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Urology Research

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Urology Research publishes peer-reviewed research articles across basic, translational, and clinical Urology medicine. The Journal covers all aspects of Urology medicine (full listing below) with an emphasis on studies that challenge the status quo of treatments and practices in Urology care or facilitate the translation of scientific advances into the clinic as new therapies or diagnostic tools.

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Application Value of Urine NMP22, OPN, and BTA Detection in the Diagnostic and Prognostic Evaluation of Bladder Urothelial Carcinoma

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Abstract: *Objective:* To investigate the application value of urine nuclear matrix protein 22 (NMP22), osteopontin (OPN), and bladder tumor antigen (BTA) detection in the diagnostic and prognostic evaluation of bladder urothelial carcinoma. *Methods:* 100 patients with bladder urothelial carcinoma who visited our hospital from January 2020 to December 2022 were selected as the case group, and 100 healthy individuals who underwent physical examination during the same period were selected as the control group. The levels of NMP22, OPN, and BTA in the urine of the two groups were detected, and their diagnostic efficacy in bladder urothelial carcinoma was analyzed. The patients in the case group were followed up to observe the relationship between these markers and prognosis. *Results:* The levels of NMP22, OPN, and BTA in the urine of the case group were significantly higher than those of the control group ($P < 0.05$). The sensitivity, specificity, and accuracy of combined detection of NMP22, OPN, and BTA for diagnosing bladder urothelial carcinoma were higher than those of single marker detection ($P < 0.05$). Follow-up results showed that patients with high levels of NMP22, OPN, and BTA had a higher recurrence rate and shorter progression-free survival ($P < 0.05$). *Conclusion:* Combined detection of urine NMP22, OPN, and BTA has high diagnostic value for bladder urothelial carcinoma, and the levels of these markers are correlated with patient prognosis, which can be used for prognostic evaluation.

Keywords: Bladder urothelial carcinoma; Urine detection; NMP22; OPN; BTA

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1. Introduction

Bladder urothelial carcinoma, as an extremely common type of malignant tumor in the urinary system, has a high incidence and mortality rate globally, posing a serious threat to human health. Early diagnosis is crucial for effective treatment, improved prognosis, and enhanced quality of life. Prognostic evaluation can assist clinicians in developing more precise and personalized treatment plans and follow-up management strategies for patients.

Traditional cystoscopy has long been regarded as the gold standard for diagnosing bladder urothelial carcinoma. However, this method is significantly invasive, causing considerable discomfort to patients during the examination, leading to low acceptance among some patients, and potentially delaying optimal diagnosis and treatment due to resistance. Urine testing, as an emerging non-invasive diagnostic method, is simple and easy to perform, requiring no complex equipment or professional skills. Patients only need to provide a morning urine sample to complete the test. This convenience greatly improves patient compliance, allowing more patients to actively cooperate with the examination. In recent years, with the deepening of medical research, some biomarkers in urine, such as nuclear matrix protein 22 (NMP22), osteopontin (OPN), and bladder tumor antigen (BTA), have gradually come into focus. Their potential value in the diagnostic and prognostic evaluation of bladder urothelial carcinoma has attracted widespread attention. Based on this background, this study aims to explore the specific application value of these biomarkers, NMP22, OPN, and BTA, in the diagnosis and treatment of bladder urothelial carcinoma. It provides clinicians with more effective and precise diagnostic and prognostic evaluation methods, further advancing the clinical diagnosis and treatment of bladder urothelial carcinoma.

2. Materials and methods

2.1. General information

100 patients diagnosed with bladder urothelial carcinoma by pathology in our hospital from January 2020 to December 2022 were selected as the case group, aged 35–78 years, with an average age of 56.33 ± 10.52 years. Simultaneously, 100 healthy individuals who underwent health checkups in our hospital during the same period were selected as the control group, aged 32–75 years, with an average age of 54.86 ± 11.27 years. After comparison, there was no statistically significant difference in general information between the two groups ($P > 0.05$), making them comparable.

Inclusion criteria: The case group was pathologically diagnosed with bladder urothelial carcinoma; aged 18 years and above; patients signed informed consent. The control group consisted of healthy individuals without a history of urinary system diseases or malignant tumors. Exclusion criteria: those with other urinary system diseases affecting biomarker test results; those who had recently undergone urinary system surgery, radiotherapy, or chemotherapy; those with severe liver and kidney dysfunction.

2.2. Methods

Morning urine samples were collected from all subjects, and the levels of NMP22, OPN, and BTA in the urine were detected using enzyme-linked immunosorbent assay (ELISA). The operations were strictly carried out according to the kit instructions to ensure the accuracy of the test results.

2.3. Observation indicators

- (1) Diagnostic performance evaluation: Using pathological diagnosis as the gold standard, the sensitivity, specificity, accuracy, positive predictive value, and negative predictive value of single and combined detection of NMP22, OPN, and BTA were calculated. Sensitivity = True Positive / (True Positive + False Negative) $\times 100\%$; Specificity = True Negative / (True Negative + False Positive) $\times 100\%$; Accuracy = (True Positive + True Negative) / Total number of cases $\times 100\%$; Positive Predictive Value = True Positive / (True Positive + False Positive) $\times 100\%$; Negative Predictive Value = True Negative /

$(\text{True Negative} + \text{False Negative}) \times 100\%$.

- (2) Prognostic evaluation: The case group patients were followed up for 2 years, and their recurrence and progression-free survival were recorded. Progression-free survival was calculated from the diagnosis of bladder urothelial carcinoma until disease recurrence, distant metastasis, or death. Patients were divided into high and low-level groups based on the median NMP22, OPN, and BTA test results, and the recurrence rate and progression-free survival were compared between the two groups.

2.4. Statistical methods

SPSS 26.0 software was used to process data. Measurement data were described using mean \pm standard deviation (SD) and analyzed using the *t*-test. Count data was expressed as [*n* (%)] and analyzed through χ^2 test. $P < 0.05$ indicated that the corresponding difference was statistically significant.

3. Results

3.1. Comparison of urine marker levels between the two groups

The levels of NMP22, OPN, and BTA in the urine of the case group were significantly higher than those of the control group, and the difference was statistically significant ($P < 0.05$). See **Table 1** for details.

Table 1. Comparison of urine marker levels between the two groups (mean \pm SD, U/mL)

Group	<i>n</i>	NMP22	OPN	BTA
Case group	100	56.38 \pm 15.24	85.67 \pm 20.13	3.56 \pm 1.21
Control group	100	12.53 \pm 5.31	30.29 \pm 10.54	1.04 \pm 0.52
<i>t</i>		27.171	24.372	19.134
<i>P</i>		< 0.001	< 0.001	< 0.001

3.2. Comparison of diagnostic performance

For single marker detection, the sensitivity of NMP22 was 72%, with a specificity of 83%; OPN had a sensitivity of 68% and a specificity of 81%; BTA demonstrated a sensitivity of 63% and a specificity of 79%. When combined detection was used, the sensitivity reached 88%, the specificity was 92%, and the accuracy was 90%, all higher than single marker detection. The difference was statistically significant ($P < 0.05$).

3.3. Comparison of prognosis analysis between the two groups

After a 2-year follow-up, patients in the high-level group of NMP22, OPN, and BTA had a significantly higher recurrence rate than those in the low-level group ($P < 0.05$). The progression-free survival period of patients in the high-level group was shorter than that of the low-level group, and the difference was statistically significant ($P < 0.05$). See **Table 2** for details.

Table 2. Comparison of prognosis analysis between the two groups

Biomarker	Group	<i>n</i>	Recurrence rate (%)	Progression-free survival (months)
NMP22	High-level group	43	18 (41.86)	11.85 ± 2.98
	Low-level group	57	11 (19.29)	19.32 ± 4.56
	t/χ^2		6.060	9.337
	<i>P</i>		0.014	< 0.001
OPN	High-level group	47	17 (36.17)	13.21 ± 3.57
	Low-level group	53	9 (16.98)	20.14 ± 4.33
	t/χ^2		4.767	8.530
	<i>P</i>		0.029	< 0.001
BTA	High-level group	38	15 (34.10)	12.67 ± 3.12
	Low-level group	62	9 (14.52)	18.95 ± 4.08
	t/χ^2		8.046	8.405
	<i>P</i>		0.005	< 0.001

4. Discussion

The incidence of bladder urothelial carcinoma is increasing year by year globally, making it one of the important causes of death from urinary system tumors. Early diagnosis facilitates timely intervention and improves patient prognosis, while prognostic evaluation provides critical information for adjusting subsequent treatment plans. Urine testing has become a popular direction for the diagnosis and monitoring of bladder cancer due to its noninvasive sample collection and easy acceptance by patients. Nuclear matrix protein 22 (NMP22), osteopontin (OPN), and bladder tumor antigen (BTA) are potential biomarkers, and their detection is expected to optimize the diagnosis and treatment process of bladder urothelial carcinoma^[1,2].

Foreign countries have started early in the field of using urine markers for bladder cancer diagnosis, with collaborative advancement in basic research and clinical translation. Many prospective studies have focused on NMP22, OPN, and BTA, exploring all aspects from molecular mechanisms to clinical efficacy. For example, a long-term cohort study at the Southwestern Medical Center in the United States tracked bladder cancer patients and healthy controls over several years, precisely quantifying urine markers^[3]. They found significant trends in the concentration of NMP22 in the urine of early-stage bladder cancer patients, providing a critical basis for setting subsequent diagnostic thresholds. Some European multicenter joint projects have collected massive samples across different medical levels to validate the indicative role of OPN in bladder cancer grading^[4]. The results have facilitated clinical stratified diagnosis and treatment. Currently, some achievements have been integrated into the clinical preliminary screening process. For instance, some community hospitals in Germany have introduced bladder cancer screening packages including BTA testing, improving the efficiency of early detection. Additionally, authoritative organizations like the International Urological Association continuously integrate cutting-edge achievements, update relevant guidelines, standardize the implementation of new technologies, promote international exchanges and cooperation, and continuously optimize detection efficiency^[5].

Although domestic research on urine biomarkers for bladder cancer lagged slightly in early stages, it has shown vigorous development in recent years. Major medical centers and research teams have actively conducted large-sample cohort studies, recruiting subjects across different regions and fully considering the genetic traits and living environment differences of the Chinese population. For example, a large tertiary hospital in Shanghai, in collaboration with multiple local hospitals, has constructed a cohort for bladder cancer urine markers among the population in East China. They have analyzed the sensitivity and specificity of NMP22 and OPN in local patients, strongly validating their applicability^[3]. However, the standardization of detection remains a prominent issue. Due to differences in equipment procurement channels and reagent brands among laboratories in various regions, data consistency is poor. For instance, the deviation in NMP22 detection values can reach 20% when the same urine sample is sent to different laboratories. Regarding combined application schemes, although there are theoretical ideas, practical operations lack a mature process and mostly remain in the small-scale exploration stage. A widely recognized, efficient, and precise combined detection mode has not been established, requiring further resource integration and collaborative research^[6,7].

NMP22, as a key component of the cell nuclear mitotic apparatus, maintains the stability of the nuclear structure and mitotic process under normal physiological conditions. When bladder urothelial cells undergo cancerous changes, the cell cycle becomes uncontrolled, and apoptosis programs are frequently initiated. During apoptosis of bladder cancer cells, the cell membrane ruptures, releasing a large amount of NMP22 originally located in the nucleus into the extracellular environment and entering the urine system. This results in a urine NMP22 concentration far exceeding that of healthy individuals^[8]. Currently, ELISA is the mainstream detection method. ELISA is based on the immunological principle of antigen-antibody specific affinity. First, NMP22-specific antibodies are coated on a solid-phase carrier. After adding the urine sample, NMP22 binds to the antibodies. Unbound substances are then washed away, and enzyme-labeled secondary antibodies are added. A chromogenic reaction occurs through substrate catalysis, and the absorbance is measured using a spectrophotometer. The NMP22 content in the urine can be accurately calculated based on a standard curve^[9].

Osteopontin (OPN), a secreted phosphorylated glycoprotein, is secreted by various cells and plays a complex role in tumor development and progression. In the context of bladder urothelial carcinoma, gene regulation is disrupted in cancer cells, significantly upregulating *OPN* gene transcription and translation activity. This leads to massive synthesis and accumulation of OPN within cells, which is then actively secreted into the extracellular space and mixed into the urine. Consequently, urine OPN levels are significantly higher than those in the normal population^[10,11]. For its detection, immunoturbidimetric assay and ELISA are commonly used methods. In the immunoturbidimetric assay, the urine sample is mixed with OPN-specific antibodies to form antigen-antibody complexes, changing the turbidity of the solution. The change in turbidity is measured using a turbidimeter, and the OPN concentration is calculated based on a standard curve. In contrast, ELISA involves immobilizing OPN antibodies, reacting with the urine sample, and then binding to labeled secondary antibodies. The OPN content in the urine is precisely quantified based on the intensity of the chromogenic or fluorescent signal^[12,13].

Bladder tumor antigen (BTA) is essentially a unique type of antigen complex on the surface of bladder cancer cells, closely related to the biological characteristics and proliferation and invasion abilities of tumor cells. In qualitative detection mode, immunochromatographic test strips play a crucial role. These test strips contain pre-fixed BTA-specific antibodies. When a urine sample is dropped onto the test strip, urine spreads along the fibrous membrane of the test strip driven by chromatography. If BTA is present in the urine, it quickly

binds to the immobilized antibodies, triggering a chromogenic reaction. This is typically manifested as the appearance of a band in a specific region of the test strip, allowing for intuitive judgment of whether BTA is positive. The operation is simple and fast, suitable for rapid initial screening at the grassroots level. In terms of quantitative detection, the advantages of chemiluminescent immunoassay are prominent ^[14,15]. This method utilizes the intensity of the light signal generated by a chemical reaction to reflect the BTA content. The urine sample reacts sequentially with labeled antibodies and solid-phase carriers. After washing, a luminescent substrate is added. The light signal is captured by detection equipment, and a precise quantitative BTA value is provided based on a calibration curve. This provides detailed data support for clinical diagnosis ^[16,17].

This study focused on the application of urine NMP22, OPN, and BTA detection in bladder urothelial carcinoma, and the results have important clinical implications. The levels of NMP22, OPN, and BTA in the case group were significantly higher than those in the control group. This indicates that these three markers are highly expressed in the urine of patients with bladder urothelial carcinoma, providing a strong basis for disease diagnosis. Combined detection has higher sensitivity, specificity, and accuracy than single-marker detection. When NMP22, OPN, and BTA are detected individually, their sensitivity and specificity have limitations ^[18]. However, combined detection integrates the advantages of each marker, improving sensitivity from a maximum of 72% for a single marker to 88% for the combination, specificity from 83% to 92%, and achieving 90% accuracy. This significantly enhances the diagnostic capability for bladder urothelial carcinoma, reducing misdiagnosis and missed diagnosis. After a 2-year follow-up, patients with high levels of NMP22, OPN, and BTA had a significantly higher recurrence rate and shorter progression-free survival compared to those with low levels. Taking NMP22 as an example, the recurrence rate in the high-level group was 41.86%, significantly higher than the 19.29% in the low-level group, and the progression-free survival was also shorter. This implies that the levels of these three markers are closely related to patient prognosis. High levels indicate a high risk of tumor recurrence and rapid disease progression. Clinicians can assess patient prognosis based on these marker levels, develop more targeted treatment and follow-up strategies, and improve patients' quality of life ^[19,20].

5. Conclusion

The combined detection of urinary biomarkers—including NMP22, OPN, and BTA—demonstrates significant diagnostic value for bladder urothelial carcinoma. Studies indicate that this multi-marker approach improves sensitivity and specificity compared to individual tests, enabling earlier and more accurate detection of malignant lesions.

Furthermore, the levels of NMP22, OPN, and BTA in urine are closely correlated with tumor progression, aggressiveness, and clinical outcomes. Elevated concentrations of these markers are associated with advanced disease stages, higher recurrence rates, and poorer survival, suggesting their utility in prognostic evaluation. Regular monitoring of these biomarkers may aid in risk stratification, treatment response assessment, and long-term follow-up for bladder urothelial carcinoma patients.

Thus, integrating NMP22, OPN, and BTA testing into clinical practice could enhance both diagnostic precision and prognostic prediction, offering a non-invasive tool to optimize patient management and improve therapeutic outcomes.

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Disclosure statement

The authors declare no conflict of interest.

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An Innovative Application and Value of Modified Fluid Position Pads in 60° Lateral Recumbency Position for da Vinci Robotic Upper Urinary Tract Surgery

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Abstract: *Objective:* To explore the application of modified fluid position pads in da Vinci robotic urology lateral position surgery and analyze its clinical application value. *Methods:* A randomized controlled study was conducted from June 2024 to June 2025 to select 120 patients from the First Affiliated Hospital of Sun Yat-sen University who met the inclusion and exclusion criteria and were randomly divided into 60 cases each in the control group and the observation group. The control group used the traditional position placement method, and the observation group applied the modified fluid position pads for position placement. The two groups were compared in terms of positioning process, patient comfort, position stability, and satisfaction of surgeons. *Results:* The comfort level of the patients in the observation group was higher than that of the control group, and the positioning process could save time compared with the control group. The position stability rate in the observation group was significantly higher than that in the control group. The satisfaction of surgeons in the observation group was also higher than that in the control group. *Conclusion:* The application of the modified fluid position pads significantly simplifies the positioning process, improves the comfort and position stability of the patients, and enhances the satisfaction of the surgeons, which has important clinical promotion value.

Keywords: Modified fluid position pads; da Vinci robot; Upper urinary tract surgery; 60° lateral position; Clinical value of application

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1. Introduction

Da Vinci Robotic Surgery is an advanced minimally invasive surgical procedure performed by a robotic arm that is remotely controlled by the surgeon. The system consists of a high-definition 3D imaging system, a flexible robotic arm, and a main console, which can complete precise operations in a small space. The da Vinci robot, which has been widely used in urology upper urinary tract surgery^[1], and its high-definition 3D field of view and image magnification feature can help the operator identify the kidney, renal pelvis, ureter, and other

complex anatomical structures more clearly ^[2]. Compared with traditional open or laparoscopic surgery, the robotic system effectively reduces the surgeon's hand tremor and improves the stability and consistency of the surgery, which is especially suitable for upper urinary tract reconstruction surgery that requires a high degree of surgical precision.

In da Vinci robotic urology upper urinary tract surgery, the 60° lateral position is a commonly used surgical position, which can provide a good view and operating space for surgical operations. However, the traditional position placement has problems such as cumbersome procedures and poor patient comfort, which not only increases the workload of healthcare professionals but also may affect the intraoperative safety of patients and surgical effect. The emergence of modified fluid position pads provides a new idea for solving these problems. A fluid pad is a postural aid made of polymer-coated special liquid material with good softness, fluidity, and pressure reduction. Its internal fluid can automatically distribute pressure according to the patient's body surface force, to achieve the effect of conforming to the body curve and uniform force. During da Vinci robotic surgery, the standardized application of intraoperative position management can effectively improve the surgical success rate of patients ^[3]. This study will deeply explore the innovative application and value of the modified fluid position pads in the 60° lateral position of da Vinci robotic urology upper urinary tract surgery.

2. Materials and methods

2.1. Sources of information

This study selected 120 patients who underwent da Vinci robotic urology upper urinary tract surgery and adopted a 60° lateral position in the First Affiliated Hospital of Sun Yat-sen University from June 2024 to June 2025. Inclusion criteria: (1) clinically diagnosed as needing da Vinci robotic urology upper urinary tract surgery; (2) no severe cardiopulmonary dysfunction and able to tolerate the 60° lateral position; (3) patients and doctors gave informed consent and voluntarily participated in this study. Exclusion criteria: (1) patients with language barriers, cognitive impairments, or other reasons for not being able to understand the study or cooperate in completing the study; (2) the existence of skin allergies, damage, and other conditions affecting the use of position; (3) those who were converted to open surgery midway or the surgery could not be completed successfully. Comparison of the two groups of patients in terms of age, gender, type of surgery, severity of the disease, and other general information, the difference was not statistically significant ($P > 0.05$), indicating comparability.

2.2. Methodology

The study was designed as a randomized controlled trial. 120 patients were randomly assigned to two groups, the observation group and the control group, with 60 patients in each group, using the random number table method.

2.2.1. Control group

The traditional body position method was used, see **Figure 1**. After the patient was successfully anesthetized, the healthcare professionals worked together to place the patient in a 60° lateral position. First, the front and rear top body position screws and hand support were installed on the operating bed, and ordinary body position pads were placed, including headrests, armpit pillows, and large pillows between the legs. After the patient was placed in a 60° lateral position, the front and rear top positions needed to be continuously adjusted to ensure that the patient's position met the surgical requirements, and then the patient was fixed with a restraint belt.



Figure 1. Control group

2.2.2. Observation group

The modified fluid position pads were used for body positioning, see **Figure 2**. The modified fluid position pads are primarily made of special fluid materials and have good plasticity and fit. After the patient was successfully anesthetized, the healthcare professionals placed the patient in a 60° lateral position. The circulating nurse rolled the modified fluid position pads to the patient's shoulder and back with a medium sheet. The position pads will automatically shape according to the patient's body contour and fit the patient's skin completely. The patient's position needs to be fine-tuned, and a restraint belt is used for auxiliary fixation.



Figure 2. Observation group

2.3. Observation indicators

This study observed the clinical application value of the modified fluid position pads in da Vinci robotic urological surgery from the following four aspects.

2.3.1. Positioning time

The time taken from the beginning of positioning until the position was completely fixed and met the surgical requirements was recorded.

2.3.2. Patient comfort

Using visual analogue scale (VAS), patients were asked to rate the comfort of the intraoperative position while they were awake at the end of the procedure, with a score of 0 indicating complete comfort and 10 indicating extreme discomfort.

2.3.3. Body position stability

Intraoperative body position stability was evaluated by the surgeon at the end of the procedure and was graded as stable, basically stable, or unstable. Stable means that the patient's body position does not move significantly during the operation, which does not affect the operation; basically stable means that the patient's body position moves slightly during the operation, but it does not affect the operation after simple adjustment; unstable means that the patient's body position moves significantly, which has a great impact on the operation and requires multiple adjustments. Stability rate = (number of stable cases + number of basically stable cases) / total number of cases \times 100%.

2.3.4. Satisfaction of surgeons

The application of the modified fluid position pads was evaluated by the surgeon at the end of the procedure and was graded as very satisfactory, satisfactory, and unsatisfactory. Satisfaction = (number of very satisfied cases + number of satisfied cases) / total number of cases \times 100%.

2.4. Statistical methods

SPSS 22.0 statistical software was used for data analysis. The measurement data were expressed as mean \pm standard deviation (SD), and the independent sample *t*-test was used for inter-group comparison; the count data were expressed as rate (%), and the χ^2 test was used for comparison between groups. $P < 0.05$ indicated that the difference was statistically significant.

3. Results

3.1. Positioning time

The body positioning time in the observation group was significantly shorter than that in the control group, and the difference between the two groups was statistically significant ($t = -21.345$, $P < 0.001$), as shown in **Table 1**.

Table 1. Time of positioning of patients in both groups

Groups	Positioning time
Observation group ($n = 60$)	12.3 \pm 2.5 min
Control group ($n = 60$)	25.6 \pm 4.2 min

3.2. Patient comfort

The comfort scores of the observation group were significantly lower than those of the control group, and the difference between the two groups was statistically significant ($t = -16.543$, $P < 0.001$), as shown in **Table 2**.

Table 2. Comfort scores of patients in the two groups

Groups	Patient comfort scores
Observation group (<i>n</i> = 60)	2.1 ± 0.8
Control group (<i>n</i> = 60)	5.6 ± 1.5

3.3. Postural stability

In the observation group, 48 patients had stable body position, 10 were basically stable, and 2 were unstable; in the control group, 32 patients had stable body position, 18 were basically stable, and 10 were unstable. The body position stability rate in the observation group was significantly higher than that in the control group, and the difference between the two groups was statistically significant ($\chi^2 = 5.926$, $P = 0.015$), as shown in **Table 3**.

Table 3. Body position stability of patients in the two groups

Groups	Body position stability rate
Observation group (<i>n</i> = 60)	96.7% (58/60)
Control group (<i>n</i> = 60)	83.3% (50/60)

3.4. Satisfaction of surgeons

Scores of the observation group were 38 very satisfactory cases, 19 satisfactory cases, and 3 unsatisfactory cases, while scores of the control group were 25 very satisfactory cases, 22 satisfactory cases, and 13 unsatisfactory cases. The satisfaction rate of the observation group was significantly higher than that of the control group, and the difference between the two groups was statistically significant ($\chi^2 = 7.912$, $P = 0.005$), as shown in **Table 4**.

Table 4. Satisfaction scores of surgeons in the two groups

Groups	Satisfaction of surgeons
Observation group (<i>n</i> = 60)	95.0% (57/60)
Control group (<i>n</i> = 60)	78.3% (47/60)

4. Discussion

This study conducted a detailed clinical trial to explore the practical clinical application of the modified fluid position pads. The results of the study are discussed in detail below.

4.1. Effect of modified fluid position pads on the position placement process

Traditional position placement methods require the use of a variety of different types of position pads and fixed frames. In the process of placement, healthcare professionals need to constantly adjust the position of the frame and the tightness of the restraint belt according to the patient's body shape, surgical requirements, etc. The operation steps are cumbersome and time-consuming. However, the modified fluid positioning pads have a unique automatic shaping feature that can quickly fit the patient's body contour. Only simple fine-tuning is required to complete the positioning, greatly reducing the operation steps and time required. This not only improves the efficiency of surgical preparation but also reduces the workload of healthcare professionals,

making the surgical process smoother.

4.2. Effect of modified fluid position pads on patient comfort

During surgery, patients maintain a fixed position for an extended period, and traditional position pads often fail to fully accommodate the patient's body, leading to local skin pressure and poor blood circulation, which can cause discomfort to the patient. The modified fluid position pads provide a snug fit for the patient's skin, evenly distributing body pressure and reducing local skin pressure, thereby effectively improving blood circulation^[4]. At the same time, its soft material also provides patients with more comfortable support, reduces the patient's intraoperative discomfort during surgery, and improves the patient's comfort, which is also of positive significance for the patient's postoperative recovery.

4.3. Effect of modified fluid position pads on position stability

The da Vinci robotic urology upper urinary tract surgery is delicate and requires a high level of patient position stability^[5]. During the traditional positioning method, the patient's position is prone to movement due to the poor fit of the positioning pads to the patient's body. The modified fluid position pads can provide stable support for the patient and reduce the patient's movement during the surgical procedure. Even if the patient is subjected to a certain external force during the operation, the modified fluid position pads can maintain the patient's position through their good elasticity and shaping ability, providing a reliable guarantee for the smooth progress of the operation^[6].

4.4. Effect of modified fluid position pads on the satisfaction of surgeons

For surgeons, the simplified placement process of the modified fluid position pads reduces their workload, improves work efficiency, and saves time for surgical preparation. During the operation, the stable patient position also makes the operation smoother and reduces surgical interference caused by position problems^[7]. All of these advantages have significantly improved the satisfaction of surgeons with the modified fluid position pads.

5. Conclusion

The application of modified fluid position pads in 60° lateral positioning for da Vinci robotic urology upper urinary tract surgery has shown clear advantages in clinical practice. Compared with traditional positioning methods, the modified fluid pads simplify the positioning process by reducing the need for repeated manual adjustments and reliance on multiple positioning accessories such as foam pads, shoulder supports, or bulky restraint systems, these pads significantly improve patient comfort, reduce positioning time, enhance body position stability, and increase surgeon satisfaction. Their ability to automatically conform to the patient's body contour, distribute pressure evenly, and provide secure support reduces the risk of pressure injuries and discomfort, making them a safer and more efficient option during lengthy and complex robotic procedures.

Despite these evident advantages, the widespread implementation of modified fluid position pads in clinical practice faces several challenges. First, the cost of the pads remains a significant barrier, especially in resource-limited settings. The materials used in their construction—such as medical-grade polymer encased fluid—are relatively expensive, and the manufacturing process is more complex compared to standard foam or gel pads. While some designs may support limited reuse with proper cleaning protocols, most are intended for

single-use, raising concerns about cost-effectiveness and environmental sustainability.

Second, the lack of standardized clinical guidelines or manufacturer-specific protocols for the use of fluid pads across different surgical specialties may hinder their broader adoption. Clinical teams may be unfamiliar with the optimal placement techniques, pressure distribution considerations, or necessary adjuncts such as restraints or supports for different surgical positions^[8]. This underscores the need for structured training and education for nursing staff and surgical assistants to ensure safe and consistent use^[9].

Third, the adaptability of modified fluid pads to a wide range of patient anatomies—such as obese individuals, patients with skeletal deformities, or those requiring extreme positioning—may be limited. In such cases, fluid pads may not provide adequate support or stability on their own and may need to be used in conjunction with other positioning tools, potentially offsetting the simplicity and efficiency gains they offer.

Furthermore, logistical issues such as inventory management, storage, sterilization protocols (if reusable), and integration into existing operating room workflows also present real-world barriers to routine use. Hospitals would need to assess the feasibility of transitioning from current equipment to fluid-based systems in terms of procurement, training, and overall return on investment^[10].

In summary, modified fluid position pads offer a promising advancement in surgical patient positioning, particularly in complex and delicate procedures such as da Vinci robotic-assisted upper urinary tract surgeries. They improve patient comfort, reduce setup time, enhance position stability, and increase surgeon satisfaction. However, to facilitate their widespread clinical adoption, efforts must be made to address current limitations, including high costs, limited reusability, training demands, and the lack of universal application protocols. Future research should focus on multi-center validation, cost-benefit analysis, and the development of standardized usage guidelines. With ongoing innovation and optimization, modified fluid position pads have the potential to become a valuable tool in the modernization of perioperative care and robotic surgery support systems.

Disclosure statement

The authors declare no conflict of interest.

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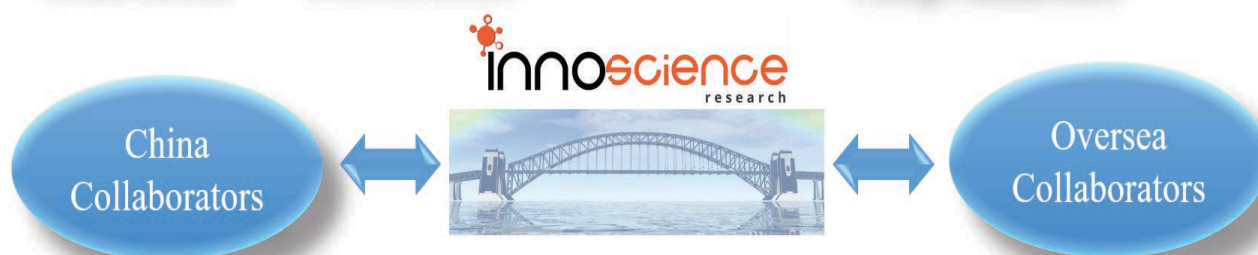
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