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Prospective study on the effects of mechanical bowel preparation under the enhanced recovery after surgery concept on electrolyte disturbances and functional recovery after robotic surgery for urologic tumors in older adults

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Abstract

Background Mechanical bowel preparation (MBP) involves the cleansing of bowel excreta and secretions using methods such as preoperative oral laxatives, retrograde enemas, and dietary adjustments. When combined with oral antibiotics, preoperative MBP can effectively lower the risk of anastomotic leakage, minimize the occurrence of postoperative infections, and reduce the likelihood of other complications. To study the effects of MBP under the Enhanced Recovery After Surgery (ERAS) concept on postoperative electrolyte disorders and functional recovery in older people with urological tumors undergoing robot-assisted surgery.

Methods Older people with urological tumors undergoing robot-assisted surgery were randomly divided into two groups. The experimental group ($n = 76$) underwent preoperative MBP, while the control group ($n = 72$) did not. The differences in electrolyte levels and functional recovery between the two groups after radical surgery for urological tumors were observed.

Results The incidence of postoperative electrolyte disorders was significantly higher in the experimental group compared to the control group, with incidence rates of 42.1% and 19.4%, respectively ($P < 0.05$). Subgroup analysis showed that the electrolyte disorder was age-related ($P < 0.05$). There were no significant differences between the two groups in terms of postoperative complications, gastrointestinal function recovery, laboratory indicators of infection, body temperature, and length of hospital stay ($P > 0.05$).

Conclusion Under the accelerated recovery background, preoperative MBP increases the risk of postoperative electrolyte disorders in older people with urological tumors and does not reduce the incidence of postoperative complications or promote postoperative functional recovery.

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Keywords Mechanical bowel preparation, Enhanced recovery after surgery, Elderly urological tumors, Electrolyte disorders, Postoperative complications and functional recovery

Introduction

Urological tumors often require radical surgery for cure. Minimally invasive (MI) techniques, like robot-assisted surgery using the da Vinci robotic system, have transformed urological procedures. The da Vinci system represents a significant advancement in MI surgery and has gained widespread acceptance [1, 2]. Most urological surgeries can now be performed robotically, leading to increased surgical volumes in developed countries [3]. Recent advancements, such as the Hugo RAS system, further expand these capabilities, offering feasible, safe, and clinically applicable robotic options for complex procedures like off-clamp partial nephrectomy and radical prostatectomy, as demonstrated in multiple recent studies [4–7]. This modern approach provides enhanced precision, shorter hospital stays, reduced postoperative pain and complications, and quicker recovery [8, 9]. Moreover, it extends the surgical possibilities to older people due to its safety and effectiveness [10].

Enhanced recovery after surgery (ERAS) is an evidence-based, multidisciplinary approach to improve surgical outcomes by optimizing the perioperative pathway, including preoperative, intraoperative, and postoperative care. ERAS aims to reduce surgical stress, enhance perioperative safety and satisfaction, minimize postoperative complications, shorten hospital stays, and accelerate recovery [11]. ERAS protocols include preoperative counseling, nutrition and fluid management, MI surgery, multimodal pain control, early mobilization, and early oral feeding, all of which reduce stress responses, complications, and facilitate faster recovery [12]. This patient-centered approach has demonstrated improved outcomes, such as reduced hospital stays, decreased complications, and enhanced patient satisfaction [13]' [14]. Preoperative mechanical bowel preparation (MBP) is an important part of the ERAS to prevent complications like infection or anastomotic leakage [15]. MBP is a mechanical cleansing of bowel excreta and secretions that includes preoperative oral laxatives, retrograde enemas, and dietary adjustments [16]. Preoperative MBP combined with oral antibiotics can reduce the risk of anastomotic leakage and reduce the risk of postoperative infections and other complications [17]. However, its necessity is controversial as it may cause fluid imbalance and electrolyte disorders affecting recovery without significantly reducing microbial load [15, 18]. Older patients, with reduced organ function and more comorbidities, face higher risks of dehydration and electrolyte imbalances from MBP [19, 20], but this evidence mainly comes from patients undergoing colorectal surgery.

Infection and anastomotic leakage are potential complications of any surgery, including robot-assisted procedures for kidney and prostate cancer. Despite sterile techniques and prophylactic antibiotics, infection risks remain due to factors like the patient's health status, other medical conditions (e.g., diabetes), and the specific procedure. Anastomotic leakage, a complication where the connection between two structures (e.g., bladder and urethra in prostate surgery) fails to heal properly, can be influenced by surgical technique, patient factors (e.g., poor nutrition, smoking), and disease-related factors (e.g., cancer extent and location) [21]. MBP is commonly used before surgery, but its impact on recovery for non-digestive system tumors is not well understood. There is limited clinical research on preoperative MBP for urological surgery, especially for elderly patients. This study focuses on urological tumor patients aged 60 or older who underwent robot-assisted surgery, comparing the effects of preoperative MBP on postoperative electrolyte levels and complications to explore its necessity for this patient group.

Objects and methods

Research objectives

The research aims to study patients who underwent urological tumor radical surgery at the Second Affiliated Hospital of Harbin Medical University between April 2021 and October 2022. It is worth noting that for patients with bladder cancer, the surgical approach included radical resection followed by abdominal ureterostomy. The study used a block randomization method, with subjects sorted based on their entry time into the study. Each block consisted of 8 participants, and random numbers generated by a computer were used to allocate participants in a 1:1 ratio to the experimental and control groups (We first determine the sample size within each block, which is referred to as the block length, then this 8 is the block length, not the total number of people enrolled). Patients with missing data will be excluded from the group). The experimental group received MBP before surgery, while the control group did not undergo MBP. The inclusion criteria were as follows: (1) age ≥ 60 years; (2) clinical diagnosis of urological tumors; (3) expected to undergo standard radical surgery for kidney, ureter, bladder, prostate, or other urological tumors; (4) the same surgical team and primary surgeons had each completed over 100 robot-assisted radical surgeries for kidney, ureter, bladder, prostate, or other urological tumors; (5) signed informed consent and voluntary participation in the study. Exclusion criteria were as follows:

(1) prior upper abdominal surgery (excluding laparoscopic cholecystectomy); (2) a history of other malignant tumors within the past 5 years; (3) severe underlying diseases or organ dysfunctions; (4) prior electrolyte imbalance and diseases affecting intestinal absorption; (5) inability to tolerate surgery for other reasons; (6) received neoadjuvant chemotherapy before surgery. The randomization process was conducted without the involvement of the surgical team, intervention implementers, or outcome analysts.

Research methods

MBP protocol

Experimental Group (MBP Group): The patients followed the ERAS protocol [22] for preoperative diet and underwent routine MBP one day before the surgery. This preparation involved orally ingesting 68.56 g of a compound polyethylene glycol electrolyte powder mixed with 1000 mL of warm water within one hour. Control Group (Non-MBP Group): The patients followed the regular ERAS protocol for preoperative diet and did not undergo MBP.

Perioperative ERAS protocol

Apart from the MBP protocol, both groups of patients followed an accelerated perioperative ERAS protocol, which included preoperative, intraoperative, and postoperative components.

Preoperative phase

The preoperative phase involved the following steps: (1) smoking cessation and alcohol abstinence for at least 2 months at the time of admission [23–25]; (2) pulmonary function exercises, including blowing balloons and climbing stairs, as instructed by medical staff; (3) special medication (antihypertensive, cardiac medications) required before surgery, with consultation from doctors; (4) carbohydrate intake, with oral consumption of a carbohydrate beverage (800 mL) at 20:00 on the evening before surgery and 400 mL two hours before surgery, after which further oral intake was restricted; (5) antibiotic prophylaxis with cefazolin sodium 1 g intravenous infusion 30 min before surgery; (6) psychological intervention for patients with anxiety or depression, assessed using the Hospital Anxiety and Depression Scale (HADS); (7) nutritional risk screening using NRS 2002, with the implementation of nutritional assessment, intervention, and monitoring for patients with a score of ≥3 points.

Intraoperative phase

This phase included goal-directed fluid management (1000–1500 mL), airway management, and lung protection strategies, such as preoperative intravenous administration of corticosteroids (methylprednisolone 20–40 mg or hydrocortisone 100 mg) to prevent bronchospasm, complications in the throat, and potential allergic reactions. Core body temperature was maintained at ≥36 °C using various warming methods during and after surgery.

Postoperative phase

The postoperative phase involved the following measures: (1) carbohydrate intake began four hours after surgery, gradually increasing from 20 mL per hour and adjusting according to the patient's condition until fully consumed; (2) early feeding with water intake at 30 mL every two hours on the first postoperative day, followed by a liquid diet after 48 h, and then a semi-liquid diet on the fifth postoperative day. The principles were to start with small quantities, thin consistency, and frequent meals. Foods that could cause gas were avoided until gastrointestinal function fully recovered, e.g., legumes, carbonated beverages, radish, and starchy vegetables; (3) removal of urinary catheters after 24 h; (4) early mobilization, guided by ankle pump exercises, knee and elbow flexion exercises to prevent lower limb venous thrombosis. Patients were gradually encouraged to sit up, stand beside the bed, walk with assistance, walk with family support inside the room, and finally walk along the corridor; (5) sleep hygiene measures were followed to form a regular sleep-wake cycle. Patients with sleep disorders received sleep-promoting medications as prescribed; (6) multimodal analgesia, including long-acting local anesthetics for abdominal plane blocks after surgery and patient-controlled analgesia (PCA) with nonsteroidal anti-inflammatory drugs administered intravenously every 12 h; (7) bowel motility assessment, with glycerin suppositories (110 mL) administered rectally if no flatus or bowel movement occurred by postoperative day 3; (8) antibiotic therapy for five days after surgery [26].

Observational indicators

Baseline characteristics

Baseline data for patients included gender, age, body mass index (BMI), educational level, tumor type, and comorbidities such as hypertension, diabetes, cardiovascular diseases, liver and kidney diseases, respiratory diseases, and cerebrovascular diseases.

Functional recovery assessment-primary observational indicators

(1) Postoperative Electrolyte Disorders: Any abnormality in serum K+, Na+, or Cl- on the first postoperative day was considered an electrolyte disorder. Subgroup analysis would explore the relationship between electrolyte disorders and age.
(2) Surgical Process: Surgical time and blood loss.

(3) Postoperative Complications: Incidence of surgical site infections, characterized by redness, swelling, or purulent discharge at the incision site; hematuria, including visible blood in the urine or positive red blood cells in the urine.
(4) Postoperative Gastrointestinal Function Recovery Indicators: Time to first flatus and first bowel movement.
(5) Length of Hospital Stay After Surgery.

Functional recovery assessment-secondary observational indicators

(1) Abnormal Gastrointestinal Function After Surgery: Daily episodes of sustained abdominal distension lasting ≥ 6 h and occurrences of nausea or vomiting with gastric contents.
(2) Laboratory Indicators: Differences in white blood cell count (WBC), C-reactive protein (CRP), neutrophil count, percentage of neutrophils, prealbumin, and albumin levels between the first postoperative day and the day of surgery. Peripheral venous blood samples were collected one hour before surgery and at 8:00 on the first postoperative day.

Table 1 Comparison of general information between the two groups

Groups	Experimental group (*n*=76)	Control group (*n*=72)	$t/Z/\chi^2$	*P*
Gender (n, %)			3.190[a]	0.074
Male	47(61.8)	34(47.2)		
Female	29(38.2)	38(52.8)		
Age [Years, M (P25, P75)]	67(63,72)	67(63,73)	-0.354[b]	0.724
BMI [Kg/m2, M (P25, P75)]	22.4(21,24)	22.4(21,23.6)	-0.524[b]	0.600
Educational attainment (n, %)			0.014[a]	0.993
Primary education	2(42.1)	30(41.7)		
Secondary education	36(47.4)	34(47.2)		
Higher education	8 (10.5)	8 (11.1)		
Type of disease (n, %)			0.039[a]	0.998
Kidney cancer	30(39.5)	28(38.9)		
Bladder Cancer	20(26.3)	19(26.4)		
Prostate Cancer	10(13.2)	9(12.5)		
Ureteral Cancer	5 (6.6)	5 (6.9)		
Renal pelvis cancer	7 (9.2)	7 (9.7)		
Other	4 (5.3)	4 (5.6)		
Comorbidities (n, %)			0.037[a]	0.847
Yes	57(75.0)	53(73.6)		
No	19(25.0)	19(26.4)		

Note a is the χ^2-value and b is the Z value

(3) Daily Temperature at 14:00 on the First Three Postoperative Days.

Statistical methods

Statistical analysis was performed using SPSS 26.0 software. To assess the distribution of continuous variables, the Shapiro-Wilk test was employed, with normally distributed continuous variables were presented as mean ± standard deviation (mean ± s), and the independent sample t-test was used for statistical inference. Non-normally distributed continuous variables were presented as median and quartiles, and the Mann-Whitney U test was used for statistical inference. Categorical data were presented as frequencies and percentages, and the chi-square test was used for statistical analysis. A significance level of $P<0.05$ was considered statistically significant.

Results

Comparison of clinical baseline data between the two groups

The study compared an Experimental group ($n=76$) to a Control group ($n=72$) to investigate differences in various aspects. Gender, age and BMI distributions were similar between the groups ($P=0.074$ for gender, $P=0.724$ for age and $P=0.600$ for BMI). Educational attainment did not differ significantly ($P=0.993$), with comparable percentages in primary, secondary, and higher education in both groups. There was no statistically significant difference in cancer type distributions ($P=0.998$), with kidney cancer being the most common in both groups (Experimental: 39.5%, Control: 38.9%). The presence of comorbidities also did not show a statistically significant difference between the groups ($P=0.847$, Table 1).

Comparison of postoperative electrolyte disorders between the two groups

Table 2 presents a comparison of electrolyte disorders and related complications between the Experimental group and the Control group. The study found that the incidence of electrolyte disorders was significantly higher in the Experimental group (42.1%) compared to the Control group (19.4%), with a statistically significant difference ($\chi2=8.863$, $P=0.003$). Furthermore, the study investigated specific electrolyte levels in both groups. The Experimental group displayed lower levels of sodium ions (139.30 mmol/L) compared to the Control group (140.75 mmol/L), with a statistically significant difference (Z = -3.177, $P=0.001$). Similarly, the Experimental group had lower levels of potassium ions (3.88 mmol/L) and chloride ions (103.20 mmol/L) compared to the Control group (potassium: 4.11 mmol/L, chloride: 104.80 mmol/L). These differences were found to be statistically significant as well (Z = -3.781, $P<0.001$ for potassium;

Table 2 Comparison of electrolyte disorders and related complications between the two groups

Groups	Experimental group ($n=76$)	Control group ($n=72$)	Z/χ^2	P
Electrolyte disorders (n, %)	32(42.1)	14(19.4)	8.863[a]	0.003
d1 sodium ions [mmol/L, M (P25, P75)	139.30 (135.80,140.83)	140.75 (138.00,142.53)	-3.177 [b]	0.001
d1 potassium ions (mmol/L, M (P25, P75))	3.88(3.59,4.08)	4.11(3.80,4.36)	-3.781 [b]	0.000
d1 chloride ion (mmol/L, M (P25, P75))	103.20 (100.7,104.33)	104.80 (102.45,107.43)	-3.787 [b]	0.000
Difference between postoperative d1 and morning of surgery sodium ions [mmol/L, M (P25, P75)	-2.80(-3.80,-2.08)	-0.80(-1.63,-0.20)	-7.057[b]	0.000
Postoperative d1 versus morning potassium ion difference [mmol/L, M (P25, P75)	-0.40(-0.52,-0.04)	-0.10(-0.17,-0.10)	-8.703[b]	0.000
Postoperative d1 versus morning chloride ion difference [mmol/L, M (P25, P75)	-3.70(-5.03,-2.88)	-1.00(-2.15,-0.28)	-8.097[b]	0.000

Note a is the χ^2-value and b is the Z value

Table 3 Age stratification of the occurrence of electrolyte disorders in the MBP group

Age(y)	Electrolyte disorders(n, %)		χ^2	P
	Yes	No		
≥60,<70	14(27.5)	37(72.5)	14.405	0.001
≥70,<80	13(68.4)	6(31.6)		
≥80	5(83.3)	1(16.7)		

Table 4 Age stratification of the occurrence of two and more electrolyte disorders in the MBP group

Age (Y)	two and more electrolyte disorders(n, %)		χ^2	P
	Yes	No		
≥60,<70	5(9.6)	47(90.4)	15.133	0.001
≥70,<80	4(21.1)	15(78.9)		
≥80	5(83.3)	1(16.7)		

Z = -3.787, $P<0.001$ for chloride). Moreover, the study analyzed the differences in postoperative and morning-of-surgery electrolyte levels between the two groups. The Experimental group exhibited significantly higher differences in sodium, potassium, and chloride ion levels between the postoperative and morning measurements compared to the Control group (Z = -7.057, $P<0.001$ for sodium; Z = -8.703, $P<0.001$ for potassium; Z = -8.097, $P<0.001$ for chloride). The findings in Table 2 indicate that the Experimental group is at a higher risk of electrolyte disorders and fluctuations in electrolyte levels during the perioperative period. These observations emphasize the importance of vigilant monitoring and timely intervention to manage electrolyte imbalances in high-risk patients. Addressing electrolyte disturbances during the perioperative phase may lead to improved postoperative outcomes and enhanced patient safety.

Table 3 presents the occurrence of electrolyte disorders in the MBP group, stratified by age. The table shows the number and percentage of participants with and without electrolyte disorders within three different age ranges: ≥60 and <70 years, ≥70 and <80 years, and ≥80 years. For the age group ≥60 and <70 years, 14 participants (27.5%) had electrolyte disorders, while 37 participants (72.5%) did not. The difference in the occurrence of electrolyte disorders between these two groups was statistically significant ($P=0.001$). In the age group ≥70 and <80 years, 13 participants (68.4%) had electrolyte disorders, and 6 participants (31.6%) did not. Again, there was a statistically significant difference in the occurrence of electrolyte disorders in this age group. Among participants aged ≥80 years, 5 participants (83.3%) had electrolyte disorders, while only 1 participant (16.7%) did not. As observed in the other age groups, the difference in the occurrence of electrolyte disorders was statistically significant.

The Table 4 presents the number and percentage of participants with two or more electrolyte disorders and those without such disorders within the same three age ranges. For the age group ≥60 and <70 years, 5 participants (9.6%) had two or more electrolyte disorders, while 47 participants (90.4%) did not. The difference in the occurrence of two or more electrolyte disorders between these two groups was statistically significant ($P=0.001$). In the age group ≥70 and <80 years, 4 participants (21.1%) had two or more electrolyte disorders, and 15 participants (78.9%) did not. Similarly, there was a statistically significant difference in the occurrence of two or more electrolyte disorders in this age group. Among participants aged ≥80 years, 5 participants (83.3%) had two or more electrolyte disorders, while only 1 participant (16.7%) did not. As with the other age groups, the difference in the occurrence of two or more electrolyte disorders was statistically significant.

Comparison of surgical process indicators between the two groups

Surgical time was longer in the Experimental group (180 min) compared to the Control group (150 min), but not statistically significant ($P=0.061$). Intraoperative bleeding was higher in the Experimental group (250 mL) compared to the Control group (200 mL), but not statistically significant ($P=0.105$). Further research with a larger sample size may clarify the significance of these differences (Table 5).

Comparison of postoperative complications, recovery, and hospital stay between the two groups

Table 6 compares postoperative complications, functional recovery indicators, and hospitalization days between the 2 groups. Surgical site infection occurred in 2.6% of the Experimental group and 4.2% of the Control group, but the difference was not statistically significant ($P=0.605$). Both groups had a similar occurrence of hematuria, with 10.5% in the Experimental group and 11.1% in the Control group ($P=0.909$). Regarding functional recovery indicators, the median time to defecation was 2 days in both groups, and the median time to ambulation was 4 days in both groups. There were no statistically significant differences in the time to defecation ($P=0.491$) or time to ambulation ($P=0.955$) between the groups. The median hospitalization days were 7 in both the Experimental and Control groups, and there was no statistically significant difference ($P=0.929$). The occurrence of nausea, vomiting, and bloating did not differ significantly between the groups ($P>0.900$ for all comparisons).

Comparison of laboratory indicators counts on postoperative day 1 between the two groups

Notably, the Experimental group showed a statistically significant difference in the percentage of neutrophils (80.3%) compared to the Control group (77.9%) ($P=0.044$), suggesting a potential activation of the inflammatory response. However, no significant differences were observed in other parameters. The WBC count on d1 was similar between the groups, as was the neutrophil count ($P>0.348$ for both). The CRP levels, indicative of inflammation, were comparable as well ($P=0.504$). Additionally, prealbumin and albumin levels on d1 showed no statistically significant differences between the groups ($P>0.060$ and $P>0.777$, respectively). Furthermore, the WBC and neutrophil count differences from baseline to d1 were not significantly different between the two groups ($P>0.596$ for both), indicating similar immune responses during the early postoperative period. While the Experimental group exhibited a higher percentage of neutrophils on d1, other biomarkers and cell counts did not significantly differ from the Control group (Table 7).

Comparison of postoperative temperature between the two groups

The P-values for postoperative body temperature at 14:00 comparisons between the Experimental and Control groups on days 1, 2, and 3 were 0.468, 0.195, and 0.987, respectively. No significant differences were found on any postoperative day (Table 8).

Table 5 Comparison of the indicators of the surgical process in the two groups

Groups	Experimental group ($n=76$)	Control group ($n=72$)	Z	P
Surgical time [min, M (P25, P75)	180(147.5,200)	150(120,180)	-1.877	0.061
Intraoperative bleeding [mL, M (P25, P75)	250(200,400)	200(150,325)	-1.620	0.105

Table 6 Comparison of postoperative complications and functional recovery indicators and hospitalization days between the two groups

Groups	Experimental group ($n=76$)	Control group ($n=72$)	$t/Z/\chi^2$	P
Surgical site infection (n, %)	2(2.6)	3(4.2)	0.267[a]	0.605
Hematuria (n, %)	8(10.5)	8(11.1)	0.013[a]	0.909
Time to defecation [days, M (P25, P75)	2.00(2,2)	2.00(2,2)	-0.689[b]	0.491
Time to defecation [days, M (P25, P75)	4.00(4,5)	4.00(4,5)	-0.056 [b]	0.955
Days of hospitalization [days, M (P25, P75)	7.00(7,8)	7.00(7,8)	-0.089 [b]	0.929
Nausea (n, %)	5(6.6)	4(5.6)	0.00 [a]	0.985
Vomiting (n, %)	3(3.9)	2(2.8)	0.15 [a]	0.963
Bloating (n %)	4(5.3)	4(5.6)	0.01 [a]	0.947

Note a is the z-value and b is the value of χ^2

Discussion

ERAS is a multimodal perioperative care pathway designed to achieve early recovery for patients undergoing major surgery. ERAS represents a paradigm shift in perioperative care by re-examining traditional practices and replacing them with evidence-based best practices when necessary [27–32]. It helps patients get back on their feet quicker while shortening hospital stays and reducing surgical complications [33]. The primary outcome of the ERAS protocol is overall compliance to selected active elements of the protocol, as registered by the patient. Secondary outcomes include Patient Reported Outcome Measures (PROMs) such as health-related quality of life, physical activity, and patient satisfaction of received care [33]. For example, one study found that the length of stay for patients treated with the ERAS program was significantly shorter than that of patients treated with non-ERAS traditional care [34].

We evaluated the clinical characteristics, surgical process, postoperative electrolyte levels, perioperative complications, and the association with MBP in two groups of patients. Compared to patients who did not receive MBP, those who underwent MBP experienced postoperative electrolyte imbalances, with a correlation between electrolyte disturbances and age. However, MBP did not

Table 7 Comparison of laboratory indicators between the two groups

Groups	Experimental group (*n* = 76)	Control group (*n* = 72)	*t* / *Z* / χ^2	*P*
d1 WBC [$\times 10^9$/L, M (P25, P75)]	11.55(9.88,12.53)	11.3(9.55,12.33)	-0.833[a]	0.405
d1 neutrophil percentage	80.3(75.45,86.83)	77.9(72.83,84.53)	-2.010[a]	0.044
[%, M (P25, P75)]	9.35(7.43,10.49)	8.85(6.49,10.49)	-1.216	0.224
d1 neutrophil count [$\times 10^9$/L, M (P25, P75)	17.45(12.2,26.5)	15.45(12.18,22.93)	-0.938[a]	0.348
d1CRP [mg/L, M (P25, P75)].	155.5 (129.5,214.75)	163.5 (130.75,222.75)	-0.668[a]	0.504
d1 prealbumin	38.29 ± 3.93	39.53 ± 4.05	1.895[b]	0.060
[mg/L, M (P25, P75)].	-4.80(-6.2,-3.375)	-5.25(-7.575,-2.85)	-0.888[a]	0.374
d1 albumin (g/L, mean ± s)	5.35 ± 2.94	5.45 ± 2.56	0.283[b]	0.777
WBC difference	19.00 ± 8.09	19.70 ± 8.15	0.520[b]	0.604
[$\times 10^9$/L, M (P25, P75)]	-57.5(-76, -40.75)	-56.5(-72.75, -38.75)	-0.530[a]	0.596
Neutrophil count difference [$\times 10^9$/L, M (P25, P75)]	-3.35(-3.53,-1.98)	-3.40(-4.40,-2.78)	-0.033[a]	0.974

Note a is the z-value, b is the t-value

Table 8 Comparison of postoperative body temperature between the two groups

Groups	Experimental group (*n* = 76)	Control group (*n* = 72)	*Z*	*P*
Postoperative d1 temperature [℃, M (P25, P75)	36.5(36.4, 36.6)	36.5(36.4, 36.6)	-0.726	0.468
Postoperative d2 temperature [℃, M (P25, P75)].	36.5(36.4, 36.6)	36.4(36.4, 36.5)	-1.297	0.195
Postoperative d3 temperature [℃, M (P25, P75)	36.4(36.3, 36.5)	36.4(36.3, 36.5)	-0.016	0.987

show any significant improvement in postoperative complications. Overall, the findings suggest that MBP may lead to postoperative electrolyte disorders in elderly urological cancer patients undergoing robot-assisted tumor resection, and its impact on reducing postoperative complications appears to be limited. However, studies have shown that when MBP is used, the incidence of morbidity increases in patients undergoing selective colorectal surgery, possibly due to increased intestinal inflammation [35].

In the field of urology, there is still little research on the impact of MBP on postoperative clinical outcomes. Therefore, some studies have suggested that in nephrectomy and radical prostatectomy, MBP has no advantage in terms of overall complications, operation time, postoperative hospital stay, and total cost [36, 37]. Compound polyethylene glycol electrolyte solution is currently recommended as an intestinal cleanser both domestically and abroad. Its long-chain polymer enters the intestinal cavity and is not absorbed, accelerating the flushing of the intestinal wall to promote defecation [38]. Adult small intestine fluid contains abundant electrolytes. While cleaning the intestines, it will exacerbate the loss of electrolytes, such as hypokalemia, hyponatremia, and hypochloremia [20, 39]. Especially in older people, due to the decline in organ function and more underlying diseases, electrolyte disorders caused by MBP may be life-threatening [19, 20]. Interventions were promptly implemented in patients presenting with electrolyte imbalances to avert further detrimental clinical outcomes. The parameters we established served as an initial prediction of whether Mean Blood Pressure was associated with the onset of electrolyte imbalances. However, we did not delve into the persistence of electrolytes and the severity of electrolyte imbalances over time. This is because we postulate that delayed intervention in patients with electrolyte imbalances could potentially exacerbate the condition, thereby impacting the patient's disease status. At present, the electrolyte imbalances in patients have not manifested any significant clinical symptoms.

Similar to early results, our data showed that the incidence of electrolyte disorders in the MBP group was significantly higher than that in the non-MBP group. Serum sodium, potassium and chloride levels were lower in the MBP group than in the non-MBP group. In our study, we found that the incidence of electrolyte disorders in older people undergoing radical urological tumor surgery with MBP was 42.1%, significantly higher than that in the non-MBP group (19.4%), indicating that MBP can cause electrolyte disorders in older people. Subgroup analysis revealed that, following MBP, the incidence of electrolyte disorders increased with age, demonstrating a statistically significant difference across all age subgroups. Specifically, the incidence rates were higher in older age groups, with the 80+age group being the most likely to experience two or more electrolyte disorders. This indicates that MBP is more likely to induce electrolyte disorders in older people. Therefore, a non-MBP strategy can be considered before surgery in older people. In addition, the impact of MBP on other clinical outcomes also needs to be considered.

Surgical site infection is one of the most common postoperative complications and greatly increases patient morbidity and hospital costs [40]. Mahajna et al. [41]

suggested that bowel cleansing for colorectal surgery may result in a large amount of residual liquid intestinal contents. Liquid residues are more likely to cause peritoneal overflow than solid intestinal contents, thereby increasing the risk of infection complications. Another study showed that MBP did not significantly change the concentration of fecal microorganisms in liquid intestinal contents [42]. In addition to these controversial aspects of MBP, Toru Sugihara et al.'s [36, 37] study also provided new evidence that the use of MBP resulted in a higher incidence of complications in older people and longer operation times for patients with higher BMI and smaller hospitals. MBP is usually an uncomfortable experience for patients. Jung et al.'s [43] randomized controlled trial showed that patients in the MBP group were more painful and less willing to undergo the same surgery again. In addition, the authors mentioned that 52% of patients in the MBP group needed help from hospital staff or relatives, which may also be a problem due to increased workload. Nausea, vomiting, abdominal distension and other gastrointestinal symptoms are common complications of oral intestinal cleansers [44]. A recent Cochrane study showed that patients in the MBP group were less willing to accept the same bowel preparation method and there was insufficient evidence to support that MBP formed a cleaner surgical area or promoted earlier bowel movement [45]. However, there is still controversy over the role of MBP in laparoscopic surgery because MBP may better expose the surgical field through intestinal decompression [46]. Evaluation studies on MBP during laparoscopic surgery are still limited. Muzii et al. [47] randomly divided 162 patients into an MBP group and a non-MBP group. No significant differences were observed in terms of surgical scope, surgical difficulty, operation time and postoperative complications.

However preoperative discomfort such as insomnia weakness and abdominal distension were significantly higher in preoperative MBP group. Some research results also show that preoperative MBP affects gastrointestinal function recovery including inhibiting postoperative intestinal motility function recovery and gastrointestinal discomfort such as nausea vomiting and abdominal distension etc. [48], it will also increase early postoperative complication rate and affect early postoperative nutritional status. Yanaihara et al. [49] retrospectively reviewed the charts of 6 MBP patients and 52 non-MBP patients who underwent laparoscopic radical nephrectomy or adrenalectomy. No differences were observed between the groups in terms of pneumoperitoneum time, blood loss, and perioperative complications. In our study, MBP did not show any difference in surgical site infection, hematuria, time to first flatus, time to first defecation, nausea vomiting and abdominal distension, operation time, blood loss, postoperative body temperature and length of hospital stay. And in the corresponding laboratory indicators including white blood cell count neutrophil count CRP prealbumin and albumin values etc. there was no difference. This may be due to our use of robotic surgery and intervention under ERAS care to effectively improve patient recovery after surgery. All enrolled patients underwent a robotic surgery plan and strictly received the ERAS program during the perioperative period including measures different from traditional concepts such as no gastric tube preoperatively 2 h fasting intraoperatively local anesthesia infiltration of incision postoperatively d1 getting out of bed and d1 drinking water etc. The difference in clinical intervention measures may improve postoperative organ function recovery.

The study investigating the impact of MBP within the ERAS concept presents significant findings, but it also has certain limitations. The small sample size reduces the generalizability of the results. Additionally, the lack of comprehensive analysis of potential confounding factors, such as comorbidities and fluid management, may introduce biases in the outcomes. To improve the study's validity, a larger sample size and a well-randomized design should be considered in future research. Moreover, long-term follow-up and a multidisciplinary approach involving various healthcare professionals would provide a more comprehensive assessment of the effects of MBP and ERAS on postoperative outcomes, patient recovery, and overall well-being. These improvements would strengthen the study's conclusions and contribute to better perioperative care for older people with urological tumors undergoing robot-assisted surgery.

Conclusion

The use of MBP before surgery increases the risk of postoperative electrolyte disturbances in older people with urological tumors, and this risk is significantly age-related. Furthermore, MBP does not improve surgical outcomes or postoperative clinical outcomes. Under the principles of ERAS, preoperative MBP should be avoided to ensure smooth surgery and postoperative recovery, and to reduce patient discomfort."

Supplementary Information

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Supplementary Material 1

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Author contributions
Hongze Liu: Guarantor of integrity of the entire study; Study concepts; Study design; Manuscript editing; Manuscript review; Data acquisition; Definition of intellectual content; Manuscript preparation.

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Data availability
All data analysed during this study are included in this published article.

Declarations

Ethics approval and consent to participate
This cross-sectional study was performed with the approval by the institutional ethical committee of The Second Affiliated Hospital of Harbin Medical University. Written informed consent was obtained from the participants for the study. All methods were carried out in accordance with relevant guidelines and regulations.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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