Original Article

Development and validation of a nomogram model for predicting acute urinary retention after transrectal prostate biopsy

Hua Wang[1#], Shuhao Li[1#], Song Wei[1], Sue Cao[2], Xi Huang[3], Cheng Hu[1]

[1]Department of Urology, The Third Affiliated Hospital of Sun Yat-sen University, Guangzhou, China; [2]Department of Radiology, The Third Affiliated Hospital of Sun Yat-sen University, Guangzhou, China; [3]Department of Ultrasound, Sun Yat-sen Memorial Hospital, Sun Yat-sen University, Guangzhou, China

Contributions: (I) Conception and design: C Hu, H Wang; (II) Administrative support: H Wang; (III) Provision of study materials or patients: X Huang; (IV) Collection and assembly of data: S Li, S Wei; (V) Data analysis and interpretation: S Li, S Cao; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

[#]These authors contributed equally to this work.

Correspondence to: Xi Huang, MD. Department of Ultrasound, Sun Yat-sen Memorial Hospital, Sun Yat-sen University, No. 107 Yanjiangxi Road, Yuexiu District, Guangzhou 510030, China. Email: huangx388@mail.sysu.edu.cn; Cheng Hu, MD. Department of Urology, The Third Affiliated Hospital of Sun Yat-sen University, No. 600 Tianhe Road, Tianhe District, Guangzhou 510630, China. Email: hucheng2@mail.sysu.edu.cn.

Background: Post-biopsy acute urinary retention (AUR) is still a common complication, often leading to extended hospital stays and greater patient discomfort. This study aimed to develop and validate a nomogram for the early identification of AUR after transrectal prostate biopsy (TRPB).

Methods: We collected data on patients who underwent TRPB at The Third Affiliated Hospital of Sun Yat-sen University between January 2019 and November 2023, including all characteristics and prostate morphological parameters. A total of 403 patients were screened for eligibility, and after strict screening, 333 patients were included in the study. These patients were randomly divided into a development cohort (n=233) and a validation cohort (n=100) in a 7:3 ratio. Moreover, the International Prostate Symptom Score (IPSS) and quality of life (QoL) before and after biopsy were collected for 66 patients with AUR with varying post-void residual urine volumes (PVR). Additionally, the voiding situation after catheter removal was also documented. Univariate and multivariate logistic regression analyses were used to identify independent risk factors for AUR. The performance of the nomogram was assessed via calibration curves, Harrell's concordance index (C-index), decision curve analysis (DCA), and clinical impact curve (CIC) analysis.

Results: The PVR (200–300 mL) group showed significantly lower IPSS and QoL on post-biopsy day 7 compared to the 301–500 mL and >500 mL groups (P<0.05 and P<0.001, respectively). Additionally, the PVR (200–300 mL) group had the highest urinary catheter removal success rate. Univariate and multivariate logistic regression analyses identified 3 clinical factors—hypercholesteremia, prostatic urethral length (PUL), and the prostatic urethral angle (PUA)—that are significantly correlated with the AUR. This nomogram exhibited strong discriminative ability in both the development and validation cohorts, with an area under the curve (AUC) of 0.834 [95% confidence interval (CI): 0.772–0.896] in the development cohort and an AUC of 0.895 (95% CI: 0.831–0.958) in the validation cohort. The Hosmer-Lemeshow test indicated a well-fitted calibration curve (P=0.69). Furthermore, DCA and the CIC suggested favorable clinical utility for the nomogram.

Conclusions: Here, we first determined that patients unable to void with a PVR >200 mL should be considered as having AUR and developed a nomogram to predict its occurrence, facilitating individualized medical treatment after TRPB.

Keywords: Prostate biopsy; nomogram; urinary retention; post-void residual urine volume (PVR); risk factors

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Introduction

Since its application by Hodge *et al.*, transrectal prostate biopsy (TRPB) has become the most popular method for diagnosing prostate cancer (1). The common complications of TRPB include fever (1.4%), sepsis (0.09%), rectal bleeding (5.9%), and voiding dysfunction (1.9%), with an overall incidence that is relatively low (2,3). Infectious complications, especially sepsis, are notably frequent and can be life-threatening (4). A European randomized trial reported that infection was the primary reason for hospital admission following TRPB, accounting for 81% of such cases (4). In recent years, transperineal prostate biopsy has been conducted to effectively reduce the occurrence of infectious complications and rectal bleeding (5). However, compared with the transrectal approach, the transperineal approach has several obvious shortcomings, including a longer operation time, increased procedural discomfort and higher financial costs, and increased risk of acute urine retention (AUR) (6). Several studies have reported that transperineal mapping biopsy (TPMB) has a higher rate of AUR compared to TRPB. According to Skouteris *et al.*, the rate can be as high as 17.7%, compared to approximately 4% for TRPB (7). Owing to the above factors, TRPB is still the most widely used biopsy method and is recommended by the American Urology Association (8).

Voiding impairment after biopsy was first reported by Zisman *et al.* (9). Following a prostate biopsy, patients may experience an increase in the severity of lower urinary tract symptoms (LUTS), potentially leading to AUR. Previous studies have suggested that its incidence can reach 50%, of which the incidence of AUR is approximately 0.4–2.5% (9,10). For AUR, only a short-term indwelling urinary catheter is sufficient to achieve satisfactory results, whereas the treatment of infectious complications or rectal bleeding can be more complex and invasive. Recent studies have suggested that a large prostate volume and a high International Prostate Symptom Score (IPSS) are risk factors for biopsy-related AUR (11,12). At present, the definitions of AUR are largely based on empirical observations and are open to broad interpretation, whereas AUR is largely defined through the volume of post-void residual urine volumes (PVR) (13). However, there is currently a lack of research on which threshold value defines a significant PVR that requires timely catheterization after prostate biopsy.

Therefore, this study aimed to define the optimal PVR at which catheterization should be recommended for biopsy patients with potential AUR and to establish a nomogram model to predict the occurrence of AUR after TRPB, which may provide valuable guidance for preoperative consultation and improve patient experience. We present this article in accordance with the TRIPOD reporting checklist (available at https://tau.amegroups.com/article/view/10.21037/tau-24-399/rc).

Highlight box

Key findings

- Patients whose post-void residual urine volume (PVR) exceeds 200 mL should be suspected of having acute urinary retention (AUR) following prostate biopsy. Hypercholesterolemia, prostatic urethral length (PUL), and prostatic urethral angle (PUA) were significantly correlated with biopsy-related AUR, enabling the construction of a nomogram to predict its occurrence.

What is known and what is new?

- Currently, the optimal PVR for patients with AUR after prostate biopsy has not been established.
- A large prostate volume and a high International Prostate Symptom Score (IPSS) have been suggested as risk factors for biopsy-related AUR. Here, we first identified 200 mL PVR as the intervention threshold for suspected AUR patients after biopsy. Moreover, hypercholesteremia, PUL, and the PUA were identified as new risk factors for biopsy-related AUR.

What is the implication, and what should change now?

- We have developed a nomogram model for prebiopsy consultations and timely identification of biopsy-related AUR.

Methods

Patient enrollment, inclusion and exclusion criteria

We retrospectively reviewed consecutive patients who underwent TRPB at The Third Affiliated Hospital of Sun Yat-sen University between January 2019 and November 2023. A total of 403 patients were screened for eligibility, of whom 333 were included in the study, whereas 70 were excluded based on the exclusion criteria. The included patients were then randomly divided into a development cohort (n=233) and a validation cohort (n=100) in a 7:3 ratio. The enrollment process is illustrated in *Figure 1*.

The inclusion criteria for patients were as follows: (I) first prostate biopsy; (II) having undergone magnetic resonance imaging (MRI) before biopsy; and (III) comprehensive records of the biopsies, pathology findings, and laboratory test results were available. The exclusion criteria were as follows: (I) repeated prostate biopsy; (II) a history of chronic urinary retention or indwelling catheters before the biopsy

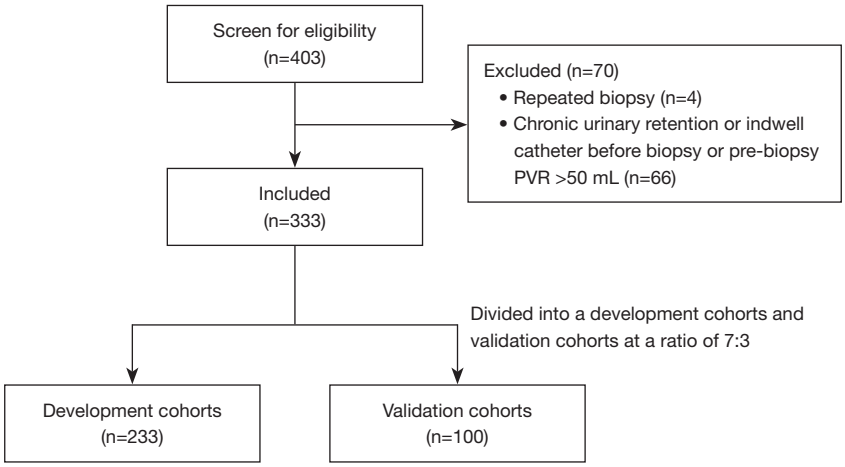

Figure 1 Flowchart illustrating the selection and grouping procedures. PVR, post-void residual urine volume.

procedure; and (III) pre-biopsy PVR greater than 50 mL.

Data collection

The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Medical Ethics Board of The Third Affiliated Hospital of Sun Yat-sen University (No. II2024-156-02) and individual consent for this retrospective analysis was waived. All the clinical and pathological variables of the enrolled patients, including age, body mass index (BMI), medical history (hypertension, diabetes, hypercholesterolemia, triglyceridemia), biopsy results, total prostate-specific antigen (tPSA) levels, and results of routine urine tests, were documented. Moreover, IPSS and quality of life (QoL) were recorded for the AUR patients before the procedure and on day 7 following the biopsy. For all the patients who underwent AUR, the catheter was removed 3 days after biopsy, and the outcomes were recorded. In addition to the above parameters, all prostatic anatomical parameters were obtained from MRI images, such as the prostatic urethral length (PUL), prostatic urethral angle (PUA), intravesical prostatic protrusion (IPP), total prostatic volume (TPV), transitional zone volume (TZV), transition zone index (TZI), and peripheral zone thickness (PZT), were also collected according to previous reports (14-16).

Biopsy protocol

TRPB was routinely performed under local anesthesia after cleaning of the bowel via enema. The prostate peripheral nerve block (PPNB) technique was used for prostate anesthesia. The procedures were as follows: using the sagittal view of transrectal ultrasound (TRUS), the junction between the prostate and the seminal vesicle was located on one side. After ensuring no blood return via aspiration, 5 mL of 1% lidocaine was injected into the periprostatic region. The ultrasound should show the gradual separation of the prostate and seminal vesicle from the rectal wall, indicating successful distribution of the local anesthetic. The same procedure was then repeated on the contralateral side to anesthetize the prostate peripheral nerves. Additionally, a bowel cleaning procedure was performed: 1 day before the biopsy, the patient was instructed to follow a low-residue diet. The night before the biopsy and 2 hours prior to the procedure, a cleansing enema was administered. An anal iodine enema was also used before the biopsy.

Systematic 12-core biopsy was performed if MRI or ultrasonography detected suspicious lesions. A Bard biopsy gun (Bard MCl 820; Becton Dickinson, and Co., Franklin Lakes, NJ, USA) and an 18-gauge biopsy needle was used. Beta-lactam antibiotics are administered 1 hour before the biopsy and continued for 2 days post-procedure.

Outcome measurement

The primary outcome measure was the occurrence of AUR. An AUR was defined as a painful inability to void with a PVR greater than 200 mL. PVR was measured by bedside ultrasound every 2 hours after voluntary urination in biopsy patients. All patients were treated with tamsulosin (0.4 mg daily) beginning the day before the biopsy procedure for

14 days. For patients with AUR, the urinary catheter was removed after 3 days of indwelling. The secondary outcome assessment was successful removal of the catheter. Clinical success was defined as the absence of acute urinary retention recurrence.

Statistical analysis

All the data were analyzed via SPSS 23.0 statistical software (IBM Corp., Armonk, NY, USA) and R software (v. 4.1.3; R Foundation for Statistical Computing, Vienna, Austria). The clinical features of patients with PVR and patients without PVR were compared via *t*-tests, Chi-squared tests, or Mann-Whitney *U* tests, as appropriate. Univariate and multivariate logistic regression analyses were performed to identify independent risk factors for PVR. Eventually, risk factors selected by multivariate analysis were used to establish a nomogram prediction model. A P value <0.05 was considered statistically significant.

To assess the discrimination and calibration of the nomogram, the area under the curve (AUC) and calibration plots (bootstrap method, 1,000 repetitions) and the Hosmer-Lemeshow test (P>0.05 indicates good agreement) were generated. Decision curve analysis (DCA) and clinical impact curve (CIC) were used to determine the clinical value of this nomogram.

Results

Baseline characteristics

A total of 333 patients were included in this study, with a median age of 69 (range, 21–92) years. In this study, 66 out of 333 patients (19.8%) required urinary catheters due to difficulty urinating, with a PVR greater than 200 mL, following prostate biopsy. A total of 66 patients were subsequently divided into 3 groups according to PVR: 200–300, 301–500, and >500 mL. We then compared the IPSS, QoL, and success rate of urinary catheter removal before the procedure and on post-biopsy day 7 among the 3 groups. No difference was found in the baseline characteristics among the 3 groups (P=0.96 and P=0.61, respectively). Compared with those in the PVR (200–300 mL) group, the IPSS and QoL on post-biopsy day 7 were significantly greater in the other 2 groups (P=0.01 and P=0.002, respectively). Moreover, the success rate of urinary catheter removal decreased significantly with increasing PVR among patients with an indwelling urinary catheter (P=0.02). All of the above results are shown in *Table 1*.

At a ratio of 7:3, the cohort was randomly divided into a development cohort (n=233) and a validation cohort (n=100). We found that hypercholesterolemia, PUL, PUA, TPV, TZV, and TZI were significantly associated with AUR (P=0.001, P<0.001, respectively). In the development cohort, we observed a longer PUL, greater PUA, TPV, TZV, and TZI in the AUR group than in the non-AUR group (P<0.001). Moreover, there was a significantly increased prevalence of hypercholesteremia (P=0.04) in the AUR group. In the validation cohort, the differences between the groups of variables were consistent with those in the development cohort (*Table 2*). The characteristics of all patients are presented in *Table 2*.

Logistic regression analysis of clinical features

Logistic regression analysis was performed to identify the independent risk factors for predicting AUR in the development cohort. Univariate analysis confirmed that hypercholesteremia, PUL, PUA, TPV, TZV, and TZI were independent risk factors for AUR (P=0.03, P<0.001, respectively) (*Table 3*). Furthermore, multivariate analysis (forward and stepwise) revealed only 3 independent risk factors, namely, PUL [odds ratio (OR) =1.086, 95% confidence interval (CI): 1.023–1.158, P<0.001], PUA (OR =1.056, 95% CI: 1.028–1.088, P<0.001), and hypercholesteremia (OR =3.013, 95% CI: 1.317–7.020, P=0.01) (*Table 4*).

Development of the prediction nomogram

We established a nomogram model to predict the presence of AUR after TRPB according to the results of multivariate analysis (*Figure 2*). To evaluate the performance of the model in the development cohort, a receiver operating characteristic (ROC) curve was drawn, and the AUC was calculated to be 0.834 (95% CI: 0.772–0.896), whereas the concordance index (C-index) was 0.823. As shown in *Figure 3A*, we observed that the AUC of the complex model was greater than the AUCs of the 3 other individual risk factors. Similarly, better performance of the complex model was shown in the validation cohort, as the AUC increased to 0.895 (95% CI: 0.831–0.958), and the C-index was 0.878, as shown in *Figure 3B*. Furthermore, as depicted in *Figure 3C*,*3D*, the calibration curve showed great agreement between the predictions made by the nomogram and the actual observations in the development and validation cohorts.

Table 1 Comparison of baseline and post biopsy values among 3 groups of patients with varying PVR

Parameters	Post-void residual urine			P value
	200–300 mL	301–500 mL	>500 mL	
IPSS (baseline)	14.59±4.02	14.61±4.51	14.89±2.69	0.96
QoL (baseline)	2 [1.75–2.39]	2 [1.65–2.25]	2.19 [1.64–2.59]	0.61
IPSS (day 7)	16 [13–20.5]	16 [13–22]	22 [19.5–24]	0.01*
QoL (day 7)	2 [2–3]	2 [2–3]	3 [3–3.25]	0.002*
Successful removal of the catheter				0.02*
Yes	40 (67.8)	12 (20.3)	7 (11.9)	
No	1 (14.3)	3 (42.9)	3 (42.9)	

Data are presented as mean ± SD, median [IQR], or n (%). Mann-Whitney *U* test was used to analyze ordinally distributed and continuous variables. Chi-squared test and Fisher's exact test were used to assess categorical variables. *, P value <0.05. PVR, post-void residual urine volume; IPSS, International Prostate Symptom Score; QoL, quality of life; SD, standard deviation; IQR, interquartile range.

Additionally, these findings were verified by the Hosmer-Lemeshow test (P=0.69 and P=0.70, respectively).

Clinical use

DCA was performed to test the clinical utility of the nomogram. As shown in *Figure 3E*, the complex model achieved an optimal overall net benefit when the threshold probability ranged from 0.1 to 0.88, suggesting that receiving early intervention is beneficial. A CIC was used to further assess the predictive utility and practical relevance of the nomogram. As depicted in *Figure 3F*, the complex model demonstrated superior net benefits across a broad spectrum of threshold probabilities. Both DCA and CIC evaluations revealed that the nomograms incorporating hypercholesterolemia, PUL, and PUA exhibited substantial predictive efficacy.

Discussion

In published reports, TRPB has been suggested to cause objective voiding impairment, with some patients even experiencing urinary retention after the procedure (17). However, a clear threshold for PVR, which determines the placement of a catheter, has not yet been established. In the present study, we proposed that a 200 mL PVR may be a cutoff point for catheterization in patients. Furthermore, nomograms are a type of mathematical device or model that is widely used to help doctors make decisions in different clinical settings, especially in predicting complications or patient prognosis. Here, we established a nomogram based on individual patient data to predict the occurrence of AUR to aid in the early detection and timely treatment of this complication.

In recent years, the European Association of Urology (EAU) guidelines have recommended transperineal prostate biopsy. However, TRPB remains widely used due to several advantages, including a low incidence of AUR, which ranges from 0% to 4.4% (18-20). In our study, AUR was detected in 66 patients (19.8%). This is because the diagnosis of AUR can be subjective, whereas the use of PVR for catheter insertion is not consistent. An inability to voluntarily pass urine with a PVR >500 mL is generally considered indicative of AUR (21). However, tissue trauma and swelling after prostate biopsy undoubtedly increase urinary resistance, exacerbating difficulties in urination and the risk of infection. An excess of 200 mL of PVR suggests incomplete emptying, and PVR greater than 200–300 mL is widely believed to be associated with a less favorable response to treatment, increasing the risk of urinary tract infections (UTIs), upper urinary tract dilation, and renal insufficiency (22,23). Therefore, we believe that PVR is the key factor for early diagnosis and timely intervention in patients with AUR. Here, through subgroup analysis of patients with different PVRs, we first identified 200 mL PVR as the intervention threshold on the basis of the significant changes in IPSS, QoL, and successful catheter removal rates between different PVR patients. We hypothesize that the result may be associated with temporary bladder dysfunction caused by bladder overdistention. Additionally, it may be also due to the more pronounced effect of tamsulosin in patients with early

Table 2 Characteristics of all patients with AUR after biopsy

Characteristics	Overall (n=333)			Development cohort (n=233)			Validation cohort (n=100)		
	Urinary retention (n=66)	Non-urinary retention (n=267)	P value	Urinary retention (n=42)	Non-urinary retention (n=191)	P value	Urinary retention (n=24)	Non-urinary retention (n=76)	P value
Age (years)	68.50 [60.25, 72.75]	69.00 [62.00, 74.00]	0.64	70.00 [61.00, 73.75]	69.00 [62.00, 74.00]	0.94	66.00 [60.00, 71.25]	69.00 [62.00, 74.25]	0.35
BMI (kg/m^2)	23.21 [21.02, 24.83]	23.41 [21.28, 25.16]	0.61	23.11 [21.02, 24.89]	23.50 [21.50, 25.12]	0.62	23.54 [21.03, 24.76]	23.24 [20.85, 25.73]	0.90
Hypertension			0.50			0.15			0.45
No	41 (62.1)	180 (67.4)		25 (59.5)	138 (72.3)		16 (66.7)	42 (55.3)	
Yes	25 (37.9)	87 (32.6)		17 (40.5)	53 (27.7)		8 (33.3)	34 (44.7)	
Diabetes			0.94			0.53			0.79
No	57 (86.4)	227 (85.0)		38 (90.5)	163 (85.3)		19 (79.2)	64 (84.2)	
Yes	9 (13.6)	40 (15.0)		4 (9.5)	28 (14.7)		5 (20.8)	12 (15.8)	
Hypertriglyceridemia			0.43			0.63			0.69
No	47 (71.2)	205 (76.8)		30 (71.4)	146 (76.4)		17 (70.8)	59 (77.6)	
Yes	19 (28.8)	62 (23.2)		12 (28.6)	45 (23.6)		7 (29.2)	17 (22.4)	
Hypercholesterolemia			0.001*			0.04*			0.006*
No	39 (59.1)	212 (79.4)		25 (59.5)	146 (76.4)		14 (58.3)	66 (86.8)	
Yes	27 (40.9)	55 (20.6)		17 (40.5)	45 (23.6)		10 (41.7)	10 (13.2)	
Infection			0.38			0.93			0.34
No	49 (74.2)	214 (80.1)		33 (78.6)	154 (80.6)		16 (66.7)	60 (78.9)	
Yes	17 (25.8)	53 (19.9)		9 (21.4)	37 (19.4)		8 (33.3)	16 (21.1)	
Cancer			0.18			0.41			0.39
No	42 (63.6)	143 (53.6)		26 (61.9)	102 (53.4)		16 (66.7)	41 (53.9)	
Yes	24 (36.4)	124 (46.4)		16 (38.1)	89 (46.6)		8 (33.3)	35 (46.1)	
Puncture (needle)	12.00 [12.00, 14.00]	12.00 [12.00, 13.00]	0.19	12.00 [12.00, 14.00]	12.00 [12.00, 13.00]	0.10	12.00 [12.00, 14.00]	12.00 [12.00, 13.00]	0.96
IPP (mm)	7.28 [3.49, 13.31]	6.47 [0.00, 12.07]	0.12	6.75 [4.02, 12.40]	6.35 [0.00, 11.88]	0.41	8.22 [3.05, 14.74]	6.94 [0.00, 12.75]	0.16
PUL (mm)	53.46 [49.06, 62.91]	42.54 [36.91, 49.61]	<0.001*	52.94 [47.58, 63.21]	43.20 [36.96, 49.83]	<0.001*	56.88 [49.68, 62.39]	41.52 [36.74, 48.33]	<0.001*
PUA (°)	60.20±15.17	47.39±13.91	<0.001*	61.84±15.06	47.32±14.58	<0.001*	57.33±15.25	47.57±12.15	0.002*
TPV (mL)	59.90 [47.13, 80.64]	43.68 [30.88, 57.76]	<0.001*	59.90 [47.13, 74.13]	43.80 [31.56, 57.76]	<0.001*	60.70 [49.79, 94.29]	43.20 [27.50, 57.87]	<0.001*
TZV (mL)	33.74 [21.72, 49.32]	17.00 [9.17, 28.02]	<0.001*	33.67 [20.69, 46.78]	17.46 [9.69, 28.02]	<0.001*	33.74 [22.01, 51.90]	16.26 [8.50, 25.40]	<0.001*
TZI	0.58 [0.43, 0.72]	0.41 [0.28, 0.54]	<0.001*	0.58 [0.44, 0.72]	0.42 [0.29, 0.54]	<0.001*	0.58 [0.42, 0.71]	0.36 [0.26, 0.52]	0.001*
PZT (mm)	8.72 [6.52, 10.48]	8.66 [6.29, 11.36]	0.87	8.46 [6.43, 11.07]	8.50 [6.01, 10.88]	0.63	9.21 [6.53, 9.70]	9.57 [6.98, 12.52]	0.19
PSA (ng/mL)	9.82 [6.68, 18.59]	11.49 [6.82, 22.14]	0.51	9.48 [6.67, 22.48]	10.45 [6.55, 23.92]	0.89	9.91 [7.08, 15.23]	11.80 [7.12, 21.75]	0.28

Data are presented as median [IQR], mean ± SD, or n (%). Ordinally distributed and continuous variables were analyzed using the Mann-Whitney *U* test, whereas categorical variables were assessed using the Chi-squared test and Fisher's exact test. A P value <0.05 was considered to indicate a statistically significant correlation. *, P value <0.05. AUR, acute urinary retention; BMI, body mass index; IPP, intravesical prostatic protrusion; PUL, prostatic urethral length; PUA, prostatic urethral angle; TPV, total prostatic volume; TZV, transitional zone volume; TZI, transition zone index; PZT, peripheral zone thickness; PSA, prostate-specific antigen; SD, standard deviation; IQR, interquartile range.

Table 3 Univariate analysis was conducted on patients in both the development and validation cohorts

Characteristics	Development cohort				Validation cohort			
	β	OR	95% CI	P value	β	OR	95% CI	P value
Age	0.009	1.010	0.975, 1.047	0.60	–0.013	0.987	0.942, 1.035	0.59
BMI	–0.025	0.975	0.874, 1.086	0.65	–0.025	0.976	0.844, 1.122	0.73
Hypertension	0.571	1.771	0.875, 3.524	0.11	–0.482	0.618	0.227, 1.582	0.33
Diabetes	–0.490	0.613	0.174, 1.679	0.39	0.339	1.404	0.405, 4.324	0.57
Hypertriglyceridemia	0.261	1.298	0.596, 2.692	0.50	0.357	1.429	0.486, 3.930	0.50
Hypercholesterolemia	0.791	2.206	1.083, 4.431	0.03*	1.551	4.714	1.653, 13.735	0.004*
Infection	0.127	1.135	0.476, 2.496	0.76	0.629	1.875	0.661, 5.108	0.22
Cancer	–0.349	0.705	0.350, 1.386	0.32	–0.535	0.586	0.215, 1.499	0.28
Puncture	0.168	1.183	0.962, 1.476	0.13	0.060	1.062	0.796, 1.476	0.70
IPP	0.017	1.017	0.971, 1.062	0.46	0.039	1.040	0.986, 1.097	0.15
PUL	0.096	1.101	1.064, 1.143	<0.001*	0.120	1.127	1.071, 1.199	<0.001*
PUA	0.064	1.067	1.041, 1.095	<0.001*	0.058	1.059	1.021, 1.104	0.003*
TPV	0.024	1.024	1.011, 1.038	0.001*	0.033	1.033	1.015, 1.056	0.001*
TZV	0.041	1.042	1.024, 1.061	<0.001*	0.042	1.042	1.021, 1.071	0.001*
TZI	3.845	46.779	7.699, 320.245	<0.001*	4.574	96.908	7.563, 1,657.540	0.001*
PZT	0.049	1.051	0.961, 1.148	0.27	–0.068	0.934	0.815, 1.059	0.30
PSA	–0.0002	1.000	NA, 1.000	0.73	–0.023	0.977	0.934, 0.997	0.19

Mann-Whitney *U* test was used to analyze ordinally distributed and continuous variables. The Chi-squared test and Fisher's exact test were used to assess categorical variables. *, P value <0.05. OR, odds ratio; CI, confidence interval; BMI, body mass index; IPP, intravesical prostatic protrusion; PUL, prostatic urethral length; PUA, prostatic urethral angle; TPV, total prostatic volume; TZV, transitional zone volume; TZI, transition zone index; PZT, peripheral zone thickness; PSA, prostate-specific antigen; NA, not available.

Table 4 Multivariate analysis was conducted on patients in both the development and validation cohorts

Characteristics	Development cohort				Validation cohort			
	β	OR	95% CI	P value	β	OR	95% CI	P value
PUL	0.074	1.086	1.023, 1.158	<0.001*	0.123	1.145	1.041, 1.279	<0.001*
PUA	0.054	1.056	1.028, 1.088	<0.001*	0.05737	1.071	1.021, 1.133	0.01*
Hypercholesterolemia	1.058	3.013	1.317, 7.020	0.01*	2.03341	9.472	2.409, 44.488	0.003*

β is the regression coefficient. *, P values <0.05. OR, odds ratio; CI, confidence interval; PUL, prostatic urethral length; PUA, prostatic urethral angle.

intervention for urinary retention, as previous studies have shown that tamsulosin can reduce the incidence of AUR after biopsy (17,24,25). Hence, we took a more proactive approach in diagnosing AUR to safeguard bladder function, especially when patients required intervention following a post-prostate biopsy PVR exceeding 200 mL.

According to the univariate logistic regression analysis, the TZV and TZI were identified as risk factors for AUR. In an early study, TZV and TZI were reported to be significantly associated with LUTS and peak urine flow (25). Similar results were demonstrated by several studies that suggested that relatively larger TPV (>45 mL) and TZV,

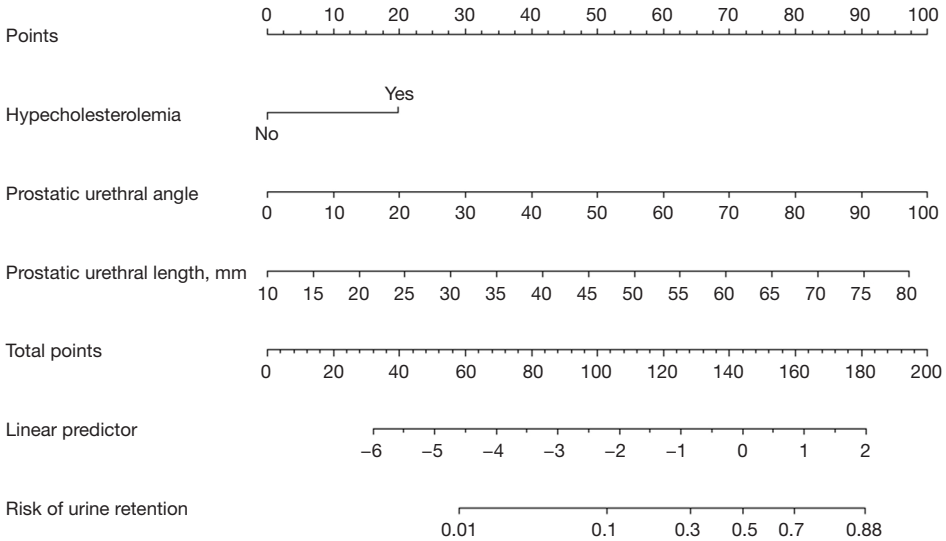

Figure 2 Nomogram for predicting the likelihood of AUR occurrence in prostate biopsy patients. AUR, acute urinary retention.

and higher TZI tend to be more likely to cause AUR (26,27). This may be attributed to more severe prostatic instrumental trauma and prostatic edema/swelling caused by prostate biopsy (10,11). In addition, in early studies, the PUL and PUA were demonstrated to correlate with the severity of LUTS, which are potential risk factors for surgery (10,11,28,29). Our study is the first to report that PUL and PUA can effectively predict the occurrence of AUR. Mechanistically, we hypothesized that prostatic instrumental trauma or edema may further increase the PUL and PUA and subsequently increase the urethral frictional force or bladder outlet resistance to trigger AUR. Additionally, we utilized MRI-measured PUL and PUA data. MRI provides high-resolution, high-contrast images depicting prostate structure, improving measurement accuracy and consistency. In contrast, TRUS images may vary owing to anatomical structures and operator proficiency, leading to uncertainties. Thus, MRI enables more precise PUA and PUL measurements, ultimately enhancing the model's overall reliability.

Older patients are more likely to develop metabolic syndrome (MetS), which is closely correlated with underlying diseases, such as central obesity, diabetes, hypertension, and dyslipidemia. Recently, evidence has supported the role of MetS parameters in LUTS due to benign prostatic enlargement (BPE) (30). As reported by Lee *et al.*, increased waist circumference is thought to aggravate LUTS (31). In addition, Gacci *et al.* reported that patients who have greater TPV and TZV always have low serum high-density lipoprotein (HDL) cholesterol levels (32). Our data revealed that hypercholesteremia significantly increased the occurrence of AUR. Therefore, this should be considered a preoperative risk factor when counseling patients prior to prostate biopsy.

Multivariate analysis was further performed in a forward stepwise manner to select risk factors that were strongly associated with AUR (entry criteria $P<0.1$, retention criteria $P<0.05$). Of the 6 clinical features, PUL, PUA, and hypercholesteremia were eventually retained and chosen for constructing a nomogram. The final nomograms were composed of 3 clinical features with the highest accuracy and calibration agreement and achieved an AUC of 0.834 in the development cohort and 0.895 in the validation cohort. Furthermore, both DCA and CIC in the current study showed that decision-making based on nomograms to address AUR added more benefit than the treat-all scheme or the treat-none scheme. Hence, the prediction model presents a practical solution for physician decision-making under these circumstances.

There are some limitations in this study. On the one hand, there may have been inevitable selection bias, as certain patients were excluded from this study because of data limitations, even though we prospectively enrolled all consecutive patients from January 2019 to November 2023 in the Third Affiliated Hospital of Sun Yat-sen University. On the other hand, subjective bias may have occurred when selecting IPSS and QoL parameters to investigate the impact of urinary catheterization on biopsy-related voiding

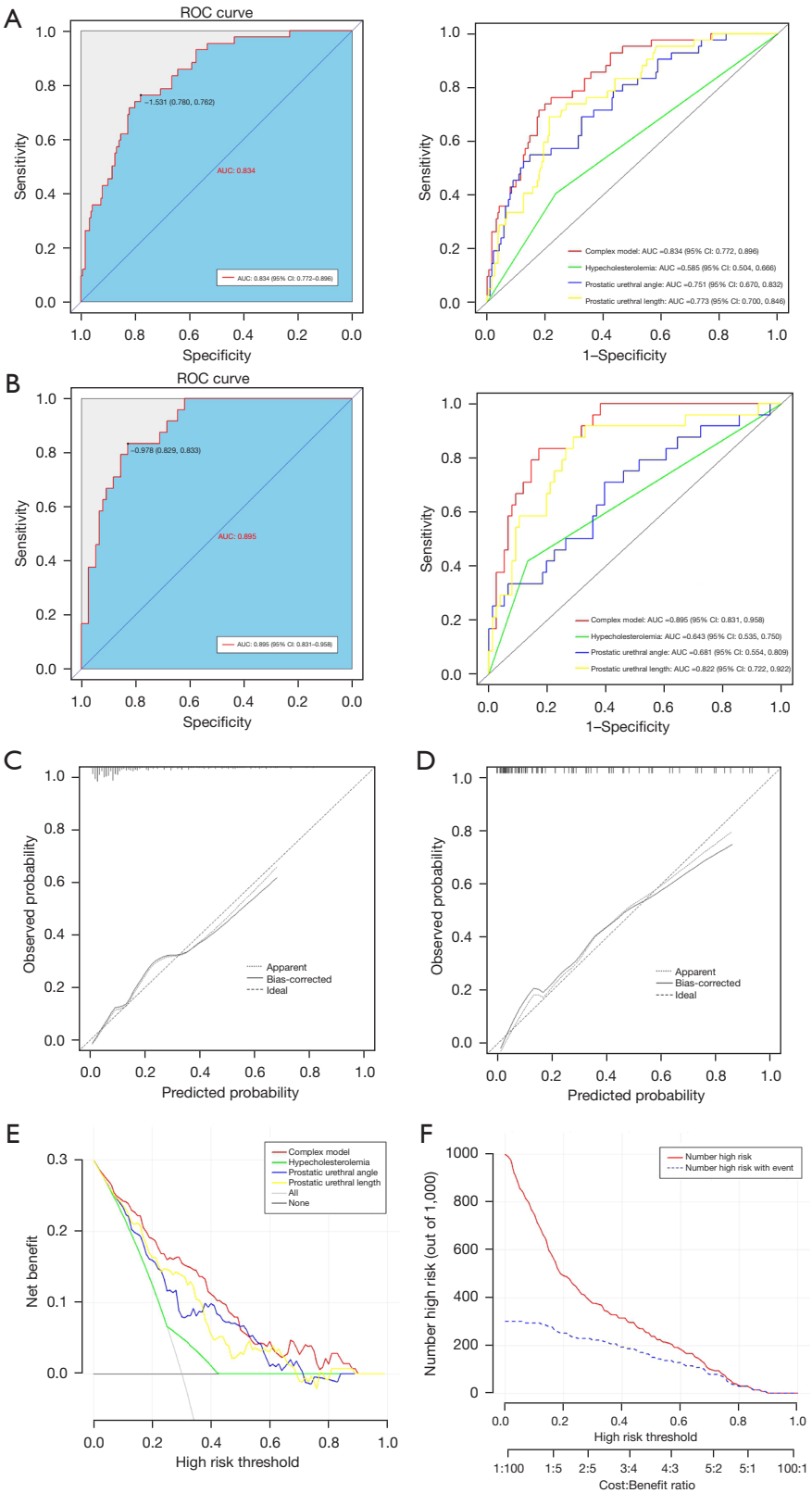

Figure 3 Assessment of the discrimination and calibration of the nomogram. ROC curves comparing the complex model with individual

feature models in the development cohort (A) and validation cohort (B). Calibration curves depicting the performance of the complex model in the development cohort (C) and validation cohort (D). Decision curves of the complex model and individual feature models for predicting AUR occurrence in prostate biopsy patients (E). CIC analysis was used to assess the model (F). ROC, receiver operating characteristic; AUR, acute urinary retention; CIC, clinical impact curve; AUC, area under curve; CI, confidence interval.

impairment under different PVR conditions. Due to insufficient follow-up data, 2 objective parameters, namely, average urinary flow rate and maximum urinary flow rate, were excluded from this study. Therefore, additional large-sample multicenter studies are needed to confirm our conclusions.

Conclusions

In this study, we defined >200 mL as the optimal PVR for indwelling catheters in patients with AUR after TRPB and developed a nomogram to predict the occurrence of AUR in patients who underwent prostate biopsy, considering 3 risk factors: PUA, PUL, and hypercholesterolemia. We aspire to enhance preprocedural consultation among clinical practitioners with the aid of this predictive model while also providing insights for the timely recognition and intervention of postprocedural urinary retention.

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None.

Footnote

Reporting Checklist: The authors have completed the TRIPOD reporting checklist. Available at https://tau.amegroups.com/article/view/10.21037/tau-24-399/rc

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Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://tau.amegroups.com/article/view/10.21037/tau-24-399/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Medical Ethics Board of The Third Affiliated Hospital of Sun Yat-sen University (No. II2024-156-02) and individual consent for this retrospective analysis was waived.

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