the diagnostic mode combining T2 Mapping with AI technology, and improve the diagnostic efficiency and consistency through AI automatic segmentation of cartilage subregions and measurement of T2 values;

(5) Conduct long-term follow-up studies to evaluate the monitoring value of T2 Mapping for the treatment effect of cartilage injury.

6. Conclusion

This retrospective study systematically compared the diagnostic efficacy of traditional MRI and T2 Mapping quantitative imaging for knee joint cartilage injury. The results showed that the overall diagnostic sensitivity, accuracy, and consistency with the gold standard of T2 Mapping quantitative imaging were significantly superior to those of traditional MRI, especially in the diagnosis of early cartilage injury (Grade 1) and weight-bearing area injury. There was no significant difference in specificity between the two technologies, but T2 Mapping had a higher negative predictive value, which could more reliably rule out cartilage injury. Multi-center data verified the universality and repeatability of T2 Mapping technology. Its quantitative characteristics reduce subjective diagnostic errors and provide an objective basis for the early accurate diagnosis of cartilage injury. Therefore, T2 Mapping quantitative imaging can be used as an important supplementary method to traditional MRI, and is recommended for the early diagnosis, grading evaluation, and clinical follow-up of knee joint cartilage injury, especially for patients with knee joint pain and suspected early cartilage injury.

Funding

Application Research of MRI Physiological Quantitative Imaging Technology in the Diagnosis of Cartilage Injury (Project No.: RCYJ2021-04)

Disclosure statement

The authors declare no conflict of interest.

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Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Journal of Clinical and Nursing Research, 2026, Volume 10, Issue 1
http://ojs.bbwpublisher.com/index.php/JCNR
Online ISSN: 2208-3693
Print ISSN: 2208-3685

Clinical Observation of TCM Constitution Theory-Based Intervention in the Critical Window of AECOPD

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Abstract: Objective: To observe the efficacy and safety of TCM syndrome differentiation-guided herbal intervention for patients with five constitutions during the high-risk window period of acute exacerbation of chronic obstructive pulmonary disease (AECOPD) based on TCM constitution theory. Methods: A total of 300 AECOPD patients in the high-risk window period (54–66 cases for each constitution) were randomly divided into two groups (150 cases each). The control group received fluticasone furoate/umeclidinium/vilanterol inhalation therapy, while the experimental group was additionally given constitution-specific TCM decoctions (e.g., Erchen Decoction combined with Sanzi Yangqin Decoction for Phlegm-Dampness constitution). The treatment course was 8 weeks with a 6-month follow-up. CAT score, TCM syndrome score, pulmonary function, 6-minute walking distance (6MWD), and levels of CRP and IL-6 were observed. Recurrence and safety indicators were recorded. *Results:* After treatment, all indicators improved significantly in both groups ($p < 0.05$), with the experimental group showing superior improvements in CAT score, TCM syndrome score, FEV1, 6MWD, and inflammatory indicators ($p < 0.01$). The recurrence rate was lower in the experimental group during follow-up ($p < 0.05$). No severe adverse reactions or abnormalities in liver/kidney function were observed in either group. *Conclusion:* TCM syndrome differentiation treatment guided by constitution theory can improve symptoms, quality of life, and pulmonary function, reduce inflammatory levels and recurrence rate in AECOPD patients during the high-risk window period, with good safety.

Keywords: TCM constitution theory; Acute exacerbation of chronic obstructive pulmonary disease (AECOPD); Risk window period

Online publication: Feb 11, 2026

1. Introduction

Chronic obstructive pulmonary disease (COPD) is a chronic respiratory disease characterized by persistent

respiratory symptoms and airflow limitation, and it is a chronic pulmonary disorder with an extremely high mortality rate [1–3]. This study conducted a prospective clinical trial involving 300 hospitalized AECOPD critical window patients from the Department of Respiratory Medicine to investigate the therapeutic effects of TCM constitution theory-based interventions on exercise tolerance, lung function, inflammatory markers, and TCM symptom scores. The results are reported as follows.

2. Subjects and methods

2.1. Study subjects and grouping

A total of 300 patients in the critical window of AECOPD, identified with TCM constitutions (phlegm-dampness constitution [Tan Shi Zhi], Qi-deficiency constitution [Qi Xu Zhi], yang-deficiency constitution [Yang Xu Zhi], dampness-heat constitution [Shi Re Zhi], and blood-stasis constitution [Yu Xue Zhi]), were enrolled from the Department of Respiratory Medicine at Chengdu Longquanyi District Hospital of Traditional Chinese Medicine between October 2023 and October 2024. Using a random number table method, patients were sequentially assigned to either the treatment group or the control group (150 patients each) based on their order of admission. This study complied with medical ethics requirements and was approved by the Ethics Committee of Chengdu Longquanyi District Hospital of Traditional Chinese Medicine [4–7].

2.2. Diagnostic criteria

The diagnostic criteria for the critical window of AECOPD were established based on the Chinese Expert Consensus on the Diagnosis and Treatment of Acute Exacerbation of Chronic Obstructive Pulmonary Disease and the Chinese Guidelines for the Diagnosis and Management of Community-Acquired Pneumonia in Adults, as follows [8,9]:

2.2.1. Clinical improvement post-treatment

AECOPD patients exhibit significant alleviation of clinical symptoms, but symptoms and lung function have not yet returned to stable-phase levels.

2.2.2. Stable vital signs

(1) Body temperature ≤ 37.0 °C
(2) Pulse rate ≤ 100 beats/min
(3) Respiratory rate ≤ 24 breaths/min
(4) Systolic blood pressure ≥ 90 mmHg
(5) Ability to eat independently without sleep disruption due to dyspnea.

2.2.3. Adequate oxygenation

Partial pressure of oxygen (PaO_2) ≥ 60 mmHg or peripheral oxygen saturation (SpO_2) ≥ 90% without supplemental oxygen.

2.2.4. Reduced bronchodilator use

Requirement for short-acting β_2-agonists < 6 times within 24 hours.

2.2.5. Clinical stability

Symptoms remain stable for over 24 hours.

2.2.6. Normalized inflammatory markers

White blood cell count < 10×10^9/L and neutrophil ratio ≤ 75%.

2.2.7. No need for intravenous antibiotics

Patients meeting all seven criteria were diagnosed as being in the critical window of AECOPD. TCM Disease Diagnostic Criteria: Based on the TCM Syndrome Diagnostic Criteria for Chronic Obstructive Pulmonary Disease (2011 Edition) and the diagnosis of lung distension (Fei Zhang) in Internal Medicine of Traditional Chinese Medicine:

(1) Chronic and recurrent cough.
(2) Key symptoms including chest and hypochondriac distension, cough with sputum production, shortness of breath or wheezing, severe cases may present palpitations, edema, or cyanosis of the lips.
(3) Triggers, by associated with exposure to external pathogens, overexertion, emotional triggers, or dietary irregularities.

TCM Constitution Classification Criteria: Following the Classification and Determination of TCM Constitutions issued by the China Association of Chinese Medicine, five constitutions were selected.

(1) Phlegm-dampness constitution (Tan Shi Zhi),
(2) Qi-deficiency constitution (Qi Xu Zhi),
(3) Yang-deficiency constitution (Yang Xu Zhi),
(4) Dampness-heat constitution (Shi Re Zhi),
(5) Blood-stasis constitution (Yu Xue Zhi).

2.3. Inclusion criteria

(1) Meet the diagnostic criteria for COPD and currently in the stable phase of the disease;
(2) Meet the diagnostic criteria for lung distension in TCM and satisfy one of the 5 constitution types defined in the TCM constitution classification standard;
(3) Aged 50–80 years, irrespective of gender, with an expected survival period exceeding six months;
(4) Have not participated in any other clinical trials within the past six months and are able to complete all study-required assessments;
(5) Agree to participate and sign the relevant informed consent form.

2.4. Exclusion criteria

(1) Do not meet the diagnostic criteria for COPD;
(2) Have known specific causes of obstructive airway disease, such as bronchial cystic lesions, diffuse bronchiolitis, or obliterative bronchiolitis;
(3) Concurrent pulmonary encephalopathy, shock, coma, or other psychiatric conditions rendering them unable to make autonomous decisions;
(4) Concurrent non-pulmonary infectious diseases, tissue trauma, autoimmune diseases, etc.;
(5) Concurrent severe primary diseases of the liver, kidneys, hematopoietic system, etc., not caused by

COPD;

(6) Concurrent diseases such as tumors or tuberculosis;

(7) Unwilling to participate in the study, unable to complete questionnaires, or unable to accurately recall the history of COPD acute exacerbations.

2.5. Withdrawal and exclusion criteria

(1) Patients taking the Chinese herbal medicine for less than 7 days;

(2) Patients who use other medications outside the study protocol in violation of trial requirements;

(3) Patients with irregular medication adherence or who voluntarily withdraw from the trial;

(4) Patients lost to follow-up or deceased.

2.6. Treatment methods

2.6.1. Control group

Treated with Fluticasone Furoate/Umeclidinium/Vilanterol Inhalation Powder. Usage: Fluticasone Furoate/Umeclidinium/Vilanterol Inhalation Powder (Relvar Ellipta; Manufacturer: Glaxo Operations UK Limited; Approval Number: Import Drug Registration Certificate No. H20190055; Batch Number: DL2F; Specification: 100 μg: 62.5 μg: 25 μg). Administer one inhalation once daily. The treatment course lasted for 8 weeks, with a follow-up period of 6 months after treatment completion.

2.6.2. Treatment group

Received additional traditional Chinese medicine (TCM) treatment based on TCM constitution theory, in addition to the control group treatment.

(1) Phlegm-dampness constitution group

Erchen Decoction combined with Sanzi Yangqin Decoction. Composition: *Pinelliae Rhizoma Praeparatum* 15 g, *Citri Reticulatae Pericarpium* 10 g, Poria 15 g, *Glycyrrhizae Radix et Rhizoma Praeparata* cum Melle 5 g, *Zingiberis Rhizoma Recens* 10 g, P*erillae Fructus* 15 g, *Descurainiae Semen Lepidii Semen* 10 g, *Raphani Semen* 15 g.

(2) Qi-deficiency constitution group

Sijunzi Decoction Composition: *Codonopsis Radix* 15 g, Poria 15 g, *Atractylodis Macrocephalae Rhizoma Praeparatum* 15g, *Glycyrrhizae Radix et Rhizoma Praeparata cum Melle* 5 g, *Astragali Radix* 15 g.

(3) Yang-deficiency constitution group

Sini Decoction. Composition: *Aconiti Lateralis Radix Praeparata* 10 g, *Zingiberis Rhizoma* 10 g, *Glycyrrhizae Radix et Rhizoma Praeparata cum Melle* 5 g, *Epimedii Herba* 15 g, *Morindae Officinalis Radix* 15 g.

(4) Dampness-heat constitution group

Gegen Qinlian Decoction Composition: Puerariae Lobatae Radix 15 g, *Scutellariae Radix* 10 g, *Coptidis Rhizoma* 10 g, *Glycyrrhizae Radix et Rhizoma Praeparata cum Melle* 5 g, Houttuyniae Herba 15 g, Mori Cortex 15 g.

(5) Blood-stasis constitution group

Taohong Siwu Decoction. Composition: *Persicae Semen* 10 g, *Carthami Flos* 10 g, *Rehmanniae Radix*

Praeparata 15 g, *Paeoniae Radix Rubra* 10 g, *Angelicae Sinensis Radix* 10 g, *Chuanxiong Rhizoma* 10 g.

The above TCM herbs were provided by Sichuan Provincial Chinese Herbal Pieces Co., Ltd. as decoction pieces. Administration: One dose daily, decocted in water and taken warm 30 minutes after meals. The treatment course lasted for 8 weeks, with a follow-up period of 6 months after treatment completion.

2.7. Observation indices

2.7.1. TCM syndrome score

A TCM syndrome scoring scale was formulated according to the Criteria for Diagnosis and Therapeutic Effects of Diseases and Syndromes in Traditional Chinese Medicine [10]. Symptoms were graded based on severity into four levels: none, mild, moderate, and severe, corresponding to scores of 0, 1, 2, and 3 points respectively. Four primary symptoms were scored: cough, expectoration (sputum production), wheezing, and shortness of breath. Changes in the TCM syndrome scores of patients in both groups before and after treatment were observed.

2.7.2. Pulmonary function testing

Pulmonary function testing was performed on patients by specialized respiratory medicine staff. Changes in the following parameters before and after treatment in both groups were observed: Forced Expiratory Volume in one second (FEV1), Forced Vital Capacity (FVC), and the FEV1/FVC ratio.

2.7.3. Exercise tolerance measurement

The 6-minute walk test (6MWT) was used to measure patients' exercise tolerance. Tests were conducted by specialized respiratory medicine staff. Changes in the 6MWT distance for patients in both groups before and after treatment were observed [11].

2.7.4. Inflammatory factor detection

Fasting venous blood samples were collected from patients' antecubital veins in the early morning. Changes in the levels of inflammatory factors, including Interleukin-6 (IL-6) and high-sensitivity C-reactive protein (hs-CRP), were observed in both groups before and after treatment. Testing was performed by our hospital's central laboratory: IL-6 was measured using Enzyme-Linked Immunosorbent Assay (ELISA), and hs-CRP was measured using immunoturbidimetry.

2.7.5. Dyspnea severity assessment

The COPD Assessment Test (CAT) score was used to assess the severity of patients' dyspnea. A higher score indicates more severe dyspnea. Changes in the CAT scores of patients in both groups before and after treatment were observed [12].

2.7.6. Incidence of exacerbation/relapse

Patients were followed up for 6 months. Cases meeting the diagnostic criteria for an acute exacerbation period were defined as relapses. The acute exacerbation rates were compared between the two groups.

2.7.7. Safety evaluation

Adverse events occurring during treatment in both groups were recorded. Changes in safety indices such as

blood routine tests, liver function, and kidney function were observed. The safety of both treatment regimens was evaluated.

2.8. Statistical methods

Statistical analysis was performed using SPSS software (version 26.0). Continuous variables that were normally distributed are presented as mean ± standard deviation (SD). Comparisons within groups before and after treatment were analyzed using the paired *t*-test. Comparisons between groups were analyzed using the independent samples *t*-test. Continuous variables that deviated from a normal distribution are presented as median and interquartile range [M (P25, P75)]. These were analyzed using non-parametric tests (Mann-Whitney U test for between-group comparisons; Wilcoxon signed-rank test for within-group comparisons). Categorical data are presented as frequencies or percentages and were compared between groups using the Chi-square (χ^2) test. All tests were two-tailed. A p-value < 0.05 was considered statistically significant.

3. Results

3.1. Comparison of baseline characteristics between the two groups

The treatment group comprised 150 patients: 80 males and 70 females; age range 51–80 years, mean age 66.12 ± 7.02 years; mean disease duration 11.15 ± 3.05 years; GOLD (Global Initiative for Chronic Obstructive Lung Disease) pulmonary function grades: Grade II: 66 cases, Grade III: 84 cases. The control group comprised 150 patients: 89 males and 61 females; age range 50–79 years, mean age 66.05 ± 5.97 years; mean disease duration 10.36 ± 3.21 years; pulmonary function grades: Grade II: 80 cases, Grade III: 70 cases. Comparisons of baseline characteristics, including gender, age, disease duration, and pulmonary function grade, between the two groups showed no statistically significant differences ($p > 0.05$), indicating comparability.

3.2. Comparison of TCM syndrome scores between the two groups before and after treatment

The results presented show that before treatment, there were no statistically significant differences ($p > 0.05$) in the TCM syndrome scores for cough, expectoration (sputum production), wheezing, and shortness of breath between the two groups.

After treatment, both groups showed significant improvements ($p < 0.05$) in the TCM syndrome scores for cough, expectoration, wheezing, and shortness of breath compared to their respective pre-treatment scores. Furthermore, the magnitude of improvement in each TCM syndrome score was significantly greater in the treatment group compared to the control group, with all differences being statistically significant ($p < 0.05$ or $p < 0.01$).

3.3. Comparison of pulmonary function indices between the two groups before and after treatment

The results presented show that before treatment, there were no statistically significant differences ($p > 0.05$) in pulmonary function indices, including FEV1, FVC, and FEV1/FVC, between the two groups.

After treatment, both groups showed significant improvements ($p < 0.05$) in FEV1, FVC, and FEV1/FVC compared to their respective pre-treatment values. Furthermore, the magnitude of improvement in FEV1 was

significantly greater in the treatment group compared to the control group, with a statistically significant difference ($p < 0.05$). However, there were no statistically significant differences between the two groups in the improvement of FVC or FEV1/FVC ($p > 0.05$).

3.4. Comparison of inflammatory markers between the two groups before and after treatment

The results presented show that before treatment, there were no statistically significant differences ($p > 0.05$) in serum levels of high-sensitivity C-reactive protein (hs-CRP) or interleukin-6 (IL-6) between the two groups.

After treatment, serum levels of hs-CRP and IL-6 decreased significantly compared to pre-treatment levels in both groups ($p < 0.05$). Furthermore, the magnitude of reduction (decrease) in serum hs-CRP and IL-6 levels was significantly greater in the treatment group than in the control group, and these differences were statistically significant ($p < 0.01$).

3.5. Comparison of 6MWT distance and CAT scores between the two groups before and after treatment

The results presented show that before treatment, there were no statistically significant differences ($p > 0.05$) in the 6-minute walk test (6MWT) distance or COPD Assessment Test (CAT) scores between the two groups. After treatment, both groups showed significant improvements ($p < 0.05$) in 6MWT distance and CAT scores compared to their respective pre-treatment values. Furthermore, the magnitude of improvement in both 6MWT distance and CAT scores was significantly greater in the treatment group than in the control group, and these differences were statistically significant ($p < 0.05$ or $p < 0.01$).

3.6. Comparison of acute exacerbation incidence between the two groups

The results presented show that all patients completed the 6-month follow-up period. In the control group: There were 62 episodes of acute exacerbation (occurring in 41 patients), resulting in an acute exacerbation incidence rate of 41.3%. Among these exacerbations:18 episodes were mild acute exacerbations that occurred during the treatment period and were resolved with outpatient management. The remaining 44 episodes occurred during the follow-up period. In the treatment group: There were 13 episodes of acute exacerbation (occurring in 13 patients), resulting in an acute exacerbation incidence rate of 8.7%. All exacerbations occurred during the follow-up period. Comparison between groups revealed that the acute exacerbation incidence rate was significantly lower in the treatment group than in the control group, with a statistically significant difference ($p < 0.05$).

3.7. Safety evaluation

During the treatment period, no significant adverse events occurred in either group. Furthermore, safety parameters, including complete blood count (CBC), liver function, and kidney function, remained within normal ranges for all patients.

4. Discussion

Clinically, COPD progresses through distinct phases: the acute exacerbation period, the high-risk window period for exacerbation, and the stable period [13]. The high-risk window period refers to the interval following the

resolution of an acute exacerbation but before achieving stable disease. During this phase, the patient's condition is highly unstable, with a substantial likelihood of recurrent acute exacerbations, which consequently increases hospitalization rates and mortality [14]. While conventional Western medical therapy has not demonstrated a significant ability to halt the progression of COPD in patients, Traditional Chinese Medicine (TCM), guided by its Holistic Concept and the theory of Syndrome Differentiation and Treatment, offers a complementary approach. TCM intervention not only alleviates clinical symptoms and improves quality of life in the short term but also, in the long term, reduces the frequency of acute exacerbations and ameliorates pulmonary structural damage. Thereby, it prevents further disease progression, embodying the fundamental TCM principle of preventing disease before it occurs, preventing deterioration in existing disease, and preventing relapse after recovery.

Funding

Longquan Yi District Health Bureau Project (Project No.: WJKY2023009)

Disclosure statement

The authors declare no conflict of interest.

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Journal of Clinical and Nursing Research, 2026, Volume 10, Issue 1
http://ojs.bbwpublisher.com/index.php/JCNR
Online ISSN: 2208-3693
Print ISSN: 2208-3685

Composite Deep-Learning Model for 90-Day mRS Prediction in Post-Stroke Patients

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Abstract: To counteract small sample size, severe class imbalance and high feature redundancy in 90-day mRS prediction after stroke, this study proposes a four-stage pipeline— "ADASYN re-sampling → clinical + statistical feature screening → dimensionality reduction → 5-fold cross-validation" —and benchmark composite deep-learning architectures. ADASYN first balances the minority classes in the original feature space. Next, a tri-level filter (clinical domain knowledge, variance threshold, mutual information) removes clinically meaningless or redundant variables, after which PCA compresses the remaining features while preserving critical neurological signatures (e.g., brain-herniation history). Four hybrid CNN–RNN models are trained and compared under strict 5-fold cross-validation; the optimal ensemble yields stable, clinically interpretable probabilities that can support individualized rehabilitation planning.

Keywords: Stroke; 90-day mRS; Composite deep learning; ADASYN; 5-fold cross-validation

Online publication: Feb 11, 2026

1. Introduction

Spontaneous intracerebral hemorrhage (ICH), a non-traumatic rupture of intraparenchymal vessels, accounts for 10–15% of all stroke admissions. Its abrupt onset, rapid progression and poor prognosis produce an acute-phase case-fatality rate of 45–50%, and roughly 80% of survivors suffer permanent neurological disability, imposing heavy medical and socio-economic burdens [1]. The 90-day modified Rankin Scale (mRS), an ordinal outcome ranging from 0 (no symptoms) to 6 (death), is the standard metric for post-stroke functional independence and rehabilitation potential. Accurate pre-discharge prediction of this score can guide early, individualized neuro-rehabilitation programs and rational allocation of intensive-care resources, ultimately reducing long-term disability [2].

Nevertheless, data-driven prediction of 90-day mRS in ICH patients faces three practical obstacles:

(1) Small sample size

High-quality datasets must integrate personal history, vascular risk factors, treatment protocols and serial neuro-imaging, all of which are costly to collect.

(2) Class imbalance

Favorable outcomes (mRS 0–2) predominate, whereas severe disability (mRS 5) and death (mRS 6) are rare, biasing classifiers toward the majority.

(3) High-dimensional redundancy

Predictive variables span demographic covariates, laboratory values, and hundreds of radiomic descriptors (volume, location, shape, texture) that often contain mutual information.

Recent advances in medical artificial intelligence have introduced machine-learning (ML) and deep-learning (DL) solutions. Machine learning can effectively handle non-linear relationships and interactions between complex features, while also being adaptable to high-dimensional and large-scale datasets [3]. Some researchers have combined modern medical diagnosis with TCM syndrome elements as predictive variables to identify key factors influencing the risk of stroke, thereby improving the accuracy of predictive models [4,5]. Cetinoglu et al. developed a convolutional neural network-based deep learning model for vascular classification and stroke detection [6]. Liu T et al. established a hybrid machine learning model based on deep neural networks to predict the onset of stroke, targeting imbalanced stroke datasets [7]. Zhu et al. employed random-forest regression, gradient-boosting machines and multilayer perceptrons to quantify ICH prognosis [8]. Mao and colleagues reviewed DL-based hemorrhage segmentation and detection, highlighting bottlenecks and remedies [9]. Wang et al. demonstrated that ML models outperform traditional regression on RMSE and MAE when both clinical and imaging features are leveraged [10]. Meng focused on ischemic stroke, offering cross-aisle insights for cerebrovascular diseases [11]. Leveraging outstanding temporal-dependency modeling, deep-learning-centered AI has become the mainstream tool for the re-analysis of medical sequential data [12]. The triad of SCLSTM, Sim-LSTM and CELSTM proposed by Liu Boda sequentially tackles auxiliary diagnosis, intervention recommendation and recovery prediction of post-stroke depression; experiments show diagnosis accuracy reaches 0.737, intervention recommendation 0.895, and recovery-prediction error drops to 4.770, surpassing existing benchmarks across the board [13]. Li Chenhao et al. presented a deep-learning fusion scheme to boost abnormal gait-recognition accuracy [14]. Zhang Yuyu et al. introduced an adaptive deep extreme learning machine that significantly raises minority-class classification accuracy [15].

Despite these efforts, the literature rarely explores composite DL, an ensemble of two or more deep architectures in ICH outcome prediction. Because ICH prognosis is simultaneously shaped by baseline clinical traits, spatial imaging patterns (hematoma shape, oedema location) and temporal dynamics (hematoma expansion, oedema progression), a single network may fail to capture all interactions. Composite models can merge complementary representational strengths, improving both discrimination and calibration.

Accordingly, this study applies composite DL to predict simplified 90-day mRS scores in 97 consecutive ICH patients. The original seven-level mRS was collapsed into four ordered categories to mitigate extreme imbalance. This study has designed a full-cycle pipeline, re-sampling, feature filtering, PCA denoising and 5-fold cross-validation, and compared four CNN–RNN hybrids that respectively specialize in spatial (CNN) and longitudinal (LSTM/GRU) modelling. The most stable ensemble was offered as a ready-to-use tool for precision neuro-rehabilitation.

2. Data processing

The dataset comprises complete clinical and imaging records of 97 stroke patients, totaling 210 variables. Clinical descriptors cover baseline demographics and medical history (age, sex, hypertension, diabetes, atrial fibrillation,

previous stroke, coronary artery disease, smoking, alcohol intake, pre-ICH mRS, systolic/diastolic blood pressure, onset-to-first-imaging time, etc.). Imaging descriptors quantify the hematoma and peri-lesional tissue (total hematoma/oedema volume, region-of-interest proportions, 3-D shape indices, grey-level distribution metrics, brain-structure ratios, etc.). The target is the 90-day mRS score (0–6). To accommodate the limited sample size and skewed class frequencies, the original seven-level mRS was collapsed into four ordered categories following established prognostic conventions: Category 0: mRS 0–1 (no or minimal disability), Category 1: mRS 2–3 (moderate disability), Category 2: mRS 4–5 (severe disability), Category 3: mRS 6 (death).

A rigorous preprocessing pipeline was then applied. Missing values were imputed with domain-appropriate statistics (median for continuous, mode for categorical). All numeric features were Z-score standardized to remove scale differences. The cohort was split into training and validation sets using clinically accepted ratios.

To counteract the scarcity of category 3 (mRS = 6) cases, Adaptive Synthetic Sampling (ADASYN) was performed in the original 210-dimensional feature space with k = 5 nearest neighbors, generating 21 synthetic minority samples and expanding the training set to 89 cases while preserving local manifold structure.

Next, a two-tier feature-selection strategy was executed:

(1) Clinical filter

15 core variables (e.g., age, GCS, total hematoma + oedema volume, onset-to-imaging time, systolic BP, hypertension history) were retained on the basis of published prognostic evidence.

(2) Data-driven filter

Imaging features with variance < 0.1 were discarded; mutual information (MI) with the collapsed mRS label was computed for the remainder, and features with MI > 0.05 were kept. The procedure reduced the dimensionality from 210 to 82 informative variables.

Finally, principal-component analysis was applied to the 82 selected features. The first 16 components, explaining ≥ 85% cumulative variance, were retained as the modelling input. This last compression step mitigates the curse of dimensionality while conserving the dominant data variance, providing a compact, denoised representation for the subsequent composite deep-learning training.

To fully align with the multi-dimensional nature of ICH-outcome prediction, structured clinical descriptors, spatially correlated imaging biomarkers, and longitudinal evolution across serial scans. This study designed four composite deep-learning architectures that share a two-branch strategy but differ in their algorithmic backbone.

Branch-1 is dedicated to static information: demographic variables and summarized imaging metrics (e.g., total volumes, shape indices) are vectorized and processed by a module chosen for tabular/spatial data (CNN or Transformer).

Branch-2 targets temporal dynamics: time-series of hematoma/oedema volumes, ventricular ratios, etc., acquired at ≤ 4 time-points, are fed to a sequence-specialized unit (LSTM, GRU or Transformer encoder).

The latent representations produced by the two branches (128-D each) were concatenated, yielding a 256-D fused embedding that is batch-normalized, dropout-regularized ($p = 0.3$) and fed to a dense classification head with Soft-max to output probabilities for the four collapsed mRS classes (0–3).

Table 1 summarizes the algorithmic assignment of every composite model; all share the same fusion logic but exploit different inductive biases to maximize information extraction from each data modality.

Table 1. Composite-model architectures

Model name	Sub-model A (role)	Sub-model B (role)
CNN + LSTM	CNN (2Conv + MaxPool, Local Features)	LSTM (units = 32, sequential dependencies)
CNN + GRU	CNN (2Conv + MaxPool, Local Features)	GRU (units = 32, light-weight temporal modelling)
LSTM + Transformer	LSTM (units = 32，base-level sequential patterns)	Transformer (4-head self-attention)
CNN + Transformer	CNN (2Conv + MaxPool, Local Features)	Transformer (4-head self-attention)

Training and validation hyper-parameters were tuned specifically for the 4-class imbalance setting:

(1) Training

The model was optimized using the Adam optimizer with a learning rate of 0.001. Categorical cross-entropy was used as the loss function. Training was performed with a batch size of 8 for a maximum of 50 epochs, with early stopping applied (patience = 10).

(2) Validation

Model selection was carried out using 5-fold stratified cross-validation within the training set, yielding approximately 54–55 training samples and 13–14 validation samples per fold. Final generalization performance was assessed on an independent hold-out test set.

(3) Evaluation metrics

Performance was evaluated using accuracy, macro-averaged F1 score, and recall for class 3 (mRS = 6). The latter was prioritized due to its clinical importance and substantial under-representation in the dataset.

3. Results

After selection the feature space shrank from 210 → 82 (60.95% redundancy removed); PCA retained 85% variance with only 16 components, raising the first-component contribution from 15.93% to 22.67%.

3.1. Model comparison

Internal CV shows CNN-LSTM is the most stable; details are given in **Table 2**.

Table 2. Performance comparison of all models

Model name	Mean accuracy (%)	Accuracy SD (%)	Mean macro-F1 (%)
CNN + LSTM	70.36	2.85	67.82
CNN + GRU	67.14	3.52	64.05
LSTM + Transformer	62.50	4.17	59.38
CNN + Transformer	65.71	3.83	62.16

3.2. Generalization comparison

To benchmark the robustness and generalization boundary of each composite architecture, this study has conducted a lateral evaluation on the fully independent test set; results are consolidated in **Table 3**.

Table 3. Performance on the independent test set

Model name	Accuracy	Macro-F1	Class-3 recall	Class-3 precision
CNN + LSTM	65.52	71.36	83.33	75.00
CNN + GRU	62.07	67.54	75.00	70.00
LSTM + Transformer	55.17	60.28	66.67	62.50
CNN + Transformer	58.62	63.81	70.00	65.00

CNN-LSTM achieved the best overall metrics:

Class 0 accuracy 72.22%, Class 1 accuracy 73.68%, with zero cross-class misclassification, confirming stable discrimination of mild disability.

Class 2 mis-classification rate 22.22%, predominantly drifting to Class 1, indicating residual confusion for moderate outcomes.

Class 3 (extreme disability) recall reached 83.33% and precision 75%, eliminating the chronic under-detection reported by earlier models and demonstrating the perceptual gain of CNN-LSTM on extreme cases.

4. Discussion

4.1. Value of the proposed pipeline

By inserting re-sampling before any dimensionality reduction, this study synthesize minority samples in the original high-dimensional feature space, preserving critical clinical signatures (e.g., brain-herniation history) that would otherwise be blurred by early compression.

Feature de-noising further removes imaging-derived variables devoid of clinical meaning (e.g., duplicate pixel counts), purifying the input pool and simultaneously increasing both information density and interpretability of the subsequent PCA components.

Closed-loop cross-validation keeps the entire hyper-parameter search and performance estimation inside the training folds, cutting off “random-fit” noise; the CNN-LSTM ensemble consequently exhibits a 2.85% accuracy SD, corroborating its stability and reproducibility.

4.2. Performance analysis

The superiority of CNN+LSTM stems from the synergy between “local-pattern extraction” and “sequential dependency modelling”: CNN detects local interactions among features (e.g., joint effect of hematoma volume and age), while LSTM captures latent temporal evolution of the selected principal components (e.g., imaging indices tracking clinical deterioration). Transformer-based variants, limited to only six time-steps, fail to exploit the full power of self-attention.

4.3. Limitations & future work

The restricted sample size caps absolute accuracy. Enlarging the cohort or incorporating richer intra-hospital time-series (vital-sign streams) is expected to boost generalizability.

5. Conclusion

The proposed pipeline—ADASYN re-sampling → dual-criteria feature selection → PCA → stratified cross-validation, addresses both small-sample and class-imbalance challenges in post-stroke mRS prediction. The CNN + LSTM ensemble achieves 65.52% accuracy and 71.36% Macro-F1 on 97 patients, with an 83.33% recall for the most critical category, offering a practical aid for clinical rehabilitation assessment.

Funding

Shanghai University of Engineering Science Undergraduate Innovation Training Program (Project No.: cx2521005)

Disclosure statement

The authors declare no conflict of interest.

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Journal of Clinical and Nursing Research, 2026, Volume 10, Issue 1
http://ojs.bbwpublisher.com/index.php/JCNR
Online ISSN: 2208-3693
Print ISSN: 2208-3685

Evaluation of the Application Effect of Intelligent Empowerment Standardized Airway Management Process in Patients Receiving Mechanical Ventilation

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Abstract: *Objective*: To investigate the application effect of intelligent empowerment standardized airway management process in patients receiving mechanical ventilation. *Methods*: A retrospective analysis was conducted on the clinical data of 79 EICU inpatients who underwent tracheal intubation and mechanical ventilation treatment at our hospital from January 2023 to May 2025. The patients were divided into a control group (conventional airway management process, n = 40) and a study group (intelligent empowerment standardized airway management process, n = 39) based on the intervention protocols they received. Oral health scores, dental plaque index, oral odor, serum inflammatory markers [C-reactive protein (CRP), procalcitonin (PCT)], clinical pulmonary infection score (CPIS), as well as the incidence of ventilator-associated pneumonia (VAP), duration of mechanical ventilation, and length of stay in the EICU were assessed before and after treatment. *Results:* The baseline values of all indicators were consistent between the two groups before intervention ($p > 0.05$). After corresponding interventions, both groups showed significant improvements in Beck oral health scores, dental plaque index, and oral odor, with more pronounced improvements observed in the study group ($p < 0.05$). After the intervention, the research group showed a significant decrease in serum CRP and PCT levels, as well as CPIS scores ($p < 0.05$). In contrast, the control group experienced an increase in these three indicators to a certain extent ($p < 0.05$). Moreover, the incidence of ventilator-associated pneumonia (VAP), duration of mechanical ventilation, and length of stay in the EICU were all lower in the research group compared to the control group, while the nurse's compliance rate with the protocol was higher in the research group ($p < 0.05$). *Conclusion:* The standardized airway management protocol empowered by intelligent technology can significantly improve nursing compliance, benefit oral health status, reduce the risk of pulmonary infection and systemic inflammation levels, and promote rapid patient recovery, demonstrating considerable potential for widespread adoption.

Keywords: Intelligent management; Airway management; Mechanical ventilation; Protocol compliance

Online publication: Feb 11, 2026

1. Introduction

While mechanical ventilation provides critical life support for critically ill patients in the Emergency Intensive Care Unit (EICU), the tracheal intubation procedure can disrupt the normal anatomical and physiological barriers of the upper respiratory tract. Given the often-compromised immune function in these patients, this disruption facilitates the translocation of oral pathogens, thereby increasing the risk of ventilator-associated pneumonia (VAP). VAP not only significantly affects patient prognosis but also prolongs the duration of mechanical ventilation and EICU stay, imposing an additional burden on healthcare resources [1]. Currently, bundled care protocols for VAP prevention have been proposed clinically, often encompassing evidence-based interventions such as standardized oral care and positioning management. However, compliance with standard care protocols remains a persistent issue in clinical practice, particularly in the high-pressure environment of the EICU, where incomplete or inconsistent implementation of nursing measures can compromise the effectiveness of VAP prevention [2]. In view of this, this study examined the clinical data of 79 patients admitted to the EICU of XXX Hospital who underwent tracheal intubation and mechanical ventilation from January 2023 to May 2025. The aim is to deeply integrate information technology with medical resources and explore the application effects of a standardized airway management process empowered by intelligent technology in patients undergoing mechanical ventilation. The findings are reported as follows.

2. Data and methods

2.1. General data

A retrospective analysis was conducted on the clinical data of 79 EICU inpatients who underwent tracheal intubation and mechanical ventilation from January 2023 to May 2025. Based on the intervention protocols received, patients were divided into a control group (conventional airway management process, n = 40) and a study group (standardized airway management process empowered by intelligent technology, n = 39). A comparison of the general data between the two groups was presented in **Table 1**, demonstrating comparability. This study complied with the Declaration of Helsinki and received informed consent exemption.

Table 1. Comparison of baseline demographic and clinical characteristics between the two groups [$\overline{x}$ ± s, n]

Group	Number of cases (n)	Age (years)	Gender (M/F, n)	BMI (kg/m^2)	APACHE II score
Control group	40	60.15 ± 10.02	23 / 17	23.44 ± 2.15	18.55 ± 3.41
Research group	39	61.24 ± 9.67	25 / 14	23.19 ± 2.08	18.98 ± 3.17
Test statistic (χ^2/t)	-	-0.492	0.361	0.525	-0.580
p-value	-	0.624	0.548	0.601	0.564

2.2. Inclusion criteria

(1) Patients receiving mechanical ventilation for the first time via oral or nasal tracheal intubation;
(2) Aged 18 years or older;
(3) Expected mechanical ventilation duration exceeding 48 hours;
(4) Complete baseline data.

2.3. Exclusion criteria

(1) Patients with a hospital stay in the EICU of less than 48 hours due to rapid deterioration or transfer;
(2) Patients diagnosed with or highly suspected of having pneumonia within 48 hours of admission or the initiation of mechanical ventilation;
(3) Pregnant or lactating women;
(4) Patients with severe infections or diseases in other organs;
(5) Patients with severe immunodeficiency, such as AIDS or neutropenia following chemotherapy;
(6) Patients with severe craniofacial trauma, oral and maxillofacial deformities, or a recent surgical history, presenting contraindications for oral care procedures;
(7) Patients with a history of severe chronic pulmonary diseases, such as chronic obstructive pulmonary disease or bronchiectasis.

2.4. Methods

The control group received routine standardized airway management. Nurses trained in airway management theory performed the interventions, relying on individual awareness and empirical judgment for practical operations. Information such as body position, cuff pressure measurements, and oral care timing was manually recorded.

The study group received smart technology-enabled interventions in addition to the control group's routine care.

(1) Smart-enabled visual management

A large electronic bulletin board was installed at the nursing station, connected in real-time to the hospital's HIS system. Given the multitasking nature of EICU care, the right side of the board featured a dynamic "bulletin" section and task reminder area, transforming implicit airway management orders (such as cuff pressure measurement, subglottic suctioning, and oral care) into intuitive task lists with numerical sequences (1, 2, 3...). The system automatically sorted tasks based on order times, ensuring nurses had up-to-date information on pending nursing tasks. Additionally, a small whiteboard was placed beside each bed as an extension of the electronic system, used to record personalized handover priorities, such as specific information like "thick sputum requiring enhanced humidification".

(2) Inspection and evaluation closed loop

Based on the standardized system template, print the dedicated "Oral Care Management Implementation Form for Patients with Artificial Airways" and hang it at the foot of the bed. This form integrates the core elements of the modified Beck Oral Assessment Scale, mandating that nurses must first conduct real-time observations of the patient's oral cavity and manually check and score it before performing the prescribed frequency of operations at 08:00, 16:00, 22:00, etc. After completing the operation, they should check the corresponding time slot and sign.

(3) Standardized intervention process

Complete the initial assessment within 6 hours of the patient's mechanical ventilation, and then assess every 8 hours using the Beck Oral Assessment Scale. Elevate the head of the bed to more than 30° provided there are no contraindications. Use a cuff pressure gauge to maintain the tracheal tube cuff pressure between 25–30 cmH_2O, measuring and adjusting it every 6 hours. Perform oral care every 8 hours using an irrigation-type oral suction tube, and perform subglottic secretion suctioning before and after the procedure.

(4) Medical-nursing collaboration and dynamic quality control

Establish a data-driven feedback decision-making mechanism. The department appoints a quality control team leader who regularly reviews the "Implementation Form" at the foot of the bed daily to calculate the trend of changes in Beck scores. If an increase in score or abnormal recording is detected, the medical-nursing collaboration procedure is initiated immediately. The nurse reports the quantitative data to the attending physician, who dynamically adjusts the intervention plan based on the score, such as "increasing the nursing frequency from q8h to q6h", "adjusting the type of irrigation solution", or "requesting an oral surgery consultation".

2.5. Observation indicators

2.5.1. Oral health indicators

The modified Beck Oral Assessment Scale was used to evaluate oral damage in patients at the time of enrollment and after 7 days of treatment. This evaluation mainly covered five aspects: lips, tongue, teeth, saliva, and gums/mucous membranes, with each aspect scored from 0 to 4 points, for a total possible score of 20 points. A higher score indicated more severe oral damage. The sense measurement method was employed to assess patients' oral malodor, with scores ranging from 0 to 5 points; a higher score indicated more severe oral malodor. The dental plaque index of patients was also evaluated, with scores assigned from 0 to 3 points based on the severity of dental plaque, from low to high; a higher score indicated more severe dental plaque.

2.5.2. Infection and inflammation indicators

Fasting venous blood samples were collected from patients at the time of enrollment and after 7 days of treatment. An automatic biochemical analyzer was used to measure serum levels of C-reactive protein (CRP) and procalcitonin (PCT). Additionally, patients underwent a Clinical Pulmonary Infection Score (CPIS), which primarily included six items such as body temperature, white blood cell count, and airway secretions, with a total possible score of 12 points. A higher score suggested more severe infection.

2.5.3. Clinical outcome indicators and procedural compliance rate

The occurrence of ventilator-associated pneumonia (VAP), duration of mechanical ventilation, and length of stay in the EICU were observed and compared between the two groups of patients. Additionally, the comprehensive compliance rate of nurses with the five core measures of the procedure (positioning, cuff pressure, subglottic suctioning, frequency of oral care, and tool usage) was evaluated. The compliance rate was calculated as follows: Compliance rate = (number of times accurately performed in practice / total number of times required to be performed) × 100%.

2.6. Statistical methods

Data analysis was performed using SPSS 22.0 statistical software. After confirming normal distribution through the Shapiro-Wilk test, measurement data were expressed as mean ± standard deviation ($\overline{x} \pm s$), and comparisons between groups were made using the independent samples *t*-test. Categorical data were expressed as rates (%), and differences between the two groups were compared using the χ^2 test. A *p*-value < 0.05 was considered statistically significant.

3. Results

3.1. Comparison of oral health indicators between the two groups of patients

The baseline Beck oral scores, oral malodor scores, and dental plaque indices were consistent between the two groups before intervention. After corresponding interventions, all three indicators significantly decreased in both groups, with the study group showing lower Beck oral scores, oral malodor scores, and dental plaque indices than the control group ($p < 0.05$). See **Table 2**.

Table 2. Comparison of oral health indicators between the two groups of patients ($\overline{x} \pm$ s, points)

Group	Number of cases (n)	Beck oral assessment scale (BOAS) score		Oral malodor score		Plaque index (PI)	
		Pre-intervention	Post-intervention	Pre-intervention	Post-intervention	Pre-intervention	Post-intervention
Control group	40	11.52 ± 1.60	9.88 ± 1.54*	3.11 ± 0.50	2.65 ± 0.45*	2.12 ± 0.51	1.75 ± 0.43*
Research group	39	11.15 ± 1.93	6.45 ± 1.12*	3.23 ± 0.61	1.14 ± 0.32*	2.19 ± 0.62	0.90 ± 0.26*
t-value	-	0.929	11.297	-0.957	17.149	-0.549	10.599
p-value	-	0.356	$p < 0.001$	0.341	$p < 0.001$	0.585	$p < 0.001$

Note: Compared with before intervention, *$p < 0.05$.

3.2. Comparison of infection and inflammation indicators between the two groups of patients

The baseline levels of infection and inflammation indicators were consistent between the two groups before intervention. After corresponding interventions, the control group showed increased levels of CRP, PCT, and CPIS scores, while the study group showed significant decreases. After intervention, the study group had significantly lower levels of CRP, PCT, and CPIS scores than the control group ($p < 0.05$). See **Table 3**.

Table 3. Comparison of infection and inflammation indicators between the two groups of patients ($\overline{x} \pm$ s)

Group	Number of cases (n)	CRP (mg/L)		PCT (ng/mL)		CPIS (points)	
		Pre-intervention	Post-intervention	Pre-intervention	Post-intervention	Pre-intervention	Post-intervention
Control group	40	74.11 ± 10.29	88.43 ± 12.05*	0.63 ± 0.20	0.89 ± 0.25*	4.15 ± 1.02	5.01 ± 1.10*
Research group	39	74.88 ± 9.68	45.10 ± 9.81*	0.67 ± 0.17	0.30 ± 0.11*	4.03 ± 0.95	3.12 ± 0.88*
t-value	-	-0.342	17.502	-0.957	13.516	0.541	8.420
p-value	-	0.733	$p < 0.001$	0.342	$p < 0.001$	0.590	$p < 0.001$

Note: Compared with before intervention, *$p < 0.05$.

3.3. Comparison of clinical outcomes and process compliance rates between the two groups of patients

The incidence of VAP, duration of mechanical ventilation, and length of stay in the EICU were significantly lower in the study group compared to the control group, while the process compliance rate was higher in the study group ($p < 0.05$). See **Table 4**.

Table 4. Comparison of clinical outcomes and process compliance rates between the two groups of patients [$\overline{x}$ ± s, n(%)]

Group	Number of cases (n)	VAP incidence	Duration of mechanical ventilation (days)	EICU length of stay (days)	Compliance rate (%)
Control group	40	8 (20.00)	10.22 ± 3.11	13.89 ± 4.05	62.33 ± 5.15
Research group	39	1 (2.56)	7.14 ± 2.02	10.35 ± 3.15	95.12 ± 2.04
Test statistic (χ^2/t)	-	4.345	5.206	4.329	37.026
p-value	-	0.037	< 0.001	< 0.001	< 0.001

4. Discussion

The colonization of oral flora and micro-aspiration in patients undergoing mechanical ventilation are the primary causes of VAP, and meticulous oral care targeting these factors is a crucial aspect of VAP prevention. However, the disconnect between traditional nursing management processes and their execution limits the effectiveness of nursing care [3]. Therefore, this study aimed to overcome the compliance challenges of traditional management by intelligently empowering standardized airway management. The specific intervention effects are as follows.

In the results of this study, the average process compliance rate among nurses in the study group was 95.12 ± 2.04%, significantly higher than the 62.33 ± 5.15% observed in the control group. This suggests that intelligent empowerment significantly improved compliance with airway management processes. The reason for this is that traditional nursing management methods have limitations in terms of timeliness and initiative when defining nursing management procedures. In contrast, the study group adopted an airway management process empowered by information technology, which first triggered nurses' attention to tasks through intuitive and visual bulletin boards, transforming abstract time concepts into intuitive visual stimuli. Furthermore, small whiteboards were placed at the bedside to remind nurses of key handover points, avoiding potential omissions in high-pressure environments and allowing them to focus on the quality of nursing care itself [4]. On the other hand, the application of nursing management implementation forms can compel nursing staff to conduct secondary confirmations during operations, helping them transition from subconscious actions to conscious verifications, thereby effectively overcoming potential oversights in their work [5]. Through the feedback decision-making mechanism of daily inspections of implementation forms by head nurses, nursing interventions can shift from empirical execution to precise decision-making. This ensures nurses' compliance with nursing interventions on one hand and enhances the precision of interventions on the other [6]. After intervention, both groups of patients showed significant improvements in Beck oral health scores, odor scores, and dental plaque indices. The reason for this lies in the fact that standardized procedures ensure the proper implementation of oral care measures. Through mechanical rinsing and negative pressure suction, these measures effectively disrupt the dental plaque biofilm, flush out debris between teeth, and remove dental plaque, improving the oral microenvironment while preventing the accumulation of dislodged plaque and waste fluids in the oropharynx [7]. The improved adherence to procedures directly translates into benefits for patients' oral health, as evidenced by more significant improvements in oral health scores [8]. Additionally, this study observed that in the control group, CPIS, CRP, and PCT levels increased after intervention, whereas in the study group, these levels significantly decreased. The reason for this is that intelligent nursing procedures may improve patients' oral environments, reduce the colonization of pathogenic bacteria in patients' mouths, significantly lower the proportion of bacteria entering the lower respiratory tract,

thereby significantly reducing the risk of VAP and the associated systemic inflammatory response, and avoiding prolonged mechanical ventilation and EICU stays as a result [9]. This is consistent with the viewpoint proposed by Liao Mingyu et al. in their study that the combined detection of indicators such as CPIS, CRP, and PCT can effectively evaluate the risk of VAP occurrence and prognosis [10].

5. Conclusion

In conclusion, the standardized airway management process empowered by intelligence can significantly improve the compliance of EICU nurses in implementing nursing measures. It may be beneficial for improving the oral health status of mechanically ventilated patients, reducing the risk of infection and systemic inflammatory response, and shortening the duration of mechanical ventilation and EICU hospitalization. However, this study still has certain limitations. As a retrospective study, there may be unobserved selection bias, and since it is a single-center study, the extrapolation of its intervention effects may be limited. In the future, multi-center, prospective randomized controlled trials are needed to enhance the credibility of the research results.

Disclosure statement

The author declares no conflict of interest.

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Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Journal of Clinical and Nursing Research, 2026, Volume 10, Issue 1
http://ojs.bbwpublisher.com/index.php/JCNR
Online ISSN: 2208-3693
Print ISSN: 2208-3685

Examining the Impact of Heparin-Free Dialysis Supplemented with Infrared Lamp Irradiation on Coagulation in Dialyzers

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Abstract: *Objective*: To investigate the effects of infrared lamp irradiation therapy on the risk of arteriovenous fistula thrombosis in patients undergoing heparin-free dialysis and those receiving appropriate reductions in heparin anticoagulation dosage during dialysis. *Methods*: This study was conducted from January 1, 2021, to December 31, 2021, involving 19 patients who regularly underwent heparin-free dialysis for more than three months at our hospital, totaling 70 patient encounters. Each patient underwent heparin-free dialysis for more than two cycles during the experimental period. The study employed a self-control design. Prior to the experiment, an experienced medical team established an emergency management group and formulated relevant emergency measures, ensuring the long-term stability of patients' vital signs before enrollment. Patients requiring heparin-free dialysis as per medical advice underwent the procedure according to the treatment manual without additional interventions. During the second heparin-free dialysis session within the experimental period, patients received 40 minutes of infrared lamp irradiation as an adjunctive therapy during the dialysis process. The study observed coagulation in the dialyzer, blood biochemical indicators, the occurrence of adverse reactions, and patient satisfaction during treatment. *Results:* The use of heparin-free dialysis combined with infrared irradiation therapy resulted in better coagulation outcomes compared to heparin-free dialysis alone ($p < 0.05$). There was no statistically significant difference in blood biochemical indicators between patients receiving heparin-free dialysis combined with infrared irradiation therapy and those receiving heparin-free dialysis alone ($p > 0.05$). There was no statistically significant difference in the number of patients experiencing adverse clinical symptoms such as angina, dizziness, and lower limb cramps, leading to treatment interruption, between those receiving heparin-free dialysis combined with infrared therapy and those receiving heparin-free dialysis alone ($p > 0.05$). Patient satisfaction was higher among those receiving heparin-free dialysis combined with infrared therapy compared to those receiving heparin-free dialysis alone ($p < 0.05$). *Conclusion:* The use of infrared lamp irradiation therapy as an adjunct to heparin-free dialysis can reduce the risk of coagulation to a certain extent without affecting the stability of core blood biochemical indicators in patients. It also reduces the incidence of clinical adverse reactions caused by coagulation, demonstrating good safety and improving patient satisfaction.

Keywords: Heparin-free dialysis; Infrared lamp; Heparin anticoagulation

Online publication: Feb 11, 2026

1. Introduction

Heparin is the most commonly used anticoagulant in extracorporeal circulation for blood purification techniques. However, with the increasing number of uremic patients in recent years, the number of cases with active bleeding has gradually risen, leading to more frequent clinical use of heparin-free dialysis [1]. Heparin-free dialysis primarily reduces the risk of coagulation by increasing blood flow velocity and regularly flushing the circuit with physiological saline. Nevertheless, in practice, it still faces the issue of a high incidence of coagulation in the extracorporeal circulation circuit, especially within the dialyzer. Moderate to severe coagulation not only decreases dialyzer efficiency and leads to inadequate treatment but may also cause blood loss, increase medical costs, and even endanger patient safety due to frequent circuit replacements or premature treatment termination [2]. Far-infrared rays are a type of electromagnetic wave with a wavelength range of 3–1000 μm, possessing penetrability and thermal effects [3]. Studies have shown that irradiation with far-infrared rays of specific wavelengths in the field of cardiovascular medicine exhibits multiple biological effects, such as improving vascular endothelial function, promoting microcirculation, inhibiting platelet aggregation, and reducing inflammatory responses [4]. However, there are few reports both domestically and internationally on the use of far-infrared irradiation as an adjunctive physical anticoagulant method in heparin-free dialysis, directly applied to the extracorporeal circulation circuit and the patient's limbs to reduce coagulation within the circuit. At our hospital's hemodialysis center, under the premise of stable patient conditions, we conducted a study comparing heparin-free dialysis with and without adjunctive infrared therapy. The results indicated that adjunctive infrared lamp irradiation therapy could, to a certain extent, reduce the risk of coagulation and the incidence of clinical adverse reactions caused by coagulation. The report is as follows.

2. Materials and methods

2.1. General information

The study subjects were 19 patients who underwent regular dialysis at our hospital for more than three months from January 1, 2021, to December 31, 2021, and required heparin-free dialysis.

2.1.1. Inclusion criteria

(1) Presence of active bleeding symptoms or high risk of bleeding;
(2) No use of any procoagulant medications in the recent period;
(3) No interventions that may promote coagulation, such as blood transfusions or intravenous infusions, during hemodialysis procedures;
(4) Excellent vascular access status, with blood flow rates through autogenous arteriovenous fistulas or central venous catheters stably reaching 240 mL/min.

2.1.2. Exclusion criteria

(1) Age under 18 years old;
(2) Individuals unable to complete the entire treatment regimen;
(3) Presence of broken skin, ulcers, or photosensitive lesions at the irradiation site;
(4) Platelet count exceeding the upper limit or falling below the lower limit of the normal reference range;
(5) Patients with diabetic nephropathy and multiple organ failure;

(6) Patients with insufficient blood flow velocity to meet the basic requirements for hemodialysis operation.

2.1.3. Study groups

Among the 19 patients, there were 11 males and 8 females; their ages ranged from 22 to 75 years, with an average age of (61.02 ± 14.76) years; the primary diseases included diabetic nephropathy (4 cases), polycystic kidney disease (2 cases), hypertensive nephropathy (6 cases), lupus nephritis (4 cases), and chronic glomerulonephritis (3 cases). Among the 19 patients, there were 2 cases of gastrointestinal bleeding, 12 cases of gingival bleeding, 1 case of skin and mucous membrane bleeding, and 4 cases were in menstruation. All patients underwent heparin-free hemodialysis three times within one week, with the treatment cycle determined according to medical advice. A description of the relevant research conducted on patients who met the inclusion criteria was provided, and both patients and their families were fully informed of the research risks and benefits and signed informed consent forms. This study was approved by the hospital's ethics committee.

2.2. Methods

Before the experiment, an emergency management team was established by experienced medical staff, and relevant emergency measures were formulated in advance to ensure long-term stability of vital signs in patients before enrollment. For patients undergoing heparin-free hemodialysis, no additional treatment was administered during the first cycle of heparin-free hemodialysis as per medical advice; during the second cycle of heparin-free hemodialysis, patients received 40 minutes of infrared lamp irradiation as an adjunctive therapy during dialysis, as per medical advice. During the experiment, close attention was paid to the patients' mental state and whether they exhibited symptoms such as angina, dizziness, and lower limb cramps, with records made accordingly. Biochemical examination indicators were monitored monthly throughout the experimental period, with hemoglobin and platelet data collected for each group of patients. The usage status of arteriovenous fistulas was assessed on a monthly basis.

2.3. Evaluation indicators

(1) Observe and compare the coagulation occurrence in the dialyzer and venous chamber, as well as the completion of dialysis procedures, following the implementation of two different flushing protocols for heparin-free dialysis. The grading criteria for evaluating the degree of coagulation in the dialysis circuit and dialyzer are as follows. Grade A: No obvious signs of coagulation, or only a small amount of fibrous cord-like coagulation is observed, with no other adverse events occurring. Grade B: Local coagulation or bundled coagulation clots are present, accompanied by mild dizziness, with no other adverse events occurring. Grade C: Relatively obvious coagulation or coagulation in more than half of the fibers is observed in the dialyzer, with some patients experiencing symptoms such as angina, dizziness, and lower limb cramps. Grade D: Severe coagulation necessitates the replacement of the dialyzer, accompanied by symptoms such as angina, dizziness, and lower limb cramps.

(2) Observe and compare changes in patients' blood biochemical indicators. Collect 5 mL of peripheral venous blood from patients and send it to the hospital's laboratory for the detection of hemoglobin, blood phosphorus, blood creatinine, and blood potassium levels using an automatic biochemical analyzer.

(3) Observe and compare the occurrence of adverse reactions in patients, including angina, dizziness, and lower limb cramps.

(4) Patient satisfaction was assessed using a self-designed satisfaction questionnaire from our hospital.

2.4. Statistical methods

Data were analyzed using SPSS 23.0 statistical software, with a significance level set at $p < 0.05$.

3. Results

3.1. Comparison of coagulation status

The coagulation status was significantly better in patients treated with heparin-free dialysis combined with infrared irradiation compared to those treated with heparin-free dialysis alone ($p < 0.05$), as shown in **Table 1**.

Table 1. Comparison of coagulation status

	Frequency of coagulation occurrence			Total number of cases	Overall clotting proportion
	Grade	Frequency	Total frequency of coagulation		
No heparin	A	98	16	19	14.0%
	B	11			
	C	5			
	D	0			
No heparin + infrared	A	105	9	19	7.9%
	B	6			
	C	3			
	D	0			

3.2. Comparison of changes in blood biochemical indicators among patients

There was no statistically significant difference in the levels of blood biochemical indicators between patients treated with heparin-free dialysis combined with infrared irradiation and those treated with heparin-free dialysis alone ($p > 0.05$), as shown in **Table 2**.

Table 2. Comparison of changes in blood biochemical indicators among patients

	Heparin-free protocol	Heparin-free + infrared protocol	Within-subject max-min difference
Hemoglobin (g/L)	81–146 g/L	75–155 g/L	-19 to +23
Phosphorus (mmol/L)	1.90–5.61 μmmol/L	1.93–4.64 μmmol/L	-0.51 to +0.55
Pre-dialysis creatinine (μmol/L)	930–2300 μmmol/L	900–2340 μmmol/L	-200 to +240
Potassium (mmol/L)	4.9–6.8 mmol/L	4.7–6.8 mmol/L	-1.2 to +1.3

3.3. Comparison of adverse reactions during dialysis among patients

There was no statistically significant difference in the number of patients experiencing adverse clinical symptoms or treatment interruptions between those treated with heparin-free dialysis combined with infrared irradiation and those treated with heparin-free dialysis alone ($p > 0.05$), as shown in **Table 3**.

Table 3. Comparison of adverse reactions during dialysis among patients

Adverse symptom	Heparin-free protocol (n = 112)	Heparin-free + infrared protocol (n = 114)
Angina Pectoris	0	0
Dizziness/Vertigo	4	4
Lower limb cramps	5	5
Treatment interruption	1	0
Total frequency of adverse symptoms	10	9
Overall incidence of adverse symptoms	8.9%	7.9%

3.4. Comparison of patient satisfaction

Patient satisfaction was significantly higher in those treated with heparin-free dialysis combined with infrared irradiation compared to those treated with heparin-free dialysis alone ($p < 0.05$), as shown in **Table 4**.

Table 4. Comparison of patient satisfaction

Protocol	Total cases (n)	Satisfaction rate
Heparin-free	19	64%
Heparin-free + infrared	19	75%

4. Discussion

Heparin-free dialysis is an important dialysis modality for end-stage renal disease (ESRD) patients with a high risk of bleeding. The coagulation status of patients undergoing heparin-free dialysis poses significant risks to their life and health safety, as well as presenting substantial challenges to healthcare providers in terms of treatment [5]. Heparin-based anticoagulants are commonly used in clinical dialysis; however, for patients with high bleeding risks, such as those with active bleeding, severe coagulation disorders, or recent surgery, the use of heparin drugs significantly increases the risk of bleeding. Therefore, heparin-free dialysis becomes the preferred dialysis method for such patients [6]. Nevertheless, during heparin-free dialysis, the contact between blood and artificial materials such as dialysis circuits and filters can easily activate the endogenous coagulation pathway, leading to platelet adhesion, aggregation, and fibrin deposition, which in turn can cause adverse events such as filter clotting and circuit coagulation. These issues not only affect the adequacy of dialysis but may also increase the patient's need for blood transfusions and medical expenses, and even endanger the patient's life [7]. How to effectively prevent coagulation during heparin-free dialysis while avoiding bleeding risks remains a pressing clinical challenge.

In recent years, the application of physical interventions in vascular protection and coagulation management for hemodialysis patients has garnered attention. Infrared lamp irradiation, as a non-invasive physical therapy method, emits far-infrared rays that can penetrate skin tissue, improve local blood circulation, dilate blood vessels, and inhibit platelet aggregation while regulating the activity of coagulation factors. It has demonstrated certain effects in the maintenance of arteriovenous fistulas and the prevention of thrombosis [8]. Studies have confirmed that infrared lamp irradiation can increase the blood flow of arteriovenous fistulas and reduce the risk of stenosis and thrombosis in fistulas [9]. The results of this study indicate that heparin-free dialysis combined with infrared irradiation is superior to heparin-free dialysis alone in terms of coagulation status ($p < 0.05$). The anticoagulant

mechanism of infrared lamp irradiation may be related to its physical properties: the far-infrared rays emitted by the infrared lamp can penetrate tissues, dilate blood vessels through thermal effects, improve local blood circulation, reduce blood viscosity, and decrease platelet aggregation. Additionally, far-infrared rays can regulate the activity of coagulation factors and inhibit the activation of the coagulation cascade, thereby delaying the coagulation process.

There was no statistically significant difference in biochemical indicator levels between patients undergoing heparin-free dialysis combined with infrared therapy and those undergoing heparin-free dialysis alone ($p > 0.05$). The stability of hemoglobin suggests that the intervention did not affect the patient's hematopoietic function or iron metabolism balance, avoiding the potential risk of worsening anemia and increasing cardiovascular complications due to the intervention. The stable levels of blood phosphorus, serum creatinine, and blood potassium indicate that infrared lamp irradiation did not interfere with the solute diffusion and convection clearance mechanisms during dialysis, nor did it affect the residual renal excretion function. By regulating the activity of coagulation factors and inhibiting platelet aggregation through far-infrared rays, the intervention did not involve pathways related to the hematopoietic system or renal solute transport, and therefore did not have adverse effects on the aforementioned core blood biochemical indicators. There was no statistically significant difference in the occurrence of adverse clinical symptoms and treatment interruption between patients undergoing heparin-free dialysis combined with infrared therapy and those undergoing heparin-free dialysis alone ($p > 0.05$), indicating that infrared irradiation therapy does not affect patient treatment and does not increase the incidence of adverse reactions, demonstrating good safety. Patients who underwent heparin-free dialysis supplemented with infrared therapy reported higher satisfaction levels compared to those who received heparin-free dialysis alone ($p < 0.05$). The reduction in coagulation-related events and adverse reactions directly enhanced the comfort of the dialysis process, alleviating discomfort caused by filter clotting, increased venous pressure, muscle cramps, and other issues, without affecting the adequacy of dialysis, the stability of core blood biochemical indicators, or increasing adverse reactions, thereby improving patient satisfaction. Although the duration of infrared irradiation used as an adjunctive therapy in this study exceeded the amounts reported in current domestic literature [10].

5. Conclusion

In summary, adjunctive treatment with infrared lamp irradiation can, to a certain extent, reduce the risk of coagulation without affecting the stability of patients' core blood biochemical indicators. It also lowers the incidence of clinical adverse reactions caused by coagulation, thereby improving patient satisfaction and demonstrating good safety and clinical value. However, this study has certain limitations: firstly, the sample size is relatively small, and it is a single-center study, which may introduce selection bias and limit the generalizability of the findings. Secondly, the observation period is relatively short, making it impossible to evaluate the long-term effects of infrared lamp irradiation. Additionally, the molecular mechanisms by which infrared lamp irradiation affects coagulation function, such as its impact on coagulation factor gene expression and platelet activation markers, were not thoroughly explored. Therefore, future research should involve multi-center, large-sample, long-term follow-up clinical studies to further validate the effects of infrared lamp irradiation and delve deeper into its mechanisms of action, providing more robust evidence for its clinical application.

Funding

2023 Hospital-Level Scientific Research and New Technology Project Initiation of Wuzhong People's Hospital (Project No.: 2023yjxjs05)

Disclosure statement

The author declares no conflict of interest.

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Publisher's note

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Journal of Clinical and Nursing Research, 2026, Volume 10, Issue 1
http://ojs.bbwpublisher.com/index.php/JCNR
Online ISSN: 2208-3693
Print ISSN: 2208-3685

Research on the Efficacy of Autologous Periosteum Graft Combined with PRP in the Treatment of Long Bone Fractures in the Extremities

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Abstract: *Objective*: To analyze the clinical application value of autologous periosteum graft combined with platelet-rich plasma (PRP) in the treatment of long bone fractures in the extremities. *Methods*: A total of 40 patients with long bone fractures in the extremities admitted to Santai Hospital Affiliated to North Sichuan Medical College from January 2023 to January 2025 were included, including cases of upper extremity forearm fractures and lower extremity femoral and tibial fractures. The patients were evenly divided using a random number table, with the control group undergoing open reduction and internal fixation (ORIF) combined with autologous periosteum graft, and the observation group undergoing ORIF, autologous periosteum graft, and PRP injection. Surgical indicators, complication rates, excellent fracture healing rates, functional satisfaction, and joint range of motion were compared between the two groups. *Results:* The surgical indicators in the observation group were similar to those in the control group ($p > 0.05$). The complication rate in the observation group was lower than that in the control group, while the excellent fracture healing rate and functional satisfaction were higher in the observation group ($p < 0.05$). *Conclusion:* Autologous periosteum graft combined with PRP technology is safe and reliable for the treatment of long bone fractures in the extremities, with satisfactory clinical outcomes.

Keywords: Periosteum graft; Long bones of the extremities; PRP; Complication rate; Fracture healing

Online publication: Feb 11, 2026

1. Introduction

Patients with fractures of the long bones of the extremities are at a higher risk of developing nonunion after surgery. Factors such as complex fractures caused by high-energy violence, infection, and improper internal fixation methods for fractures can all potentially lead to fracture nonunion. The treatment of fracture nonunion is time-consuming and challenging, representing a significant dilemma in current orthopedic trauma care [1,2]. Therefore, to enhance the likelihood of primary fracture healing, this study treated long bone fractures with high-risk factors for nonunion by combining autologous periosteal transplantation with Platelet-Rich Plasma (PRP) on the basis of internal fracture fixation. A retrospective analysis was conducted on cases from our hospital from

January 2023 to January 2025, and the report is presented as follows.

2. Data and methods

2.1. General information

Forty patients with fractures of the long bones of the extremities admitted to Santai Hospital Affiliated to North Sichuan Medical College from January 2023 to January 2025 were selected and evenly divided using a random number table into a control group and an observation group, with 20 patients in each group. In the control group, there were 10 males and 10 females, aged between 20 and 64 years, with an average age of (42.65 ± 4.18) years. In the observation group, there were 11 males and 9 females, aged between 18 and 62 years, with an average age of (42.30 ± 4.29) years. There were no significant differences in the data between the two groups ($p > 0.05$).

2.1.1. Inclusion criteria

(1) Patients with comminuted fractures of the ulna, radius, tibia, or femur who are planned to undergo surgical treatment;
(2) Patients aged between 18 and 65 years;
(3) Patients with complete postoperative follow-up for more than 6 months.

2.1.2. Exclusion criteria

(1) Patients with extremely poor cardiopulmonary function;
(2) Patients unwilling to participate in the study;
(3) Patients with surgical contraindications.

2.2. Methods

2.2.1. Control group

(1) Preparation of PRP

Blood Collection and Anticoagulation: After routine disinfection of the skin, use a blood collection needle along with a dedicated separation tube to collect venous blood up to the 8 mL mark (black indicator). Immediately after blood collection, gently invert the test tube 10–20 times to ensure thorough mixing of the anticoagulant with the blood. If collecting multiple tubes, complete the inversion and mixing simultaneously with the assistance of an assistant, ensuring gentle handling throughout the process to prevent hemolysis. First Centrifugation and Plasma Separation: Place the balanced blood collection tubes symmetrically in the centrifuge and centrifuge at a speed of 3500–4000 rpm for 5–10 minutes. After the machine stops, remove the tubes and let them stand for 3–5 minutes to ensure full precipitation of platelets. Then, use a 10 mL syringe equipped with an elongated needle (≥ 7 cm) to aspirate the supernatant layer by layer from top to bottom, which is the platelet-poor plasma (PPP), until approximately 1–2 mL of serum remains.

(2) Surgical procedure

Taking the tibial intramedullary nailing operation as an example, after achieving the desired anesthetic effect, apply and inflate a pneumatic tourniquet. Position the patient in a supine position and use a parapatellar approach. Make a longitudinal incision along the medial side of the patellar tendon to open the expansion portion of the extensor retinaculum. Use retractors to pull the patellar tendon laterally and protect it with a

protective sleeve. Select the intersection point approximately 3 cm medial to the tibial crest and the anterior margin of the tibial plateau as the needle entry point. Use an awl to create an opening, insert a guidewire, and drill through the cortical bone along the guidewire using a trephine. Expand the medullary canal with a flexible reamer, insert an intramedullary nail of appropriate size and length, lock the distal screws, and use an aiming device to lock the proximal screws. Finally, install the end cap.

(3) Periosteal preparation

Taking the ipsilateral tibia as an example. Make a longitudinal incision centered on the fracture site, exposing the skin and subcutaneous tissue, and create an appropriately sized incision. Bluntly dissect the subcutaneous tissue to reach the medial aspect of the tibia. Given that the periosteum in the anteromedial region of the tibia is relatively thick, while the lateral periosteum is thinner, the anteromedial region is typically chosen for harvesting. Incise the periosteum longitudinally along the tibial crest and the anterolateral margin of the diaphysis, and make a transverse incision at the distal end of the initial incision to form a rectangular periosteal flap. The area of this flap should be 10–15% larger than the bone defect area. Subsequently, use a periosteal elevator to gently elevate the entire layer of periosteum from the distal to the proximal end, keeping it closely adhered to the bone surface. Rotate the vascularized periosteal flap to cover approximately one-half to two-thirds of the fracture circumference, and then suture the periosteum to the adjacent soft tissue with a few stitches using antibacterial Vicryl sutures for fixation.

2.2.2. Observation group

PRP Resuspension and Collection: Shake the remaining serum portion approximately 20–30 times to thoroughly wash off the platelets adhering to the tube walls and separating gel. Finally, invert the tube and use a 3 mL syringe to extract all the liquid from the tube, which is the required platelet-rich plasma (PRP). The surgical procedure and periosteal preparation methods are the same as those in the control group. After suturing the periosteum and adjacent soft tissues, irrigate the wound cavity with normal saline and inject the prepared PRP into the wound cavity, leaving a drainage tube in place.

Within 24 hours after surgery, all patients are routinely administered intravenous cefuroxime sodium (1.5 g, q8h) to prevent infection. Oral analgesics (celecoxib capsules + tramadol hydrochloride sustained-release tablets) are also given. For patients undergoing lower limb surgery, low molecular weight heparin calcium (4000 IU) is routinely administered subcutaneously starting 12 hours after surgery, once daily. The plasma drainage tube is removed on the second day after surgery.

2.3. Observation indicators

(1) Surgical indicators

Observe indicators such as surgical time and intraoperative blood loss.

(2) Complication rate

Observe the probability of complications such as skin infection around the incision, skin necrosis, nonunion, malunion, vascular nerve injury, and ipsilateral intermuscular venous thrombosis.

(3) Excellent and good rate of fracture healing

Patients are followed up in the outpatient clinic 12 months after surgery, and anteroposterior and lateral DR images of the long bone fracture site are taken to assess fracture healing. Excellent indicates no abnormalities such as pain or infection, no malunion, adjacent joint mobility exceeding 90% of the healthy

side, or normal mobility, and normal daily activity ability; good indicates mild pain or mild infection, no malunion, adjacent joint mobility exceeding 70% to 90% of the healthy side, and basically normal daily activity ability; poor indicates severe pain and infection, malunion, adjacent joint mobility less than 70% of the healthy side, and failure to recover daily activity ability.

(4) Functional satisfaction

A self-made functional satisfaction scale was used, covering aspects such as joint range of motion and weight-bearing walking, with a total score of 100 points. Scores exceeding 75 points indicated high satisfaction, scores between 40 and 75 points indicated basic satisfaction, and scores below 40 points indicated dissatisfaction.

2.4. Statistical analysis

Data processing was conducted using SPSS 28.0 statistical software. Count data were expressed as [n/%], and the chi-square (c^2) test was used for analysis. Measurement data were tested for normal distribution using the K-S method and expressed as [$\overline{x} \pm s$]. Comparisons between groups were made using the independent samples t-test, while comparisons within groups were made using the paired *t*-test. A *p*-value less than 0.05 was considered statistically significant.

3. Results

3.1. Comparison of surgical indicators between the two groups

The surgical indicators in the observation group were similar to those in the control group ($p > 0.05$), refer **Table 1**.

Table 1. Comparison of surgical indicators between the two groups [$\overline{x} \pm s$]

Group	Number of cases (n)	Operative time (min)	Intraoperative blood loss (mL)
Observation group	20	108.67 ± 9.74	101.98 ± 7.71
Control group	20	110.81 ± 9.87	103.86 ± 6.98
t-value	-	0.690	0.808
p-value	-	0.494	0.424

3.2. Comparison of complication rates between the two groups

The complication rate in the observation group was lower than that in the control group ($p < 0.05$) (see **Table 2**).

Table 2. Comparison of complication rates between the two groups [n/%]

Group	Number of cases (n)	Incision infection	Skin necrosis	Nonunion	Malunion	Vascular/nerve injury	Ipsilateral intermuscular vein thrombosis	Overall incidence rate
Observation group	20	0	0	0	0	0	1 (5.00)	5.00 (1/20)
Control group	20	1 (5.00)	1 (5.00)	1 (5.00)	0	1 (5.00)	2 (10.00)	30.00 (6/20)
χ^2-value	-	-	-	-	-	-	-	4.329
p-value	-	-	-	-	-	-	-	0.038

3.3. Comparison of excellent and good fracture healing rates between the two groups

The excellent and good fracture healing rate in the observation group was higher than that in the control group ($p < 0.05$), refer **Table 3**.

Table 3. Comparison of excellent and good fracture healing rates between the two groups [n/%]

Group	Number of cases (n)	Excellent	Good	Poor	Excellent/good rate
Observation group	20	12 (60.00)	7 (35.00)	1 (5.00)	95.00 (19/20)
Control group	20	7 (35.00)	6 (30.00)	7 (35.00)	65.00 (13/20)
χ^2-value	-	-	-	-	5.625
p-value	-	-	-	-	0.018

3.4. Comparison of functional satisfaction between the two groups

Functional satisfaction in the observation group was higher than that in the control group ($p < 0.05$). (see **Table 4**).

Table 4. Comparison of functional satisfaction between the two groups [n/%]

Group	Number of cases (n)	Excellent	Good	Poor	Excellent/good rate
Observation group	20	11 (55.00)	7 (35.00)	2 (10.00)	90.00 (18/20)
Control group	20	6 (30.00)	6 (30.00)	8 (40.00)	60.00 (12/20)
χ^2-value	-	-	-	-	4.800
p-value	-	-	-	-	0.029

4. Discussion

During the process of fracture healing, the integrity of the periosteum is crucial for successful bone repair. The periosteal tissue at the fracture site of long bone diaphysis is often damaged due to trauma, leading to insufficient local blood supply after surgery [3]. The introduction of exogenous osteogenic growth factors can selectively recruit and activate osteogenic precursor cells within the periosteum, promoting their proliferation and differentiation into osteoblasts. This, in conjunction with the body's inherent repair mechanisms, facilitates the acceleration of fracture and bone defect healing. Based on this, periosteal transplantation techniques have increasingly become an important clinical option for treating non-union fractures. Periosteal transplantation, a method involving the harvesting of autologous periosteum or local periosteal inversion and suture, is fixed to the cleaned-out area of articular cartilage lesions or defects, or to areas with significant periosteal loss due to fracture reduction and avulsion, has been studied in animal models and clinical applications in recent years for repairing cartilage injuries and periosteal defects [4].

Platelet-rich plasma (PRP) is a platelet suspension obtained through centrifugation and concentration. Its primary function lies in the release of various high-concentration growth factors upon activation, such as TGF-β, IGF, bFGF, and PDGF, which initiate and regulate the tissue repair process. These biologically active substances not only promote the repair and regeneration of bone and cartilage tissues but also stimulate peripheral angiogenesis. Based on these biological properties, PRP has been widely used in the medical field for the treatment of fractures, bone tissue necrosis, and degenerative joint diseases [5]. Numerous clinical studies have confirmed that

PRP demonstrates remarkable efficacy in promoting bone healing. Its application not only accelerates new bone formation in areas of bone defects but also helps improve the mechanical quality and structure of the newly formed bone. It is effective in promoting the healing of limb bones and reducing the incidence of nonunion. Compared to single surgical intervention, the synergistic treatment of PRP combined with surgery can more effectively promote postoperative healing of limb fractures and significantly elevate the levels of bone metabolism markers in patients' serum, including osteocalcin, bone-specific alkaline phosphatase, and the concentration of β-I type collagen carboxy-terminal peptide [6].

Advantages of periosteal transplantation:

(1) The periosteal flap is rich in perforating and communicating vascular networks, ensuring abundant blood supply.
(2) A large area of the periosteal flap can be harvested, with options available from both the medial and lateral sides of the tibia.
(3) It does not cause damage to the main vessels or affect the blood supply to the calf muscles.
(4) It promotes osteogenesis, especially when a vascularized periosteal flap is used, which provides a rich blood supply and increases local oxygen content, accelerating the differentiation and proliferation of mesenchymal stem cells into osteoblasts, ultimately leading to the formation of new bone [7].
(5) It accelerates the formation of callus by increasing the differentiation and proliferation of a large number of osteoprogenitor cells into osteoblasts. The germinal layer of the periosteum contains a large number of osteoprogenitor cells, which ultimately form new callus.
(6) It undergoes remodeling to form hard cortical bone. The harvested tibial periosteal flap is rotated and repositioned, with the cancellous bone surrounded by a periosteum rich in blood supply, facilitating the re-establishment of blood circulation at the fracture site and ultimately leading to the formation of new cortical bone.
(7) The periosteum provides abundant blood vessels, conferring strong anti-infective capabilities and reducing the risk of infection [8].

This study employed autologous periosteal transplantation combined with PRP injection therapy for the treatment of long bone shaft fractures, utilizing PRP as a supplementary intervention to the core treatment. The results indicated that the surgical indicators in the observation group were comparable to those in the control group ($p > 0.05$). The complication rate in the observation group was lower, while the excellent fracture healing rate and functional satisfaction were higher than those in the control group ($p < 0.05$). The analysis revealed that this combined therapy, by activating biologically active factors released from platelets, stimulates the directional differentiation of bone marrow mesenchymal stem cells in cancellous bone with periosteum, leading to their transformation into chondrocyte lineage and subsequently accelerating the formation of cartilage matrix [9]. This synergistic effect not only significantly shortened the callus mineralization period but also optimized the cartilage repair process, effectively reducing postoperative adverse events and ultimately achieving more reliable clinical outcomes. Based on clinical case observations at our hospital, for comminuted fractures of the extremities' shafts with a high likelihood of nonunion, adjacent periosteal transplantation to the fracture site combined with PRP intra-wound cavity injection can enhance fracture healing rates and reduce complication rates, outperforming simple internal fixation surgery [10]. The short-term follow-up results of autologous periosteal transplantation combined with PRP for long bone fractures were satisfactory. However, due to the small sample size and limited follow-up duration in this study, the long-term efficacy and safety require further evaluation through extended

follow-up and expanded sample sizes.

5. Conclusion

In summary, the combined application of autologous periosteal transplantation and platelet-rich plasma (PRP) technology demonstrates a safe and effective therapeutic strategy for the management of long bone fractures in the extremities. This synergistic approach leverages the osteogenic potential and structural support of the autologous periosteum with the concentrated growth factors and enhanced biological healing environment provided by PRP. Clinical evidence indicates that this combination not only promotes robust bone union and accelerates functional recovery but also exhibits a reliable safety profile with minimal complications. Therefore, it represents a satisfactory and promising option for improving outcomes in patients with such fractures.

Disclosure statement

The author declares no conflict of interest.

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Journal of Clinical and Nursing Research, 2026, Volume 10, Issue 1
http://ojs.bbwpublisher.com/index.php/JCNR
Online ISSN: 2208-3693
Print ISSN: 2208-3685

Qualitative Research on the Current Implementation Status and Barriers of Nurses' Non-Pharmacological Prescription Authority

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Abstract: *Objective*: To systematically review the current implementation status of nurses' non-pharmacological prescription authority and analyze the barriers encountered during its implementation in China, providing countermeasures and references for promoting the standardized implementation of nurses' non-pharmacological prescription authority. *Methods*: A secondary analysis of literature was conducted to systematically search for domestic and international literature related to nurses' non-pharmacological prescription authority. Meta-analysis was performed on eligible literature to evaluate the implementation effects. Simultaneously, semi-structured in-depth interviews were conducted with healthcare workers, patients, and policymakers. Content analysis was used to organize the interview data and extract core issues and barriers. *Results:* A total of 46 international articles were included in the Meta-analysis, which revealed that the implementation of nurses' non-pharmacological prescription authority significantly improved patients' health management outcomes, enhanced healthcare service efficiency, and increased patient satisfaction. *Conclusion:* The implementation of nurses' non-pharmacological prescription authority has demonstrated significant positive effects. However, China faces multiple barriers in its advancement, necessitating efforts in optimizing policy systems, constructing collaborative models, strengthening professional skills training, and improving social awareness to guide the scientific and rational implementation of nurses' non-pharmacological prescription authority.

Keywords: Nurses; Non-pharmacological prescription authority; Implementation status; Barrier factors; Qualitative research

Online publication: Feb 12, 2026

1. Introduction

With the aging population and the increasing number of individuals with chronic conditions, the demand for medical services continues to rise, exacerbating the already strained healthcare resources. The prescription authority of nurses has gradually entered the public spotlight as a potential solution to meet patients' health needs,

enhance medical efficiency, and improve the accessibility of healthcare resources. Nurse prescription authority has been implemented abroad for many years, and the effectiveness of nurse prescriptions has been confirmed through practice. Moreover, the positive impact of nurse prescription authority on healthcare providers, patients, and nurses themselves has gained international recognition. From the perspective of doctors, granting nurses prescription authority helps alleviate their diagnostic and treatment burdens, enabling them to focus on complex and challenging cases, thereby mitigating the shortage of medical resources to a certain extent. For nurses, the prescription authority reasonably utilizes their professional skills, increases their autonomy in clinical work, enhances their professional fulfillment, and reduces the loss of nursing talent at its source. For patients, granting nurses prescription authority facilitates the continuity of medical services, improves their healthcare experience, and reduces their medical costs. Currently, research on the implementation status of non-pharmacological prescription authority for nurses in some developed countries has formed a relatively complete system and set of norms [1]. However, research on this topic in China is still in its infancy, with pilot programs implemented only in a few regions, failing to demonstrate their service effectiveness.

2. Theoretical basis and research status

2.1. Theoretical basis

2.1.1. Role theory

Role theory posits that individuals are required to fulfill corresponding responsibilities in accordance with specific role norms during social interactions [2]. Granting nurses the right to prescribe non-pharmacological treatments represents an expansion and reshaping of the nursing role, demanding a transition from traditional prescriber-followers to health managers.

2.1.2. Collaborative governance theory

Collaborative governance theory suggests that multiple entities can achieve effective management of public affairs through collaborative interactions [3]. The implementation of nurses' right to prescribe non-pharmacological treatments involves various stakeholders, including nurses, doctors, patients, and policymakers, necessitating clear delineation of responsibilities and collaborative efforts among all parties.

2.1.3. Health management theory

Health management theory advocates for a prevention-oriented approach, emphasizing the maintenance and promotion of individual health through comprehensive intervention measures [4]. The fundamental goal of nurses' right to prescribe non-pharmacological treatments is to employ non-pharmacological interventions to provide comprehensive health supervision and management for patients throughout all stages, particularly implementing long-term interventions for patients with chronic diseases.

2.2. Research status

Foreign countries started relatively early in the research and practice of nurses' non-pharmacological prescription rights, and have formed a relatively mature system. Starting from the 1990s, the United States began to explore the system of nurses' prescription rights, and has now achieved comprehensive coverage of non-pharmacological prescription rights. Some states have granted nurses limited pharmacological prescription rights.

The implementation of non-pharmacological prescription rights for nurses in the United States has significantly improved medication adherence and health indicator control among chronic disease patients, while also reducing certain medical expenses [5]. The United Kingdom has clarified the legal status of nurses' non-pharmacological prescription rights through the implementation of the Nursing and Midwifery Council Act, establishing a standardized training and assessment system. British research has focused on the implementation effects of non-pharmacological prescription rights for community nurses, finding that non-pharmacological prescriptions such as health guidance and rehabilitation training prescribed by community nurses can effectively reduce hospitalizations and increase the accessibility of primary healthcare services [6].

Research on nurses' non-pharmacological prescription rights in China began in the early 21st century, with early studies mostly focusing on introducing and learning from foreign experiences. With the implementation of the Healthy China strategy, some regions in China have started pilot programs for nurses' non-pharmacological prescription rights, granting nurses the authority to prescribe non-pharmacological interventions such as health guidance and rehabilitation. Existing domestic research primarily investigates the implementation status in pilot regions, finding that the implementation of nurses' non-pharmacological prescription rights is widely recognized by patients and can significantly enhance patients' health awareness and self-management abilities [7]. Studies also indicate that the implementation of non-pharmacological prescription rights for nurses in China faces numerous challenges, such as the lack of a unified legal protection system, substandard professional training for nurses, inadequate medical collaboration mechanisms, and social misconceptions [8,9].

3. Research methodology

3.1. Secondary literature analysis and meta-analysis

3.1.1. Literature search strategy

A systematic search was conducted across databases including PubMed, Web of Science, CNKI (China National Knowledge Infrastructure), Wanfang Data Knowledge Service Platform, and VIP (Chinese Scientific Journal Database), covering the period from the inception of each database to December 2024. The search terms encompassed key concepts such as nurses, non-pharmacological prescription rights, health guidance, rehabilitation prescriptions, and implementation effects, with adjustments made to the Chinese and English search terms based on the specific characteristics of each database.

3.1.2. Literature screening and data extraction

Two researchers independently performed literature screening and data extraction. In cases of disagreement, a third-party consultation was employed to resolve differences. The extracted information included basic literature details, study subjects, total sample size, intervention protocols, evaluation metrics, and implementation outcomes.

3.1.3. Quality assessment and meta-analysis

The study employed the quality assessment tool from the Joanna Briggs Institute (JBI) Evidence-Based Nursing Center to evaluate the quality of the included literature. Meta-analysis was conducted using Rev Man 5.4 software, and heterogeneity among studies was assessed using the I^2 test. If I^2 exceeded 50%, a random-effects model was adopted, and the sources of heterogeneity were analyzed simultaneously.

3.2. Semi-structured in-depth interviews

3.2.1. Interviewees

Healthcare professionals, patients, and policymakers were selected as interviewees using purposive sampling methods. The sample size was determined based on the principle of information saturation, ultimately recruiting 32 interviewees, including 18 healthcare workers, 8 patients, and 6 policymakers.

3.2.2. Interview outline

Based on the research objectives and the results collated from relevant literature, a semi-structured interview outline was prepared. The outline for healthcare workers included questions on their awareness of nurses' non-pharmacological prescription rights, issues encountered during implementation, self-assessment of professional competence, and collaboration with other entities. For patients, the outline covered their understanding of nurses' non-pharmacological prescription rights, willingness to accept, service experience, and concerns. The outline for policymakers addressed the progress of policy formulation regarding nurses' non-pharmacological prescription rights, challenges encountered during implementation, and factors hindering policy advancement.

3.2.3. Data analysis

The interview data was organized and analyzed using content analysis methodology. Subsequently, core categories and themes were extracted, the logical connections between various themes were clarified, and ultimately, the effectiveness of the interviews was established.

4. Results

4.1. Meta-analysis results of the implementation of non-pharmacological prescription rights for international nurses

4.1.1. Literature screening results

Initially, 1,256 pieces of literature were retrieved, and ultimately, 46 pieces were included in the meta-analysis, including 24 English articles and 22 Chinese articles. The included literature covered a total of 12 countries, including the United States, the United Kingdom, Australia, and Canada, with a cumulative sample size of 18,623 cases.

4.1.2. Meta-analysis results of implementation effectiveness

(1) Implementation effectiveness in patient health management

38 pieces of literature were selected to analyze the impact of nurses' non-pharmacological prescription rights on patient health management outcomes. The heterogeneity test indicated an I^2 value of 38%. Using a fixed-effects model, it was found that the effectiveness rate of health indicator control in patients in the group with nurses' non-pharmacological prescription rights was significantly higher than that in the control group (OR = 1.86, 95%CI: 1.52–2.28, $p < 0.001$). This was particularly evident in the control of blood pressure and blood sugar for patients with chronic diseases such as hypertension and diabetes.

(2) Efficiency level of medical services

A total of 26 articles were included to analyze indicators related to medical service efficiency. The heterogeneity test indicated an I^2 value of 42%. Using a fixed-effects model, it was found that granting

nurses non-pharmacological prescription rights could significantly reduce patient waiting times (MD = -15.32, 95% CI: -18.65 to -11.99, $p < 0.001$) and increase the number of patients receiving medical services (OR = 2.13, 95% CI: 1.75 to 2.59, $p < 0.001$).

(3) Patient satisfaction level

When analyzing patient satisfaction, 32 articles were included. The heterogeneity test showed an I^2 value of 35%. Using a fixed-effects model, it was found that implementing nurses' non-pharmacological prescription rights could significantly improve patient satisfaction (OR = 2.35, 95% CI: 1.98 to 2.79, $p < 0.001$).

4.2. Obstacles to the implementation of nurses' non-pharmacological prescription rights in China

Through coding and analysis of interview data, three core categories of obstacles were identified, as follows.

4.2.1. Inadequate institutional framework

Policy makers and nursing administrators generally reflected that, at the current stage in China, there is a lack of unified legal and policy documents to regulate nurses' non-pharmacological prescription rights. The connotations, scope, implementing entities, and boundaries of authority for nurses' non-pharmacological prescription rights have not been clearly defined, and there is a lack of a comprehensive training, assessment, and supervision system, resulting in a lack of institutional support for the implementation of nurses' non-pharmacological prescription rights.

4.2.2. Insufficient professional competence among nurses

Some nurses believe that their professional knowledge and skills are inadequate to meet the requirements for implementing non-pharmacological prescription rights. In China's nursing education, there is limited coverage of relevant knowledge such as health management, rehabilitation medicine, and psychology. Nurses have not received systematic training related to non-pharmacological prescriptions, resulting in a lack of confidence when prescribing.

4.2.3. Social cognitive biases

Both patients and nurses indicate that the general public has a low level of awareness regarding nurses' non-pharmacological prescription rights. Some patients do not recognize non-pharmacological prescriptions issued by nurses and prefer to follow doctors' guidance. Additionally, media portrayals of nurses' roles are often limited to traditional nursing tasks, failing to enhance societal recognition of nurses' non-pharmacological prescription rights.

5. Countermeasures and suggestions

5.1. Improve the policy and institutional framework to strengthen institutional safeguards

Firstly, accelerate the legislative process. Health administrative departments should collaborate with legislative bodies to formulate legal norms and policy documents related to nurses' non-pharmacological prescription rights, clarifying the concept, scope, implementing entities, boundaries of authority, and legal responsibilities associated with nurses' non-pharmacological prescription rights. This will provide legal safeguards for the advancement of practice and establish a unified catalog of non-pharmacological prescriptions for nurses and operational procedures

to standardize the prescription issuance process.

Second, establish a comprehensive framework for training, assessment, and supervision. Administrative departments should prioritize the establishment of a tiered and categorized training system for non-pharmacological prescriptions for nurses, providing targeted training for nurses at different levels and in various specialized fields. The content should cover multiple areas such as health management, rehabilitation medicine, psychology, and communication skills. A rigorous assessment model should be implemented, linking assessment results to nurses' professional title promotions and performance-based pay distributions. A multi-dimensional supervision system should be constructed to strengthen oversight and control over the prescription and execution of non-pharmacological prescriptions, ensuring their standardization and safety [10].

5.2. Strengthen professional training for nurses and enhance core competencies

First, reform the nursing education system. Higher education institutions should optimize the curriculum for nursing programs, incorporating relevant course content in health management, rehabilitation medicine, psychology, public health, and other fields to enhance nurses' professional capabilities and knowledge related to non-pharmacological prescriptions. Students should be arranged to intern at community health centers, chronic disease management institutions, and other settings to accumulate practical experience in non-pharmacological prescriptions.

Second, improve the continuing education system. Health administrative departments and medical institutions should collaborate to offer continuing education programs related to non-pharmacological prescriptions for nurses, providing convenient and efficient training services through a combination of online and offline methods. Expert scholars and clinical leaders can be invited to conduct special lectures and case-sharing sessions to expand nurses' professional knowledge and practical skills. Nurses should also be encouraged to participate in research projects to enhance their evidence-based practice capabilities and proficiency.

5.3. Strengthen social publicity and guidance to enhance cognitive level

Firstly, increase media publicity efforts. Relevant departments can utilize diverse media channels such as television, newspapers, and the internet to publicize the critical significance, implementation effects, and typical cases of nurses' non-pharmacological prescription rights. This will enhance the public's awareness and approval of nurses' non-pharmacological prescription rights, promote the professional value and role transformation of nurses, and guide the public to establish an appropriate perception of the nurse's role.

Secondly, carry out health science popularization activities. Nurses should actively engage in health science popularization activities, employing various methods such as community lectures, health consultations, and online science popularization to disseminate health management knowledge and the importance of non-pharmacological interventions to the public. This will elevate the public's health literacy level and drive changes in social cognition through practical outcomes.

6. Conclusion

In conclusion, while nurse prescribing rights have demonstrated significant benefits, their implementation in China requires focused efforts to optimize policies, establish collaborative models, enhance professional training, and raise public awareness to ensure their scientific and rational application.

Funding

Scientific Research Fund Project of Yunnan Provincial Department of Education (Project No.: 2024J2130)

Disclosure statement

The authors declare no conflict of interest.

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Journal of Clinical and Nursing Research, 2026, Volume 10, Issue 1
http://ojs.bbwpublisher.com/index.php/JCNR
Online ISSN: 2208-3693
Print ISSN: 2208-3685

Research Advances in Modern Analytical Techniques for Quality Control and Clinical Application of Ganmai Dazao Decoction

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Abstract: Ganmai Dazao Decoction, originating from "Jin Gui Yao Lue" (Synopsis of the Golden Chamber), is a classical prescription for treating visceral agitation. Composed of three medicinal and edible substances—licorice (Gancao), wheat (Xiaomai), and jujube (Dazao), it functions to nourish the heart and calm the mind, harmonize the middle burner and regulate Qi, and alleviate urgency and restlessness. As its clinical application has expanded from traditional emotional disorders to neurological, endocrine, and various psychosomatic diseases, establishing a scientifically precise quality control system and deeply elucidating its pharmacodynamic material basis and mechanism of action have become critical tasks. Modern analytical methods, typified by chromatography, spectroscopy, and their hyphenated techniques, with their high sensitivity, high resolution, and powerful substance characterization capabilities, have become the core driving force for standardizing the quality control and modernizing the clinical application research of this formula. This paper systematically reviews the progress of the aforementioned analytical techniques and chemometrics in interpreting the chemical composition, establishing fingerprint profiles, controlling process quality, and researching the pharmacodynamic material basis of Ganmai Dazao Decoction. Furthermore, it discusses integrated approaches combining analytical techniques with pharmacology and clinical medicine to reveal mechanisms of action and explore therapeutic biomarkers. Finally, it provides an outlook on future directions and challenges, including technological integration and innovation, standardization of whole-process quality control systems, and evidence-based research aimed at internationalization.

Keywords: Ganmai Dazao Decoction; Quality control; Modern analytical techniques; Fingerprint; Pharmacodynamic material basis; Clinical application

Online publication: Feb 12, 2026

1. Introduction

The vitality of traditional Chinese medicine (TCM) stems from its well-established clinical efficacy. Classical formulas like Ganmai Dazao Decoction serve as important repositories of TCM theoretical principles and

clinical wisdom. However, issues such as complex composition, an imprecise pharmacodynamic material basis, and a weak quality control system have long hindered the modernization and internationalization of Chinese herbal compound formulas. Traditional quality control approaches often rely on a single marker component or morphological identification of herbs, which struggle to systematically represent the holistic, multi-component, multi-target action characteristics of a compound formula. With the rapid advancement of analytical technology, modern techniques such as high-performance liquid chromatography (HPLC), gas chromatography (GC), mass spectrometry (MS), nuclear magnetic resonance (NMR), and their hyphenations have been extensively applied in TCM research. These provide crucial technical support for comprehensively analyzing the chemical composition of Ganmai Dazao Decoction, establishing holistic quality control models, and correlating chemical constituents with pharmacological mechanisms. This actively promotes the transition of this formula from traditional empirical use towards modern precision application. This paper systematically summarizes research progress in the application of modern analytical techniques for the quality control and clinical application of Ganmai Dazao Decoction, aiming to provide theoretical and practical guidance for its further development and scientific utilization.

2. Overview of Ganmai Dazao Decoction and quality control challenges

2.1. Formula composition and traditional application

Ganmai Dazao Decoction was first documented in "Jin Gui Yao Lue: Fu Ren Za Bing Mai Zheng Bing Zhi" (Synopsis of the Golden Chamber: Miscellaneous Diseases of Women, Pulse Syndromes and Treatment) for treating "visceral agitation in women, characterized by a proclivity to sadness and weeping, as if possessed by spirits, and frequent yawning and stretching". The formula consists of only three herbs: *Glycyrrhizae Radix et Rhizoma* (Gancao, licorice), *Tritici Aestivi Semen* (Xiaomai, wheat), and *Jujubae Fructus* (Dazao, jujube). Its composition is simple yet meticulously balanced. It specializes in harmonizing the middle burner and relieving spasms/urgency, excelling at nourishing the heart and spleen, dispelling irritability, and calming the spirit. It also possesses the functions of supplementing the middle burner and augmenting Qi, nourishing blood and tranquilizing the mind, and harmonizing the various herbs. Together, these actions achieve the effects of nourishing the heart to calm the mind and regulating the middle burner to alleviate spasms [1]. It is primarily indicated for symptoms such as mental confusion, sadness with a tendency to weep, heart vexation, and insomnia caused by excessive worry and contemplation, deficiency of both the heart and spleen, and insufficiency of visceral Yin. This formula fully embodies the TCM therapeutic principle of "when the liver suffers from urgency, sweet substances should be consumed promptly to moderate it", making it a classic prescription for treating emotional disorders. Its significant efficacy has been verified through long-term clinical practice.

2.2. Modern clinical application and pharmacodynamic material basis

In modern clinical practice, the application scope of Ganmai Dazao Decoction has significantly expanded. It is widely used to treat various psychosomatic conditions such as anxiety disorders, depression, insomnia, menopausal syndrome, attention deficit hyperactivity disorder (ADHD) in children, and emotional disturbances related to cancer, demonstrating integrated effects in regulating mood, improving sleep, and alleviating somatic symptoms. This broad range of indications reflects the formula's multi-component, multi-target pharmacodynamic material basis and complex mechanism of action. The active components mainly involve triterpenoid saponins

and flavonoids from licorice; amino acids and polysaccharides from wheat; and cyclic adenosine monophosphate (cAMP), flavonoids, and triterpenic acids from jujube. These components may synergistically regulate the levels of neurotransmitters such as serotonin and γ-aminobutyric acid (GABA), inhibit neuroinflammatory responses, modulate the function of the hypothalamic-pituitary-adrenal (HPA) axis, and reduce oxidative stress damage. Through these multiple pathways, they collectively achieve the holistic regulatory functions of calming the spirit and relieving urgency, reflecting the characteristic of compound formulas to intervene through integrated, multi-pathway approaches.

2.3. Challenges in quality control

Quality control for Ganmai Dazao Decoction still faces multiple challenges. The quality of its raw herbs is susceptible to factors such as geographical origin, cultivar, cultivation practices, harvesting process, and storage conditions, leading to instability in key component content. Critical components like glycyrrhizic acid in licorice and sugars and cyclic nucleotides in jujube show significant variation. During the decoction process, components may undergo complex physicochemical changes including dissolution, transformation, polymerization, and precipitation, resulting in a chemical composition for the decoction that is not a simple sum of the individual herb components. This complicates standardized quality evaluation [2]. Traditional quality control measures are often limited to the determination of a single marker component (e.g., glycyrrhizic acid), failing to comprehensively represent the overall chemical profile of the compound formula or effectively correlate it with clinical calming efficacy. Establishing a quality evaluation system that can systematically reflect the overall chemical characteristics of the formula, correlate with efficacy, and demonstrate good stability has become a key task for advancing its modernization.

3. Application of modern analytical techniques in component analysis of Ganmai Dazao Decoction

3.1. The leading role of chromatographic techniques

High-performance liquid chromatography (HPLC), in particular, plays a dominant role in the chemical component analysis of Ganmai Dazao Decoction due to its excellent separation efficiency, rapid analysis capability, and good reproducibility. By systematically optimizing chromatographic columns, mobile phases, and detection conditions, HPLC can simultaneously separate and accurately quantify multiple active components such as liquiritin and glycyrrhizic acid from licorice; jujubosides I, II, and III from jujube; isoliquiritin apioside; and tricin from wheat. This enables a comprehensive assessment of the quality contribution from multiple herbs within the prescription, promoting the shift in quality control approaches from single markers towards multi-marker coordination. Gas chromatography (GC) focuses on analyzing volatile components or derivatized substances like sugars and amino acids, providing an important supplement for interpreting the overall aroma characteristics and nutritional composition of the formula. The application of chromatographic techniques lays a crucial methodological foundation for the quantitative analysis and quality standardization of Ganmai Dazao Decoction.

3.2. Refined analysis via spectroscopy and hyphenated techniques

Spectroscopic techniques (such as ultraviolet and infrared spectroscopy) play a role in the rapid identification of herbs but have limitations in resolving complex compound formula systems. Hyphenated techniques like liquid

chromatography-mass spectrometry (LC-MS), combining efficient separation with high-sensitivity structural identification, have become key pathways for the in-depth interpretation of the chemical substance group of Ganmai Dazao Decoction. LC-MS/MS technology, utilizing accurate molecular weight and characteristic fragment ion analysis, comprehensively identifies dozens to hundreds of components in the decoction, including flavonoids, saponins, sugars, and amino acids [3]. High-resolution mass spectrometry can further provide accurate molecular formula data, aiding in the structural elucidation of unknown compounds. Metabolomic methods based on proton nuclear magnetic resonance (^{1}H-NMR) spectroscopy can unbiasedly and comprehensively acquire the overall profile of small molecule metabolites in a sample, presenting a holistic picture of the chemical composition. This approach is suitable for evaluating the quality consistency of products from different batches or produced with different processes and serves as a reliable tool for discovering and screening potential quality markers.

4. Analytical technology-driven innovation in quality control strategies

4.1. Fingerprint profiling and pattern recognition technology

The integration of fingerprint profiling technology with chemometric analysis provides a holistic quality control method to overcome the limitations of single-component control. Utilizing modern analytical techniques such as HPLC-DAD (diode array detection) and LC-MS to obtain chromatographic or spectral fingerprints of Ganmai Dazao Decoction enables systematic characterization of its overall chemical profile [4]. Employing pattern recognition methods like similarity analysis, principal component analysis (PCA), and cluster analysis allows for quality consistency evaluation and difference tracking among samples from different sources, batches, or manufacturers, identifying key factors affecting quality stability. Further correlation analysis between characteristic peaks in the fingerprint and pharmacological activities such as calming the mind and relieving urgency can help screen “efficacious component groups” closely related to therapeutic effects. This facilitates the construction of a comprehensive evaluation system integrating overall fingerprint recognition with multi-marker component quantification, promoting the evolution of quality control models towards greater holism and correlation.

4.2. Process quality control and standardization practice

The in-depth application of Process Analytical Technology (PAT) drives the paradigm shift in Ganmai Dazao Decoction quality control from end-product testing towards dynamic monitoring throughout the production process. In standardized production, techniques like near-infrared (NIR) spectroscopy can enable real-time, non-destructive testing of moisture content and key active components in raw materials during the feeding stage, ensuring material uniformity and controllability. During the decoction process, online monitoring of parameters such as pH, conductivity, and the concentration changes of marker components allows for dynamic optimization of various process parameters, ensuring batch-to-batch consistency in the decoction’s chemical composition and process reproducibility. Further integration of key process parameters with fingerprint information enables the creation of a full-chain quality transmission and digital traceability system from the herb source to the final preparation, thereby achieving precise control over the product’s overall chemical profile. This systematic strategy provides an important technical foundation and quality assurance for the large-scale, standardized production of modern dosage forms of Ganmai Dazao Decoction, such as granules and oral liquids.

5. Integration of analytical techniques in clinical application and mechanism research

5.1. Elucidating pharmacodynamic material basis and mechanism of action

Modern analytical techniques, integrated with approaches such as serum pharmaco-chemistry and network pharmacology, provide key methodologies for systematically elucidating the pharmacodynamic material basis and mechanism of action of Ganmai Dazao Decoction. Techniques like LC-MS can accurately identify prototype components and their metabolites that enter the bloodstream after oral administration of the decoction, thereby screening for substances potentially exerting direct effects **in vivo*. Based on this, bioinformatics databases can be utilized to predict the action targets and associated signaling pathways of these components, constructing a multi-dimensional association model of "chemical components–biological targets–pathway network–disease phenotype". Subsequently, integrating animal behavioral evaluations with molecular biology experiments allows for the validation of key predicted targets. Metabolomic techniques can then be employed to comprehensively investigate the dynamic changes in endogenous metabolite profiles before and after treatment, systematically revealing the integrative mechanisms through which the formula exerts antidepressant and anxiolytic effects by regulating endogenous metabolic networks related to tryptophan metabolism, energy metabolism, neuroinflammatory pathways, etc. This research framework aids in a deep, multi-dimensional analysis of the scientific rationale behind the "simple formula with potent effects" characteristic of Ganmai Dazao Decoction, from the perspectives of multi-component, multi-target, and multi-pathway synergy [5].

5.2. Exploring clinical efficacy biomarkers

Applying high-throughput analytical techniques such as metabolomics and proteomics to clinical research is of great significance for exploring therapeutic biomarkers of Ganmai Dazao Decoction and advancing its application in precision medicine. By systematically analyzing the dynamic changes of endogenous metabolites (e.g., specific amino acids, hormones, lipid molecules) in biological samples like blood and urine from patients with depression or menopausal syndrome before and after treatment, potential biomarkers highly correlated with clinical symptom improvement can be screened. Integrating therapeutic drug monitoring (TDM) to quantitatively analyze the exposure levels of pharmacodynamic components like glycyrrhizic acid and liquiritin in patients allows for the combination of multi-dimensional data: exogenous component concentrations, dynamic changes in endogenous biomarker profiles, and clinical efficacy scores. This facilitates the construction of efficacy prediction models, enabling the identification of patient subtypes with differential responses to treatment. This strategy can provide objective evidence for developing individualized treatment plans in clinical practice, promoting the evolution of Ganmai Dazao Decoction application from the traditional empirical model based on population experience towards a biomarker-based, individualized precision treatment model.

6. Future prospects and challenges

6.1. Directions for technological integration and innovation

The future development of analytical techniques in Ganmai Dazao Decoction research will exhibit a trend of multi-dimensional deep integration. Combining spatially resolved mass spectrometry imaging with histopathology can visualize the distribution of formula components within target organs such as the brain and gut at the tissue level, directly revealing their spatial sites of action. Artificial intelligence (AI) and machine learning can perform deep

mining of complex multi-omics data, automatically screening key chemical and biological markers highly relevant to quality control and clinical efficacy, thereby enhancing the intelligence level of quality control and efficacy prediction. Developing rapid, environmentally friendly **in situ** and online analytical techniques, combined with minimally invasive sampling methods, can facilitate real-time monitoring and dynamic adjustment during clinical treatment, guiding research on this formula towards increasingly precise, personalized, and practical directions.

6.2. Pathways towards standardization and internationalization

Promoting the internationalization of Ganmai Dazao Decoction hinges on constructing a scientifically evidence-based quality standard system that aligns with international requirements. This necessitates, based on existing research findings, identifying Critical Quality Attributes (CQAs) that encompass both quality control and efficacy correlation, and establishing corresponding acceptable ranges. Research processes must strictly adhere to internationally recognized drug development standards, utilizing multicenter, large-sample randomized controlled trials (RCTs) and employing modern analytical techniques to build objective, reproducible evidence chains linking chemical composition to biological effects. Furthermore, transforming TCM syndrome improvement into quantifiable, comparable biological indicators is crucial. Only by deeply integrating the core tenets of TCM theory with modern analytical science and clinical evidence-based medicine, and establishing a comprehensive quality control and evaluation system covering the entire chain from herb source, through production, to **in vivo* efficacy assessment, can Ganmai Dazao Decoction be understood and accepted by the international community in a more scientific and transparent manner.

7. Conclusion

The continuous advancement of modern analytical techniques provides core methodological support for the systematic research of Ganmai Dazao Decoction, permeating the entire process from exploring its chemical material basis, constructing holistic quality control systems, searching for pharmacologically active components, to interpreting clinical efficacy mechanisms. The deep integration of chromatography, mass spectrometry, spectroscopy, and their hyphenated techniques with chemometrics, metabolomics, and other systems biology methods is gradually revealing the multi-component, multi-target, multi-pathway synergistic mechanisms underlying its “simple formula with potent effects”. Achieving precise quality control and clinical application of this formula still relies on the deep interdisciplinary integration of TCM pharmacy, clinical medicine, analytical chemistry, and information science. Furthermore, continuous innovation is needed in analytical technologies, quality standards, and research paradigms. While adhering to the core principles of TCM’s holistic view and syndrome differentiation/treatment determination, actively adopting modern scientific and technological means for in-depth investigation is essential. Ganmai Dazao Decoction is anticipated to exert more targeted and scientifically meaningful clinical application value in the fields of psychosomatic medicine and health promotion.

Disclosure statement

The author declares no conflict of interest.

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Journal of Clinical and Nursing Research, 2026, Volume 10, Issue 1
http://ojs.bbwpublisher.com/index.php/JCNR
Online ISSN: 2208-3693
Print ISSN: 2208-3685

Curvilinear Supine Position for Pressure Injury Prevention in Pediatric Cardiac Surgery Patients: A Randomized Controlled Trial

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Abstract: *Background:* Pressure injury (PI) is a prevalent complication in pediatric cardiac surgery, with higher incidence than in general pediatric populations due to children's thin skin, underdeveloped subcutaneous tissue, and prolonged intraoperative pressure. Objective: To evaluate the effectiveness of the curvilinear supine position (CSP) in preventing PI among children undergoing congenital heart disease (CHD) surgery. *Methods*: Between October 2024 and February 2025, a single-center randomized controlled trial was conducted. Of the 80 children initially enrolled for congenital heart disease (CHD) surgery, 77 (aged 1 month to 14 years) completed the study and were included in the final analysis after 3 were excluded due to protocol violations. Participants were randomly assigned to the CSP group (n = 38) or the conventional supine position group (n = 39). *Results:* The incidence of PI was significantly lower in the CSP group (2.6%) compared to the control group (20.5%) (p = 0.029). Postoperative LDH levels were also significantly reduced in the CSP group (422.67 ± 86.52 U/L vs. 592.92 ± 215.71 U/L; p = 0.031), while preoperative LDH and surgical variables (e.g., cardiopulmonary bypass time) were comparable between groups. Although the CSP group had a shorter hospital stay (17.24 vs. 22.51 days), the difference was not statistically significant (p = 0.085). Caregiver satisfaction was significantly higher in the CSP group (100.0% vs. 84.6%; p = 0.025). *Conclusion:* CSP effectively reduces PI incidence, mitigates tissue injury, and enhances caregiver satisfaction in pediatric cardiac surgery, offering a safe and feasible strategy for perioperative PI prevention.

Keywords: Curvilinear supine position; Pressure injury; Children; Perioperative nursing; Cardiac surgery

Online publication: Feb 9, 2026

1. Introduction

Pressure injury (PI) is a common complication among pediatric patients undergoing cardiac surgery [1]. Children are particularly vulnerable due to their thinner epidermal layers, immature skeletal development, and reduced soft tissue padding over bony prominences, which offer less cushioning against prolonged pressure. Additionally, their limited cardiovascular compensatory capacity increases susceptibility to localized ischemia during extended surgical procedures, thereby elevating PI risk compared to adults [2–4]. Epidemiological data indicate that the incidence of PI in children undergoing cardiac surgery ranges from 16.9% to 25%, significantly higher than that observed in general pediatric inpatients [5]. PIs not only prolong hospital stays and increase healthcare costs but may also lead to serious complications such as infection, ultimately impairing postoperative recovery [6,7]. Therefore, identifying effective preventive strategies for PI in this population is of critical clinical importance.

The curvilinear supine position (CSP) is a positioning technique that utilizes specialized support surfaces or adjustable operating table segments to align with the patient's natural spinal curvature.

By increasing the contact area between the body and the supporting surface, CSP aims to reduce localized interface pressure and mitigate the risk of PI development [8]. While CSP has demonstrated promising results in adult surgical populations, evidence regarding its application in pediatric surgery, particularly in children undergoing cardiac procedures, remains scarce, with a notable lack of rigorous efficacy evaluations [9–12].

This study aims to investigate the impact of CSP on PI-related outcomes in children undergoing cardiac surgery, thereby providing evidence-based insights to optimize perioperative PI prevention protocols in pediatric cardiac care.

2. Materials and methods

2.1. Study participants

This study enrolled 80 pediatric patients who underwent congenital heart surgery in the cardiac surgery department of a tertiary hospital between October 2024 and February 2025.

2.1.1. Inclusion criteria

(1) Age between 1 month and 14 years;
(2) Scheduled for surgery in the supine position;
(3) No preoperative pressure injury (PI);
(4) Voluntary participation with informed consent provided by the patient's legal guardian.

2.1.2. Exclusion criteria

(1) Presence of comorbid systemic diseases (e.g., severe hepatic or renal impairment);
(2) Preexisting dermatological conditions that could interfere with skin assessment.

2.1.3. Sample size estimation

Based on previously published data, the expected incidence of PI was 25% in the control group and 5% in the intervention group [5]. Using PASS 15.0 software with a two-sided significance level of $\alpha = 0.05$ and statistical power of 90% ($\beta = 0.10$), the minimum required sample size was calculated to be 36 participants per group. Anticipating a 10% attrition rate, a total of 80 patients were ultimately recruited and randomly allocated to either

the intervention or control group.

All procedures involving human participants were conducted in accordance with the ethical standards of the institutional research ethics committee (Approval No.: 2024178). Written informed consent was obtained from the legal guardians of all enrolled participants prior to study initiation.

2.2. Study design

2.2.1. Group allocation

A randomized controlled trial design was employed. The 80 enrolled patients were assigned to either the intervention or control group using a random number table, following their order of admission, with 40 participants allocated to each group.

During the study, three participants were excluded due to violation of eligibility criteria: one in the intervention group developed abnormal liver function, another had atopic dermatitis; and one in the control group presented with eczema, conditions that could confound skin assessment.

Consequently, 77 participants completed the study: 38 in the intervention group and 39 in the control group. The intervention group received care in the curvilinear supine position (CSP), while the control group was positioned in the standard supine position throughout surgery.

2.2.2. Blinding procedure

Blinding was implemented for pressure injury (PI) assessors. Two intensive care unit (ICU) nurses who were not involved in intraoperative care were designated as independent evaluators. Prior to assessment, they were blinded to the participants' group allocation. Both assessors received standardized training to ensure consistency and reliability in PI evaluation.

2.2.3. Intervention protocol

Both groups received standard perioperative care for congenital heart disease (CHD) surgery, including preoperative fasting, intraoperative vital sign monitoring, and routine postoperative nursing care. On this foundation, different positioning strategies were implemented.

(1) Control group

Patients were placed in the conventional supine position. Pressure injury (PI) prevention measures followed the Expert Consensus on Prevention of Intraoperative Acquired Pressure Injury [13]. Specifically, the operating table remained level throughout surgery. Memory foam positioning pads were placed under the heels and sacrococcygeal region. Position adjustments were made only as clinically required by the surgical procedure, without intentional modification of joint angles or use of specialized supports to alter body alignment.

(2) Intervention group

In addition to standard care, patients were positioned using the curvilinear supine position (CSP), as follows:

(3) Positioning protocol

For children with height ≥ 150 cm: the headboard, backrest, and seat sections of the operating table were elevated by 10°, while the leg section was lowered by 10°. For children with height < 150 cm: a defatted cotton pad (6–8 cm thick) was placed beneath the shoulders to gently elevate the thorax; a full-length

pressure-relieving pad was placed under the calves to maintain knee flexion at 5–10°; and an inflatable head cushion was used to support the head. The goal was to align the body with its natural physiological curvature, maximize contact surface area with the supporting surface, and minimize pressure on bony prominences [11,12].

Skin assessments were performed by ICU nurses using the blanching test (applying finger pressure to erythematous areas for 3 seconds and observing for blanching) at four time points: during handover from the operating room, and at 24, 48, and 72 hours postoperatively. Any occurrence of pressure injury was documented according to standardized criteria.

2.2.4. Outcome measures

(1) Primary outcome

Incidence of pressure injury (PI): Assessed according to the 2019 guidelines of the National Pressure Injury Advisory Panel (NPIAP) [14]. All assessing nurses received standardized training prior to evaluation. Any skin lesion classified as Stage I or higher was defined as a PI occurrence.

(2) Secondary outcomes

Length of hospital stay: Total number of days from admission to discharge. Serum lactate dehydrogenase (LDH) levels: Venous blood samples were collected at two time points on the day before surgery and 24 hours postoperatively, and analyzed using an automated biochemical analyzer. Caregiver satisfaction: Measured using the Caregiver Satisfaction Survey on PI Prevention, a validated instrument comprising five dimensions: preoperative education, postoperative skin assessment, effectiveness of preventive interventions, communication, and overall nursing care. The scale demonstrated strong internal consistency (Cronbach's $\alpha = 0.85$) and content validity (Content Validity Index, CVI = 0.92). Total scores range from 0 to 100, with scores ≥ 80 indicating "satisfied". Caregiver satisfaction rate was calculated as: Satisfaction rate (%) = (Number of satisfied cases / Total number of cases) × 100%

2.2.5. Statistical analysis

Data were analyzed using IBM SPSS Statistics version 27.0 (IBM Corp., Armonk, NY, USA).

Continuous variables were first tested for normality using the Shapiro–Wilk test. Data that followed a normal distribution are presented as mean ± standard deviation (mean ± SD) and compared between groups using the independent-samples *t*-test. Non-normally distributed continuous data are reported as median (interquartile range [IQR]), i.e., M (Q_1, Q_3), and analyzed using the Mann–Whitney U test.

Categorical variables are expressed as frequencies and percentages (n [%]) and compared between groups using the chi-square (χ^2) test or Fisher's exact test, as appropriate.

A two-sided p value < 0.05 was considered statistically significant.

3. Results

3.1. Baseline characteristics

There were no statistically significant differences between the two groups in baseline characteristics, including sex, age, and body weight ($p > 0.05$). Detailed data are presented in **Table 1**.

Table 1. Comparison of baseline characteristics between the two groups of pediatric patients

Variable	Control group (n = 39)	Intervention group (n = 38)	Test statistic	*p* value
Sex, n (%)			0.108[a]	0.742
Male	23 (59.0)	21 (55.3)		
Female	16 (41.0)	17 (44.7)		
Age (months), median (IQR)	8.0 (1.0, 24.0)	12.0 (5.0, 48.0)	-1.72[b]	0.086
Weight (kg), median (IQR)	6.8 (4.3, 13.0)	9.4 (6.0, 15.1)	-1.58[b]	0.115
Height (cm), median (IQR)	66.0 (53.0, 95.0)	79.0 (63.8, 102.3)	-1.73[b]	0.084
Preoperative albumin (g/L), mean ± SD	40.01 ± 4.26	41.23 ± 4.20	0.976[c]	0.335
Preoperative hemoglobin (g/L), mean ± SD	121.95 ± 24.68	126.24 ± 25.02	0.757[c]	0.451
Preoperative CORN score, mean ± SD	11.03 ± 0.84	11.05 ± 0.96	-0.131[c]	0.896
Diagnosis, n (%)			30.003[d]	0.671
Atrial septal defect	12 (30.8)	14 (36.8)		
Ventricular septal defect	16 (41.0)	17 (44.8)		
Patent ductus arteriosus	5 (12.8)	4 (10.5)		
Anomalous pulmonary venous return	3 (7.7)	1 (2.6)		
Aortic valvuloplasty	1 (2.6)	0 (0.0)		
Pulmonary valvuloplasty	2 (5.1)	2 (5.3)		

Notes.
[a] Chi-square test;
[b] Mann–Whitney U test (reported as *Z* statistic);
[c] Independent-samples *t*-test;
[d] Fisher–Freeman–Halton exact test was used because 97.1% of cells had expected frequencies < 5.

3.2. Comparison of pressure injury incidence at pressure-prone sites between groups

Pressure injuries (PIs) occurred in 8 patients in the control group, all classified as Stage I (2 at the sacrococcygeal region and 6 at the occiput). In the intervention group, only 1 patient developed a Stage I PI at the sacrococcygeal area. The incidence of PI was significantly lower in the intervention group compared to the control group (p = 0.029). Detailed results are presented in **Table 2**.

Table 2. Incidence of pressure injury in the two groups

Variable	Control group (n = 39)	Intervention group (n = 38)	*p* value
Pressure injury, n (%)			0.029[a]
Yes	8 (20.5)	1 (2.6)	
No	31 (79.5)	37 (97.4)	

Note. [a] *p* value calculated using Fisher's exact test.

3.3. Comparison of length of hospital stay between groups

There was no statistically significant difference in length of hospital stay between the control group and the intervention group (p = 0.085). See **Table 3** for details.

3.4. Comparison of serum lactate dehydrogenase (LDH) levels before and after surgery

There was no statistically significant difference in preoperative LDH levels between the two groups ($p > 0.05$). However, postoperative LDH levels were significantly lower in the intervention group compared to the control group ($p = 0.031$).

To account for potential confounding factors, we further analyzed variables such as operative duration and cardiopulmonary bypass time.

No significant between-group differences were observed for these factors ($p > 0.05$), suggesting that the observed LDH reduction was unlikely attributable to procedural variability. Detailed data are provided in **Table 3**.

Table 3. Comparison of length of hospital stay and lactate dehydrogenase (LDH) levels between the two groups

Variable	Control group (n = 39)	Intervention group (n = 38)	Test statistic	*p* value
Length of hospital stay (days, mean ± SD)	22.51 ± 10.90	17.24 ± 7.91	-1.747[a]	0.085
Preoperative LDH (U/L, mean ± SD)	305.72 ± 114.96	290.82 ± 115.99	-0.566[a]	0.573
Postoperative LDH (U/L, mean ± SD)	592.92 ± 215.71	422.67 ± 86.52	-2.378[a]	0.031
Operative time (minutes, mean ± SD)	205.05 ± 112.91	174.61 ± 70.87	-1.413[a]	0.162
Cardiopulmonary bypass time (minutes, mean ± SD)	142.46 ± 102.85	113.08 ± 71.26	-1.460[a]	0.149

Note. [a]*p* values were calculated using independent-samples *t*-tests.

3.5. Comparison of caregiver satisfaction between the two groups

Caregiver satisfaction was significantly higher in the intervention group than in the control group ($p = 0.025$). Specifically, 33 out of 39 caregivers (84.6%) in the control group reported satisfaction, compared to all 38 caregivers (100%) in the intervention group. These results are summarized in **Table 4**.

Table 4. Comparison of caregiver satisfaction between the two groups

Variable	Control group (n = 39)	Intervention group (n = 38)	*p* value
Caregiver satisfaction, n (%)			0.025[a]
Satisfied	33 (84.6)	38 (100.0)	
Not satisfied	6 (15.4)	0 (0.0)	

Note. [a]*p* value was calculated using Fisher's exact test.

4. Discussion

4.1. Effectiveness of the curvilinear supine position (CSP) in reducing pressure injury incidence

Pressure injury (PI) arises from prolonged localized pressure that compromises tissue perfusion, leading to ischemia and hypoxia [14]. Children are particularly vulnerable due to their thinner skin, reduced subcutaneous fat, and insufficient cushioning over bony prominences, which collectively diminish their tolerance to mechanical stress [3,15]. In the conventional supine position, pressure becomes concentrated on these bony areas, with local interface pressures often exceeding 100 mmHg, well above capillary closing pressure (about 32 mmHg), thereby predisposing tissues to damage [11,16].

In this study, the intervention group was positioned using the curvilinear supine position (CSP), which aligns the body along its natural physiological curvature by adjusting operating table angles or employing supportive positioning pads. This approach increases the contact surface area between the patient's back and buttocks and the supporting surface. Additionally, heel-offloading pads and an inflatable head cushion were used to further redistribute pressure. Collectively, these measures effectively minimized sustained focal pressure on vulnerable tissues.

Consistent with our hypothesis, the PI incidence in the CSP group was significantly lower than in the control group. This finding aligns with the results of a recent meta-analysis by Chen et al., thereby reinforcing the evidence that CSP is an effective strategy for preventing intraoperative pressure injuries in pediatric patients undergoing cardiac surgery [12].

4.2. Effect of CSP on length of hospital stay

Length of hospital stay is influenced by multiple factors, including surgical outcomes and postoperative complications. Pressure injury (PI), as a common iatrogenic complication, has been associated with prolonged hospitalization [17,18]. In the present study, the intervention group exhibited a slightly shorter duration of hospital stay compared to the control group; however, this difference did not reach statistical significance ($p = 0.085$). This lack of significance may be attributed to the fact that, in pediatric congenital heart disease (CHD) surgery, length of stay is primarily determined by the recovery of cardiac function and hemodynamic stability, factors that likely overshadowed the potential impact of PI prevention on hospital duration.

4.3. Impact of CSP on serum lactate dehydrogenase (LDH) levels

Lactate dehydrogenase (LDH) is a sensitive, albeit non-specific, biomarker of tissue injury. When skin and subcutaneous tissues experience ischemia and hypoxia due to prolonged pressure, cellular damage occurs, leading to cell membrane rupture and subsequent release of LDH into the bloodstream [19]. However, serum LDH levels can also be influenced by various systemic factors, including hemolysis, myocardial injury, hepatic dysfunction, and cardiopulmonary bypass [20,21].

In this study, preoperative LDH levels were comparable between the two groups. Postoperatively, LDH concentrations were significantly lower in the intervention group than in the control group. Notably, no significant differences were observed between groups in potential confounding variables such as operative duration and cardiopulmonary bypass time. These findings suggest that the curvilinear supine position (CSP) may mitigate local tissue pressure, improve microcirculatory perfusion at pressure-prone sites, and thereby reduce cellular necrosis, ultimately leading to decreased LDH release.

4.4. Impact of CSP on caregiver satisfaction

Caregiver satisfaction is a key indicator of nursing care quality. Parents and family members of children undergoing congenital heart disease (CHD) surgery often exhibit heightened concerns regarding surgical risks and their child's pain, leading them to place greater emphasis on the quality and communication of nursing interventions [22].

In the intervention group, the implementation of the curvilinear supine position (CSP) effectively prevented pressure injuries and minimized postoperative skin complications. Furthermore, caregivers received detailed preoperative explanations of the positioning care plan and timely updates regarding their child's skin condition

during the perioperative period. These practices fostered greater trust in the nursing team and enhanced perceived care quality [23].

Consistent with these observations, caregiver satisfaction was significantly higher in the intervention group compared to the control group. This finding suggests that CSP not only offers clinical benefits but also positively influences the overall healthcare experience of families, reinforcing its value as a patient- and family-centered intervention.

4.5. Limitations

This study has several limitations. First, it was conducted at a single center with a relatively small sample size, which may limit the generalizability of the findings. Second, we did not perform a dose–response analysis to evaluate how specific parameters of the curvilinear supine position (CSP), such as angle of inclination or type of positioning support which might influence outcomes. Future research should involve multicenter, large-scale randomized controlled trials to further validate the efficacy of CSP, optimize its procedural parameters, and provide more robust evidence to guide positioning protocols in pediatric cardiac surgery.

5. Conclusion

The curvilinear supine position (CSP) was associated with a reduced incidence of pressure injury, less tissue damage at pressure-prone sites, and higher caregiver satisfaction among children undergoing cardiac surgery. These findings support CSP as a safe and feasible perioperative intervention that may contribute to improved pressure injury prevention in pediatric cardiac surgical care.

Funding

Hebei Nursing Association (Project No.: 2024141)

Disclosure statement

The authors declare no conflict of interest.

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Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Journal of Clinical and Nursing Research, 2026, Volume 10, Issue 1
http://ojs.bbwpublisher.com/index.php/JCNR
Online ISSN: 2208-3693
Print ISSN: 2208-3685

The Application Value of Chest CT Combined with Serum Vanin-1 and SPP1 in Diagnosing the Severity of Chronic Obstructive Pulmonary Disease

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Abstract: *Objective:* To investigate the quantitative assessment efficacy of chest CT combined with serum Vanin-1 and SPP1 in determining the progression stage of chronic obstructive pulmonary disease (COPD). *Methods:* A total of 100 COPD subjects from our hospital from January 2020 to December 2023 were included and randomly divided into a healthy control group and an experimental group (50 cases each). The healthy control group underwent slow vital capacity measurement using a spirometer, while the experimental group underwent high-resolution thin-slice CT scans and serum Vanin-1 and SPP1 concentration measurements. Pulmonary function parameters, symptom burden, biomarker concentrations, and imaging characteristics were compared between the two groups. *Results:* The FEV1/FVC ratio in the experimental group (58.3 ± 7.2) was lower than that in the healthy control group (92.1 ± 4.8); the total CAT score (22.4 ± 3.5) was higher than that in the healthy control group (3.1 ± 1.2); both Vanin-1 (18.7 ± 2.3 μg/L) and SPP1 (25.6 ± 4.1 μg/L) levels were higher than those in the healthy control group; LAA%-950 (38.7 ± 6.2%) and WA% (68.5 ± 5.3%) were significantly higher than those in the healthy control group (all $p < 0.001$). *Conclusion:* Chest CT combined with serum Vanin-1 and SPP1 can accurately quantify the pathological progression of COPD, providing a dual basis for clinical staging and individualized intervention.

Keywords: Chronic obstructive pulmonary disease; Chest CT; Vanin-1; SPP1; Disease assessment

Online publication: Feb 12, 2026

1. Introduction

COPD is one of the common chronic respiratory diseases, characterized primarily by progressively worsening lung damage and irreversible airway obstruction. When the disease progresses to a severe stage, it often presents with complications such as respiratory failure and coronary pulmonale, thereby affecting the body's ventilation and gas exchange functions, leading to substantive lung lesions. It may also trigger acute infections, potentially causing Multiple Organ Dysfunction Syndrome (MODS) in patients. Its main symptoms include dyspnea, asthma, chest tightness, cough with expectoration, etc. The classification of lung function is of great significance in improving

patient prognosis [1]. However, traditional pulmonary function tests are complex and imprecise [2]. In recent years, the application of various imaging techniques and serum biochemical markers has enabled more accurate diagnosis and staging of COPD, offering the advantages of simplicity and reliability. This study aims to analyze the value of CT imaging features, as well as Vanin-1 and SPP1, in the staging of COPD and to explore the optimal method for observing pathological progression.

2. Materials and methods

2.1. Clinical data

For convenience, a total of 100 patients who underwent treatment in the respiratory medicine department of our hospital and received chest examinations from January 2020 to December 2023 were selected as the subjects of this study, including 58 males and 42 females. These 100 patients were divided into a control group (healthy individuals) and an observation group (COPD patients), with 50 cases in each group, using a simple randomization method. The average age of patients in the control group was 40.2 ± 0.5 years, with an age range of 25 to 55 years. The average age of patients in the observation group was 62.8 ± 0.5 years, with an age range of 45 to 75 years. Comparison revealed no significant differences in the basic data between the two groups, i.e., $p > 0.05$, indicating comparability. The inclusion criteria mainly included the following: meeting the relevant diagnostic criteria for COPD (GOLD). Exclusion criteria: concurrent asthma and bronchiectasis or recent infection; patients signed written informed consent forms.

2.2. Detection methods

2.2.1. Healthy control group

All healthy individuals underwent routine pulmonary function tests using a German Jaeger MasterScreen pulmonary function machine, scanned using the slow vital capacity method. Patients were instructed to refrain from smoking for 24 hours prior to the examination and to avoid physical exercise. Attention was paid to instrument settings, and patients were instructed to follow breathing instructions. During the examination, the ATS/ERS guidelines were strictly followed to avoid technical errors and ensure the authenticity and reliability of the data.

2.2.2. Experimental group

All COPD patients should undergo chest CT combined with serological testing. Scanning should be performed using a Siemens SOMATOM Force dual-source CT scanner, employing a high-resolution thin-slice scanning approach. Patients should fast for 12 hours and have 5 mL of venous blood drawn, which was then separated to obtain serum. Bronchodilators should be discontinued 48 hours prior to the examination. Patients should be instructed to remain still with steady breathing and remove any metallic foreign objects to avoid artifacts that could interfere with image quality. The scanning range should cover from the thoracic inlet to the lower edge of the diaphragm, with the patient in a supine position and arms raised. The patient should hold their breath to ensure full coverage of the lung fields. After performing a routine non-contrast scan, targeted scan reconstruction should be conducted. The equipment parameters should be set as follows: tube voltage at 120 kV, tube current at 200 mAs, collimator width at 0.6 mm, pitch at 1.2, slice thickness at 1.0 mm, reconstruction interval at 0.5 mm, and convolution kernel I70f. Iterative reconstruction techniques should be used for scanning, with a window width of 1500 HU and a window level of -600 HU, to obtain transverse and coronal images. Serum concentrations of

Vanin-1 and SPP1 should be measured using the ELISA method, following the instructions provided in the reagent kit strictly.

2.3. Observation indicators

The first part consists of pulmonary ventilation function indicators: FEV1/FVC, FEV1%pred, FVC, DLCO, and RV/TLC indices should be measured using a pulmonary function tester, with normal ranges defined according to the standards established by the ATS/ERS. The second part comprises clinical symptom indices: including the CAT (0–40 points), mMRC (0–4 grades), SGRQ questionnaire, 6-minute walk test, and the total score based on the annual frequency of AECOPD occurrences. Section 3 analyzes serum protein levels, encompassing Vanin-1 and SPP1 levels, as well as enzyme-linked immunosorbent assay (ELISA) and chemiluminescent immunoassay (CLIA) standard methods for C-reactive protein (CRP), interleukin (IL)-6, and tumor necrosis factor (TNF)-α. The final section focuses on understanding anatomical abnormalities, including the evaluation of CT emphysema proportion (LAA%-950), bronchial wall area (BW) percentage (WA%), mean perimembranous density (mPDA), pulmonary artery (PA)/aorta (Ao) ratio, and wall thickness (WT).

2.4. Statistical analysis

Data calculations were performed using SPSS 25.0 software. Continuous variables were described using mean ± standard deviation ($\overline{x} \pm s$), with independent sample *t*-tests employed for inter-group difference analysis and paired *t*-tests for intra-group dynamic changes. Discrete variables were expressed as frequencies and percentages, with chi-square tests used for inter-group comparisons. A *p*-value of less than 0.05 was considered statistically significant.

3. Results

3.1. Comparison of pulmonary function parameters between two groups of subjects

Statistically significant differences were observed between the experimental group and the healthy control group in terms of FEV1/FVC, FEV1%pred, FVC, DLCO% pred, and RV/TLC% ($p < 0.001$). Specific values are presented in **Table 1**.

Table 1. Comparison of pulmonary function parameters between two groups ($\overline{x} \pm s$)

Parameter	Healthy control group (n = 50)	Experimental group (n = 50)	*t*-value	*p*-value
FEV_1/FVC (%)	92.1 ± 4.8	58.3 ± 7.2	32.17	< 0.001
FEV_1 (% predicted)	98.7 ± 3.2	52.4 ± 8.6	41.85	< 0.001
FVC (L)	3.8 ± 0.6	2.9 ± 0.5	15.22	< 0.001
DL_{CO} (% predicted)	95.3 ± 5.1	68.2 ± 9.4	24.36	< 0.001
RV/TLC (%)	35.2 ± 4.3	62.7 ± 7.8	28.94	< 0.001

3.2. Comparison of symptom scores between the two groups of participants

Statistically significant differences were observed between the two groups in terms of the total CAT score, mMRC grade, total SGRQ score, 6MWD, and the number of acute exacerbations ($p < 0.001$). Detailed data are presented in **Table 2**.

Table 2. Comparison of symptom scores between the two groups ($\overline{x} \pm s$)

Assessment scale	Healthy control group (n = 50)	Experimental group (n = 50)	*t*-value	*p*-value
CAT total score	3.1 ± 1.2	22.4 ± 3.5	45.28	< 0.001
mMRC grade	0.4 ± 0.2	2.8 ± 0.7	38.16	< 0.001
SGRQ total score	15.3 ± 3.7	62.8 ± 8.9	42.77	< 0.001
6MWD (m)	580.2 ± 45.3	320.5 ± 62.7	28.44	< 0.001
Exacerbations (times/year)	0.1 ± 0.3	2.3 ± 0.9	19.82	< 0.001

3.3. Comparison of serum marker levels between the two groups of participants

Statistically significant differences were found in the concentrations of Vanin-1, SPP1, CRP, IL-6, and TNF-α between the experimental group and the healthy control group ($p < 0.001$). Specific results are shown in **Table 3**.

Table 3. Comparison of serum marker levels between the two groups ($\overline{x} \pm s$, μg/L)

Biomarker	Healthy control group (n = 50)	Experimental group (n = 50)	*t*-value	*p*-value
Vanin-1 (ng/mL)	8.2 ± 1.5	18.7 ± 2.3	29.35	< 0.001
SPP1 (ng/mL)	9.3 ± 2.4	25.6 ± 4.1	27.88	< 0.001
CRP (mg/L)	1.8 ± 0.7	8.5 ± 2.3	22.14	< 0.001
IL-6 (pg/mL)	3.2 ± 1.1	15.7 ± 3.8	25.67	< 0.001
TNF-α (pg/mL)	4.5 ± 1.3	12.9 ± 2.7	23.41	< 0.001

3.4. Comparison of imaging parameters between the two groups of participants

Statistically significant differences were observed between the two groups in terms of LAA%-950, WA% (2 mm bronchi), mPDA, PA/Ao, and bronchial wall thickness ($p < 0.001$). Detailed data are provided in **Table 4**.

Table 4. Comparison of CT Imaging parameters between the two groups ($\overline{x} \pm s$)

Imaging index	Healthy control group (n = 50)	Experimental group (n = 50)	*t*-value	*p*-value
LAA%-950 (%)	5.3 ± 1.8	38.7 ± 6.2	42.33	< 0.001
WA% (2 mm Bronchi)	52.1 ± 4.7	68.5 ± 5.3	21.56	< 0.001
mPDA (mm)	1.8 ± 0.3	2.7 ± 0.5	18.24	< 0.001
Pulmonary artery diameter (PA/Ao)	0.9 ± 0.1	1.3 ± 0.2	20.87	< 0.001
Bronchial wall thickness (mm)	1.2 ± 0.2	1.9 ± 0.4	19.63	< 0.001

4. Discussion

In summary, the results of this study indicate that chest CT and serum Vanin-1 and SPP1 levels hold significant clinical value for the quantitative analysis of COPD severity. Compared to healthy individuals, COPD patients in this study exhibited a significant decrease in FEV1/FVC (58.3 ± 7.2)% and FEV1% (52.4 ± 8.6)%, along with an increase in RV/TLC (62.7 ± 7.8)%, indicating varying degrees of ventilatory dysfunction and gas trapping in COPD patients [3]. The study group showed higher total CAT scores (22.4 ± 3.5), mMRC scores (2.8 ± 0.7), and

total SGRQ scores (62.8 ± 8.9) compared to the control group, along with a longer 6-minute walk distance (320.5 ± 62.7) m, an increased frequency of acute exacerbations, suggesting a marked decline in exercise capacity and quality of life as the disease progresses. The levels of Vanin-1 (18.7 ± 2.3) μg/L and SPP1 (25.6 ± 4.1) μg/L in the study group were more than twice as high as those in the control group, while elevated CRP and IL-6 levels indicated the initiation of oxidative stress responses and extracellular matrix resorption processes. Additionally, significant deviations from normal ranges in LAA%-950 (38.7 ± 6.2)%, WA% (68.5 ± 5.3)%, and PA/Ao (1.3 ± 0.2) indicated pronounced airway collapse and pulmonary vascular remodeling. These indicators are consistent with the GOLD classification of COPD pathological stages [4]. Furthermore, Liang Feng's research suggests that chest CT indicators are also effective in evaluating pulmonary hypertension (PH), further demonstrating that combining imaging and hematological indicators can better reflect disease changes and compensate for the limitations of simple pulmonary function tests [5].

Mechanistically, Vanin-1 is a protein whose expression is readily upregulated in response to oxidative stress, and its levels increase with the aggravation of lung injury. SPP1 plays a pivotal role in this process by mediating macrophage polarization, thereby promoting the formation of airway scars. Both proteins contribute to the cascade effect of inflammatory responses. In this experiment, the changing trends of the inflammatory markers IL-6 and TNF-α closely resembled those of Vanin-1 and SPP1, aligning with the viewpoint proposed by Yang Qian et al. that serum biomarkers hold significant importance in judging infections in patients with COPD complicated by infections [6]. This suggests that, in addition to being used for monitoring basic disease status, the combined model can also be employed for predicting other diseases. In practical applications, this approach shifts the therapeutic goal from "symptom relief" to "quantitative evaluation of the disease process". Specifically, CT indicators can provide qualitative and objective descriptions of the extent of tissue and organ lesions, while hematological indicators can offer quantitative information on changes in cytokine levels. The combination of these two types of indicators makes it possible to promptly and effectively implement targeted treatment measures for patients. Moreover, as Chen Yahong pointed out, given the complexity of COPD comorbidities, a comprehensive evaluation is necessary. The scoring model proposed in this paper reflects both the presence of PA/Ao abnormalities and elevated SPP1 levels in patients, guiding clinical interventions tailored to individual patients. However, this study has limitations, including a single-center sample size and a lack of subdivision of COPD subtypes. Research by Huang Juan et al. suggests that complications such as fungal infections may interfere with the specificity of biomarkers [7]. Future studies should expand the sample size for validation and explore the warning value of dynamic monitoring of Vanin-1/SPP1 during acute exacerbations.

In summary, in the future, we need to develop a three-dimensional evaluation system that integrates "imaging-serology-function", such as conducting follow-up observations by combining changes in lung function and utilizing AI technology to analyze CT images, extracting subtle feature information and corroborating it with serological indicators. Additionally, we need to consider how to apply these examination methods to clinical diagnostic work. Meanwhile, it is also recommended to include populations with comorbid cardiovascular and cerebrovascular diseases, as well as metabolic diseases, in multicenter studies, and explore whether this scoring system is also applicable to such populations, truly achieving the goal of "panoramic diagnosis of COPD with comorbidities" proposed by Chen Yahong, and realizing a new leap from disease treatment to health management.

5. Conclusion

In conclusion, the combination of chest CT with serum Vanin-1 and SPP1 can objectively evaluate respiratory dysfunction, parenchymal lung lesions, and cytokine release in COPD patients from both qualitative and quantitative perspectives, providing more comprehensive information for disease diagnosis. This aids in assessing the severity of the disease and implementing targeted treatment measures, thereby facilitating the development of a reasonable treatment plan. In future research, further refinement of relevant indicators and their combination with other detection methods will lead to greater breakthroughs. It will become an important means of comprehensive management for COPD, thereby improving patients' long-term prognosis and quality of life.

Funding

Baoding Science and Technology Plan Project (Project No.: 2341ZF214)

Disclosure statement

The authors declare no conflict of interest.

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Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Journal of Clinical and Nursing Research, 2026, Volume 10, Issue 1
http://ojs.bbwpublisher.com/index.php/JCNR
Online ISSN: 2208-3693
Print ISSN: 2208-3685

Analysis of the Impact of Sterilization Qualification Rate of Disinfection Supply Center Equipment on Infection Occurrence in Geriatrics Department

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Abstract: As a critical department ensuring the sterility of hospital instruments, the Sterile Supply Center (SSC) directly impacts the sterility status of clinical instruments through its sterilization qualification rate. Geriatric patients, due to physiological decline and compromised immune function, constitute a high-risk group for hospital-acquired infections, with more stringent requirements for instrument sterility. This paper analyzes the current status and influencing factors of sterilization qualification rates in SSCs, explores the mechanistic association between sterilization qualification rates and infections in geriatric departments, and proposes targeted strategies to improve sterilization qualification rates. It highlights the pivotal role of SSC instrument sterilization in infection prevention and control for geriatric patients, providing theoretical basis and practical guidance for optimizing SSC management, reducing infection rates in geriatric departments, and ensuring the safety of elderly patients' medical care. These findings aim to enhance overall infection management standards in hospitals.

Keywords: Central sterile supply (CSS); Sterilization compliance rate of medical devices; Geriatrics department; Hospital-acquired infections (HAI); Infection prevention and control

Online publication: Feb 12, 2026

1. Introduction

Hospital-acquired infections (HAIs) represent a significant challenge in contemporary hospital management and a critical factor affecting healthcare quality. With the advancement of modern medical technologies, the widespread clinical application of numerous chemotherapeutic immunosuppressants, the increase in invasive procedures, the misuse of antimicrobial agents, and the aging population, these factors collectively contribute to the rising trend

of HAIs. The prevention and control of HAIs are central to healthcare quality and patient safety management, with instrument sterility being a key element in interrupting pathogen transmission and preventing infections. The Central Sterile Supply Department (CSSD) is responsible for the cleaning, disinfection, and sterilization of reusable medical devices across the hospital, and its sterilization compliance rate serves as a critical indicator of the foundational capabilities in HAI prevention and control. Geriatric patients, who are typically elderly and often comorbid with underlying conditions, have weakened immune defenses. The use of sterilization-defective instruments can easily lead to various HAIs, which may not only exacerbate the patient's condition but also pose life-threatening risks in severe cases. Some hospitals' CSSDs exhibit management deficiencies in the sterilization process, resulting in unstable sterilization compliance rates, thereby creating potential risks for geriatric infections. A systematic analysis of these factors holds significant clinical and managerial value.

2. Current status and influencing factors of sterilization compliance rate for medical devices in central sterile supply units

2.1. Current status of sterilization compliance rate for medical devices

Although some hospital disinfection supply centers have established basic procedures for instrument sterilization, the actual sterilization qualification rate still exhibits fluctuations. Certain hospitals lack comprehensive monitoring of sterilization quality, relying solely on physical and chemical monitoring during the sterilization process without emphasizing microbiological sampling of sterile items after storage. This results in substandard sterilized instruments potentially entering clinical settings. In some primary or older hospitals, disinfection supply center equipment updates are delayed, with sterilizers showing signs of aging and performance instability, potentially leading to suboptimal sterilization temperatures or insufficient sterilization time, directly affecting the efficacy of instrument sterilization. Additionally, some disinfection supply center staff exhibit lapses in adhering to sterilization protocols, such as exceeding instrument loading density limits or incorrectly setting sterilization parameters. These issues further hinder the maintenance of a consistently high sterilization qualification rate, posing risks to infection control in clinical departments, particularly geriatric care units.

2.2. Key factors affecting sterilization compliance rate of medical devices

Sterilization of surgical instruments is a critical measure for preventing hospital-acquired infections and a primary strategy to reduce infection rates. The effectiveness of sterilization for medical devices entering human tissues and organs directly impacts the threat of blood-borne diseases to public health. Thorough cleaning is a prerequisite for qualified sterilization, and the complete cleaning of surgical instruments is as important as disinfection and sterilization, as inadequate cleaning can compromise the efficacy of these processes. However, due to varying conditions and facilities across hospitals in China, the methods for cleaning and disinfecting surgical instruments differ. As a systematic task, the qualification rate of instrument sterilization is influenced by multiple factors. First, the quality of instrument cleaning: residual blood, tissues, or other organic matter not fully removed after use can form a "biofilm", hindering the action of sterilization agents. Some staff members may underestimate the importance of the cleaning phase, leading to simplified procedures or misuse of cleaning tools, which negatively affect subsequent sterilization outcomes. Second, the management of sterilization equipment and consumables: failure to perform regular maintenance and calibration of sterilizers or to conduct standardized performance verification can result in malfunctions such as temperature sensor failures. Additionally, inappropriate selection of

sterilization packaging materials or poor sealing performance may lead to contamination of sterilized instruments during storage or transportation. Finally, the standardization of personnel operations: some staff members lack a solid understanding of sterilization principles and the specific requirements for different types of instruments. Deviations in key operational aspects, such as instrument classification, loading density control, and sterilization parameter settings, can further compromise sterilization efficacy and cause fluctuations in the qualification rate.

3. Mechanism of the impact of sterilization compliance rate of medical devices in the central sterile supply unit on infection incidence in geriatrics

3.1. Sterile non-compliant instruments directly cause infections in geriatrics departments

In geriatric patient care, surgical instruments, puncture needles, urinary catheters, suction tubes, and other medical devices are frequently used. If these instruments fail to meet sterilization standards, residual pathogens such as bacteria, fungi, and viruses on their surfaces can be transmitted to patients through direct contact. The use of inadequately sterilized instruments during surgery allows pathogens to invade tissues via surgical incisions, leading to surgical site infections. Elderly patients have weaker wound healing capabilities, making them prone to post-infection complications such as wound redness, exudation, and delayed healing. In severe cases, systemic infections may develop. For elderly patients requiring long-term urinary catheterization, exposure to substandard sterilized catheters can introduce pathogens into the urethra, compromising the mucosal barrier and causing urinary tract infections. Additionally, the degeneration of urinary system function in elderly patients increases the likelihood of recurrent infections and complicates treatment. Substandard sterilized instruments serve as direct carriers of pathogens, constituting a significant predisposing factor for infections in geriatric care.

3.2. Increased variability in sterilization compliance rate and challenges in infection prevention and control in geriatrics

The long-term instability of sterilization compliance rates in the disinfection supply center compromises the sustained sterility of medical devices used in geriatric departments, leaving infection control efforts vulnerable to passive responses [1]. During periods of declining compliance rates, geriatric departments may experience multiple unexplained infections within a short timeframe. Given the concealed nature of sterilization issues, tracing infection sources in the early stages proves challenging, potentially leading to wider infection spread. To address fluctuations in sterilization compliance, geriatric departments must enhance infection monitoring frequency and adjust preventive measures, such as conducting secondary disinfection of used devices and strengthening patient infection screening. These measures increase the workload of healthcare staff and may delay optimal infection control opportunities due to untimely adjustments. The instability of sterilization compliance rates disrupts the continuity of infection prevention in geriatric departments, further elevating infection risks.

3.3. Low sterilization compliance rate affects overall diagnostic and therapeutic safety in geriatrics

A persistently low sterilization compliance rate for medical devices can have ripple effects on the overall safety of geriatric care. Frequent infection incidents may erode trust in hospital services among patients and their families, ultimately damaging the institution's reputation. Elderly patients requiring additional anti-infective therapy often experience aggravated underlying conditions, such as dramatic blood glucose fluctuations in diabetic patients or

heart failure in cardiovascular patients. This not only increases medical costs but also prolongs hospital stays, consuming limited healthcare resources. Should mass infections occur due to substandard sterilized equipment, it may trigger medical disputes and disrupt routine clinical operations. The low sterilization compliance rate indirectly compromises hospital quality and operational efficiency by compromising geriatric care safety.

4. Strategies to improve the sterilization compliance rate of instruments in the central sterile supply unit

4.1. Improve the quality management system for the entire process of instrument sterilization

The device recycling process requires the establishment of a classified recycling system to avoid mixing devices of different contamination levels, thereby reducing the risk of cross-contamination. Devices used by patients with specific infections must undergo closed-loop recycling and special labeling management to achieve risk control at the source. The cleaning process implements a standardized "cleaning-rinse-end rinse" procedure, equipped with dedicated cleaning equipment and agents. Complex devices such as arthroscopes and staplers are cleaned manually with assistance, while technologies like ATP biofluorescence detection are employed to objectively evaluate cleaning effectiveness, ensuring complete removal of organic matter. The sterilization process strictly adheres to a triple-monitoring system combining physical, chemical, and biological monitoring. Physical monitoring records parameters such as sterilization temperature, time, and pressure. Chemical monitoring involves attaching chemical indicator tape to each package of devices and placing chemical indicator cards inside the packages. Biological monitoring is conducted weekly, and a traceability mechanism linking monitoring results to sterilization batches must be established to ensure traceable sterilization efficacy and accountability [2]. A quality supervision team is formed to conduct regular spot checks on the quality of each process. Information systems are utilized to achieve electronic recording and analysis of quality data throughout the entire process, enabling data trend analysis to identify and address potential risks in a timely manner, ensuring controllable sterilization processes and continuous quality improvement.

4.2. Strengthen standardized management of sterilization equipment and consumables

Professional technicians must be regularly invited to perform maintenance and performance calibration of the sterilizer. A comprehensive equipment performance verification should be conducted annually to ensure that the sterilizer's temperature control accuracy, vacuum level, and steam quality meet standard requirements. Performance testing must be repeated after each equipment repair or key component replacement to prevent "operation with malfunctions". An equipment operation record should be established, detailing each usage time, sterilization batch, fault conditions, and repair information to facilitate traceability of equipment status. Additionally, a no-load B-D test should be performed daily before operation to verify the cold air exhaust efficiency of the pre-vacuum pressure steam sterilizer, ensuring the equipment operates at optimal conditions. In terms of consumable management, strict screening of sterilization packaging material suppliers is required, with non-woven fabrics and paper-plastic packaging bags compliant with national quality standards selected to ensure adequate barrier properties and breathability. A supplier quality evaluation and exit mechanism should be established, with quality sampling conducted before use to identify issues such as damage or poor sealing. Single-use sterile packaging materials must undergo strict access management and batch traceability. Sterilized

items should be stored according to specifications, with control over storage environment temperature, humidity, and ventilation conditions. The "first-in-first-out" inventory management principle should be implemented, with regular checks on the validity period of sterile items and packaging integrity to prevent packaging damage or microbial contamination during storage. This ensures reliable sterilization compliance from both equipment and consumable perspectives [3].

4.3. Strengthening the professional competency development of personnel in the central sterile supply unit

A tiered training program has been established, requiring new staff to undergo 3–6 months of systematic pre-job training. The curriculum covers principles of instrument cleaning and sterilization, operational protocols, infection control knowledge, and equipment usage methods, adopting a "theory + practice + on-the-job training" model. Experienced senior staff serve as mentors for one-on-one guidance, with independent job placement contingent upon passing assessments. On-duty personnel participate in quarterly professional training sessions to update their expertise in line with the latest industry standards and guidelines. These include interpreting new requirements of the "Hospital Sterile Supply Center Management Standards", learning advanced precision instrument handling and sterilization procedures, and incorporating interactive teaching methods such as case discussions and scenario simulations [4]. Regular skill operation assessments and case analysis meetings are organized to enhance staff's practical abilities and problem-solving skills through simulated instrument cleaning and sterilization operations and analysis of sterilization non-compliance cases. Assessment results are linked to job authorization, establishing a scientific performance evaluation mechanism. Key indicators such as sterilization compliance rate, adherence to operational protocols, and quality defect detection rate are incorporated into the evaluation system. Assessment outcomes correlate with performance distribution, excellence awards, and professional title promotions, incentivizing staff to shift from "quality demanded" to "quality desired", fostering a positive work culture and cultural awareness of "quality-focused, quality-driven" practices.

5. Conclusion

The sterilization compliance rate of medical devices in the Central Sterile Supply Unit (CSSU) is directly and closely associated with the incidence of infections in geriatric departments, with its level determining the robustness of the foundational defense against geriatric infections. Currently, some hospitals exhibit management deficiencies and operational issues in the sterilization of CSSU devices. These problems need to be addressed by improving the comprehensive quality management system, enhancing the management of equipment and consumables, and strengthening the professional training of personnel. Improving this compliance rate can reduce the incidence of geriatric infections, ensure patient safety in diagnosis and treatment, and promote the refined development of hospital infection control. Hospitals should continue to focus on sterilization quality, incorporate it into the infection control strategy, optimize relevant measures to achieve stable improvement in compliance rates, and provide strong support for infection prevention and control.

Disclosure statement

The authors declare no conflict of interest.

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Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Journal of Clinical and Nursing Research, 2026, Volume 10, Issue 1
http://ojs.bbwpublisher.com/index.php/JCNR
Online ISSN: 2208-3693
Print ISSN: 2208-3685

Proposal, Promotion, and Practice and Application of Damage Control Surgery Concept in Trauma Treatment at Grassroots Hospitals

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Abstract: The concept of Damage Control Surgery (DCS) emphasizes prioritizing hemorrhage control, preventing hypothermia, correcting coagulopathy, and acidosis in trauma treatment. The application of the DCS concept in trauma treatment at grassroots hospitals faces numerous challenges such as limited resources, high technical difficulty, and insufficient multidisciplinary collaboration. Therefore, DCS strategies need to be adapted to simplified processes to create conditions for subsequent treatment. This paper retrieves relevant literature to discuss the proposal, promotion, and application of the DCS concept, aiming to provide evidence-based basis for optimizing trauma treatment outcomes at grassroots hospitals.

Keywords: Damage control surgery; Concept promotion; Grassroots hospitals; Trauma treatment

Online publication: Feb 12, 2026

1. Introduction

Trauma is the leading cause of death among young and middle-aged people worldwide, and timely and effective treatment is crucial for reducing mortality [1]. Traditional surgical operations pursue thorough repair of injuries, but for patients with severe trauma who are already in pathological states such as shock, hypotension, coagulopathy, and acidosis, their physiological functions are at the limit of life. However, traditional operations require prolonged procedures, massive blood loss, and stress responses, which will further consume the patient's limited physiological reserves, leading to an increased risk of multiple organ failure [2,3]. Against this background, the concept of Damage Control Surgery emerged. Its core lies in adopting a phased treatment strategy to prioritize stabilizing the patient's vital signs and creating conditions for subsequent definitive surgery [4]. Since its proposal in the 1990s, the DCS concept has been rapidly promoted in the field of trauma medicine, becoming an important paradigm for treating patients with severe multiple injuries [5]. However, the application of the DCS concept at grassroots hospitals faces many challenges. For example, grassroots hospitals lack a sound trauma treatment system, advanced equipment, and technical personnel, making it difficult to fully implement the standardized

processes of the DCS concept. In recent years, with the advancement of the hierarchical diagnosis and treatment system and the strengthening of trauma center construction, grassroots hospitals have begun to actively explore the application model of the DCS concept. This study aims to sort out the development of the DCS concept, analyze its application status and problems in trauma treatment at grassroots hospitals, and provide reference for grassroots hospitals to improve their trauma treatment level. The specific report is as follows.

2. Literature search strategy

Domestic and foreign databases were searched, including CNKI, Wanfang Data, VIP Chinese Science and Technology Journal Database, PubMed, Embase, Web of Science, etc. Core keywords: Damage Control Surgery, Damage Control Concept, Trauma Management, Primary Hospital/Grassroots Hospital. Search time limit: from the establishment of the database to October 2025. Clinical studies (such as randomized controlled trials, cohort studies, case-control studies), systematic reviews, Meta-analyses, expert consensuses, and reviews were included, while non-systematic studies such as conference papers, dissertations, and case reports were excluded. High-quality studies were prioritized, such as those with clear research design, sufficient sample size, complete data, and reasonable statistical methods.

3. Problems faced by trauma treatment at grassroots hospitals

3.1. Shortage of talents and insufficient professional capabilities

(1) Grassroots hospitals refer to primary medical and health institutions that directly provide basic medical and public health services to residents in streets, towns, communities, or rural areas, including township hospitals at or below level 2, community health service centers, township health centers, village clinics, etc. Due to the general shortage of senior surgical talents in emergency medicine, orthopedics, neurosurgery, general surgery, etc., in grassroots hospitals, especially the insufficient number of professional physicians who have received systematic trauma treatment training [6].

(2) Most grassroots doctors lack an in-depth understanding of the DCS concept and are not proficient in key technologies such as trauma assessment, fixation, hemostasis, and transportation, making it difficult to accurately grasp the timing and extent of damage control in actual treatment, resulting in some patients failing to receive standardized treatment in a timely manner.

(3) Grassroots hospitals have relatively poor working conditions, insufficient software and hardware equipment, low salaries, and limited career development. Young and experienced medical staff tend to flow to large hospitals, leading to a talent shortage.

3.2. Lack of equipment and materials

(1) Emergency equipment such as ventilators, defibrillators, and monitors in grassroots hospitals are insufficient in quantity and aging, which cannot meet the treatment needs of trauma patients [7]. In addition, the reserves of blood products and emergency drugs are insufficient, especially in remote areas, which cannot meet the emergency blood transfusion needs of patients with traumatic massive hemorrhage.

(2) Most grassroots hospitals are equipped with imaging equipment such as CT and MRI, but often lack key equipment such as bedside portable ultrasound machines, bedside X-ray machines, thromboelastography machines, interventional surgery-related equipment (such as DSA, REBOA), and hybrid operating rooms, resulting in the inability to timely complete Focused Assessment with Sonography for Trauma (FAST) or

hemostatic resuscitation.

3.3. Non-standardized treatment processes

The trauma treatment process lacks standardization, early warning for severe trauma before admission is not timely, the connection between pre-hospital emergency care and in-hospital treatment is disconnected, the response efficiency of the green channel is low, and even some grassroots hospitals have not established a clear damage control resuscitation strategy. The choice of fluid resuscitation and surgical timing is arbitrary, which can exacerbate coagulation disorders. The postoperative monitoring and complication management processes are incomplete, affecting the patient's rehabilitation effect [8].

3.4. Lagging informatization construction

(1) The medical information systems between grassroots hospitals and superior hospitals have not achieved interconnection and interoperability, and the data formats of medical records, inspection reports, etc., are not unified and cannot be directly shared, affecting treatment decisions [9].

(2) Grassroots hospitals lack professional information technology personnel, and the support for telemedicine equipment and technology is insufficient, making it impossible to conduct timely remote consultations with superior experts to obtain professional guidance.

(3) Grassroots hospitals lack professional information management personnel, and their ability to train and apply new equipment and technologies is insufficient, affecting medical quality and safety.

4. Connotation and proposal background of the damage control surgery concept

Damage Control Surgery is a treatment concept for severe trauma or complex surgical diseases, whose core is to prioritize ensuring the patient's life safety through a phased treatment strategy [10]. At the beginning of the 20th century, surgical technology gradually advanced, but the mortality rate of patients with severe trauma remained high. In 1983, scholars such as Stone first proposed the concept of "damage control", emphasizing that when severe trauma leads to physiological disorders of the body, priority should be given to controlling fatal factors such as hemorrhage and contamination rather than pursuing a one-time perfect operation [11]. In 1993, Rotondo et al. formally defined it as "Damage Control Surgery" and clarified the process of phased treatment.

5. Promotion of the damage control surgery concept

5.1. International promotion

The DCS concept was first introduced in the treatment of abdominal trauma, and trauma centers in Europe and the United States took the lead in incorporating it into standard treatment processes. By shortening surgical time, controlling hemorrhage and contamination, the mortality rate of patients with severe trauma has been significantly reduced [12]. In recent years, the application scope of the DCS concept has expanded to fields such as orthopedics, vascular surgery, and cardiothoracic surgery, becoming an important strategy for the treatment of complex trauma and critical illnesses [13]. Academic organizations such as the American Association for the Surgery of Trauma (AAST) and the American College of Surgeons (ACS) have promoted the global dissemination of the DCS concept through seminars, training courses, and the publication of guidelines.

5.2. Domestic promotion

In 1997, Academician Li Jieshou first proposed the DCS concept in China and carried out theoretical demonstrations, animal experiments, and clinical studies, laying the foundation for the development of the DCS concept in China. From 2006 to 2015, the DCS concept gradually gained attention in China, and more and more hospitals began to try its application, such as in the treatment of abdominal trauma, severe burns, and multiple injuries [14]. Since 2016, the DCS concept has become an important treatment concept in fields such as trauma surgery and emergency medicine in China, widely used in hospitals at all levels. Many hospitals have incorporated the DCS concept into the trauma treatment process and established multidisciplinary collaborative teams to improve the success rate of treating patients with severe trauma. At the same time, a large number of academic conferences and training courses have been held in China to promote the popularization and standardized application of the DCS concept.

In recent years, through academic exchanges, training programs, and case sharing, the awareness of the DCS concept among doctors at grassroots hospitals has been significantly improved. Many grassroots hospitals have realized the importance of this concept in the treatment of severe trauma and multiple injuries and have begun to try its application in the treatment of abdominal trauma, pelvic fractures, etc., especially in controlling hemorrhage, reducing surgical time, and lowering complications [15].

6. Practice and application of the damage control surgery concept in trauma treatment at grassroots hospitals

6.1. Phase 1: Rapid damage control

Due to limited medical resources (equipment, blood sources, specialist strength) and technical level, the first phase of the practice of the DCS concept in trauma treatment at grassroots hospitals is “rapid damage control”, which is a key initial step. For patients with severe trauma whose physiological functions are on the verge of collapse, the attending emergency physician should abandon initial complex assessments and quickly complete a “rapid fatal risk screening” within 5 seconds to determine whether there is “life-threatening massive hemorrhage” (the core), whether they are in a dangerous environment, and whether emergency exposure/separation is required. Avoid delaying the handling of “fatal risks” due to step-by-step assessments.

For example, for visible massive hemorrhage on the body surface, such as limb artery rupture and large blood vessel injury in the neck/axilla/groin area, there is no need to wait for subsequent assessments, and the hemostasis procedure should be initiated immediately. A strong tourniquet (commercial CAT or SOF-T type) can be used to bandage the proximal end of the bleeding limb or compress and bandage the bleeding wound; for patients with occult massive hemorrhage and unstable hemodynamics, such as massive intrathoracic hemorrhage, cardiac tamponade, and rupture of intra-abdominal parenchymal organs, “assessment while treatment” is required, and “thoracotomy or laparotomy” should be performed as early as possible to avoid delaying the treatment timing due to waiting for sufficient blood sources, stable vital signs, or CT and other imaging results. In addition, it should be emphasized that at the pre-hospital treatment scene, the attending physician needs to quickly assess whether the environment where the patient is located poses an immediate danger to the patient or rescuers. The core is to “first escape danger, then implement treatment” to avoid secondary injuries caused by environmental risks. For example, at traffic accident scenes (unextinguished vehicles, risk of secondary collision), fire/explosion scenes, high-altitude fall scenes (fall of remaining objects), electric shock environments, etc., the patient needs to be quickly transferred

to a safe area. If the patient is suspected of spinal fracture, transfer should be performed while maintaining a neutral spinal position to avoid aggravating spinal cord injury. Faced with a complex treatment environment, only by simplifying operational strategies can time and conditions be gained for subsequent rescue and treatment.

6.2. Phase 2: Fluid resuscitation in trauma units

The resuscitation phase in trauma units of grassroots hospitals faces dual challenges of resources and technology, but it is still a key link determining patient prognosis. Feasible measures include:

(1) Prioritize equipping with portable ultrasound, simple hemostatic instruments, and rapid detection equipment to ensure timely Focused Assessment with Sonography for Trauma (FAST) and coagulation function monitoring. Use dynamic monitoring technology to real-time assess hemodynamic status and adjust fluid infusion speed according to indicators such as pulse pressure variation and cardiac output.

(2) Use bedside thromboelastography to real-time monitor coagulation function and guide the transfusion of blood products based on the results.

(3) Adopt body cavity lavage rewarming, intravenous infusion of warmed fluids (37–40°C), and combine with warm air blankets, heating mattresses, and other equipment to quickly raise the patient's core temperature above 36 °C.

(4) Establish a Trauma Team Activation (TTA) group, and work collaboratively with a Multidisciplinary Team (MDT) including surgery, anesthesia, ICU, and laboratory departments to formulate standardized resuscitation processes and clarify the time nodes and division of responsibilities for each link.

6.3. Phase 3: Definitive surgery

After the patient's condition stabilizes, grassroots hospitals select the appropriate timing for definitive surgery according to their own capabilities and the patient's situation.

(1) Use minimally invasive technologies such as laparoscopy and thoracoscopy for definitive surgery to reduce surgical trauma and blood loss, shorten surgical time, and lower the risk of infection.

(2) For vascular injuries, customized vascular grafts or vascular stents are used for reconstruction according to the location and degree of injury.

(3) Introduce tissue-engineered skin, tendons, bones, and other repair materials for covering wounds and repairing defective tissues.

(4) With the help of intraoperative three-dimensional image navigation systems, real-time locate the injury site and surrounding tissue structures, and dynamically adjust the surgical strategy according to the patient's physiological status in combination with real-time monitoring equipment such as hemodynamics and coagulation function.

(5) Establish a green channel for trauma treatment, integrate multidisciplinary teams such as surgery, critical care medicine, anesthesia, and imaging, and realize the whole process from preoperative assessment, surgical implementation to postoperative rehabilitation.

6.4. Application effects

Against the background of limited resources and relatively weak trauma treatment capabilities at grassroots hospitals, the application of the DCS concept has not only optimized the treatment process but also highlighted its unique adaptability and advantages. Scholars such as Yang Mei selected 100 emergency critically ill trauma

patients as research objects, and the results showed that the rescue success rate of the observation group was higher than that of the control group ($p < 0.05$), indicating that the DCS concept helps improve the rescue success rate [16]. By controlling massive hemorrhage, repairing life-threatening organ injuries and other measures, Damage Control Surgery prioritizes handling life-threatening injuries, stabilizes vital signs, gains valuable treatment time for patients, and improves the success rate. Scholars such as Li Xiaodong selected the clinical data of 120 patients with severe abdominal trauma and acute abdomen, and the results showed that the indwelling time of drainage tubes, postoperative exhaust time, eating time, and hospital stay of patients treated with Damage Control Surgery were shorter than those of the control group; the incidence of postoperative complications such as infection and anastomotic leakage was significantly lower than that of the control group ($p < 0.05$), indicating that the DCS concept helps promote patient recovery and reduce the incidence of complications [17]. This concept emphasizes avoiding further damage to the patient's physiological functions caused by excessive surgery. Through phased treatment, sufficient internal environment adjustment and organ function support are obtained during the resuscitation phase, which helps reduce the risk of complications and improve the quality of rehabilitation.

7. Conclusion

Since its proposal in the 1980s, the concept of Damage Control Surgery has continuously developed and become a core strategy in the field of trauma treatment. At grassroots hospitals, although the application of the DCS concept faces challenges such as insufficient equipment and inadequate training, significant progress has been made by simplifying surgical processes, strengthening multidisciplinary collaboration, and optimizing transfer mechanisms; secondly, through the in-depth assistance model of "Grade A tertiary hospitals–grassroots hospitals", carry out trauma treatment simulation drills and damage control resuscitation technology training, focusing on improving the capabilities of emergency assessment, hemostasis, resuscitation, performance of definitive surgery, and postoperative intensive care. In the future, with the deepening of technological innovation and regional collaboration, the DCS concept will be further integrated into the grassroots emergency process, providing more effective evidence for improving the level of grassroots trauma treatment.

Disclosure statement

The authors declare no conflict of interest.

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Publisher's note

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Journal of Clinical and Nursing Research, 2026, Volume 10, Issue 1
http://ojs.bbwpublisher.com/index.php/JCNR
Online ISSN: 2208-3693
Print ISSN: 2208-3685

Research on the Clinical Outcomes of Surgical Treatment for Patients with Oral and Maxillofacial Tumors

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Abstract: Due to the special anatomical location, complex functions, and significant impact on patients' appearance and psychology, the treatment of oral and maxillofacial tumors has always been a key and difficult issue in the field of head and neck surgery. With the rapid development of surgical technology, microsurgical reconstruction technology, perioperative management, and multidisciplinary treatment models, surgical treatment has occupied a core position in the comprehensive treatment system of oral and maxillofacial tumors. Based on this, this paper conducts research on the clinical outcomes of surgical treatment for patients with oral and maxillofacial tumors, expounds the optimization strategies of surgical treatment, and analyzes the clinical effects of the optimized surgical treatment, aiming to provide a reference for the clinical treatment of oral and maxillofacial tumors.

Keywords: Oral and maxillofacial tumors; Surgical treatment; Clinical outcomes; Optimization strategies

Online publication: Feb 12, 2026

1. Introduction

The oral and maxillofacial region includes multiple important anatomical structures such as the oral cavity, jawbones, salivary glands, facial skin, and soft tissues. For tumors occurring in this region, whether benign or malignant, treatment decisions need to seek a difficult and precise balance between eradicating the disease, preserving functions, and maintaining appearance. Historically, radiotherapy was one of the main treatment methods for certain types of oral cancer, especially early lesions. However, the particularity of this region and the limitations of radiotherapy itself have promoted the continuous innovation and development of surgical treatment [1]. Currently, surgical treatment has become the preferred or core treatment method for most solid oral and maxillofacial tumors, especially malignant ones, due to its advantages of achieving complete tumor resection, providing accurate pathological staging, and performing functional repair and reconstruction simultaneously. Therefore, exploring the clinical outcomes of surgical treatment for patients with oral and maxillofacial tumors is of great significance.

2. Existing problems of traditional radiotherapy methods

Radiotherapy is a physical therapy that relies on ionizing radiation for treatment. Its basic principle is to inhibit the proliferation of cancer cells by damaging the DNA structure of tumor cells, thereby achieving clinical cure. In the multidisciplinary combined treatment system of oral and maxillofacial malignant tumors, although traditional radiotherapy can partially change the trend of disease progression, due to the complex anatomical structure and high tissue density of this region, conventional radiotherapy is difficult to achieve precise irradiation positioning, leading to various risks and challenges. These problems are mainly manifested in the following aspects.

2.1. Poor postoperative local tissue function recovery

The oral and maxillofacial region contains various sensitive tissue systems, mainly involving core parts such as nerves, blood vessels, muscles, and glands. Traditional radiotherapy is difficult to accurately avoid surrounding normal structures, easily causing regional hemorrhage, edema, or fibrosis, and reducing the speed of body function recovery; if oral glands are damaged, symptoms such as secretory disorders, thirst, and dry lips will occur, bringing great inconvenience to patients' eating and speech. In addition, damage to muscle tissue can also result in limited mouth opening and weakened masticatory muscle strength. For the nervous system, in addition to affecting facial sensory function, symptoms such as hyperalgesia can also occur, seriously affecting the quality of life of patients after surgery. The damage caused by the above radiation is often irreversible and will persist after the end of radiotherapy. Relevant organs still cannot return to normal physiological functions, which long-term damages the patient's physical health [2].

2.2. Insufficient treatment accuracy and limited local control effect

Traditional radiotherapy locates and delineates the target area based on imaging information, making it difficult to distinguish the boundary between tumors and surrounding normal tissues, resulting in a large irradiation field that damages normal tissue cells with uneven dose distribution; at the same time, the irradiation dose received by local lesions is insufficient to achieve a curative effect. For head and neck tumors with deep and complex shapes, the existing means still have deficiencies in radiation energy and accuracy, resulting in the irradiation field not fully covering the target area and reducing the local control rate; some cancer cells are resistant to ionizing radiation, thereby reducing the effectiveness of conventional treatment and leading to poor prognosis of patients [3].

2.3. Adverse effects on patients' long-term prognosis and function preservation

Long-term prognosis and function preservation are important indicators for evaluating the treatment effect of oral and maxillofacial tumors. Due to the significant damage to normal tissues caused by traditional radiotherapy, it will not only lead to various functional disorders in patients after surgery but also trigger a series of long-term complications, such as osteoradionecrosis, radiation caries, and facial soft tissue atrophy. These complications will further aggravate the patient's damage and affect the patient's long-term quality of life [4]. The local control effect of traditional radiotherapy is limited, and the tumor recurrence rate is relatively high. The treatment of recurrent tumors is more difficult, and the patient's survival rate will also decrease significantly. The destruction of facial appearance and functional disorders will also bring a serious psychological burden to patients, causing psychological problems such as anxiety and depression, which affect the patient's treatment compliance and long-term prognosis.

3. Optimization strategies for surgical treatment of patients with oral and maxillofacial tumors

To overcome the drawbacks of traditional treatment methods and enhance the diagnosis and treatment effect of oral and maxillofacial tumors, systematic improvement and strengthening should be carried out for the current treatment steps from three key nodes: preoperative evaluation, surgical operation, and postoperative management, to realize the full combination of precision medicine and efficient recovery.

3.1. Preoperative precision evaluation and personalized surgical plan formulation

Preoperative precise evaluation is the key basis for formulating personalized surgical plans and the core guarantee for improving treatment effects. During evaluation, multimodal imaging examination technology should be used to comprehensively analyze the anatomical characteristics, location, size, shape, infiltration degree, and regional lymph node metastasis of the tumor, combined with various factors such as the patient's overall health status. Currently, commonly used technical means include oral and maxillofacial CT, MRI, and ultrasound imaging. CT and MRI can accurately show the spatial relationship between the tumor and surrounding structures and its extension range; ultrasound is suitable for detecting cervical lymph node status; pathological biopsy can determine the histological type and differentiation degree, providing a reliable basis for clinical decisions [5]. Based on precise evaluation, an individual surgical plan should be established according to the patient's individual situation. If the tumor is small in size and limited in infiltration range, local resection can be adopted first to completely remove the lesion while preserving surrounding normal tissues and functional structures as much as possible; if the tumor is large in size and highly invasive, extended radical resection should be performed, and neck lymph node dissection should be combined if necessary to greatly reduce the recurrence rate; if the lesion involves important facial areas or key organ systems, functional protection and aesthetic repair needs should be considered in the initial design, and auxiliary means such as flap transfer and bone reconstruction should be arranged in advance to achieve both postoperative appearance optimization and physiological function recovery. In addition, age factors and other possible health risks should be considered, the risks related to surgery should be comprehensively weighed, and targeted interventions should be implemented to effectively ensure the safety of diagnosis and treatment and the achievement of expected curative effects [6].

3.2. Intraoperative precision operation and integrated application of minimally invasive technology

Precise surgical operation is a key factor in improving clinical efficacy and reducing tissue damage. During diagnosis and treatment, advanced equipment and technical means should be used to perform precise resection of tumor lesions, and efforts should be made to protect the safety of adjacent normal tissues and important neurovascular structures. For example, the intraoperative navigation system can real-time feedback the spatial positional relationship of instruments, providing efficient positioning assistance for surgeons and preventing operational errors due to visual limitations; intraoperative frozen pathological examination can determine whether the margin status meets the standards in a short time, so as to ensure the complete removal of cancerous parts, thereby greatly reducing the possibility of local recurrence. The use of minimally invasive technology not only reduces the scope of surgical wounds but also improves the efficiency of patients' postoperative recovery [7]. Currently, this technology is widely used in the treatment of oral and maxillofacial tumors and is gradually expanding towards diverse directions such as endoscopic assistance and robotic intervention. Precise operation

with endoscopes shows unique advantages in tumor resection in complex anatomical regions due to its small incisions, excellent field of view, and low bleeding rate; robotic surgery performed with high-precision mechanical arms and high-definition imaging systems further improves the diagnosis and treatment effect and ensures operational safety with its excellent spatial positioning ability. During clinical operations, strict adherence to sterile principles should be followed to prevent infection risks, and the total operation time should be reduced through refined process design to prevent tissue ischemic damage and related complications [8].

3.3. Construction of a postoperative multidimensional rehabilitation management system

Postoperative rehabilitation management is a key link in tissue function recovery and improvement of patients' quality of life, which is of great significance. Clinically, a systematic management model including physiological regulation, psychological intervention, nutritional support, and other aspects should be established to provide theoretical support for the comprehensive rehabilitation of patients, and personalized nursing strategies should be implemented to achieve the best curative effect. In terms of rehabilitation medicine, personalized training plans should be formulated to comprehensively assess the patient's surgical type and postoperative recovery status [9]. For example, for individuals after oral and maxillofacial surgical reconstruction, special training such as masticatory muscle group exercise, swallowing function improvement, and articulatory organ coordination should be carried out in stages to promote the recovery of various functions to normal. If the patient is accompanied by symptoms such as local swelling and pain, measures such as alternating hot and cold therapy and ultrasonic physical therapy can be used to improve blood circulation and relieve discomfort. At the same time, the wound care process should be strictly followed, dressings should be changed regularly, the wound should be cleaned correctly, the wound healing status should be closely observed, and potential infections, bleeding, and other conditions should be detected and resolved as early as possible. In terms of psychological intervention, since oral and maxillofacial tumor surgery will affect the patient's facial appearance and physiological functions, it is easy to cause negative emotions such as anxiety, depression, and damaged self-esteem in patients [10]. Therefore, it is necessary to focus on doctor-patient communication, pay close attention to the patient's psychological changes, and provide personalized psychological support services in a timely manner; cases of treatment effects and successful rehabilitation of related diseases can be shown to patients to enhance their treatment confidence; it is recommended that the patient's family also pay more attention to and support the patient to help reduce postoperative stress reactions and promote the smooth progress of the postoperative recovery process [11]. In terms of nutritional support, postoperative patients are at risk of insufficient nutritional intake due to limited chewing and swallowing functions. A nutritional support plan should be formulated according to the individual recovery process. For example, in the early postoperative period, patients can be provided with liquid or semi-liquid diets, and adequate protein and vitamin supply should be ensured to facilitate wound healing and body rehabilitation; as the patient's physiological functions gradually improve, they can gradually transition to a normal diet mode. Health education and guidance should also be strengthened to avoid irritating foods such as spicy and hard foods, thereby reducing the risk of oral mucosal injury [12].

4. Clinical outcomes of surgical treatment for patients with oral and maxillofacial tumors

By implementing optimization strategies such as preoperative precision evaluation, intraoperative precision

operation combined with minimally invasive technology, and postoperative multidimensional rehabilitation management, the clinical outcomes of surgical treatment for patients with oral and maxillofacial tumors have been significantly improved, mainly reflected in various aspects such as postoperative tissue function recovery, postoperative complication rate, patient's quality of life, and psychological state.

4.1. Significant effect on postoperative tissue function recovery

The optimized surgical treatment plan relies on preoperative precise evaluation and personalized planning, which not only ensures the complete resection of tumor tissue but also preserves the patient's normal anatomical structure and physiological functions as much as possible. The application of precise technology and minimally invasive methods during the implementation process greatly reduces the risk of damage to important tissues such as surrounding nerves, blood vessels, and muscles, providing a solid guarantee for postoperative functional reconstruction. The subsequent formulated systematic rehabilitation exercise plan also promotes the effective recovery of functions such as chewing, swallowing, and speech [13]. Compared with traditional radiotherapy, this therapy has significantly improved the overall recovery effect of oral and maxillofacial functions. Most subjects can gradually achieve self-care in diet and recovery of language communication ability, maintaining good facial appearance characteristics, thereby greatly reducing the decline in quality of life caused by functional impairment.

4.2. Effective reduction in postoperative complication rate

Traditional radiotherapy causes significant damage to surrounding tissues, which is likely to lead to symptoms such as dry mouth, mucosal ulceration, limited mouth opening, and osteomyelitis. The updated surgical plan reduces trauma and infection to a lower level through intraoperative precise operation, maintenance of a strict sterile environment, and application of minimally invasive technology; under the established sound wound management and comprehensive follow-up mechanism after surgery, most potential disease risks can be detected and addressed early. This new plan can effectively reduce the incidence of complications. For common manifestations such as delayed wound healing, wound bleeding, or local swelling, they can be successfully controlled under professional and technical care. The patient's entire condition converges rapidly, the length of hospital stay is significantly reduced, and the feeling of mental fatigue is alleviated [14].

4.3. Significant improvement in patients' quality of life and psychological state

Quality of life and psychological state are key comprehensive indicators for evaluating the treatment effect of patients with oral and maxillofacial tumors. The optimized surgical treatment plan not only improves the patient's postoperative tissue function and reduces the incidence of complications but also provides psychological intervention and nutritional support after surgery, relieving the patient's negative psychological emotions such as anxiety and depression and improving the psychological state. With the gradual recovery of the patient's facial appearance and physiological functions, self-confidence is significantly enhanced, and they can face life with a more positive attitude. The recovery of normal physiological functions enables patients to re-participate in social activities such as social interaction and work, and their quality of life is improved. Compared with patients after traditional radiotherapy who have a low quality of life due to functional disorders and psychological problems, the overall quality of life of patients after surgical treatment has been qualitatively improved [15].

5. Conclusion

In summary, in the treatment pattern of oral and maxillofacial tumors, radiotherapy and surgical treatment each have their clear positions and indications. However, for resectable lesions, especially advanced lesions, modern surgical treatment has shown more definite tumor eradication ability, more proactive functional recovery strategies, and a more manageable complication spectrum compared with traditional radiotherapy through comprehensive optimization of its technology. With the continuous development of medical technology, more precise and minimally invasive surgical treatment technologies should be further explored, postoperative management plans should be improved, the treatment effect should be continuously enhanced, the clinical prognosis of patients should be improved, and the harm of the disease to patients' physical and mental health should be further reduced.

Disclosure statement

The author declares no conflict of interest.

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Journal of Clinical and Nursing Research, 2026, Volume 10, Issue 1
http://ojs.bbwpublisher.com/index.php/JCNR
Online ISSN: 2208-3693
Print ISSN: 2208-3685

A Case of Severe Trauma with Iliac Vascular Injury was Treated using a Time-Based Chain Approach

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Abstract: Severe trauma often involves complex injuries, leading to high disability and fatality rates. Effective treatment requires prompt and coordinated efforts across multiple disciplines to enhance success rates. Time-based chain rescue is crucial in managing severe trauma. A patient with chest and abdominal injuries and hemorrhagic shock was transferred from an ambulance to our hospital. Our trauma team-initiated pre-hospital first aid, utilized an emergency green channel, and conducted rapid ultrasound, collaborating across disciplines. The patient eventually recovered and was discharged.

Keywords: Severe trauma; Hemorrhagic shock; Time point of trauma; Chain-type treatment

Online publication: Feb 12, 2026

1. Introduction

With societal development, trauma has become the fifth leading cause of death globally, while severe trauma has emerged as the primary cause of death among young and middle-aged adults in China [1,2]. Severe trauma is often caused by violent factors such as falls from heights, traffic accidents, and workplace injuries. These patients present with critical conditions that progress rapidly, frequently leading to multi-tissue and multi-organ dysfunction. Such injuries are often accompanied by adverse events like massive hemorrhage and vascular occlusion. The key factor for patient survival is receiving timely, accurate, and highly efficient team-based treatment within a short timeframe [3]. This study presented a case report of a patient with severe trauma complicated by iliac vascular injury admitted to the Emergency Trauma Center of Changzhou Seventh People's Hospital. Drawing on our center's clinical experience in managing such cases, we discuss the diagnosis and treatment of severe trauma complicated by iliac vascular injury, aiming to provide insights for the management of similar trauma patients.

2. Case data

Patient, male, 58 years old, laborer. On July 5, 2024, at 08:50, he was transported to the hospital via 120 emergency services after being struck in the chest and abdomen by a steel pipe for 10 minutes. At 08:40, while working, the patient was accidentally struck in the chest and abdomen by a steel pipe. Immediately after the injury, he developed abdominal pain that progressively worsened, accompanied by numbness in the right lower limb. The prehospital emergency physician assessed the patient as conscious with a distressed expression. Physical examination findings: Temperature: 36.8 ℃, Heart rate: 125 beats/min, Blood pressure: 102/81 mmHg, Oxygen saturation: 90%. TISS score: 17. Intravenous access was established for fluid resuscitation, supplemented with oxygen via face mask. Preliminary assessment indicated the patient met the criteria for "Ambulance Critical Trauma Patient Early Warning" and was triaged via telephone alert to the emergency department. At 09:15, the ambulance arrived at the emergency department. The patient was admitted directly to the resuscitation room via the green channel. The emergency surgeon examined the patient: T 36.6 ℃, heart rate 135 bpm, blood pressure 92/78 mmHg, oxygen saturation 95%, shock index 1.47, altered mental status, agitated and restless, unable to communicate verbally. No external head injuries. Bilateral pupils equal and round, diameter 3 mm, with active light reflexes. Scattered contusions on chest and abdominal walls. Right lower abdomen purple and swollen. Right thigh swollen with limited mobility. Patient uncooperative for remainder of examination. No significant past medical history; denies history of hypertension, diabetes, coronary heart disease, or other chronic conditions. 09:20 Initial assessment completed. Preliminary diagnosis: 1. Multiple trauma: Thoracic injury, abdominal injury, vascular injury? 2. Complication of injury: Traumatic hemorrhagic shock. 09:25 Bedside rapid ultrasound reveals splenic hematoma, perihepatic hematoma, and pelvic hematoma. The patient is in critical condition. Immediately activate the trauma response team. Simultaneously initiated emergency transfusion protocol. At 09:30, completed central venous catheterization and administered tranexamic acid for hemostasis, supplemented with analgesic and sedative therapy. At 09:48, commenced infusion of 2 units of Type A red blood cells and 200 mL of frozen plasma. At 09:55, completed plain and contrast-enhanced CT scans of the chest and abdomen (see **Figure 1**). Examination findings: Fracture of the left 11th rib; suspected splenic rupture with subcapsular hematoma, minimal perihepatic hemorrhage, and pelvic hematoma; occlusion of the right iliac artery. ISS score: 27. Admitted to the operating room at 10:00 for surgery. Intraoperatively, complete transverse transection of the small intestine and mesentery in the right lower abdomen was observed, with bleeding from the mesenteric stump (see **Figure 2**). Partial small bowel resection with intestinal anastomosis and mesenteric repair was performed. Surgery concluded at 12:25, with the patient's vital signs gradually stabilizing. At 13:40, the Interventional Radiology Department conducted percutaneous selective angiography, confirming occlusion of the right external iliac artery (see **Figure 3**). Right external iliac artery stenting was performed, followed by right iliac artery balloon angioplasty and right external iliac artery thrombectomy. Good blood supply was restored to the external iliac artery (see **Figure 4**). The patient was admitted to the ICU for further treatment postoperatively. The patient was discharged in good condition on July 31, 2024.

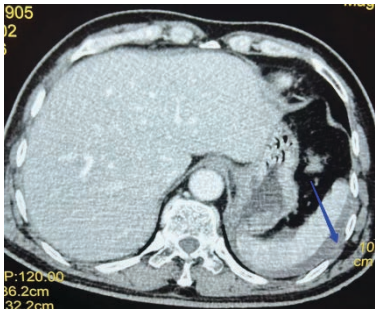

Figure 1. Abdominal CT reveals intra-abdominal hemorrhage.

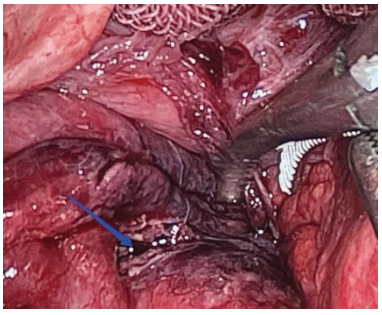

Figure 2. Intraoperative findings reveal intestinal perforation and mesenteric hemorrhage.

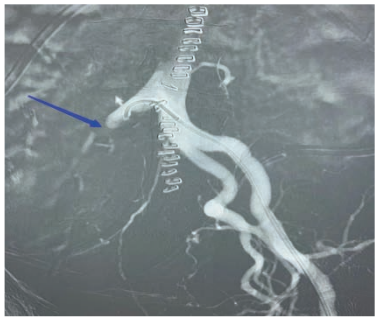

Figure 3. Contrast imaging reveals occlusion of the external iliac artery.

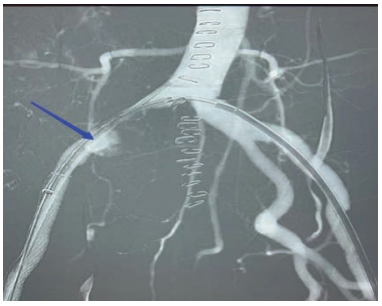

Figure 4. Lateral iliac artery recanalization.

3. Discussion

Multiple trauma constitutes a distinct disease category, and how to provide more effective treatment for patients with severe multiple injuries has become a hot topic and major challenge in the field of emergency medicine [4]. The previous treatment model primarily involved transporting patients to the emergency department for initial care. Upon admission, emergency physicians would sequentially call for specialist consultations based on the location and severity of injuries. This approach resulted in prolonged treatment times, low efficiency, and a lack of comprehensive treatment capabilities [5]. Patients with this condition often present a "triple contradiction": the contradiction between the complexity of injuries and the urgency of treatment, the contradiction between multiple organ injuries and the fragmentation of specialized care, and the contradiction between high treatment costs and uncertain prognosis [6]. The traditional treatment model reveals three major shortcomings: 1. Time delay: Studies indicate that the average time from hospital admission to surgery for severely injured patients reaches 118 minutes, with mortality increasing by 12% for every 30-minute delay [7]. 2. Inefficient collaboration: The single-specialty consultation model increases decision-making time by over 40%. 3. Fragmented resources: A study by Peking Union Medical College Hospital indicates that the lack of an integrated treatment system reduces medical resource utilization by 35% [8]. The International Trauma Care Consortium (ITACCS) proposes the "Time Window Theory", emphasizing that the first 60 minutes post-injury constitute the golden hour for critical care. Within this period, the initial 10 minutes (the platinum hour) determine the survival rate for 80% of hemorrhagic shock patients [9]. Recent studies suggest that improving critical care for severely injured patients requires shifting from individual efforts to collaborative teamwork, and replacing tiered consultations and hierarchical reporting with rapid response, swift

decision-making, and prompt treatment by team members, a necessary approach to enhance the quality of care for critically injured patients [10].

Starting in June 2023, our hospital implemented a time-based chain-of-care approach for treating severely injured patients, which essentially represents a restructuring of the trauma care process. The system encompasses two major modules: pre-hospital emergency care and in-hospital treatment. It establishes standard timelines for each treatment phase, dividing complex resuscitation procedures into distinct time-based milestones. Each milestone is assigned a target time threshold, with individual accountability assigned for resuscitation responsibilities. This approach breaks away from traditional sequential workflows, enabling simultaneous execution of diagnostic procedures and resuscitation efforts. The successful treatment of this patient was achieved through the hospital's time-based chain-of-care model and the comprehensive trauma-related specialty care capabilities.

This patient's journey from injury to operating room took only 80 minutes (injured at 08:40, surgery commenced at 10:00). The 15-minute rapid prehospital transport secured critical time for subsequent treatment, aligning with findings reported by Liu Haixia et al. on the effectiveness of "battle trauma treatment centers". Through prehospital alerts and pre-positioned hospital teams, the time to resuscitation for critically ill patients can be reduced to under 45 minutes. The core advantages of this model are twofold: First, it enables earlier intervention by initiating critical care measures, such as establishing intravenous access and maintaining vital signs, during the prehospital phase to prevent deterioration. Second, it facilitates resource prepositioning through an "ambulance critical care alert" mechanism, allowing the hospital trauma team to prepare personnel, equipment, and blood products before patient arrival, significantly accelerating response times. During the prehospital emergency phase, prehospital emergency physicians rapidly conduct trauma assessments and initiate prehospital resuscitation. The 5G transmission system enables real-time sharing of vital signs. Establishing intravenous access for fluid resuscitation and administering oxygen via face mask maintains blood oxygen levels, alleviating patient anxiety while stabilizing vital functions. Seamless coordination with hospital emergency triage reduces in-hospital handover time and minimizes preparation delays for in-hospital resuscitation. Rapid prehospital treatment and transport lay the foundation for subsequent in-hospital care, achieving "hospital admission upon arrival".

Treatment time is an independent factor influencing the prognosis of patients with severe trauma. Zhang Jigang et al. confirmed through a study of 1,263 trauma patients that those with a pre-hospitalization delay exceeding 60 minutes had a 30-day mortality rate 2.3 times higher than patients with delays under 30 minutes. In this case, the treatment process strictly adhered to critical time points at each stage, with a total emergency room and resuscitation time of 45 minutes. This fully complies with the "time-sensitive" principle for managing severe trauma. During the in-hospital resuscitation phase, our trauma resuscitation team comprises emergency department and trauma center medical staff with clearly defined responsibilities. Each team consists of 3 physicians and 2 nurses: Physician C handles endotracheal intubation, airway protection, and central venous catheterization. Nurse A manages venous access, while Nurse B is responsible for blood collection and medication preparation. Upon receiving prehospital emergency notification for a severely injured patient, the hospital immediately activates its emergency response team. A green channel is opened upon the patient's arrival. Within 5 minutes of admission, initial assessment and venous blood sampling are completed. Within 10 minutes, bedside rapid ultrasound confirms visceral bleeding, triggering the trauma team response. Deep venous catheterization is completed within 15 minutes. Blood transfusion begins within 33 minutes. Contrast-enhanced CT is completed within 40 minutes. The patient enters the operating room for surgery within 45 minutes. The rescue process is

seamlessly interconnected, minimizing the time patients with severe trauma spend waiting for treatment while enhancing the continuity and rigor of care. The efficient implementation of this process relies on three key measures: First, the application of standardized assessment tools, the TI score (17 points) is used pre-hospital to rapidly identify critically ill patients, while the ISS score (27 points) is employed in-hospital to quantify injury severity, providing objective criteria for determining treatment priorities. Second is the integration of point-of-care rapid diagnostic technologies: Bedside ultrasound (FAST examination) can identify splenic, hepatic, and pelvic hemorrhages within 10 minutes, eliminating the time delays associated with traditional imaging studies. This aligns with the "ultrasound-guided injury control" concept proposed by Du Zhe et al., the technique elevates the diagnostic accuracy for intra-abdominal hemorrhage to 92%, significantly reducing decision-making time for surgical interventions. Finally, the optimization of the emergency transfusion process: From initiating the transfusion protocol to commencing red blood cell infusion took only 18 minutes (09:30–09:48). This achievement stems from the hospital's implementation of a "rapid blood transfusion pathway for trauma patients". Through measures such as pre-stocking blood and rapid ABO blood typing, the traditional transfusion preparation time was reduced by 50%. Precise control of critical time points not only enhances rescue efficiency but also enables visual management of treatment quality through "timeline tracing". In this case, each operational node is documented, providing data support for subsequent process optimization. This aligns with the findings of comparative studies by Jiang Shirong et al., the integrated trauma emergency model achieves a 68% higher treatment documentation completeness rate than traditional models, facilitating continuous improvement.

The primary challenge in treating this patient lies in the combination of abdominal organ injuries and iliac vascular injuries, requiring on-site decision-makers to possess multidisciplinary trauma management capabilities. Iliac vascular injuries occur in approximately 3–5% of severe trauma cases, yet carry a mortality rate as high as 40–60%, primarily due to uncontrollable massive hemorrhage and subsequent distal limb ischemia and necrosis [11]. This patient also presented with a ruptured mesentery and intra-abdominal hemorrhage, significantly increasing the complexity of treatment. Research has demonstrated that the MDT model can reduce treatment decision errors in complex trauma patients by 42% and increase treatment success rates by 27%. In this case, our department established a clear sequence of "damage control first, staged reconstruction second" through preoperative discussions, thereby avoiding the limitations of single-specialty decision-making. This approach was crucial to the successful treatment. Following thorough consultation between the Trauma Center and the Vascular Intervention Department, exploratory laparotomy is performed first to identify the bleeding site, followed by damage control surgery (DCS). Definitive surgery is then conducted by the relevant specialty. This strategy aligns with the damage control surgery (DCS) concept recommended by the International Trauma Society, for patients with an ISS score > 25, the mortality rate for definitive surgery performed in a single stage reaches 58%, whereas DCS reduces mortality to 29% [7]. During the emergency room phase, through the collaborative efforts of the emergency trauma team, the patient was smoothly transferred to the operating room with a delay time of 45 minutes. In the surgical phase, the trauma center performed exploratory laparotomy to confirm the diagnosis, followed by intestinal resection and mesenteric repair to promptly "turn off the tap" and control bleeding. Once vital signs stabilized, the patient was transferred to the interventional radiology department for vascular management, where endovascular intervention was performed, achieving rapid vascular recanalization. Endovascular therapy has now become the preferred treatment for iliac artery occlusion. Studies indicate that the vascular recanalization rate achieved through endovascular therapy is comparable to that of open surgery, while offering advantages such as minimal trauma, rapid postoperative recovery, and shorter hospital stays. Additionally, endoscopic treatment

avoids the trauma of secondary surgery, making it particularly suitable for patients with concomitant abdominal infections or coagulation disorders. This aligns with the rapid postoperative recovery observed in this case. The patient underwent intensive care unit (ICU) monitoring postoperatively, receiving anti-inflammatory therapy and treatment to correct coagulation dysfunction. The patient recovered well and was discharged successfully 26 days after surgery.

One of the key factors in this patient's survival was the timely provision of effective treatment. The timeliness of trauma care demonstrates that patients can achieve optimal therapeutic outcomes through interventions administered within a specific "time window". The successful treatment of this patient was achieved by the hospital's implementation of a severe trauma timeline as the central framework. By using time as the key metric, the hospital integrated pre-hospital and in-hospital care, strictly controlled the duration of each treatment phase, and enhanced the efficiency of the rescue efforts. This approach ensured the patient received effective treatment within the shortest possible timeframe. Pre-hospital care for the patient; definitive diagnosis and maintenance of vital signs in the emergency resuscitation room; damage control surgery at the trauma center; specialized definitive surgery. This seamless chain of care ensured successful treatment outcomes, demonstrating the hospital's multidisciplinary collaborative capabilities in managing severe trauma. However, continuous optimization remains possible in the following areas: Early warning technology for vascular injury: Iliopsoas artery injuries often present insidiously. While this case was definitively diagnosed via CTA, the examination took 40 minutes. Introducing bedside vascular ultrasound contrast imaging could provide preliminary assessment of vascular occlusion or rupture within 10 minutes, enabling earlier decision-making for surgical intervention. Regular Team Training: The efficient operation of chain-based treatment relies on seamless coordination among team members. Our hospital conducts monthly trauma simulation drills, focusing on training "time-sensitive response protocols" (e.g., deep venous catheterization within 15 minutes), which has increased team collaboration efficiency by 50%. This achieves seamless integration between skills training and real-world application, consistent with the effectiveness of the "Combat Trauma Center" regular drill mechanism [12].

4. Conclusion

In summary, while models for treating severe trauma vary, the overarching principle remains consistent. Time-based chain-of-care approaches offer advantages such as efficiency and speed, thereby enhancing the success rate of resuscitation for severely injured patients and ensuring effective treatment outcomes. It can comprehensively document the entire treatment process for patients, trace and address issues at each stage for improvement, optimize clinical workflows, control medical quality, enhance the hospital's capacity to treat severely injured patients, reduce adverse event rates, and provide a replicable clinical pathway for complex trauma care. Future efforts should focus on strengthening prehospital-to-hospital information exchange, introducing precision diagnostic technologies, and optimizing team training to address increasingly complex trauma care challenges.

Funding

Jiangsu Provincial Hospital Association Hospital Management Innovation Research Fund (Project Ni.: JSYGY-3-2025-267)

Disclosure statement

The authors declare no conflict of interest.

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Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Journal of Clinical and Nursing Research, 2026, Volume 10, Issue 1
http://ojs.bbwpublisher.com/index.php/JCNR
Online ISSN: 2208-3693
Print ISSN: 2208-3685

Comparative Study on the Efficacy and Safety of Faricimab and Conbercept in the Treatment of Diabetic Macular Edema

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Abstract: *Objective*: To compare the clinical efficacy and safety of intravitreal injection of faricimab and conbercept in the treatment of diabetic macular edema (DME). *Methods*: A total of 50 patients diagnosed with DME in our hospital from January 2023 to May 2025 were selected and randomly divided into an observation group and a control group, with 25 cases in each group, using a random number table method. The observation group received intravitreal injection of faricimab, while the control group received intravitreal injection of conbercept. Both groups adopted a loading phase plus maintenance phase treatment regimen. The best-corrected visual acuity (BCVA, expressed in logMAR) and central subfield thickness (CST) of the two groups were compared before treatment and at 1, 3, and 6 months after treatment, and the incidence of adverse events during treatment was recorded. *Results:* The logMAR BCVA in the observation group was lower than that in the control group at 3 and 6 months after treatment (both $p < 0.05$). The CST in the observation group was smaller than that in the control group at 1, 3, and 6 months after treatment (all $p < 0.05$). There was no statistically significant difference in the overall incidence of adverse events between the two groups ($\chi^2 = 0.189$, $p = 0.663$). *Conclusion:* Both intravitreal injections of faricimab and conbercept are effective in improving visual acuity and reducing macular edema in patients with DME, with good safety profiles. However, faricimab demonstrates superior efficacy in the medium to long term (3 and 6 months) compared to conbercept, making it more suitable for long-term treatment of patients with DME.

Keywords: Diabetic macular edema; Faricimab; Conbercept; Intravitreal injection; Efficacy; Safety

Online publication: Feb 12, 2026

1. Introduction

Diabetic macular edema (DME) is one of the common microvascular complications of diabetes, characterized by the accumulation of fluid in the macular region and the disruption of the blood-retinal barrier as its core pathological features. It can lead to a sharp decline in central vision and metamorphopsia, posing a severe threat to the visual function of patients and being one of the primary causes of blindness in diabetic patients [1,2]. With the

clinical application of anti-vascular endothelial growth factor (anti-VEGF) drugs, breakthrough progress has been made in the treatment of DME, which has become a first-line treatment option [3]. Faricimab, as a novel dual-target anti-VEGF drug, can simultaneously inhibit VEGF-A and Ang-2, while Conbercept is a domestically produced anti-VEGF drug with widespread clinical application [4]. However, regarding the comparative efficacy, differences in the extent of visual improvement, and safety risks of these two drugs in the treatment of DME, the current clinical research evidence is insufficient, and there is still a lack of clear guidance for their clinical application selection. Based on this, this study aims to clarify the differences in clinical efficacy between Faricimab and Conbercept in the treatment of DME through prospective clinical comparative analysis, systematically evaluate their improvement effects on patients' best-corrected visual acuity and central macular thickness, and monitor and compare the types and incidence rates of adverse reactions, providing high-quality evidence-based medical evidence for clinically optimizing DME treatment plans and individualizing drug selection.

2. Materials and methods

2.1. General information

A total of 50 patients diagnosed with diabetic macular edema (DME) who visited the ophthalmology department of our hospital from January 2023 to May 2025 were selected as the study subjects.

2.1.1. Inclusion criteria

(1) Meeting the diagnostic criteria for DME outlined in the 2024 edition of the "Clinical Practice Guideline for Diabetic Retinopathy" by the American Academy of Ophthalmology [5];
(2) Foveal-involving macular edema, with optical coherence tomography (OCT) showing a central subfield thickness (CST) ≥ 320 μm;
(3) Best-corrected visual acuity (BCVA) ranging from 0.3 to 0.8 (logMAR 0.1 to 0.5);
(4) A diabetes duration of ≥ 3 years with stable glycemic control (glycated hemoglobin < 7.5%);
(5) Informed consent obtained from the patients, who signed the informed consent form.

2.1.2. Exclusion criteria

(1) Coexistence of other retinal diseases (e.g., age-related macular degeneration, retinal vein occlusion);
(2) Previous history of intravitreal injections or ocular surgery;
(3) Presence of other ocular conditions affecting vision, such as ocular infections, glaucoma, or cataracts;
(4) Severe systemic organic diseases affecting the heart, liver, or kidneys;
(5) Allergy to any component of the study drug.

2.1.3. Study groups

Patients were randomly assigned to the observation group and the control group using a random number table method, with 25 patients in each group. In the observation group, there were 14 males and 11 females; ages ranged from 45 to 72 years, with a mean age of (58.6 ± 6.3) years; the duration of diabetes ranged from 3 to 15 years, with a mean duration of (8.2 ± 2.5) years; the logMAR BCVA before treatment was (0.32 ± 0.08), and the CST was (426.8 ± 35.2) μm. In the control group, there were 13 males and 12 females, aged between 46 and 73 years old, with an average age of (59.2 ± 6.5) years old. The duration of diabetes ranged from 3 to 16 years, with an average

of (8.5 ± 2.7) years. Before treatment, the logMAR BCVA was (0.33 ± 0.09), and the CST was (430.2 ± 36.5) μm. There were no statistically significant differences in general data such as gender, age, duration of diabetes, logMAR BCVA, and CST between the two groups before treatment ($p > 0.05$), indicating comparability.

2.2. Treatment methods

Before treatment, both groups of patients underwent comprehensive routine ocular examinations (including visual acuity, intraocular pressure, slit-lamp examination, fundus ophthalmoscopy, OCT, etc.) and general physical examinations to assess the feasibility of treatment. All injection procedures were performed by the same experienced ophthalmologist, strictly adhering to aseptic techniques. Three days before injection, levofloxacin eye drops were administered four times a day to prevent infection. During the injection, surface anesthesia was applied, and the eyelids were held open with a speculum. The needle was inserted 3.5 mm posterior to the inferotemporal corneal limbus, and the drug was slowly injected before withdrawing the needle. The puncture site was then pressed for 3 to 5 minutes, and the procedure was concluded after observing no abnormalities.

The observation group received an intravitreal injection of Faricimab at a dose of 6 mg each time, while the control group received an intravitreal injection of Conbercept at a dose of 0.5 mg each time. Both groups adopted a loading phase + maintenance phase treatment regimen: during the loading phase, injections were administered once a month for three consecutive times; the maintenance phase commenced in the fourth month, during which the resolution of macular edema was evaluated based on OCT examination results. If the central subfield thickness (CST) was < 320 μm and visual acuity remained stable, injections were given once every three months; if CST was ≥ 320 μm, injections were administered once every two months. The total follow-up period was six months.

2.3. Observation indicators

(1) Best-corrected visual acuity (BCVA)

Assessed using a standard logarithmic visual acuity chart, with visual acuity converted to logMAR values for statistical analysis. Lower logMAR values indicate better visual acuity. Measurements were taken before treatment and at 1, 3, and 6 months post-treatment.

(2) Central subfield thickness (CST)

Measured using spectral-domain OCT by scanning a 5 mm area of the macular region and averaging three measurements of retinal thickness at the fovea. Measurements were taken before treatment and at 1, 3, and 6 months post-treatment.

(3) Safety indicators

Adverse events occurring in patients in both groups during treatment were recorded, including ocular adverse events (conjunctival hemorrhage, ocular pain, increased intraocular pressure, vitreous opacity, etc.) and systemic adverse events (headache, nausea, fluctuations in blood pressure, etc.). The incidence of adverse events was calculated.

2.4. Statistical methods

Data analysis was performed using SPSS 26.0 statistical software. Measurement data were expressed as mean ± standard deviation ($\overline{x} \pm s$). Paired *t*-tests were used for comparisons within groups before and after treatment, while independent sample *t*-tests were used for comparisons between groups. Categorical data were expressed as rates (%), and comparisons were made using the χ^2 test. A *p*-value of less than 0.05 was considered statistically significant.

3. Results

3.1. Comparison of logMAR BCVA between the two groups before and after treatment

The logMAR BCVA in the observation group was lower than that in the control group at 3 and 6 months after treatment (both $p < 0.05$). See **Table 1**.

Table 1. Comparison of logMAR BCVA between the two groups before and after treatment

Group	Before treatment	1 month of treatment	3 months of treatment	6 months of treatment
Observation group (n = 25)	0.32 ± 0.08	0.24 ± 0.07	0.18 ± 0.06	0.13 ± 0.05
Control group (n = 25)	0.33 ± 0.09	0.25 ± 0.08	0.22 ± 0.07	0.18 ± 0.06
t-value (vs. control)	0.415	0.470	2.169	3.201
p-value (vs. control)	0.680	0.640	0.035	0.002

3.2. Comparison of CST between the two groups before and after treatment

The CST in the observation group was smaller than that in the control group at 1, 3, and 6 months after treatment (all $p < 0.05$). See **Table 2**.

Table 2. Comparison of CST between the two groups before and after treatment

Group	Before treatment	1 month of treatment	3 months of treatment	6 months of treatment
Observation group (n = 25)	426.82 ± 35.21	358.63 ± 28.55	312.44 ± 22.36	298.63 ± 18.54
Control group (n = 25)	430.22 ± 36.51	375.45 ± 29.86	338.64 ± 25.77	324.84 ± 21.62
t-value (vs. control)	0.335	2.036	3.840	4.601
p-value (vs. control)	0.739	0.047	< 0.001	< 0.001

3.3. Comparison of adverse events between the two groups

During the treatment period, a small number of adverse events occurred in both groups, all of which were mild to moderate in severity. These events were relieved after symptomatic treatment, and no serious adverse events (such as endophthalmitis, retinal detachment, or severe systemic allergic reactions) occurred. There was no statistically significant difference in the overall incidence of adverse events between the two groups ($\chi^2 = 0.189$, $p = 0.663$). See **Table 3**.

Table 3. Comparison of adverse events between the two groups

Group	Conjunctival hemorrhage	Eye pain	Elevated intraocular pressure	Overall incidence rate (%)
Observation group (n = 25)	1	1	0	2 (8.0)
Control group (n = 25)	2	1	1	4 (16.0)
χ^2-value	-	-	-	0.189
p-value	-	-	-	0.663

4. Discussion

DME (Diabetic Macular Edema) is a common complication of diabetic retinopathy with a complex pathogenesis.

It is primarily associated with the overexpression of VEGF (Vascular Endothelial Growth Factor) and the accumulation of fluid in the macular region due to the disruption of the blood-retina barrier. If left untreated, it can lead to a severe decline in vision or even blindness, significantly affecting the patient's quality of life [6]. Currently, intravitreal injection of anti-VEGF drugs is the first-line treatment for DME, aiming to alleviate macular edema and improve visual acuity by inhibiting VEGF activity [7].

Conbercept is an anti-VEGF drug independently developed in China, belonging to the class of fusion proteins. It can specifically bind to multiple subtypes of VEGF-A, inhibiting angiogenesis and vascular leakage. Conbercept has been widely used in the treatment of DME with proven efficacy [8]. Faricimab is a novel bispecific antibody that not only inhibits VEGF-A but also inhibits angiopoietin-2 (Ang-2). Ang-2 can exacerbate macular edema by disrupting vascular stability, so faricimab can exert its effects through a dual pathway, more effectively stabilizing the blood-retina barrier and reducing macular edema [9]. This study compared the efficacy of the two drugs in treating DME. The results showed that after 1, 3, and 6 months of treatment, the logMAR BCVA (Best Corrected Visual Acuity) of both groups significantly decreased compared to before treatment, and the CST (Central Subfield Thickness) significantly decreased compared to before treatment. This indicates that both drugs can effectively improve visual acuity and macular edema in patients with DME, consistent with previous research findings.

Further analysis revealed that at 3 and 6 months of treatment, the logMAR BCVA in the observation group was lower than that in the control group, and the CST was smaller than that in the control group, with statistically significant differences. However, there were no statistically significant differences in these indicators between the two groups at 1 month of treatment. This suggests that the short-term efficacy of faricimab is generally comparable to that of conbercept, but faricimab demonstrates superior medium- to long-term efficacy. The reason for this may be related to the dual mechanism of action of faricimab: on the one hand, by specifically inhibiting the VEGF-A signaling pathway, it effectively reduces leakage from retinal choroidal neovascularization, thereby alleviating fluid accumulation in the macular region from the source [9]. On the other hand, its inhibitory effect on Ang-2 stabilizes the morphology and function of vascular endothelial cells, reduces vascular permeability, and subsequently decreases the recurrence of macular edema, ultimately achieving a more sustained therapeutic effect [10]. Additionally, pharmacokinetic analysis shows that faricimab has a relatively longer half-life, enabling it to maintain stable and effective drug concentrations in ocular tissues, significantly prolonging its duration of action. This may also be one of the key factors contributing to its superior medium- to long-term efficacy compared to conbercept.

In terms of safety, there was no statistically significant difference in the incidence of adverse events between the two groups in this study, and all adverse events were mild to moderate in severity. They were alleviated after symptomatic treatment, with no serious adverse events such as endophthalmitis or severe hemorrhage occurring. The two most common ocular adverse events were conjunctival hemorrhage. Based on the analysis of clinical operation records, this symptom was primarily associated with injection procedures and constituted a transient reaction that resolved spontaneously without the need for special intervention. In the control group, one case of transient intraocular pressure elevation occurred, which rapidly returned to the normal range after treatment with topical antihypertensive eye drops, without causing adverse effects on the patient's visual function. The aforementioned safety data fully demonstrate that both Faricimab and Conbercept exhibit good safety profiles for the treatment of diabetic macular edema (DME), with controllable clinical application risks.

Although this study clarified the differences in short-term and mid-term efficacy between the two drugs

in treating DME, it still has certain limitations and requires an objective assessment of the applicability of the research findings. Firstly, the sample size was relatively small, and the follow-up period was short, which limited the ability to evaluate the long-term durability and safety of the two drugs. Additionally, as this was a single-center study, the results may have geographical limitations, potentially leading to insufficient representativeness and difficulty in fully extrapolating the findings to DME patient populations with different regional and clinical characteristics, thereby introducing potential geographical and selection biases. Future research should involve large-sample, multicenter studies with long-term follow-up to further validate the efficacy and safety of the two drugs, providing more comprehensive and reliable evidence-based medical support for optimizing individualized treatment plans for DME.

5. Conclusion

In conclusion, both Faricimab and Conbercept administered via intravitreal injection are effective in improving visual acuity and reducing macular edema in patients with DME, with good safety profiles. However, Faricimab demonstrates superior mid- to long-term (3- and 6-month) efficacy compared to Conbercept, making it more suitable for long-term treatment in patients with DME.

Disclosure statement

The authors declare no conflict of interest.

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Journal of Clinical and Nursing Research, 2026, Volume 10, Issue 1
http://ojs.bbwpublisher.com/index.php/JCNR
Online ISSN: 2208-3693
Print ISSN: 2208-3685

The Impact of Early Postoperative Rehabilitation Training on Balance Ability and Quality of Life in Elderly Patients with Hip Fracture

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Abstract: Objective: To analyze the improvement effect of early postoperative rehabilitation training on balance ability and quality of life in elderly patients with hip fracture. Methods: A total of 50 elderly patients with hip fracture admitted to our hospital from January 2023 to January 2024 were selected and divided into the observation group (25 cases) and the control group (25 cases) by random number table method. The control group received routine nursing, while the observation group received early rehabilitation training on the basis of routine nursing. The balance ability (Berg Balance Scale, BBS) and quality of life (SF-36) of the two groups were compared. *Results:* The BBS scores of the observation group at all postoperative time points were significantly higher than those of the control group ($p < 0.05$), and the quality-of-life scores of the observation group were also significantly higher than those of the control group ($p < 0.05$). *Conclusion:* Early postoperative rehabilitation training for elderly patients with hip fracture can improve their balance ability, enhance their quality of life, and reduce the incidence of postoperative complications, which is worthy of clinical promotion.

Keywords: Elderly hip fracture; Early postoperative rehabilitation training; Balance ability; Quality of life; Complications

Online publication: Feb 12, 2026

1. Introduction

Hip fracture in the elderly is a common traumatic disease in orthopedics, including femoral neck fracture and intertrochanteric fracture. With the aggravation of aging, the incidence of this disease is increasing year by year. According to relevant statistics, the annual incidence of hip fracture in the elderly over 65 years old in the world is 3–5%, and the disability rate within 1 year after operation is 50–60%. Due to the decline of physical function, weakened muscle strength and decreased balance ability, elderly patients are prone to complications such as muscle atrophy, joint stiffness and deep vein thrombosis after long-term bed rest and immobilization after fracture, which seriously affects the recovery of patients' balance ability, reduces their quality of life, and causes a huge burden on families and society. At present, surgical treatment is still the main treatment method for elderly hip

fracture, which can restore the anatomical structure of the fracture and facilitate early activities. However, the timeliness and scientificness of postoperative rehabilitation training are crucial for patients' rehabilitation. The traditional rehabilitation model mostly starts intervention after the patient's condition stabilizes after operation, at which time the patient has developed varying degrees of disuse muscle atrophy, increasing the difficulty of rehabilitation. Based on the above situation, this study selected 50 elderly patients with hip fracture as research objects, and analyzed the actual effect of early postoperative rehabilitation training through group comparison, so as to provide certain reference for improving the postoperative rehabilitation program of elderly hip fracture [1].

2. Materials and methods

2.1. Clinical data

A total of 50 elderly patients with hip fracture admitted to the orthopedics department of our hospital from January 2023 to January 2024 were selected and divided into the observation group (25 cases) and the control group (25 cases) by random number table method. In the observation group, there were 11 males and 14 females, aged 65–88 years, with an average of (76.32 ± 5.41) years. In the control group, there were 12 males and 13 females, aged 66–89 years, with an average of (77.15 ± 5.63) years. This study has been approved by the medical ethics committee [2].

2.1.1. Inclusion criteria

(1) Diagnosis of elderly hip fracture conforms to the standard, confirmed by X-ray or CT examination;
(2) Patients and their families are informed and consent to sign the informed consent form.

2.1.2. Exclusion criteria

(1) Complicated with severe heart, liver, kidney and other organ failure;
(2) Complicated with malignant tumors and coagulation disorders. There were no statistically significant differences in general data such as gender, age, fracture type, cause of injury and comorbidities between the two groups ($p > 0.05$), which were comparable.

2.2. Methods

Both groups underwent routine surgery and basic nursing (vital sign monitoring, wound care, anti-infection, pain management, etc.) [3,4].

2.2.1. Control group

Routine postoperative rehabilitation nursing. During bed rest, ankle flexion and extension and isometric contraction training of quadriceps were performed twice a day, 15 to 20 minutes each time; after the condition improved 2 to 3 weeks after operation, help patients sit up, stand and walk, and gradually increase the difficulty.

2.2.2. Observation group

On the basis of the control group, the observation group carried out early postoperative rehabilitation training. A rehabilitation team composed of rehabilitation physicians, responsible nurses and rehabilitation therapists formulated an individualized rehabilitation training plan according to the patient's surgical method and physical condition.

2.2.3. Training strategy

Training started 1–3 days after operation, and the training content was carried out in stages.

Stage 1 (1–7 days after operation): Bedside passive training + active assisted training to prevent muscle atrophy and joint restriction.

(1) Passive training

Rehabilitation therapists helped patients complete passive flexion and extension training of hip and knee joints, with the angle starting from 30° and gradually increasing to 90°, 10–15 min each time, twice a day;

(2) Active assisted training

Guided patients to carry out ankle dorsiflexion and plantar flexion training, 10 min each time, three times a day; isometric contraction training of quadriceps, contraction for 5–10 s each time, 10–15 times per group, three groups a day; gluteus maximus contraction training, 10 times per group, three times a day;

(3) Respiratory function training

Guided patients to carry out abdominal breathing training, 10 min each time, twice a day, to prevent pulmonary infection.

Stage 2 (8–14 days after operation): Focus on active training and preliminary balance function training to enhance muscle strength and joint range of motion.

(1) Active training

Patients independently completed active flexion and extension training of hip and knee joints, gradually increasing the training angle and range, about 15 min each time, twice a day; straight leg raising training, the lifting height starts from 10 cm and gradually increases to 30 cm, 10 times per group, three groups a day;

(2) Balance function training

Assisted patients to sit by the bed with both feet on the ground for sitting balance training, 10 min each time, twice a day

(3) Transfer training

Guided patients to perform bed-chair transfer training with the help of walkers, 10–15 min each time, twice a day.

Stage 3 (15d after operation–discharge): Focus on intensive balance function training and walking training to improve activities of daily living.

(1) Balance function training

Single-leg standing and eyes-closed standing, 5–10 min each time, twice a day;

(2) Walking training

Straight-line walking and turning walking, gradually extending the walking distance and increasing the walking speed, 20–30 min each time, twice a day;

(3) Activities of daily living training

Dressing, washing, eating, etc., 15–20 min each time, twice a day. Patients were followed up for 6 months after discharge, and rehabilitation training was regularly guided through telephone and outpatient review.

2.3. Observation indicators

(1) Balance ability

Evaluated by Berg Balance Scale (BBS) at 1 month, 3 months and 6 months after operation, with a total

of 14 items, 0–4 points per item, total score 0–56 points, higher score indicates better balance [5].

(2) Quality of life

Evaluated by the 36-Item Short Form Health Survey (SF-36) at 6 months after operation, including 7 aspects such as physical function, bodily pain, general health and social function, 0–100 points per dimension, higher score indicates better quality of life [6].

2.4. Statistical methods

The data in this group were processed and analyzed with SPSS21.0 software. Measurement data were expressed as ($\bar{x} \pm s$) and tested by *t* test; count data were expressed as % and tested by χ^2 test. $p < 0.05$ was considered statistically significant.

3. Results

3.1. Comparison of BBS scores between the two groups at different postoperative time points

At 1 month, 3 months and 6 months after operation, the BBS scores of the observation group were significantly higher than those of the control group ($p < 0.05$). The specific results are shown in **Table 1**.

Table 1. Comparison of BBS scores between the two groups at different postoperative time points ($\bar{x} \pm s$)

Groups	Number of cases	1 month after operation (points)	3 months after operation (points)	6 months after operation (points)
Observation group	25	32.45 ± 4.21	41.68 ± 5.32	50.32 ± 4.89
Control group	25	25.12 ± 3.89	33.25 ± 4.98	42.15 ± 5.12
t	-	6.3939	5.7841	5.7698
p	-	0.0000	0.0000	0.0000

3.2. Comparison of SF-36 scores between the two groups at 6 months after operation

At 6 months after operation, the scores of each dimension of SF-36 in the observation group were significantly higher than those in the control group ($p < 0.05$). The specific results are shown in **Table 2**.

Table 2. Comparison of SF-36 scores between the two groups at 6 months after operation ($\bar{x} \pm s$)

Groups	Number of cases	Physical function (points)	Bodily pain (points)	General health (points)	Social function (points)
Observation group	25	78.32 ± 6.54	75.12 ± 5.89	72.45 ± 6.12	79.68 ± 5.98
Control group	25	65.15 ± 5.98	62.35 ± 6.12	60.12 ± 5.89	66.32 ± 6.45
t	-	7.4307	7.5172	7.2581	7.5947
p	-	0.0000	0.0000	0.0000	0.0000

4. Discussion

The core of postoperative rehabilitation for elderly hip fracture is to restore limb function, improve balance ability

and quality of life. Elderly patients recover slowly after operation, and if not intervened in time, adverse outcomes such as muscle atrophy and joint adhesion are likely to occur. The results of this study showed that the BBS scores of the observation group at all postoperative time points were higher than those of the control group, indicating that early rehabilitation training can significantly improve the patient's balance ability. The reason is that early rehabilitation carries out passive, active and balance training in stages, stimulates muscle contraction, enhances muscle strength, improves joint range of motion, and balance training improves body stability [6–10]. The BBS score of the observation group was significantly improved 1 month after operation, indicating that early intervention can break the vicious circle of bed rest, muscle atrophy and balance decline; the score was close to normal 6 months after operation, indicating long-term effectiveness. Quality of life is an important evaluation index of postoperative rehabilitation effect, which is affected by limb function, pain, social participation, etc. This study showed that at 6 months after operation, the observation group scored higher than the control group in all dimensions of SF-36, indicating that early rehabilitation can improve the patient's quality of life. Because early rehabilitation improves balance and muscle strength, promotes the recovery of limb function, reduces dependence on others, and improves physical function and general health scores; improved limb function reduces pain and improves sleep and vitality levels; patients participate in social activities as soon as possible, improving social function and mental health scores [11–13]. The control group started rehabilitation late, had slow recovery of limb function, long duration of pain, limited social participation, and poor improvement in quality of life. Early rehabilitation focuses on individualization, formulates rehabilitation plans according to the type of surgery and physical condition, advances them step by step in stages, and strengthens training monitoring. No serious complications such as prosthesis loosening occurred in the observation group, which verified the safety of the program. However, this study has a small sample size, single center and short follow-up time, so the results may be biased [14,15]. In the future, the sample size should be increased, and multi-center research and long-term follow-up are needed to determine the long-term effect.

5. Conclusion

In conclusion, early postoperative rehabilitation training for elderly patients with hip fracture can improve balance ability, enhance quality of life, and have high safety, which is worthy of clinical promotion. Clinically, attention should be paid to early rehabilitation intervention, a professional team should be established, individualized plans should be formulated, guidance and monitoring should be strengthened, and rehabilitation effects should be improved.

Funding

Chongqing Education Science Planning Project. Project Name: Research on Talent Training of Community Rehabilitation Major in Higher Vocational Colleges Based on OBE Concept (Project No.: K23ZG3420222)

Disclosure statement

The authors declare no conflict of interest.

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Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Journal of Clinical and Nursing Research, 2026, Volume 10, Issue 1
http://ojs.bbwpublisher.com/index.php/JCNR
Online ISSN: 2208-3693
Print ISSN: 2208-3685

Effects of Continuous Care on Children with Enterostomy and Their Families in China

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Abstract: *Background:* Continuous care for children with enterostomy and their families has been gaining popularity in China. *Objective*: To evaluate the feasibility of continuous care for children with enterostomy and their families in China. *Methods*: The PubMed, Web of Science, Embase, Cochrane Library, EBSCO, CNKI, CBM, VIP, and WanFang were searched for clinical trials until December 30, 2025. Two reviewers independently searched articles, evaluated quality and extracted data. This review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). *Results:* 33 studies involving 2774 participants were included. The meta-analysis showed that continuous care strategy can significantly reduce the incidence of complications in children with enterostomy (OR = 0.20, 95% CI = 0.16–0.26, $p < 0.001$, I2 = 0%), effectively improve the family caregiver ability for enterostomy (MD = -10.34, 95% CI= -13.82 to -6.85, $p < 0.001$, I2 = 99%), shorten the time for family members to replace stoma bags (MD= -13.57, 95% CI=-19.66 to -7.49, $p < 0.001$, I2 = 100%), and alleviate negative emotions such as anxiety (SMD= -1.80, 95% CI = -2.36 to -1.23, $p < 0.001$, I2 = 92%) and depression (SMD= -1.54, 95% CI= -2.04 to -1.04, $p < 0.001$, I2 = 89%) in the families of the affected children. *Conclusions*: Continuous care can reduce complications of enterostomy in children, improve the family caregiver ability for enterostomy and alleviate negative emotions of family members such as anxiety and depression.

Keywords: Continuous care; Pediatric enterostomy; Family members; Enterostomy nursing; Meta-analysis

Online publication: Feb 9, 2026

1. Introduction

Pediatric enterostomy is a surgical method that lifts the intestine to the abdominal wall as a temporary excretory outlet. It is mainly adopted to rescue critically ill children with acute abdominal diseases such as intestinal obstruction, intestinal necrosis, and congenital anorectal malformation [1,2]. Because of the pathological

characteristics of affected children, the primary disease is complex, and their resistance is poor. After enterostomy, they are susceptible to pathogen invasion and various complications, which not only increase the pain of children but also endanger their lives [3,4]. Children's stomas are usually temporary, and they will be closed after 3 to 6 months [5,6]. After the children with enterostomy are discharged from the hospital, the family will be the main place for care, and parents will be the primary caregivers. However, since a lack of medical knowledge and professional training, it is usually difficult for parents to fully grasp the nursing methods after enterostomy surgery during short-term hospitalization. They will encounter various challenges in the process of home care, such as enterostomy care, complications of infant diseases, and life stress [7,8].

Continuous care interventions can enable pediatric patients to continue receiving professional nursing in different healthcare settings, such as from hospitals to homes. It is widely considered to be a key element in high-quality medical services and is crucial for children with enterostomy and their families [9,10]. Currently, continuous care interventions are mostly supplied by enterostomal therapists (ETs) or professional nursing staff trained in enterostomy treatment, including all elements of enterostomy care, which help affected children and their families obtain extended and professional nursing services from medical staff after enterostomy [11–13]. For example, reading enterostomy care manuals and video nursing guidance, using online platforms, and telephone-assisted outpatient follow-up or home visits [14–16].

In China, continuous care strategy has been widely applied in children with enterostomy and their families and has achieved many potential benefits. Wu et al. reported that continuous care can not only markedly promote the postoperative quality of life for children with enterostomy but also alleviate their anxiety and depression by providing appropriate psychological counseling to family members [17]. Geng et al. found that continuous care after discharge can effectively decrease the complications of children with enterostomy, increase their care satisfaction, and promote their postoperative quality of life [18]. Gao et. al reported that WeChat-based continuous care can significantly improve the nursing ability and quality of life of parents, and decrease the incidence of complications in children with enterostomy [3].

Although individual trials on continuous care have achieved numerous potential benefits, there is a lack of a systematic review and meta-analysis on its promising outcomes in children with enterostomy and their families. Thus, the study intended to analyze the optimum existing proofs, summarize the feasibility of the reported survey results, and evaluate the effectiveness of continuous care on children with enterostomy and their families in China, to afford an evidence-based approach for medical nursing staff and provide a continuous care strategy for children with enterostomy and their families.

2. Methods

This review was carried out by the PRISMA declaration guidelines [19]. The protocol has been registered on PROSPERO with registration number CRD42023479320. Moreover, primary searches of the major data libraries did not discover any ongoing or published systematic reviews and meta-analyses with this objective.

2.1. Search strategy

Clinical trials of continued care strategy adopted for children with enterostomy and their families were searched by computer in Embase, EBSCO, Web of Science, PubMed, China Biology Medicine (CBM), Cochrane Library, Wanfang Data (Wanfang), China National Knowledge Infrastructure (CNKI) and VIP Chinese Science and

Technology Journal Database (VIP). Each database was retrieved up to December 30, 2025, without any language restrictions.

2.2. Inclusion and exclusion criteria

2.2.1. Inclusion criteria

(1) Study design
Randomized controlled trials, quasi-randomized controlled trials, or cohort studies;

(2) Participants
Children with enterostomy in China (≤ 18 years);

(3) Interventions
Continuous care provided by ETs or professional nursing staff who have received training in enterostomy care;

(4) Outcomes
Health variables of affected children and their families, including complications of children with enterostomy, enterostomy care ability of family members and negative emotions of family members.

2.2.2. Exclusion criteria

(1) Studies did not use a control group;
(2) Studies that only included adult patients (> 18 years);
(3) Studies from case reports, conference abstracts, reviews, letters, or duplicate publications;
(4) Literature that the full text was unavailable, outcomes were unclear, or interventions were different.

2.3. Data synthesis

Review Manager software (version 5.4) was adopted for the meta-analysis. For binary variables such as complications of children with enterostomy, odds ratio (OR) with 95% confidence interval (CI) was calculated as an effect indicator. For continuous variables such as family caregiver ability for enterostomy, length of time for family members to replace stoma bags, and anxiety and depression of family members; if the scales used were the same, mean difference (MD) with 95% CI was select for effect measures; if the scales adopted were different, standardized mean difference (SMD) with 95% CI was calculated as effect indicators [20]. The heterogeneity test of the included literature was carried out with χ^2 test and I^2 statistics [21]. The fixed-effects model was adopted if $p > 0.1$ or $I^2 < 50\%$; the random-effects model was employed if $p < 0.1$ or $I^2 > 50\%$. Funnel plots, Egger's test and Begg's test were adopted to evaluate the publication bias when the number of included literatures was greater than or equal to 10 [22]. $p < 0.05$ was recognized statistically significant. The sensitivity analysis was performed by successively deleting the individual literature to assess the robustness and reliability of the results [23].

3. Results

3.1. Complications of children with enterostomy

27 studies including 2030 pediatric patients (1030 in continuous care group and 1000 in routine care group) reported complications in children with enterostomy [3,14–16,18,24–45]. The fixed effects model was adopted to carry out the meta-analysis due to no statistical heterogeneity was observed (I2 = 0%, $p = 0.94$). The results revealed

that the incidence of complications of children with enterostomy in the continuous care group was remarkably less than that in the conventional care group, with statistical significance (OR = 0.20, 95% CI = 0.16–0.26, $p < 0.001$), illustrating that the continuous care intervention could decrease the complications of children with enterostomy, as shown in Figure 1.

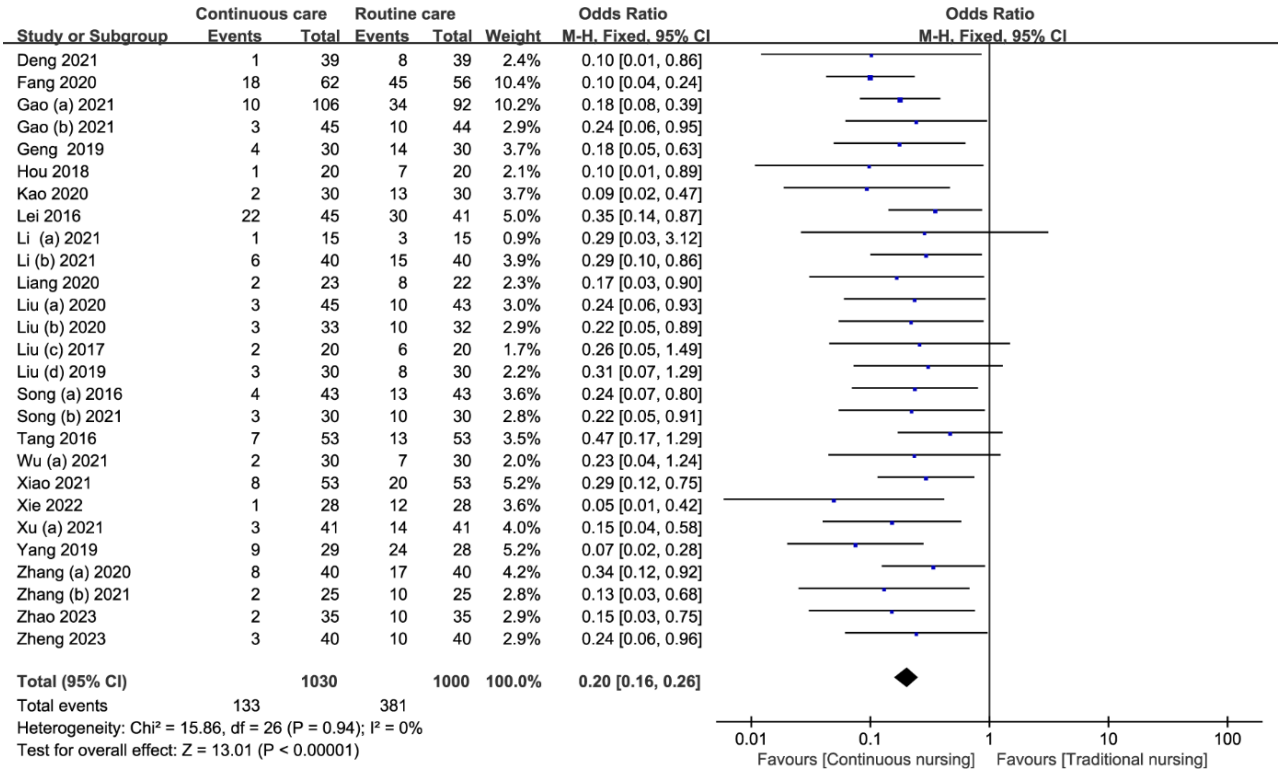

Figure 1. Forest plot of complications in children with enterostomy.

3.2. Family caregiver ability for enterostomy

Five studies involving 474 participants (244 in continuous care group and 230 in routine care group) reported the family caregiver ability for enterostomy, all evaluated using the family caregiver task inventory (FCTI) [3,31,41,46,47]. The random effects model was employed to conduct the meta-analysis because the statistical heterogeneity was significant ($I^2 = 99\%$, $p < 0.001$). The results showed that the family caregiver ability for enterostomy in the continuous care group was remarkably higher than that in the routine care group, and the diversity between the two groups was statistically remarkable (MD = -10.34, 95% CI = -13.82 to -6.85, $p < 0.001$). Thus, the continuous care strategy could promote the family caregiver ability for enterostomy, as illustrated in **Figure 2**.

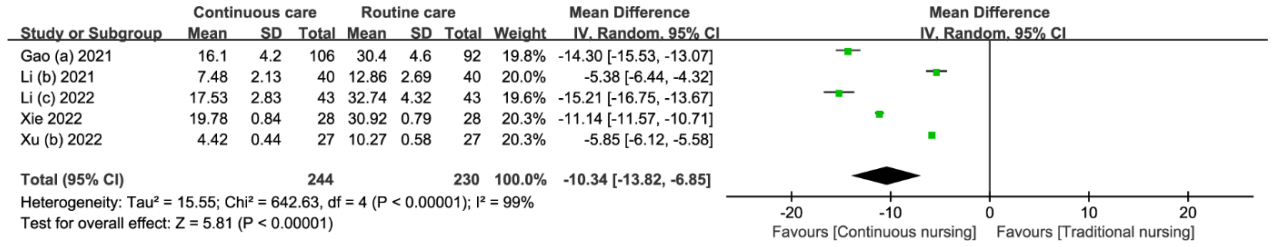

Figure 2. Forest plot of family caregiver ability for enterostomy.

3.3. Length of time for family members to replace stoma bags

Seven studies including 431 participants (216 in continuous care group and 215 in routine care group) reported the duration of family member replacement of stoma bags [14,15,27,34–36,45]. The random effects model was adopted to perform the meta-analysis due to the statistical heterogeneity was significant (I^2 = 100%, p < 0.001). The results revealed that the duration of family members replacing stoma bags in the continuous care group was significantly shorter than that in the conventional care group, and the diversity between the two groups was statistically remarkable (MD = -13.57, 95% CI = -19.66 to -7.49, p < 0.001). Thereby, the continuous care strategy could shorten the length of time for family members to replace stoma bags, as displayed in **Figure 3**.

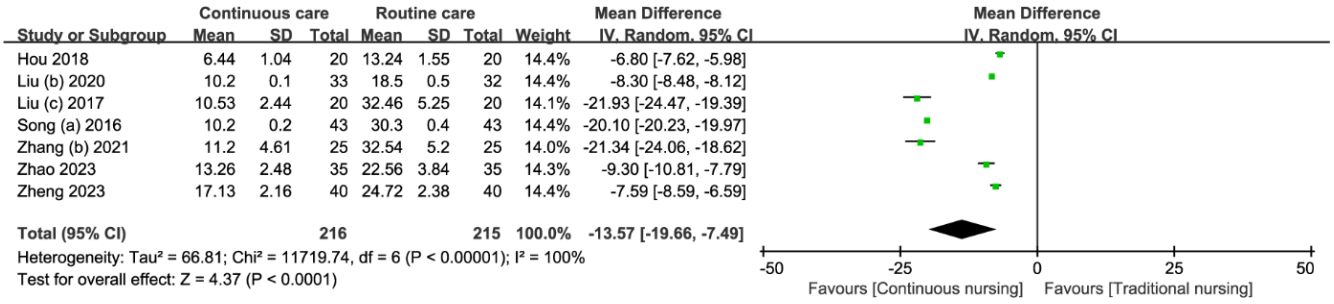

Figure 3. Forest plot of length of time for family members to replace stoma bags.

3.4. Anxiety of family members

Nine studies involving 941 participants (481 in continuous care group and 460 in routine care group) reported the anxiety of family members, of which eight studies used the self-rating anxiety scale (SAS) as the evaluation tool and one study adopted the generalized anxiety disorder (GAD) as the evaluation tool [17,18,37,40,43,47–50]. The random effects model was employed to conduct the meta-analysis due to the statistical heterogeneity was significant (I^2 = 92%, p < 0.001). The results revealed that the anxiety of family members in the continuous care group was remarkably lower than that in the conventional care group, and the diversity between the two groups was statistically remarkable (SMD = -1.80, 95% CI = -2.36 to -1.23, p < 0.001), indicating that the continuous care intervention could alleviate the anxiety of family members, as shown in **Figure 4**.

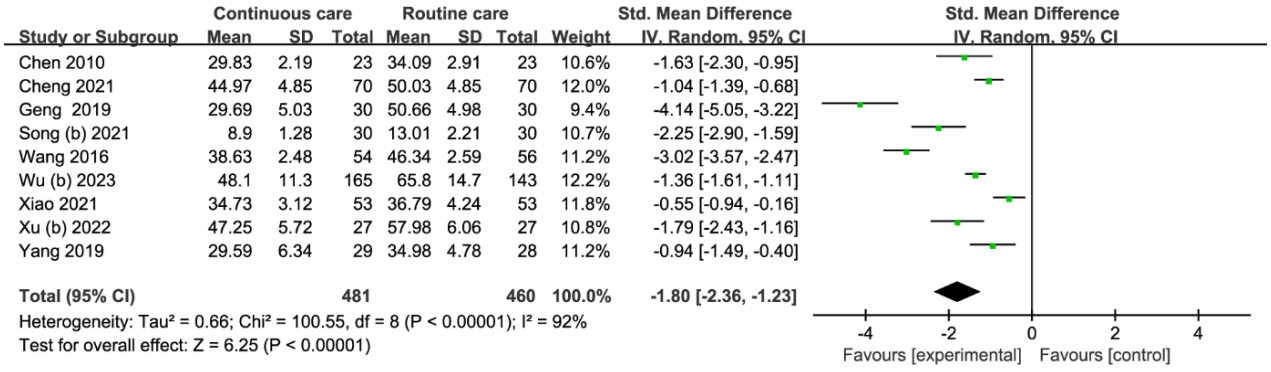

Figure 4. Forest plot of anxiety of family members.

3.5. Depression of family members

Eight studies including 863 participants (443 in continuous care group and 420 in routine care group) reported the depression of family members, of which seven studies adopted the self-rating depression scale (SDS) as the evaluation tool and one study used the Edinburgh postnatal depression scale (EPDS) as the evaluation

tool [17,18,33,43,47–50]. The random effects model was employed to conduct the meta-analysis due to the statistical heterogeneity was significant (I^2 = 89%, p < 0.001). The results illustrated that the depression of family members in the continuous care group was significantly lower than that in the routine care group, and the diversity between the two groups was statistically remarkable (SMD = -1.54, 95% CI = -2.04 to -1.04, p < 0.001), indicating that the application of continuous care strategy could alleviate the depression of family members, as displayed in **Figure 5**.

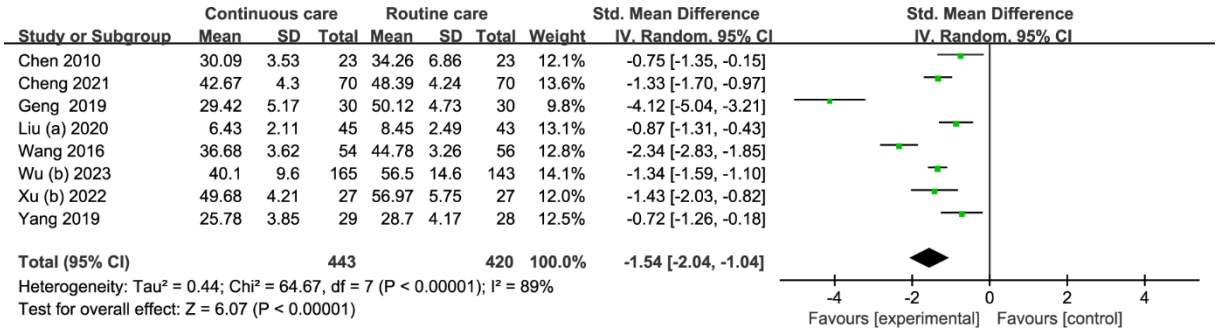

Figure 5. Forest plot of depression of family members

4. Conclusion

The findings of this review suggest that continuous care for children with enterostomy and their families in China can significantly decrease the complications of children with enterostomy, effectively promote the enterostomy care ability of family members, and alleviate negative emotions of primary caregivers such as depression and anxiety. Due to the positive effects of continuous nursing intervention on children with enterostomy and their families, it is necessary to incorporate continuous care strategy into clinical practice and conduct further research.

Disclosure statement

The authors declare no conflict of interest.

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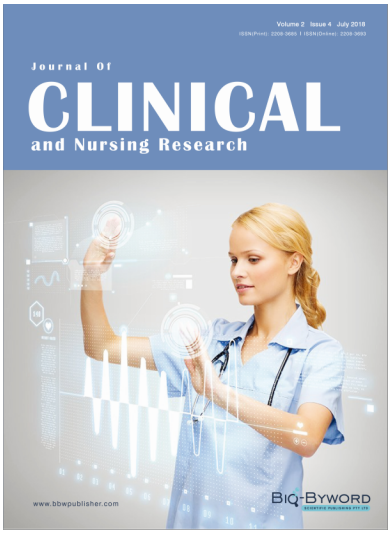

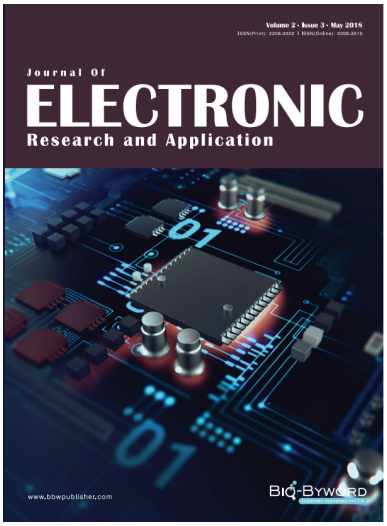

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