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ORIGINAL ARTICLE

Prostate Disease

Suprapubic cystostomy versus nonsuprapubic cystostomy during monopolar transurethral resection of prostate: a propensity score-matched analysis

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We aim to reassess the safety of the monopolar transurethral resection of the prostate (M-TURP) without suprapubic cystostomy at our institution over the past decade. This retrospective study was conducted in patients who underwent M-TURP at Peking University First Hospital between 2003 and 2013. A total of 1680 patients who had undergone M-TURP were identified, including 539 patients in the noncystostomy group and 1141 patients in the cystostomy group. After propensity score matching, the number of patients in each group was 456. Smaller reductions in hemoglobin and hematocrit (10.9 g *vs* 17.6 g and 3.6% *vs* 4.7%, respectively) were found in the noncystostomy group. In addition, patients undergoing surgery without cystostomy had their catheters removed earlier (4.6 days *vs* 5.2 days), required shorter postoperative stays in the hospital (5.1 days *vs* 6.0 days), and were at lower risk of operative complications (5.7% *vs* 9.2%), especially bleeding requiring blood transfusion (2.9% *vs* 6.1%). Similar findings were observed in cohorts of prostates of 30–80 ml and prostates >80 ml. Furthermore, among patients with a resection weight >42.5 g or surgical time >90 min, or even propensity-matched patients based on surgical time, those with cystostomy seemed to be at a higher risk of operative complications. These results suggest that M-TURP without suprapubic cystostomy is a safe and effective method, even among patients with larger prostates, heavier estimated resection weights, and longer surgical times.

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INTRODUCTION

Benign prostatic hyperplasia (BPH), the most common benign neoplasm in men, is clinically characterized by lower urinary tract symptoms and can cause urinary retention, hematuria, urinary tract infection (UTI), bladder calculi, or dilation of the upper urinary tract with or without renal insufficiency.[1–3] Despite the introduction of medical therapy and alternative minimally invasive procedures, the monopolar transurethral resection of the prostate (M-TURP) still represents the "gold standard" in the operative management of BPH.[4]

In Europe, Mauermayer,[5] Hartung and May[6] developed the TURP technique, which has increased in popularity. In this technique, TURP is divided into four steps: midlobe resection, paracollicular transurethral resection (TUR), resection of the lateral lobes and ventral parts, and apical resection. Further development included Reuter's continuous-flow resectoscopes[7] and suprapubic trocar systems,[8] both of which provided a low irrigation pressure.[9] Suprapubic cystostomy during surgery is usually performed based on the surgeon's preference and the patient's characteristics.

In a recently published study, we found that there was no increase in TUR syndrome despite the fact that more patients with larger prostates received M-TURP without a suprapubic cystostomy.[10] Severe forms of TUR syndrome are rarer but they require treatment in the Intensive Care Unit at least overnight. The theoretical risk factors for TUR syndrome include a high irrigation pressure, patent prostatic sinuses, prolonged surgical time, and the application of hypotonic irrigation fluid.[10] A resection time of >90 min, estimated prostate weight >45 g, age >80 years, acute urinary retention, and African descent are associated with increased morbidity.[11–13] Therefore, we compared patients who received M-TURP in the noncystostomy group with those in the cystostomy group. This retrospective analysis provides insight into the M-TURP without cystostomy at our institution over the past decade.

MATERIALS AND METHODS

Study cohort

A retrospective review was conducted on all of the patients who underwent M-TURP at Peking University First Hospital from January 1, 2003 to December 31, 2013. Patients were only eligible for inclusion if their primary reason for TURP was BPH. If prostate cancer was diagnosed preoperatively or if their postoperative pathology was not compatible with a BPH diagnosis, the patients were excluded from the study. Patients who had undergone open prostatectomy were also not included in this analysis. Permission was granted by the Institutional Review Board of Peking University First Hospital to

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review the medical records and to gather all aspects of the research and retrospective clinical materials, as per the Declaration of Helsinki. Furthermore, it was specifically approved that no informed consent would be obtained as the data were going to be analyzed anonymously.

Equipment and surgeons

At our institution, continuous-flow resectoscopes, such as the Iglesias model, have been used. A 16F suprapubic trocar and cannula for establishing continuous flow may also be preferred when trying to resect larger prostates (>80 g), according to the technique described by Dr. O Paul from Madsen of Madison, Wisconsin, USA. A 14F Foley catheter was inserted into the bladder, which was kept for 1–2 days after surgery, and the balloon was inflated in the bladder. Electroresection and coagulation for M-TURP were performed by a monopolar, high-frequency current with a maximum cutting power of 200 W and a coagulating power of 80 W. A microprocessor-controlled electrical unit with an active electrode that transduces permanent signals to the processor allows for real-time power adjustment. A total of 24 surgeons with more than 1 year of surgical experience with thirty or more cases of M-TURP were responsible for all the operations.

Data

Inpatient charts, anesthetic, operative, and pathology reports, and discharge summaries were reviewed. The recorded data included the age, body mass index, comorbidities, the International Prostate Symptom Score, quality of life score, urinary flow rate and voided volume, and the American Society of Anesthesiologists (ASA) physical status classification (ASA grade). In addition, the pre- and post-operative hemoglobin, hematocrit, and serum sodium were recorded. The prostate size estimated by preoperative ultrasonography, weight of resected prostate, and surgical time were requested and used to calculate the percentage of resected tissue (weight of resection/prostate size) and resection efficiency (weight of resection/surgical time). Based on the length of the hospital stay after surgery, the postoperative day on which the urinary catheter was removed for a trial of voiding, as well as operative complications during the postoperative course, was evaluated. An operative complication was graded using the modified Clavien classification system.[14,15]

Statistical analysis

Descriptive data are shown as numbers and percentages. Continuous data are reported as arithmetic mean ± s.d. After the total cohort analyses, propensity score matching was performed to further elucidate the characteristics of the patients. Noncystostomy cases were 1:1 matched with the closest-propensity cystostomy cases. The propensity scores were calculated using a multivariable logistic regression model based on factors that demonstrated significant differences between the two groups in the total cohort.[16] Statistical analysis was performed using Chi-square test for categorical variables and a one-way analysis of variance for continuous variables. Univariate logistic regression analyses using parameters judged to be risk factors for operative complications were performed. Multivariate logistic regression models including only predictors at univariate analyses ($P < 0.05$) were then generated. The odds ratios were calculated with 95% confidence interval. $P < 0.05$ was considered statistically significant. SPSS version 22.0 (IBM, New York, NY, USA) and R software version 3.3.2 (The R Foundation for Statistical Computing, Vienna, Austria) were used for the statistical analysis.

RESULTS

During the research period, a total of 1680 patients who had undergone M-TURP were identified. Totally 539 patients underwent M-TURP without cystostomy, while 1141 patients underwent M-TURP with cystostomy. The patient demographics and the preoperative variables of the group are shown in **Table 1**. Patients in the noncystostomy group seemed to have lower average flow rates (3.0 ± 1.8 ml s^{-1} *vs* 3.3 ± 1.7 ml s^{-1}, $P = 0.014$) and PSA levels (5.86 ± 7.88 ng ml^{-1} *vs* 8.14 ± 6.44 ng ml^{-1}, $P < 0.001$) than those in the cystostomy group.

After propensity score matching, the number of patients in each group was 456 (**Table 1**). The mean age of the patients was 70.0 ± 7.16 years in the noncystostomy group and 70.2 ± 7.30 years in the cystostomy group. No significant differences were observed preoperatively between the two groups in the body mass index, comorbidities, the International Prostate Symptom Score, quality of life score, average/peak flow rate, voided volume, PSA, hemoglobin, hematocrit, serum sodium, the ASA grade, or prostate size.

In **Table 2**, the clinical management related to the surgery and the postoperative course for the propensity-matched cohort are displayed. Although no remarkable difference was found in the prostate size between the study groups, the patients in the noncystostomy group tended to have less tissue resected (23.9 ± 17.4 g *vs* 34.6 ± 21.7 g, $P < 0.001$), a shorter surgical time (61.08 ± 29.10 min *vs* 82.15 ± 33.32 min, $P < 0.001$), lower percentage of resected tissue (41.8% ± 29.3% *vs* 62.7% ± 28.2%, $P < 0.001$), and lower resection efficiency (0.41 ± 0.26 g min^{-1} *vs* 0.45 ± 0.23 g min^{-1}, $P = 0.010$), than those in the cystostomy group. In addition, the postoperative hemoglobin and hematocrit were higher in the noncystostomy group than in the cystostomy group (128.9 ± 21.6 g l^{-1} *vs* 120.8 ± 20.7 g l^{-1}, $P < 0.001$; 37.1% ± 5.4% *vs* 35.6% ± 5.5%, $P < 0.001$, respectively), and smaller reductions in hemoglobin and hematocrit were found in the noncystostomy group (10.9 ± 12.8 g l^{-1} *vs* 17.6 ± 15.2 g l^{-1}, $P < 0.001$; 3.6% ± 3.4% *vs* 4.7% ± 4.5%, $P < 0.001$, respectively). Nevertheless, there were no obvious differences in the postoperative serum sodium or the reduction in serum sodium between the two groups. Patients undergoing surgery without cystostomy had their catheters removed earlier (4.6 ± 4.00 days *vs* 5.2 ± 4.29 days, $P < 0.001$) and required shorter postoperative stays in the hospital (5.1 ± 2.75 days *vs* 6.0 ± 2.83 days, $P < 0.001$).

Furthermore, according to the prostate volume, the patients were divided into three cohorts: prostates <30 ml (78 patients), prostates 30–80 ml (484 patients), and prostates >80 ml (350 patients). Both among the patients with prostates 30–80 ml and those with prostates >80 ml, the patients in the noncystostomy group tended to have less tissue resected, shorter surgical times, and lower percentages of resected tissue. In addition, higher postoperative hemoglobin and hematocrit values, smaller reductions in the hemoglobin and hematocrit, and shorter postoperative in-hospital courses were found in the noncystostomy group. However, no differences were found in the postoperative serum sodium or the reduction in serum sodium.

Patients in the cystostomy group were at a higher risk of operative complications, especially bleeding requiring blood transfusion, than those in the noncystostomy group (9.2% *vs* 5.7%, $P = 0.044$; 6.1% *vs* 2.9%, $P = 0.017$, respectively). However, among the patients with prostates 30–80 ml and those with prostates >80 ml, no significant difference was found in the operative complications between the two groups (**Table 2**).

The predictors of the major complications after TURP are reported in **Table 3**. In univariate analysis, the weight of the resected prostate, surgical time, and cystostomy during operation were predictors of the overall complications (odds ratio = 1.017, $P = 0.001$; odds ratio = 1.010, $P = 0.003$; and odds ratio = 1.678, $P = 0.046$, respectively) in spite of there being no remarkable differences in the multivariate analysis. In addition, a larger amount of tissue resected and longer surgical time were

Table 1: Patient demographics and preoperative variables

Variable	*Before matching*		*After matching*	
	Noncystostomy group (n=539)	*Cystostomy group (n=1141)*	*Noncystostomy group (n=456)*	*Cystostomy group (n=456)*
Age (year, mean±s.d.)	70.4±6.9	70.7±6.9	70.0±7.2	70.2±7.3
BMI (kg m^{-2}, mean±s.d.)	23.8±3.2	24.1±3.6	24.0±3.1	23.9±3.0
Comorbidity, *n* (%)				
Cardiac and cerebrovascular diseases (including hypertension)	88 (59.1)	213 (53.9)	231 (50.7)	216 (47.4)
Diabetes	29 (19.5)	69 (17.5)	77 (16.9)	76 (16.7)
Respiratory diseases	12 (8.1)	40 (10.1)	38 (8.3)	50 (11.0)
Other urological diseases	34 (22.8)	77 (19.5)	102 (22.4)	80 (17.5)
Neurological diseases	6 (4.0)	9 (2.3)	11 (2.4)	8 (1.8)
Others	33 (22.1)	67 (17.0)	100 (21.9)	77 (16.9)
IPSS (mean±s.d.)	24.5±7.9	22.6±7.6	23.2±7.8	23.4±7.3
QoL (mean±s.d.)	4.9±1.1	4.8±1.0	4.7±1.0	4.7±1.0
Peak flow (ml s^{-1}, mean±s.d.)[#]	6.9±3.9	7.5±3.6	7.3±3.9	7.4±3.5
Average flow (ml s^{-1}, mean±s.d.)[#]	3.0±1.8	3.3±1.7[*]	3.4±1.9	3.5±1.7
Voided volume (ml, mean±s.d.)[#]	136.1±105.6	139.1±86.5	149.2±104.7	148.4±96.7
PSA (ng ml^{-1}, mean±s.d.)	5.86±7.88	8.14±6.44[*]	5.11±6.20	5.48±7.08
Hemoglobin (g l^{-1}, mean±s.d.)	139.8±17.7	140.2±14.8	139.8±16.1	138.3±17.3
Hematocrit (%, mean±s.d.)	40.7±4.9	40.8±4.7	40.7±4.8	40.3±4.7
Serum sodium (mmol l^{-1}, mean±s.d.)	140.8±2.8	140.7±2.8	140.6±3.0	140.6±2.6
ASA grade (mean±s.d.)	2.0±0.4	2.0±0.4	2.0±0.4	2.0±0.4
Prostate size (g, mean±s.d.)	83.3±43.0	83.5±41.0	78.6±41.8	76.1±39.6

[#]Patients with urinary retention and who were unable to void before TURP were excluded from the calculations of the mean peak flow, average flow, and voided volume. Two groups were matched using propensity score computing with average flow and PSA; [*]Statistically significant, cystostomy group compared with the noncystostomy group (P<0.05). ASA grade: American Society of Anesthesiologists physical status classification; BMI: body mass index; IPSS: International Prostate Symptom Score; QoL: quality of life score; PSA: prostate-specific antigen; s.d.: standard deviation; TURP: transurethral resection of the prostate

associated with a higher risk of experiencing bleeding (odds ratio = 1.029, P = 0.001; and odds ratio = 1.016, P < 0.001, respectively).

The receiver operator characteristic curve analysis showed that the optimal cutoff value of the weight of the resected prostate and the surgical time for the prediction of complications among the patients in the noncystostomy group was 42.5 g (sensitivity: 0.537; specificity: 0.804; area under the curve: 0.682) and 90 min (sensitivity: 0.561; specificity: 0.803; area under the curve: 0.745). Further analyses were performed according to the weight of the resection and surgical time. Among the patients with a weight of resection >42.5 g, those in the noncystostomy group had shorter surgical times and postoperative in-hospital courses, and among the patients with a surgical time >90 min, those in the noncystostomy group had less tissue resected and smaller reductions in the hematocrit and serum sodium (**Table 4**). Only among patients with a weight of resection ≤42.5 g were those in the noncystostomy group at a lower risk of bleeding (1.5% *vs* 4.0%, P = 0.044).

After the noncystostomy group and cystostomy group were 1:1 propensity matched based on the surgical time, the weight of the resected tissue, percentage of prostate resected, and resection efficiency were lower in the noncystostomy group than in the cystostomy group (27.2 ± 18.4 g *vs* 31.4 ± 19.5 g, P = 0.001; 36.5% ± 24.2% *vs* 42.2% ± 23.8%, P = 0.001; 0.42 ± 0.26 g min^{-1} *vs* 0.45 ± 0.22 g min^{-1}, P = 0.30, respectively, **Table 5**). However, the patients in the noncystostomy group had their catheters removed earlier (4.6 ± 4.0 days *vs* 5.2 ± 3.9 days, P < 0.001) and had shorter postoperative stays (5.1 ± 3.0 days *vs* 5.9 ± 2.6 days, P < 0.001). No difference was found in operative complications between the two groups.

DISCUSSION

Since the introduction of TURP in the early 20th century, complications have continued to fall with concurrent technical and instrument development. Contemporary data from our institution (analyzing 2249 patients treated between 1992 and 2013) revealed a 10.1% morbidity rate and 0.1% mortality rate following M-TURP. Patients with an ASA grade ≥3 and higher Charlson Comorbidity Index (CCI) scores were more likely to demonstrate a higher incidence of morbidity than those with a lower grade, whereas the ASA grades and CCI scores were not independent predictors of complications.[17]

TUR syndrome, a dilutional hyponatremia (serum sodium <125 mmol l^{-1}) caused by the early perforation of the capsular veins or sinuses with a consecutive influx of hypotonic irrigating fluid, is characterized by nausea, vomiting, arterial hypotension, mental confusion, and visual disturbances.[9] Currently, TUR syndrome is fortunately rare in current practice with the use of modern irrigation fluids, improved surgical techniques, and instrumentation.[18] Heidler *et al*.[19] showed that fluid absorption seems to be avoidable with an appropriate drainage system. The risk of TUR syndrome is eliminated because of the use of bipolar or laser technology with 0.9% sodium chloride solution as the irrigation fluid.[20–25]

At our institution, TUR syndrome was seen in 0.6% of the cases, which is consistent with the current pooled mean TUR syndrome rate of <1% obtained by Rassweiler *et al*.[9] No significant difference was found between the patients in the noncystostomy group and those in the cystostomy group, and the two groups showed similar postoperative reductions of serum sodium with comparable resection efficiency, even among patients with prostates >80 ml. Our finding is attributed to the use of a video camera, improved anesthetic techniques, and advancements in TURP technology that may have improved the resection efficiency, as well as the preoperative application of 5-α-reductase inhibitors, which leads to less vascularity and better surface coagulation even with short-term use.[26]

Table 2: Clinical management and operative complications for the propensity-matched cohort

	Total		*Prostates (30–80 ml)*		*Prostates (>80 ml)*	
	Noncystostomy group (n=456)	*Cystostomy group (n=456)*	*Noncystostomy group (n=244)*	*Cystostomy group (n=240)*	*Noncystostomy group (n=176)*	*Cystostomy group (n=174)*
Prostate size (g, mean±s.d.)	78.6±41.8	76.1±39.6	55.8±14.4	55.9±14.2	120.9±34.2	116.9±30.2
Weight of resected prostate (g, mean±s.d.)	23.9±17.4	34.6±21.7*	25.1±18.6	35.3±21.8*	22.1±15.8	32.9±21.1*
Surgical time (min, mean±s.d.)	61.08±29.10	82.15±33.32*	60.47±26.98	81.43±32.28*	61.30±30.12	81.09±34.38*
Percentage of prostate resected (%, mean±s.d.)	41.8±29.3	62.7±28.2*	49.2±31.6	68.2±37.5*	19.73±16.06	29.71±20.81*
Resection efficiency (g min^{-1}, mean±s.d.)	0.41±0.26	0.45±0.23*	0.44±0.30	0.45±0.23	0.38±0.21	0.42±0.22
Postoperative hemoglobin (g l^{-1}, mean±s.d.)	128.9±21.6	120.8±20.7*	128.0±20.0	121.8±17.4*	128.0±21.2	124.9±24.5*
Postoperative hematocrit (%, mean±s.d.)	37.1±5.4	35.6±5.5*	37.3±6.1	35.9±4.9*	36.3±6.7	34.0±5.9*
Postoperative serum sodium (mmol l^{-1}, mean±s.d.)	137.3±5.8	137.6±6.0	137.2±6.5	137.9±5.7	137.8±5.9	137.2±6.1
Hemoglobin (g l^{-1}, mean±s.d.)	10.9±12.8	17.6±15.2*	10.7±13.6	18.8±16.4*	10.3±9.0	14.0±9.6*
Hematocrit (%, mean±s.d.)	3.6±3.4	4.7±4.5*	3.4±4.1	4.8±4.3*	3.6±4.0	5.6±3.9*
Serum sodium (mmol l^{-1}, mean±s.d.)	3.3±5.8	3.0±6.3	3.3±6.2	3.0±4.9	3.4±5.6	3.2±6.2
Postoperative in-hospital course, mean±s.d.						
Catheter removed (day)	4.6±4.0	5.2±4.3*	5.0±4.8	5.4±4.9*	4.3±2.9	4.6±2.1*
Postoperative days in hospital (day)	5.1±2.7	6.0±2.8*	5.2±2.9	6.0±2.8*	4.9±2.5	6.0±3.1*
Grade 1 complications, *n* (%)						
Urinary retention after catheter removal	4 (0.9)	3 (0.7)	4 (1.6)	2 (0.8)	0	1 (0.6)
Urinary incontinence	0	2 (0.4)	0	1 (0.4)	0	1 (0.6)
Grade 2 complications, *n* (%)						
Bleeding requiring blood transfusion	13 (2.9)	28 (6.1)*	7 (2.9)	14 (5.8)	5 (2.8)	13 (7.5)
Urinary tract infection with bacteremia requiring antibiotics	9 (2.0)	16 (3.5)	4 (1.6)	7 (2.9)	4 (2.3)	8 (4.6)
Pneumonitis	1 (0.2)	2 (0.4)	1 (0.4)	1 (0.4)	0	1 (0.6)
Deep vein thrombosis	0	0	0	0	0	0
Cerebrovascular complications	1 (0.2)	1 (0.2)	0	1 (0.4)	1 (0.6)	0
Grade 3a complications, *n* (%)						
Clot retention, re-operation needed	7 (1.5)	12 (2.6)	5 (2.0)	6 (2.5)	1 (0.6)	3 (1.7)
Grade 3b complications, *n* (%)						
Urethral stenosis or bladder neck contracture	2 (0.4)	3 (0.7)	1 (0.4)	2 (0.8)	1 (0.6)	0
Grade 4a complications, *n* (%)						
Pulmonary thromboembolism	1 (0.2)	1 (0.2)	0	1 (0.4)	1 (0.6)	0
Myocardial infarction	1 (0.2)	2 (0.4)	1 (0.4)	0	0	2 (1.1)
Heart failure	1 (0.2)	1 (0.2)	1 (0.4)	0	0	1 (0.6)
Respiratory dysfunction	0	0	0	0	0	0
Grade 4b complications, *n* (%)						
TUR syndrome	29 (0.4)	0	1 (0.4)	00	1 (0.6)	0
Multi-organ dysfunction	0	1 (0.2)	0	0	0	1 (0.6)
Grade 5 complications, *n* (%)						
Death	0	1 (0.2)	0	0	0	1 (0.6)
Number of patients	26 (5.7)	42 (9.2)*	16 (6.6)	21 (8.8)	9 (5.1)	16 (9.2)

*Statistically significant, cystostomy group compared with the noncystostomy group ($P<0.05$). TUR: transurethral resection; s.d.: standard deviation

Interestingly, in a recently published study by Nakahira *et al*.[27] multivariate regression analysis revealed that continuous irrigation through a suprapubic cystostomy was associated with a significantly increased risk of TUR syndrome. According to their observations, a number of patients had abdominal swelling owing to irrigation fluid leaking from the drainage point into the extraperitoneal space and abdominal cavity. Even if a suprapubic cystostomy should be inserted into the extraperitoneal area, the peritoneum can absorb large amounts of leaked irrigation fluid, inducing hyponatremia in patients.

Comparing the other major morbidity outcomes between the two groups, the incidence of overall complications or bleeding requiring blood transfusion was lower in the noncystostomy group than in the cystostomy group, and patients in the cystostomy group tended to be at lower risk of overall complications and UTI in spite of there being no statistically remarkable difference. A higher resection weight has been associated with greater blood loss.[28] As the two groups had similar resection efficiencies and the cystostomy group showed a longer surgical time, the patients in the cystostomy group had more tissue resected (both in weight and percentage), which benefited from the clearer vision field. The approximately 3.5% UTI rate was rather low,[9] but in a multi-center study by Colau *et al*.,[29] the incidence of postoperative UTI was 21.6%, including a 2.3% rate of septic shock. According to our survey, the UTI rate in the cystostomy group was higher, which may be attributed to the longer surgical time and need for more catheters. The increased postoperative complications, in turn, may be conducive to the need for a longer postoperative course in the hospital.

Our analyses revealed that the weight of the resected prostate and the surgical time, instead of the suprapubic cystostomy during the operation, were independent predictors of bleeding requiring transfusion and showed optimal cutoff values of an estimated

Table 3: Uni- and multi-variable logistic regression analysis for predictors of major complications for the propensity-matched cohort

	Overall complications (OR [95% CI]; P)		*Bleeding requiring transfusion, (OR [95% CI]; P)*	
	Univariable analyses	*Multivariable analyses*	*Univariable analyses*	*Multivariable analyses*
Age (year)	1.023 (0.987–1.059); 0.214	-	1.038 (0.992–1.087); 0.105	-
BMI (kg m^{-2})	0.965 (0.889–1.048); 0.402	-	0.943 (0.849–1.048); 0.275	-
Preoperative comorbidities				
Cardiac and cerebrovascular diseases	1.112 (0.678–1.823); 0.674	-	0.990 (0.529–1.853); 0.976	-
Diabetes	0.954 (0.488–1.865); 0.891	-	1.214 (0.549–2.682); 0.632	-
Respiratory diseases	1.477 (0.706–3.092); 0.301	-	2.008 (0.863–4.675); 0.106	-
Other urological diseases	0.944 (0.504–1.768); 0.857	-	1.311 (0.630–2.726); 0.469	-
Neurological diseases	2.388 (0.678–8.409); 0.175	-	2.576 (0.575–11.544); 0.216	-
Others	0.788 (0.404–1.536); 0.485	-	0.436 (0.153–1.240); 0.120	-
ASA grade	1.743 (0.929–3.269); 0.083	-	1.942 (0.886–4.257); 0.097	-
Prostate size (g)	0.997 (0.991–1.004); 0.447	-	1.003 (0.995–1.010); 0.500	-
Weight of resected prostate (g)	1.017 (1.007–1.028); 0.001*	1.011 (1.000–1.023); 0.056	1.031 (1.020–1.043); <0.001*	1.029 (1.012–1.047); 0.001*
Surgical time (min)	1.010 (1.003–1.016); 0.003*	1.007 (0.999–1.015); 0.092	1.019 (1.012–1.027); <0.001*	1.016 (1.007–1.025); <0.001*
Percentage of prostate resected (%)	1.386 (0.966–1.987); 0.076	-	1.704 (1.157–2.508); 0.007*	0.620 (0.311–1.237); 0.175
Resection efficiency (g min^{-1})	1.859 (0.736–4.696); 0.190	-	2.899 (0.998–8.417); 0.050	-
Suprapubic cystostomy during operation	1.678 (1.010–2.787); 0.046*	1.262 (0.726–2.193); 0.410	2.229 (1.140–4.361); 0.019*	1.113 (0.534–2.318); 0.776

*Statistically significant, cystostomy group compared with the noncystostomy group ($P<0.05$). OR: odds ratio; ASA grade: American Society of Anesthesiologists physical status classification; BMI: body mass index; CI: confidence interval

resection weight of 42.5 g and a surgical time of 90 min to predict the development of operative complications among patients who underwent M-TURP without cystostomy. It should be noted that among patients with a resection weight >42.5 g or surgical time >90 min, those with cystostomy seemed to be at a higher risk of operative complications, especially bleeding and UTI. Therefore, it was concluded that the patients with an estimated heavier resection weight and longer surgical time who underwent M-TURP without cystostomy might be less likely to experience complications. Furthermore, since the length of the surgical time plays a significant role in the greater tissue resection and hemoglobin reduction, we performed propensity score matching based on similar surgical times, and patients who underwent M-TURP with cystostomy experienced longer postoperative hospital courses and seemed to be more likely to suffer from operative complications. Our hypothesis is that suprapubic cystostomy during operation would only be suitable for patients with a larger prostate who received surgical intervention by TURP beginners, since suprapubic cystostomy could provide a clear vision field that not only results in higher resection efficiency but also leads to more blood loss.

However, our analysis of data from two decades of TURP is limited by the retrospective nature of the study and the lack of detailed medication histories, short-term clinical outcomes, and long-term follow-up. In addition, due to the lack of postoperative data, the direct results of the surgery cannot be evaluated. However, the patient demographics and blood tests were carefully evaluated using the data recorded in the comprehensive preoperative and anesthetic records to ensure accuracy. The advantages of our observations are based on the facts that our institution provides all urological care for a discrete population of men, few open prostatectomies are performed for BPH, and M-TURP has remained the main endosurgical approach to BPH in our area. As far as we know, this is the first large-scale population-based retrospective study in China to reassess the safety of M-TURP without cystostomy.

As alternative therapeutic options, greenlight photovaporization (PVP) and holmium laser prostatectomy (HoLEP) allow effective superficial tissue coagulation, which minimizes the intravascular absorption of fluid, rendering the development of TUR syndrome unlikely. However, despite the reported decreases in bleeding, TUR syndrome remains a possibility with HoLEP.[27] In addition, according to our previous analysis, PVP and HoLEP show higher incidences of urinary retention (9.3% and 5.2%, respectively), and PVP additionally exhibits a relatively high incidence of bladder neck contracture (2.6%) in larger prostates based on data from 2011 to 2013 (urinary retention, 0.2%; urethral stenosis or bladder neck contracture, 0.2%).[10] Continued surgical intervention development is expected to eliminate these complications.

CONCLUSIONS

The endoscopic transurethral resection of the prostate performed using M-TURP without cystostomy, when compared with M-TURP with cystostomy, is associated with fewer postoperative complications, no increase in TUR syndrome and a shorter postoperative course in the hospital and thus is a safe and effective method, even among patients with larger prostates, heavier estimated resection weights, and longer surgical times.

AUTHOR CONTRIBUTIONS

RQG participated in the data acquisition, statistical analysis, and drafting of the manuscript. YSM helped to acquire data including checking the database and participated in the statistical analysis and drafting of the manuscript. WY conceived the study, participated in the statistical analysis, and helped to draft the manuscript. KZ conceived the study, had full access to all the data in the study, and took responsibility for the integrity of the data and the accuracy of the data analysis. BX participated in the data acquisition and helped to draft the manuscript. YXX participated in critical revision and manuscript editing. SLW participated in critical revision and manuscript editing. BNP conceived the study and participated in critical revision. All authors read and approved the final manuscript.

Table 4: Clinical management and operative complications according to weight of resection and surgical time for the propensity-matched cohort

	Weight of resection (≤42.5 g)		*Weight of resection (>42.5 g)*		*Surgical time (≤90 min)*		*Surgical time (>90 min)*	
	Noncystostomy group (n=390)	*Cystostomy group (n=328)*	*Noncystostomy group (n=66)*	*Cystostomy group (n=128)*	*Noncystostomy group (n=406)*	*Cystostomy group (n=311)*	*Noncystostomy group (n=50)*	*Cystostomy group (n=145)*
Prostate size (g, mean±s.d.)	81.7±43.8	76.9±39.3	65.2±27.1	75.2±40.8*	78.0±41.3	76.7±38.6	83.1±45.9	74.9±41.6
Weight of resected prostate (g, mean±s.d.)	18.0±9.7	23.7±8.9	50.9±11.0	55.8±19.8	22.5±16.2	28.9±15.4*	35.8±22.7	46.5±27.5*
Surgical time (min, mean±s.d.)	57.09±25.23	75.54±31.31*	79.27±25.50	100.91±32.07*	53.76±17.43	64.02±16.25*	120.50±36.06	121.04±26.58
Percentage of prostate resected (%, mean±s.d.)	27.7±20.5	36.7±22.0*	76.1±13.4	72.3±16.7	39.0±29.9	46.7±21.2*	43.4±28.1	50.7±23.8
Resection efficiency (g min^{-1}, mean±s.d.)	0.34±0.19	0.35±0.16	0.67±0.29	0.58±0.21*	0.40±0.23	0.44±0.20*	0.32±0.21	0.39±0.23
Postoperative hemoglobin (g l^{-1}, mean±s.d.)	131.7±17.5	129.1±17.4	114.2±19.4	115.8±20.1	130.1±20.8	129.0±18.3	121.0±23.4	117.9±22.4
Postoperative hematocrit (%, mean±s.d.)	37.9±5.9	37.2±5.1	33.3±6.3	34.1±5.3	37.5±6.8	37.3±5.2	35.3±6.8	34.2±6.8
Postoperative serum sodium (mmol l^{-1}, mean±s.d.)	137.7±5.8	137.4±6.1	137.6±6.2	137.2±5.0	137.6±6.3	138.1±6.5	138.8±2.9	137.2±3.9
Hemoglobin (g l^{-1}, mean±s.d.)	10.0±13.2	11.6±12.8	18.5±10.4	23.5±14.3	10.1±11.4	12.0±11.7	16.0±15.9	21.4±16.8
Hematocrit (%, mean±s.d.)	3.3±4.2	3.7±4.6	5.4±3.2	6.5±4.3	3.2±3.8	3.9±4.7	5.3±4.2	6.4±5.0*
Serum sodium (mmol l^{-1}, mean±s.d.)	3.2±5.8	2.9±6.2	3.2±4.3	3.4±3.8	3.3±5.7	2.7±5.8	1.3±2.8	3.4±4.9*
Postoperative in-hospital course, mean±s.d.								
Catheter removed (day)	4.7±4.2	5.4±5.03*	3.9±1.7	4.7±1.3*	4.6±4.2	5.2±4.7*	4.6±2.4	5.2±3.3*
Postoperative days in hospital (day)	5.1±2.7	5.9±2.7*	4.9±3.6	6.5±3.2*	5.0±2.6	5.9±2.4*	5.4±3.6	6.4±3.5*
Grade 1 complications, *n* (%)								
Urinary retention after catheter removal	3 (0.8)	3 (0.9)	0	0	4 (1.0)	3 (1.0)	0	0
Urinary incontinence	0	1 (0.3)	0	1 (0.8)	0	1 (0.3)	0	1 (0.7)
Grade 2 complications, *n* (%)								
Bleeding requiring blood transfusion	6 (1.5)	13 (4.0)*	7 (10.6)	15 (11.7)	9 (2.2)	9 (2.9)	4 (8.0)	19 (13.1)
Urinary tract infection with bacteremia requiring antibiotics	3 (0.8)	2 (0.6)	6 (9.1)	14 (10.9)	7 (1.7)	5 (1.6)	2 (4.0)	11 (7.6)
Pneumonitis	1 (0.3)	2 (0.6)	0	0	0	0	1 (2.0)	2 (1.4)
Deep vein thrombosis	0	0	0	0	0	0	0	0
Cerebrovascular complications	0	0	1 (1.5)	1 (0.8)	1 (0.2)	0	0	1 (0.7)
Grade 3a complications, *n* (%)								
Clot retention, reoperation needed	6 (1.5)	9 (2.7)	1 (1.5)	3 (2.3)	7 (1.7)	7 (2.3)	0	5 (3.4)
Grade 3b complications, *n* (%)								
Urethral stenosis or bladder neck contracture	2 (0.5)	2 (0.6)	0	1 (0.8)	2 (0.5)	1 (0.3)	0	2 (1.4)
Grade 4a complications, *n* (%)								
Pulmonary thromboembolism	0	0	1 (1.5)	1 (0.8)	1 (0.2)	0	0	1 (0.7)
Myocardial infarction	1 (0.3)	1 (0.3)	0	1 (0.8)	1 (0.2)	1 (0.3)	0	1 (0.7)
Heart failure	1 (0.3)	1 (0.3)	0	0	0	0	1 (2.0)	1 (0.7)
Respiratory dysfunction	0	0	0	0	0	0	0	0
Grade 4b complications, *n* (%)								
TUR syndrome	2 (0.5)	0	0	0	2 (0.5)	0	0	0
Multi-organ dysfunction	0	1 (0.3)	0	0	0	1 (0.3)	0	0
Grade 5 complications, *n* (%)								
Death	0	1 (0.3)	0	0	0	1 (0.3)	0	0
Number of patients	18 (4.6)	25 (7.6)	7 (10.6)	17 (13.3)	22 (5.4)	18 (5.8)	4 (8.0)	24 (16.6)

*Statistically significant, cystostomy group compared with the noncystostomy group ($P<0.05$). TUR: transurethral resection; s.d.: standard deviation

Table 5: Clinical management and operative complications

	Noncystostomy group (n=330)	*Cystostomy group (n=330)*
Prostate size (g, mean±s.d.)	77.1±41.5	75.4±37.7
Weight of resected prostate (g, mean±s.d.)	27.2±18.4	31.4±19.5*
Surgical time (min, mean±s.d.)	69.52±29.44	73.43±31.80
Percentage of prostate resected (%, mean±s.d.)	36.5±24.2	42.2±23.8*
Resection efficiency (g min^{-1}, mean±s.d.)	0.42±0.26	0.45±0.22*
Postoperative hemoglobin (g l^{-1}, mean±s.d.)	128.2±19.7	127.8±18.6
Postoperative hematocrit (%, mean±s.d.)	36.9±6.4	36.3±5.3
Postoperative serum sodium (mmol l^{-1}, mean±s.d.)	137.1±5.8	137.5±6.2
Hemoglobin (g l^{-1}, mean±s.d.)	12.0±11.6	13.2±12.1
Hematocrit (%, mean±s.d.)	3.8±4.3	4.1±4.8
Serum sodium (mmol l^{-1}, mean±s.d.)	3.2±6.1	3.0±5.4
Postoperative in-hospital course, mean±s.d.		
Catheter removed (day)	4.6±4.0	5.2±3.9*
Postoperative days in hospital (day)	5.1±3.0	5.9±2.6*
Grade 1 complications, *n* (%)		
Urinary retention after catheter removal	1 (0.3)	3 (0.9)
Urinary incontinence	0	2 (0.6)
Grade 2 complications, *n* (%)		
Bleeding requiring blood transfusion	11 (3.3)	10 (3.0)
Urinary tract infection with bacteremia requiring antibiotics	7 (2.1)	4 (1.2)
Pneumonitis	1 (0.3)	1 (0.3)
Deep vein thrombosis	0	0
Cerebrovascular complications	1 (0.3)	0
Grade 3a complications, *n* (%)		
Clot retention, reoperation needed	6 (1.8)	9 (2.7)
Grade 3b complications, *n* (%)		
Urethral stenosis or bladder neck contracture	0	2 (0.6)
Grade 4a complications, *n* (%)		
Pulmonary thromboembolism	1 (0.3)	0
Myocardial infarction	1 (0.3)	1 (0.3)
Heart failure	1 (0.3)	1 (0.3)
Respiratory dysfunction	0	0
Grade 4b complications, *n* (%)		
TUR syndrome	0	0
Multi-organ dysfunction	0	1 (0.3)
Grade 5 complications, *n* (%)		
Death	0	1 (0.3)
Number of patients	20 (6.1)	24 (7.3)

*Statistically significant, cystostomy group compared with the noncystostomy group ($P<0.05$). TUR: transurethral resection syndrome; s.d.: standard deviation

COMPETING INTERESTS

All authors declare no competing interests.

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