Urinary bladder hypertrophy and overactive bladder determine urinary continence after radical prostatectomy

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Abstract

Background. Several clinical and biological factors exacerbate urinary incontinence (UI) and reduce the patient's quality of life after radical prostatectomy (RP).

Objectives. The purpose of this study was to evaluate the effects of urinary bladder hypertrophy and overactive bladder (OAB) on UI in patients after RP.

Material and methods. Seventy patients were enrolled in the study and were divided into 2 groups: patients with bladder outlet obstruction (BOO) but without OAB (group I; n = 20) and patients with BOO and OAB (group II; n = 50). Before the RP procedure, all patients were administered IPSS and OAB symptom questionnaires and ultrasonography and uroflowmetry were performed. The follow-up visits were scheduled for 1, 3, 6, 9, and 12 months after the operation to evaluate postoperative continence.

Results. The results show that patients with BOO and concurrent OAB experienced urinary bladder hypertrophy. Patients with OAB presented a normal desire to void with less urinary bladder capacity. The coexistence of OAB before RP resulted in more extensive UI, as measured with the ICIQ-UI-SF scores and postoperative daily pad usage. A gradual improvement in urinary continence was observed. Urinary incontinence was significantly less severe in successive check-ups (3, 6, 9, and 12 months after RP). Urgency was responsible for 1–15% or 16–29% of episodes of urinary leakage in 20% and 16% of cases, respectively.

Conclusions. Patients with preoperative OAB are at a higher risk of developing more severe UI after RP, and the restoration of pre-surgery urinary continence is limited.

Key words: radical prostatectomy, urinary incontinence, bladder wall thickness, urinary bladder hypertrophy, overactive bladder

Cite as

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Introduction

Prostate cancer is one of the most common neoplasms among elderly males in Europe.¹ High-risk prostate cancer accounts for 26–39% of all cancers and most of the patients with organ-confined prostate cancer undergo radical prostatectomy (RP).² The most common postoperative complications are erectile dysfunction and urinary incontinence (UI). In general, patients who have undergone RP mainly report stress urinary incontinence.³ However, stress with coexisting urge UI (mixed type) is also observed in a smaller percentage of patients after RP. The etiopathogenesis of UI after RP is multifactorial.⁴ Our observations indicate that a certain group of patients who undergo open retropubic radical prostatectomy is characterized by more intense UI, because of overactive bladder (OAB) and other reasons. Overactive bladder develops due to secondary changes within the urinary bladder wall caused by long-term obstruction of urine flow at the enlarged prostate. Prostate cancer always coexists with benign prostatic hyperplasia, which is responsible for benign prostatic enlargement (BPE). Benign prostatic enlargement leads to urinary bladder outlet obstruction, which causes structural changes to the bladder (e.g., hypertrophy). Urinary bladder hypertrophy may lead to detrusor muscle overactivity, according to the myogenic theory of this disease's development. Overactive bladder can increase stress UI and significantly reduce patients' quality of life after RP. Ultrasonographic measurement of bladder wall thickness is useful in OAB diagnosis. Increased thickness of the urinary bladder remains a valuable positive predictor of detrusor overactivity development in patients diagnosed with OAB.⁵ Several predictive factors for UI after RP have been defined: the patient's age, body mass index (BMI), lower urinary tract symptom score, prostate volume, and comorbidity index. Moreover, detrusor overactivity correlates with continence status following RP.^{4,6} Based on clinical observations and a number of factors affecting urinary continence after surgery, the issue of post-prostatectomy UI is demanding. In general, the severity of UI after RP is unpredictable; it also varies in each patient depending on other factors affecting the patient's continence (especially bladder hypertrophy).⁷ Therefore, the purpose of the study was to evaluate the effect of urinary bladder structural changes due to bladder outlet obstruction (BOO) and OAB on UI in patients with prostate cancer undergoing open retropubic RP.

Methods

Patients

The study included 90 patients with prostate cancer who qualified for open retropubic RP, and was conducted from 2016 to 2018. All patients presented with organ-confined

prostate cancer (cT1c-T2c) confirmed by magnetic resonance imaging. Seventy patients were enrolled for further analysis. The remaining 20 patients were excluded from the study for incomplete follow-up due to the need for adjuvant therapy (radiotherapy) or for failure to report for follow-up visits after surgery.

Study protocol

All 70 patients with prostate cancer selected for further analysis presented with BOO, based on the average urine flow rates (Q_{avg}) obtained from uroflowmetry. The cut-off value of Q_{avg} was set at <10 mL/s. All patients were divided into two groups: patients with BOO but without OAB (group I) and patients with BOO and concurrent OAB (group II). The two groups were necessary due to the diversity of lower urinary tract symptoms (LUTS) observed in the patients due to OAB. All patients presented voiding LUTS due to BOO, and the majority of patients also presented storage LUTS due to OAB. At the initial assessment, all patients with prostate cancer who qualified for open retropubic RP were given the International Prostate Symptom Score (IPSS) questionnaire. The IPSS questionnaire assesses LUTS and consists of 7 questions about symptoms related to benign prostatic hyperplasia and its enlargement, as well as 1 question about quality of life of the patients. The scoring range is from 0 to 35 points. The scores 0, 1–7, 8–19, and 20–35 points are defined as asymptomatic patient, mild LUTS, moderate LUTS, and severe LUTS, respectively. Overactive bladder symptoms were estimated using 2 different OAB symptom scores (OABSS), designed by Blaivas et al. and Homma et al.^{8–10} Blaivas's OABSS scale is focused on LUTS due to OAB, as well as urinary bladder self-control. It consists of 7 questions and the scoring range is from 0 to 28 points. The higher the overall score, the greater the severity of OAB symptoms. Homma's OABSS scale is a questionnaire consisting of 4 questions about the number of LUTS due to OAB. The total score is the sum of all 4 scores related to each OAB symptom and the scoring range is from 0 to 15 points. The highest score indicates extremely severe OAB symptoms.¹¹ An OABSS total score of >3 points on the Homma questionnaire and/or >4 points on the Blaivas questionnaire were set as the inclusion criterion for group II (patients with OAB).

Additionally, we performed an ultrasonographic evaluation of the urinary bladder and prostate and a uroflowmetry test for each patient (see below). The follow-ups were scheduled for 1, 3, 6, 9, and 12 months after open retropubic RP in order to evaluate the functional outcomes and the severity of UI. At the follow-ups, postoperative continence was assessed and each patient was asked to complete an ICIQ-UI-SF questionnaire (International Consultation on Incontinence Questionnaire Urinary Incontinence – Short Form). The validated ICIQ-UI-SF questionnaire evaluates 3 issues of urine leakage: “frequency,” “quantity,” and “impact on everyday life.” The total score is the sum

of points connected with these 3 issues and it ranges from 0 to 21 points. The ICIQ-UI-SF questionnaire contains 8 additional questions concerned with the occurrence of urine leakage which are not included in the total ICIQ-UI-SF questionnaire score.¹² Stress UI was also estimated, based on measurements of pad usage per day. A daily pad usage of 0 pads and/or an ICIQ-UI-SF score of 0 points indicated that the patient was continent; all patients with a daily pad usage of 1 were defined as socially continent. These criteria for determining continence status were based on the study by Grabbert et al.¹³ In addition, we created a new scale (the VAS-UI: Visual Analogue Scale – Urinary Incontinence) to assess the contribution of urgency to UI after open retropubic RP. The VAS-UI consists of a straight line whose endpoints represent “0% urge UI and 100% stress UI” and “100% urge UI.” The patients were asked after surgery to indicate between the 2 endpoints the proportion of their incontinence that is urge UI. The study was approved by the Local Ethical Committee.

Ultrasonographic evaluation

At the initial consultation (before RP), each patient underwent a transabdominal ultrasonographic evaluation (USG) of the structure of the prostate and urinary bladder. Three-dimensional ultrasonography was used to assess the prostate volume [mL]. In each patient, the USG was performed when urinary bladder filling was related to a normal desire to void. This was done in order to reproduce the physiological (functional) filling of the urinary bladder and the bladder and detrusor wall thickness (BWT and DWT) for each patient. Functional urinary bladder wall thickness (fBWT) (in mm) and functional detrusor muscle thickness (fDWT) (in mm) were measured along the sagittal plane in the anterior bladder wall. The means of 3 measurements of fBWT and fDWT were calculated. Moreover, we recorded the surface area (SA) (in cm²), which covers the bladder capacity and illustrates the degree to which the bladder is filled. In addition, we defined a new parameter called the adjusted-BWT index (aBWTi). The aBWT index is calculated from the functional urinary bladder wall thickness (fBWT), the surface area (SA), and the prostate volume (V_{prostate}) using the following formula: $\text{aBWTi} = \text{fBWT} \times \text{SA} \times 0.1 / V_{\text{prostate}}$. It is known that the BWT depends on the degree to which the urinary bladder is full. In addition, the prostate volume determines the extent of the bladder outlet obstruction. A bladder outlet obstruction which is increased due to an enlarged prostate affects the urinary bladder structure and the thickening of the urinary bladder wall. Therefore, in our cohort we measured the functional bladder wall thickness (fBWT), which is affected by the degree of bladder filling. The main goal in defining this new parameter was an attempt to homogenize the study group, but we also tried to define a simple parameter to determine the severity of UI after open retropubic RP for urologists conducting

preoperative evaluations of patients with prostate cancer who qualified for radical treatment. The aBWT index, thanks to its simplicity and straightforward calculation (based only on USG measurements of the urinary bladder and prostate), can become a useful tool in the preoperative assessment of RP and in determining the predictive factor of UI after RP.

Uroflowmetry

Uroflowmetry was performed in each patient at the initial assessment (before RP). Uroflowmetry was initiated when the patient reported a normal desire to void. We recorded the following parameters: 1) the maximum urine flow rate (Q_{max}) (in mL/s), 2) the average urine flow rate (Q_{avg}) (in mL/s), and 3) the urine flow time (FT) (in seconds). After the patient voided, we measured the post-void residual urine (PVR) (in mL) using three-dimensional transabdominal ultrasonography. In addition, we introduced a new parameter to evaluate the area under the uroflowmetric curve: the UFM_{AUC} . The UFM_{AUC} is the absolute value obtained by multiplying the average urine flow (Q_{avg}) by the urine flow time (FT). The UFM_{AUC} seems to more accurately describe the function of the lower urinary tract than single parameters, such as Q_{max} and Q_{avg} , which depend on how full the bladder is. Considering the fact that uroflowmetry is dependent on bladder fullness, the creation of the UFM_{AUC} provides for a more unified study group and links urine flow rate to bladder fullness and the efficacy of bladder voiding (functional activity), which is indirectly expressed by the FT during uroflowmetry. The main goal in defining the UFM_{AUC} was to unify the study group despite the different bladder volumes producing a normal desire to void.

Exclusion criteria

The exclusion criteria were as follows: 1) neoadjuvant (any time before) or adjuvant radiotherapy or brachytherapy (within the 12-month follow-up period); 2) macroscopic infiltration of the urinary bladder (pT4); 3) neurological deficiencies (e.g., stroke, spinal cord injury, multiple sclerosis, Parkinson's disease, etc.) which would cause an inability to control the urinary bladder; 4) urethral strictures; 5) previous surgery – such as transurethral resection of the prostate (TURP) or adenectomy – performed up to 12 months prior to the RP; and 6) any form of constant catheterization (indwelling catheter or clean intermittent catheterization).

Statistical analysis

All of the results are presented as medians (along with 25th–75th percentiles). The normality of the data was determined by the Kolmogorov–Smirnov test. As the data did not fulfil the criteria of normality, a nonparametric

Friedman test was performed – followed, where necessary, by a Wilcoxon test with Bonferroni correction – to compare the differences between dependent groups (repeated measurements). The Mann–Whitney test was used to compare the differences between independent groups (group I vs. group II). Intragroup measurements of all analyzed preoperative and postoperative parameters were tested using Spearman's correlation due to the “non-normal” distribution of the data. The data was considered statistically significant when $p < 0.05$. The statistical analyses were conducted using SPSS v. 24.0 software (IMB Corp., Armonk, USA).

Results

Preoperative assessment

The mean age of the patients in groups I and II were 66.5 and 68.0 years, respectively. The preoperative lower urinary tract symptom evaluations, USG characteristics, and uroflowmetric parameters are summarized in Table 1. All patients included in the study presented BOO and moderate or severe lower urinary tract symptoms (LUTS), based on their IPSS score and uroflowmetry. In comparison with group I (BOO without OAB), more patients in group II reported LUTS due to OAB on the Blaivas and Homma OABSS questionnaires (1 vs 12, $p < 0.05$; and 1 vs 6, $p < 0.05$, respectively). Patients with BOO and concurrent

OAB experienced more urinary bladder hypertrophy than patients with only BOO. Urinary bladder hypertrophy was identified during USG as an increased functional bladder wall thickness (fBWT) and functional detrusor wall thickness (fDWT) (2.7 vs 2.3 mm, $p < 0.05$; and 1.3 vs. 1.0 mm, $p < 0.05$, respectively). Moreover, patients with OAB experienced a normal desire to void when their bladders were less full, which was reflected in the reduced surface area under ultrasound (37.0 vs 53.0 cm², $p < 0.05$); consequently, the median values of voided urine volume were correspondingly smaller (194 vs 340 mL, $p < 0.05$). Compared to patients with BOO, the adjusted-BWT index in patients with BOO and OAB was lower, though not statistically significantly lower. The UFM_{AUC} was significantly higher in patients with BOO than in patients with coexisting OAB (346 vs 195, $p < 0.05$).

Postoperative assessment

The postoperative ICIQ-UI-SF scores were analyzed in all 70 patients during the 12 months of follow-up. Of the patients with BOO but not OAB (group I), 50% achieved complete urinary continence within 12 months of RP (ICIQ-UI-SF score = 0 points), whereas only 30% of patients with BOO and concurrent OAB (group II) did so. All of the patients with BOO and OAB suffered moderate to severe UI according to their ICIQ-UI-SF scores (6–10 and >11 points, respectively) in the 3 months after RP. Patients with BOO but not OAB mostly reported mild UI in the 3 months after surgery in 75% of the cases. Six months after the surgery, none of the patients reported UI (ICIQ-UI-SF score >11 points). The Friedman test revealed that the ICIQ-UI-SF questionnaire differed with time in both group I ($\chi^2(4) = 72.903$, $p = 0.000$) and group II ($\chi^2(4) = 197.204$, $p = 0.000$). Postoperative ICIQ-UI-SF questionnaire scores in the 12-month period are summarized in Table 2.

Table 1. Preoperative lower urinary tract symptom evaluation, ultrasonography characteristics, and uroflowmetry parameters in patients with prostate cancer who qualified for radical prostatectomy

Questionnaire evaluation			
Questionnaire	Group I	Group II	p-value
OABSS (Blaivas et al.)	1 (1–2)	12 (7–14)	$p < 0.05$
OABSS (Homma et al.)	1 (1–2)	6 (3–8)	$p < 0.05$
IPSS	12 (5–16)	13 (10–17)	ns
Ultrasonography			
Parameter	Group I	Group II	p-value
Prostate volume [mL]	40 (35–48)	40 (35–51)	ns
fBWT [mm]	2.3 (2.1–2.6)	2.7 (2.3–3.1)	$p < 0.05$
fDWT [mm]	1.0 (0.9–1.1)	1.3 (1.1–1.7)	$p < 0.05$
SA [cm ²]	53.0 (44.4–60.8)	37.2 (30.3–48.5)	$p < 0.05$
aBWT _I index [1]	0.26 (0.23–0.35)	0.24 (0.18–0.34)	ns
Uroflowmetry			
Parameter	Group I	Group II	p-value
Q _{max} [mL/s]	13 (10–16)	10 (7–11)	$p < 0.05$
Q _{avg} [mL/s]	8 (7–9)	6 (4–8)	$p < 0.05$
Flow time [s]	42 (33–49)	35 (29–44)	$p < 0.05$
V _{void} [mL]	340 (302–379)	194 (159–263)	$p < 0.05$
PVR [mL]	20 (0–40)	30 (0–55)	ns
UFM _{AUC} [1]	346 (262–381)	195 (150–261)	$p < 0.05$

Table 2. Postoperative ICIQ-UI-SF questionnaire scores

Follow-up	Group	Score							
		0 points		1–5 points		6–10 points		over 11 points	
		n	[%]	n	[%]	n	[%]	n	[%]
1 month	I	0	0	0	0	8	40	12	60
	II	0	0	0	0	1	2	49	98
3 months	I	0	0	15	75	4	20	1	5
	II	0	0	0	0	37	74	13	26
6 months	I	0	0	19	95	0	0	0	0
	II	0	0	26	52	24	48	0	0
9 months	I	4	20	16	80	0	0	0	0
	II	1	2	49	98	0	0	0	0
12 months	I	10	50	10	50	0	0	0	0
	II	15	30	35	70	0	0	0	0

In our cohort, we observed a gradual improvement in urinary continence (groups I and II). The reduction in the severity of UI was statistically significant in the successive follow-ups (3, 6, 9, and 12 months after RP) (Table 3).

In comparison with patients with BOO alone, the severity of postoperative UI was significantly higher in patients with BOO and OAB symptoms at the 9-month follow-up. After 12 months, we recorded no statistically significant difference in UI (Table 4).

We found statistically significant positive correlations between the Blaivas et al. OABSS score and the severity of UI, according to the ICIQ-UI-SF questionnaires (1, 3, 6, and 9 months after RP, $p < 0.01$ for each). Moreover, Homma OABSS scores positively correlated with the severity of UI, according to the ICIQ-UI-SF questionnaire 3 months after surgery ($p < 0.01$) (Fig. 1).

Table 3. Comparison of postoperative evaluations in successive follow-ups in groups I and II

Group	Follow-up				
	1 month	3 months	6 months	9 months	12 months
ICIQ-UI-SF questionnaire					
I	12 (9–13)	5 (3–6)*	3 (3–3)*,&	1 (1–3)*,&,#	0.5 (0–1)*,&,#,¶
II	14 (13–16)	9 (7–11)*	5 (4–6)*,&	3 (3–3)*,&,#	1 (0–3)*,&,#,¶
Daily pad usage					
I	2 (1–2)	2 (1–2)	1 (1–1)*,&	0 (0–1)*,&,#	0 (0–0)*,&,#
II	3 (3–4)	2 (2–3)*	1 (1–2)*,&	1 (0–1)*,&,#	0 (0–1)*,&,#,¶
Percentage attendance of urge urinary incontinence					
I	0 (0–20)	0 (0–20)	0 (0–0)	0 (0–0)	0 (0–0)
II	13 (0–26)	13 (0–26)	10 (0–20)*,&	0 (0–15)*,&,#	0 (0–15)*,&,#

* $p < 0.005$ vs 1 month; & $p < 0.005$ vs 3 months; # $p < 0.005$ vs 6 months; ¶ $p < 0.005$ vs 9 months.

Fig. 1. Correlations between OABSS questionnaire scores and ICIQ-UI-SF questionnaire scores or daily pad usage after radical prostatectomy

Table 4. Comparison of postoperative evaluations of groups I and II

Postoperative evaluation	Follow-up	Group I	Group II	p-value
ICIQ-UI-SF questionnaire	1 month	12 (9–13)	14 (13–16)	$p < 0.05$
	3 months	5 (3–6)	9 (7–11)	$p < 0.05$
	6 months	3 (3–3)	5 (4–6)	$p < 0.05$
	9 months	1 (1–3)	3 (3–3)	$p < 0.05$
	12 months	0.5 (0–1)	1 (0–3)	ns
Pad usage	1 month	2 (1–2)	3 (3–4)	$p < 0.05$
	3 months	2 (1–2)	2 (2–3)	$p < 0.05$
	6 months	1 (1–1)	1 (1–2)	$p < 0.05$
	9 months	0 (0–1)	1 (0–1)	$p < 0.05$
	12 months	0 (0–0)	0 (0–1)	ns
Percentage attendance of urge urinary incontinence	1 month	0 (0–20)	13 (0–26)	ns
	3 months	0 (0–20)	13 (0–26)	ns
	6 months	0 (0–0)	10 (0–20)	$p < 0.05$
	9 months	0 (0–0)	0 (0–15)	$p < 0.05$
	12 months	0 (0–0)	0 (0–10)	$p < 0.05$

Table 5. Postoperative daily pad usage

Follow-up	Group	Number of pads per day					
		0 pad		1 pad		> 1 pad	
		n	[%]	n	[%]	n	[%]
1 month	I	0	0	5	25	15	75
	II	0	0	1	2	49	98
3 months	I	0	0	8	40	12	60
	II	1	2	7	14	42	84
6 months	I	3	15	17	85	0	0
	II	4	8	30	60	16	32
9 months	I	15	75	5	25	0	0
	II	16	32	31	62	3	6
12 months	I	17	85	3	15	0	0
	II	31	62	19	38	0	0

Regarding daily pad usage in our cohort, we observed that most of the patients with only BOO (group I) reported full urinary continence in terms of pad usage (85%). Concurrent OAB symptoms (group II) influenced the everyday use of pads. In this group of patients, full urinary continence (0 pads per day) and social continence (1 pad per day) were reported in 62% and 38% of cases, respectively. None of the patients from our cohort were using more than 1 pad per day by the 12-month follow-up examination. In the first 3 months post-op, most of the patients experienced UI requiring the use of at least 1 pad per day (60% for patients without OAB and 84% for patients with OAB). The Friedman test showed that daily pad usage differed with time in both group I ($\chi^2(4) = 71.150$, $p = 0.000$) and group II ($\chi^2(4) = 183.361$, $p = 0.000$). Postoperative daily pad usage over the 12-month period is summarized in Table 5.

According to these results, urinary continence improved with time after RP. We also observed a reduction in postoperative daily pad usage over time (Table 3). As compared to the patients with BOO alone, the patients with OAB symptoms and BOO required more pads per day in the first 9 months following RP. At the 12-month follow-up, we recorded no statistically significant differences in daily pad usage (Table 4).

A statistically significant positive correlation was found between the Blaivas OABSS score and daily pad usage (1, 3, and 9 months after RP, $p < 0.01$ for each). Also, the Homma OABSS score positively correlated with daily pad usage at the 1-month and 3-month follow-up examinations ($p < 0.01$) (Fig. 1).

In our cohort, at least 50% of patients reported stress UI (urine leakage not triggered by urgency). We observed that 36% of the patients with BOO and OAB still experienced mixed UI 12 months after RP; the mixed UI was mainly of the stress type. In 20% of the patients with BOO and OAB, urgency was the cause of urinary leakage in 1–15% of episodes of UI, while in 16% of patients it contributed to 16–29% of UI episodes. The Friedman test revealed that the proportion of urge UI differed with time only in group II ($\chi^2(4) = 32.680$, $p = 0.000$) — not in group I. The postoperative proportion of urge UI 12 months after RP is summarized in Table 6.

Discussion

Development of OAB after RP accounts for 15.2 to 37.8% of cases.¹⁴ Several underlying mechanisms in the pathogenesis of post-prostatectomy OAB have been proposed. The impact that surgery has on the anatomical relationships of the lower urinary tract and its innervation seems indisputable if we consider the context of UI. A number of preoperative factors also have a negative impact on a patient's continence after RP (e.g., the patient's age, preexisting LUTS, body weight, functional urinary bladder changes, etc.).⁴ Preoperative functional changes of the bladder (hypertrophy of the bladder wall) are caused by bladder outlet obstruction due to benign enlargement of the prostate. In our cohort, patients with OAB symptoms had hypertrophy of the bladder wall and detrusor muscle. It is worth mentioning that increased thickness of the bladder is a predictor of detrusor overactivity in patients with OAB.^{7,15}

The main goal of our study was to carry out a functional assessment and analysis of the physiological conditions for each patient during ultrasound of the urinary bladder. Patients with prostate cancer who qualify for RP belong to a very heterogeneous group due to the varying severity of bladder outlet obstruction and associated voiding issues and/or storage LUTS. In our cohort, the patients with OAB symptoms were characterized by less urinary bladder capacity, so this dependence could affect the absolute

Table 6. Postoperative percentage attendance of urge urinary incontinence in urinary incontinence after radical prostatectomy

Follow-up	Group	Percentage attendance of urge urinary incontinence							
		0%		1–15%		16–29%		above 30%	
		n	[%]	n	[%]	n	[%]	n	[%]
1 month	I	11	55	0	0	7	35	1	5
	II	23	46	3	6	13	26	11	22
3 months	I	11	55	2	10	6	30	1	5
	II	24	48	3	6	11	22	12	24
6 months	I	16	80	3	15	1	5	0	0
	II	24	48	9	18	12	24	5	10
9 months	I	20	100	0	0	0	0	0	0
	II	28	56	12	24	9	18	1	2
12 months	I	20	100	0	0	0	0	0	0
	II	32	64	10	20	8	16	0	0

value (non-physiological) of BWT and DWT. It seems reasonable to measure BWT and DWT at a constant bladder volume in further experiments. We observed no statistically significant differences of adjusted-BWT index in either group. The lack of differences in aBWTi could be explained by the fact that there is no simple correlation between increasing prostate volume and more severe LUTS as a result of bladder outlet obstruction. Smaller prostates often cause more severe bladder outlet obstruction. The creation of the UFM_{AUC} seems to be justified, as it contains two variables which are dependent on how full the urinary bladder is: flow time and average urine flow. In our cohort, patients with OAB symptoms had a lower value of UFM_{AUC}. Thus, this parameter may be useful in the preoperative evaluation of patients with prostate cancer who qualified for RP — along with other data (e.g., OABSS questionnaire scores, fBWT, fDWT, etc.) — for predicting the degree of UI after surgery.

Our results revealed that the coexistence of OAB in patients before RP results in more extensive UI after surgery, as measured by the ICIQ-UI-SF score. Sebesta et al. reported that approximately one-third of patients' urgency or urge UI was the primary cause of UI following RP.¹⁶ Most patients after RP regain continence comparable to their presurgical continence within the first 12 months post-op. However, during the subsequent 12 months, a modest improvement in continence has also been observed.^{4,17} In our cohort, patients with OAB were characterized by a slower improvement in urinary continence at the 12-month follow-up than patients with only bladder outlet obstruction. Only 30% of OAB patients were fully continent according to their ICIQ-UI-SF scores (0 points) after RP. Urodynamic evaluations of patients after RP revealed detrusor overactivity in about 3–63% of cases.³ In their study, Hosier et al. showed that OAB and storage LUTS frequently occur in patients who have undergone RP;¹⁸ Song et al. reported that more than half of their patients developed detrusor overactivity within

3 years of RP.¹⁹ Similarly, in our cohort, 36% of the patients still experienced urge UI 12 months after surgery. The severity of this type of incontinence ranged from 1–15% (20% of patients) to 16–19% (16% of patients).

Moreover, we observed increased daily pad usage following RP in patients with OAB. In our cohort, patients with no OAB symptoms reported full or social continence in the 12-month postoperative period in 85% and 15% of cases, respectively, while patients with concurrent OAB achieved full continence in 62% of cases and social continence in 38% of cases. In their long-term functional analysis of patients after RP, Grabbert et al. found full and social continence in terms of pad usage in 36% and 27% of patients after 3 months, in 53% and 24% after 12 months, in 56% and 22% after 24 months, and in 63% and 17% of cases after 36 months.¹³ Sebesta et al. reported that 31.7% of their RP cohort were fully continent.¹⁶ Urine leakage at least once a day occurred in 16.8% and 9.2% of patients, respectively.

Regarding the occurrence of urgency in the post-prostatectomy period, all patients without OAB prior to surgery reported UI due to urgency. Conversely, patients with LUTS caused by OAB before RP still reported urge UI in 36% of cases after 12 months. The urgency was responsible for 1–15% or 16–29% of episodes of urinary leakage in 20% and 16% of cases, respectively. In most cases, it is difficult to indicate whether urine leakage is caused by urgency. Urgency may exacerbate the existing stress UI. In contrast, episodes of urgency may result from the activation of the reflex arc connecting the proximal urethra to the detrusor muscle. Stress UI is always present to varying degrees in patients after RP. It should also be mentioned that stress UI may intensify urge UI. Based on an animal model, it can be postulated that this phenomenon is likely associated with the stimulation of the afferent nerves of the proximal part of the urethra by urine (due to sphincter insufficiency after RP), leading to detrusor muscle contraction (inducing or exacerbating

existing detrusor overactivity).²⁰ The Visual Analogue Scale – Urinary Incontinence (VAS-UI) that we use seems to be very helpful in patients with prostate cancer who qualify for RP. In the case of a patient with coexisting OAB, a heavier course of UI should be expected. The VAS-UI scale is a simple diagnostic tool that provides a quick and easy indication of whether a given patient actually has urgency after surgery. This information seems crucial for more precisely managing patients who present with OAB symptoms following RP as well as for administering drugs which affect urinary bladder function (e.g., anticholinergic drugs, β 3-adrenergic agonists, etc.), and thus for reducing the severity of OAB and post-prostatectomy UI.

In our analysis, we found a statistically significant positive correlation between Blaivas OABSS score and post-operative UI according to ICIQ-UI-SF score (9 months after surgery) and daily pad usage (1, 3, and 9 months after surgery). The Homma OABSS score was characterized by fewer statistically significant positive correlations with UI as assessed in the postoperative course. The scores from this questionnaire correlated with daily pad usage during the first 3 months after surgery, as well as with the ICIQ-UI-SF score 3 months after RP. Our data indicates that the OABSS questionnaire designed by Blaivas et al. is a precise diagnostic tool for OAB as it assesses the degree of overlap of OAB symptoms and it can indicate the probability of an unfavorable course of recovery after RP (more severe and longer lasting UI), especially during the first 9 months after a procedure.

Considering the above-mentioned data, urinary bladder wall hypertrophy and functional disorder of the urinary bladder (e.g., OAB) are important factors affecting urinary continence after RP. Overactive bladder may develop because of long-term bladder outlet obstruction and benign prostatic enlargement, which coexist in most patients diagnosed with prostate cancer. Furthermore, RP may intensify preoperative OAB. In many cases, RP affects the innervation of lower urinary tracts and leads to functional changes in the bladder, such as detrusor overactivity and/or decreased bladder compliance. Patients with preoperative OAB are at higher risk of developing more severe UI after RP, the return to urinary continence will be slower, and the continence regained after 12 months will be slightly worse than for patients without OAB. The improvement in postoperative urinary continence should be multidirectional, especially during the first 2 years after RP. Pelvic floor muscle physiotherapy can reduce the degree of stress UI, which is also responsible for urinary bladder dysfunction (especially OAB). On the other hand, patients with OAB should receive targeted therapy to reduce the severity of OAB. This treatment should include pharmacotherapy, e.g., antimuscarinic drugs and/or β 3-adrenergic agonists (first-line treatment). In cases where the patient does not respond to pharmacotherapy, intravesical botulinum toxin type A injections should be considered as a second-line treatment after RP. Perhaps

in the future, patients with severe OAB who are at a higher risk of unfavorable post-prostatectomy UI outcomes will undergo intravesical botulinum toxin type A injections at the same time as their RP. However, further research is necessary in this area.

Conclusions

In summary, our study showed that patients with bladder outlet obstruction and concurrent OAB are characterized by urinary bladder hypertrophy. The coexistence of OAB in patients before RP results in more severe UI after the surgery, as measured by ICIQ-UI-SF score and daily pad usage; the restoration of pre-surgery urinary continence is also limited. The OABSS questionnaire designed by Blaivas et al. is a precise diagnostic tool for OAB and should be widely implemented in urological practice in the preoperative assessment of patients with prostate cancer who qualify for RP.

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