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Spontaneous voiding is surprisingly recoverable via outlet procedure in men with underactive bladder and documented detrusor underactivity on urodynamics

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Abstract

Aims: To identify clinical and urodynamic factors leading to spontaneous voiding in men with detrusor underactivity (DU) and suspected bladder outlet obstruction who underwent an outlet de-obstruction procedure.

Methods: We identified 614 men who underwent an outlet procedure at our institution from 2005 to 2014. Men were stratified by bladder contractility index (BCI). The primary outcome was spontaneous voiding after surgery. Data were analyzed in Statistical analysis system software.

Results: Of the 131 men who underwent preoperative urodynamics, 122 (mean age 68 years) had tracings available for review. DU (BCI < 100) was identified in 54% (66 of 122), of whom only 68% (45 of 66) voided spontaneously before surgery, compared with 82% (46 of 56) of men with BCI ≥ 100. At a mean follow-up of 6.4 months postoperatively, 79% (52 of 66) of men with DU were able to void spontaneously, compared with 96% (54 of 56) of men with BCI ≥ 100. In men with a BCI < 100 unable to void before surgery, 57% (12 of 21) recovered spontaneous voiding after surgery. On logistic regression for the outcome postoperative spontaneous voiding, significant preoperative characteristics, and urodynamic factors included preoperative spontaneous voiding (odds ratio [OR] = 9.460; 95% confidence interval [CI] = 2.955-30.289), increased maximum flow rate (Qmax; OR = 1.184; 95% CI = 1.014-1.382), increased detrusor pressure at maximum flow (Pdet@Qmax; OR = 1.032; 95% CI = 1.012-1.052), DU with BCI < 100 (OR = 0.138; 95% CI = 0.030-0.635), and obstruction with bladder outlet obstruction index > 40 (OR = 5.595; 95% CI = 1.685-18.575).

Conclusion: Outlet de-obstruction improves spontaneous voiding in men with DU and may benefit men who do not meet the urodynamic threshold for obstruction.

KEYWORDS
follow-up studies, male, muscle contraction, prostatic hyperplasia, urologic surgical procedures

Abbreviations: AUA, American Urological Association; BCI, bladder contractility index ($BCI = Pdet@Q_{max} + 5 \times Q_{max}$); BOOI, bladder outlet obstruction index ($BOOI = Pdet@Q_{max} - 2 \times Q_{max}$); CI, confidence interval; OR, odds ratio; $Pdet@Q_{max}$, detrusor pressure at maximum flow; PVR, post void residual; Q_{max}, maximum flow rate; SD, standard deviation; UDS, urodynamics; UTI, urinary tract infection.

1 | INTRODUCTION

The underactive bladder (UAB) is a poorly understood disease entity which has been recently recognized by the National Institutes of Health as a top research priority within the National Institute on Aging, and the International Congress of Urologic Research and Education on Aging Underactive Bladder. UAB is the antithesis of the more studied overactive bladder, representing an unmet medical need receiving much less attention historically.[1-4] The American Urological Association (AUA), Society of Urodynamics Female Pelvic Medicine and Urogenital Reconstruction, International Continence Society (ICS), and European Association of Urology have published guidelines regarding the management of benign prostate hyperplasia and the performance of urodynamics (UDS).[5-9] The diagnosis of UAB is typically made in the setting of urinary retention and elevated post void residual (PVR). It often arises as the sequela of bladder outlet obstruction (BOO), neurologic injury or poorly controlled diabetes, however many cases are idiopathic. Symptoms are not specific and can include urinary hesitancy, urinary frequency, sensation of incomplete emptying, weak stream, and straining to void.

The ICS defines detrusor underactivity (DU) as a "*Low detrusor pressure or short detrusor contraction time, usually in combination with a low urine flow rate resulting in prolonged bladder emptying and/or a failure to achieve complete bladder emptying within a normal time span.*"[10-12] Many patients are assumed to have BOO on the basis of lower urinary tract symptoms, and it is not until late in their diagnosis that DU is suspected after surgical treatments directed at relieving bladder obstruction have failed to improve symptoms. Research into DU and outcomes in bladder management is gaining priority. Bladder detrusor failure is akin to heart failure, in that weakening contractile strength leads to significant secondary morbidity and economic costs, as a result of urinary retention, bladder catheterization, recurrent urinary tract infections, renal failure, sepsis, hospitalizations, and surgical procedures.[13]

Bladder dysfunction is suggested to be irreversible at the time of diagnosis. Intensive efforts are underway to develop therapies aimed at improving bladder contractile strength and to identify this disorder earlier in life. We sought to identify clinical and urodynamic factors in men with clinically suspected BOO with or without DU who underwent a de-obstruction procedure over a 9-year period.

2 | MATERIALS AND METHODS

After obtaining institutional review board approval, we identified 614 men who underwent an outlet de-obstruction procedure at our institution from October 2005 to August 2014. From this group, we identified 131 men who underwent preoperative urodynamic pressure-flow evaluation of the bladder outlet. An independent two-reviewer case-by-case retrospective urodynamic tracing and chart review of each medical record was performed on the 122 of 131 men who had complete preoperative UDS and follow-up data available for review. Extracted data included: baseline patient characteristics, the presence of diabetes, history of urinary tract infection, alpha blocker use, 5α reductase inhibitor use, preoperative spontaneous voiding, AUA symptom and quality of life scores, preoperative free uroflowmetry (maximum flow rate [Q_{max}], voided volume, and PVR), and preoperative pressure-flow UDS. Urodynamic reports and tracings were reviewed for bladder capacity, the presence of detrusor overactivity, urodynamic Q_{max}, detrusor pressure at maximum flow (Pdet@Q_{max}), PVR, and abdominal straining to void.

Degree of obstruction was quantified in men using the bladder outlet obstruction index ($BOOI = Pdet@Q_{max} - 2 \times Q_{max}$) to express the relationship between detrusor contractile pressure at maximum flow (Pdet@Q_{max} [cm H_2O]) and Q_{max} (mL/s).[14] The state of high pressure and low flow voiding is suggestive of BOO, with a BOOI of greater than 40 generally accepted as diagnostic of BOO in a male who is clinically obstructed.[14,15] Bladder contractility was quantified in men using the bladder contractility index ($BCI = Pdet@Q_{max} + 5 \times Q_{max}$), with a BCI less than 100 classified as DU.[14]

Following an outlet de-obstruction procedure, patient characteristics after surgery were identified by chart review of each medical record. Our primary outcome of interest was the presence of the ability to spontaneously void after surgery without the need for intermittent catheterization or indwelling catheter. Each record was categorized by postoperative voiding function: spontaneous void, intermittent catheterization, and indwelling catheter. Additional extracted follow-up data included: postoperative urinary tract infection, AUA symptom and quality of life scores, and postoperative free uroflowmetry (Q_{max}, voided volume, and PVR).

Data were analyzed in Statistical analysis system software (Cary, NC) for our primary outcome (spontaneous voiding after surgery) and the strata of BCI ($BCI \geq 100$ vs $BCI < 100$) for our variables of interest using χ^2 (categorical variables), t test (continuous variables, pooled test if equal variance and Satterthwaite test if unequal variance), and logistic regression methods. Logistic regression β coefficient results are presented to describe the size and direction of the relationship between each covariate (categorical binary variables [presence vs absence]; continuous variables [per unit

change]) and the response variable (postoperative spontaneous voiding). $P < .05$ was defined as significant.

3 | RESULTS

Of the 131 men who underwent UDS, 122 (mean age 68 ± standard deviation [SD] 11 years) had preoperative urodynamic tracing available for review (Table 1). Baseline characteristics included diabetes in 22% (27 of 122), any instance of preoperative urinary tract infection (UTI) in 23% (28 of 122), the use of alpha blockers in 81% (99 of 122), the use of 5α reductase inhibitors in 41% (50 of 122), a mean AUA symptom score of 18 ± SD 7.8 and quality of life score of 3.7 ± SD 1.6. Preoperative free uroflowmetry demonstrated a mean Q_{max} 7.8 ± SD 5.7 mL/s, voided volume 174 ± SD 145 mL, and PVR 209 ± SD 221 mL. On UDS, DU (BCI < 100) was identified in 54% (66 of 122) of men, with only 68% (45 of 66) of these men voiding spontaneously before surgery, compared to 82% (46 of 56) of men with BCI ≥ 100. All men with DU who underwent an outlet procedure had clinically suspected obstruction (eg, trabeculation, bi- or tri-lobar hypertrophy, or urodynamic confirmation), and the absence of suspicion for overriding neurologic cause (eg, spinal stenosis). At a mean follow-up of 6.4 months, 79% (52 of 66) of men with DU were able to void spontaneously, compared to 96% (54 of 56) of men with BCI ≥ 100.

On logistic regression (Table 2) for the outcome postoperative spontaneous voiding, significant preoperative characteristics, and urodynamic factors include: preoperative spontaneous voiding (odds ratio [OR] = 9.460; 95% confidence interval [CI] = 2.955-30.289), increased urodynamic Q_{max} (OR = 1.184; 95% CI = 1.014-1.382), increased Pdet@Q_{max} (OR = 1.032; 95% CI = 1.012-1.052), and obstruction with BOOI > 40 (OR = 5.595; 95% CI = 1.685-18.575). DU with BCI < 100 was associated with a lower likelihood of voiding spontaneously postoperatively (OR = 0.138; 95% CI = 0.030-0.635). Elevated preoperative PVR alone was significantly, albeit weakly, associated with reduced odds of spontaneous void after a de-obstructive outlet procedure (free uroflowmetry PVR $\beta = -0.003$ per mL [OR = 0.997; 95% CI = 0.995-0.999; $P < .05$]; urodynamic PVR $\beta = -0.002$ per mL [OR = 0.998; 95% CI = 0.996-1.000; $P < .05$]). Factors which were not independently associated with spontaneous voiding after surgery include diabetes, preoperative UTI, use of alpha blocker, use of 5α reductase inhibitor, free uroflowmetry Q_{max} and voided volume, urodynamic bladder capacity, detrusor overactivity, and the presence of abdominal straining.

When outcomes were stratified by bladder contractility for BCI < 100 vs BCI ≥ 100 (Table 3), the only baseline non-urodynamic characteristic that was significantly different between groups was the AUA quality of life score, which was poorer in men with DU (mean 4.1 ± SD 1.5) vs men with BCI ≥ 100 (mean 3.4 ± SD 1.5). On UDS, all urodynamic parameters were significantly different between groups when stratified by bladder contractility. Weak bladders (BCI < 100) demonstrated: greater bladder capacity, PVR, and abdominal straining; and reduced detrusor overactivity, Q_{max}, Pdet@Q_{max}, and BOOI. In men with a weak bladder contraction (BCI < 100), only 32% (21 of 66) of men had a BOOI > 40 ($P < .001$). On postoperative follow-up, the AUA symptom and quality of life scores improved in both groups vs preoperatively. The scores remained more symptomatic in the DU group vs those with normal contractility. On follow-up, there was an improvement in mean Q_{max} and PVR in both underactive (BCI < 100) and non-UABs. There was a significantly greater Q_{max} noted at longest follow-up in men who had a strong bladder contraction before surgery (postoperative Q_{max} mean 16 ± SD 12 mL/s [BCI ≥ 100] vs 11 ± SD 6.5 mL/s [BCI < 100], $P < .05$).

When outcomes for UABs (BCI < 100) were stratified by BOOI, for BOOI ≤ 40 (n = 45) vs BOOI > 40 (n = 21), there were no statistically significant differences in any of the baseline or follow-up characteristics (Table 4). On preoperative UDS, UABs which were not obstructed by pressure flow criteria (BOOI ≤ 40) were less likely to demonstrate detrusor overactivity (31% [14 of 45] vs 57% [12 of 21], $P < .05$), had a greater urodynamic maximum flow rate (Q_{max} mean 4.4 ± SD 4.4 mL/s [BOOI ≤ 40] vs 2.3 ± SD 2.1 mL/s [BOOI > 40], $P < .05$), and a lower detrusor pressure at maximum flow (Pdet@Q_{max} mean 27 ± SD 17 cm H_2O [BOOI ≤ 40] vs 60 ± SD 13 cm H_2O [BOOI > 40], $P < .05$). In men with DU, and no obstruction by pressure flow criteria, there was a non significantly lower rate of postoperative spontaneous voiding observed after surgery (73% [33 of 45] vs 90% [19 of 21], $P = .113$).

When outcomes for men with BCI < 100 who were unable to void before surgery (n = 21) were stratified by postoperative spontaneous voiding, there were no statistically significant differences in any of the preoperative characteristics (Table 5). On follow-up, 57% (12 of 21) of these men were able to void spontaneously following surgery. Spontaneous voiding was associated with improved AUA symptom score (mean 7 ± SD 5) and quality of life (mean 1.3 ± SD 0.6). Diabetes was non significantly associated with lower probability of postoperative voiding ($P = .163$). The presence of abdominal straining to void (42% [5 of 12] vs 22% [2 of 9], $P = .350$) was non significantly associated with the ability to void after surgery.

4 | DISCUSSION

The prevalence of UAB has been estimated at 9% to 43%, varying by age and comorbid conditions,[16] with

TABLE 1 Overall baseline, preoperative urodynamic and follow-up characteristics (n=122)

Baseline characteristics	
Age (y, mean ± SD)	68 ± 11
Diabetes (n, %)	27 (22%)
Preoperative UTI (n, %)	28 (23%)
Alpha blocker (n, %)	99 (81%)
5α reductase inhibitor (n, %)	50 (41%)
Preoperative spontaneous voiding (n, %)	91 (75%)
AUA symptom score (mean ± SD)	18 ± 7.8
AUA quality of life score (mean ± SD)	3.7 ± 1.6
Preoperative Q_{max} (mL/s, mean ± SD)	7.8 ± 5.7
Preoperative voided volume (mL, mean ± SD)	174 ± 145
Preoperative PVR (mL, mean ± SD)	209 ± 221
Preoperative urodynamics	
Bladder capacity (mL, mean ± SD)	448 ± 310
Detrusor overactivity (n, %)	59 (48%)
Urodynamic Q_{max} (mL/s, mean ± SD)	5.3 ± 4.6
Pdet@Q_{max} (cm H_2O, mean ± SD)	66 ± 42
Urodynamic PVR (mL, mean ± SD)	252 ± 270
Abdominal straining to void (n, %)	20 (16%)
BCI (Pdet@Q_{max} + 5 × Q_{max}, mean ± SD)	93 ± 52
BCI < 100 (n, %)	66 (54%)
BOOI (Pdet@Q_{max} − 2 × Q_{max}, mean ± SD)	55 ± 42
BOOI > 40 (n, %)	73 (60%)
Postoperative follow-up	
Follow-up (mo, mean ± SD)	6.4 ± 10
Postoperative UTI (n, %)	13 (11%)
Postoperative spontaneous voiding (n, %)	106 (87%)
AUA symptom score (mean ± SD)	12 ± 8.6
AUA quality of life (mean ± SD)	2.6 ± 1.9
Postoperative Q_{max} (mL/s, mean ± SD)	14 ± 9.9
Postoperative voided volume (mL, mean ± SD)	180 ± 148
Postoperative PVR (mL, mean ± SD)	85 ± 119
Postoperative change in PVR (mL, mean ± SD)	−124 ± 179

Abbreviations: AUA, American Urological Association; BCI, bladder contractility index; BOOI, bladder outlet obstruction index; Pdet@Q_{max}, detrusor pressure at maximum flow; PVR, post void residual; Q_{max}, maximum flow rate; SD, standard deviation; UTI, urinary tract infection.

many patients not receiving the diagnosis of UAB until late in the course of the bladder dysfunction.[17] Consistent with the high prevalence of UAB symptoms, the risk factors for DU are common and include age, diabetes, cardiovascular disease, and neurologic impairment.[18] General awareness of this condition and symptom overlap with BOO have made it difficult to detect when urinary symptoms are caused by DU.[19] As awareness improves, it will be prudent that physicians accurately screen and treat curable causes of UAB before detrusor contractile failure occurs. To make a meaningful impact on this disease entity, we need to further characterize the natural history of detrusor contractile function (and decline) over time, and outcomes after a de-obstructive outlet procedure.[20] This will allow for improved screening, diagnosis, and preventive modalities, and also help determine when a de-obstructive intervention should be pursued. As the natural history of UAB has yet to be fully delineated, the time point of a mandatory preventive de-obstructive intervention is still unknown. Our findings provide additional insight into the recovery of spontaneous voiding in men with DU and may be useful in counseling men considering intervention who have weak bladder contractility, but who are not obstructed by urodynamic pressure-flow criteria (Table 4).

In our series of men who underwent UDS followed by a de-obstructive outlet procedure, 122 men were stratified by BCI for the primary outcome of spontaneous voiding after surgery. Notable aspects of our study population include the large proportion of men (54%, 66 of 122) who had documented DU (BCI < 100) on UDS. At a mean follow-up of greater than 6 months, our major finding was that 79% (52 of 66) of men with DU were able to void spontaneously, compared with 96% (54 of 56) of men with BCI ≥ 100. Significant preoperative characteristics and urodynamic factors associated with spontaneous voiding were the ability to spontaneously void before surgery, increased urodynamic Q_{max}, increased Pdet@Q_{max}, a BCI ≥ 100, and a BOOI > 40 (Table 2).

There are several important points that should be acknowledged when interpreting and generalizing our results. First and foremost is the patient selection in our study design. We identified 614 men who underwent an outlet de-obstruction procedure at our institution from 2005 to 2014. We acknowledge the long timeframe over which UDS and surgical interventions were performed, by a heterogeneous group of multiple providers according to their standard practice, before de-obstructive outlet procedure. From this group, there were 122 men with chart reviewed and verified preoperative UDS. The strength of our approach is the large sample size and the granularity of detail which was systematically assessed from chart review, most particularly the two independent reviewers reassessing the urodynamic tracings. Limitations of our approach include the fact that UDS were not performed postoperatively to confirm resolution of obstruction in the patients who failed to void postoperatively. There was selection bias since not all patients were followed up at equal intervals and for equal durations of time after surgery. Additional limitations which should be considered when

TABLE 2 Logistic regression for outcome postoperative spontaneous voiding (n = 122)

	β coefficient	OR (95% CI)	P value
Baseline characteristics			
Age, y	−0.035	0.966 (0.920-1.013)	.154
Diabetes	−0.887	0.412 (0.134-1.261)	.120
Preoperative UTI	−0.130	0.878 (0.259-2.973)	.834
Alpha blocker	0.799	2.222 (0.688-7.177)	.182
5α reductase inhibitor	0.484	1.623 (0.527-5.000)	.399
Preoperative spontaneous voiding	2.247	9.460 (2.955-30.289)	<.001
AUA symptom score	−0.028	0.973 (0.884-1.070)	.569
AUA quality of life score	−0.499	0.607 (0.279-1.323)	.209
Preoperative Q_{max}, mL/s	0.040	1.041 (0.927-1.168)	.500
Preoperative voided volume, mL	0.002	1.002 (0.998-1.007)	.326
Preoperative PVR, mL	−0.003	0.997 (0.995-0.999)	<.05
Preoperative urodynamics			
Bladder capacity, mL	−0.001	0.999 (0.998-1.001)	.287
Detrusor overactivity	0.214	1.238 (0.430-3.569)	.693
Urodynamic Q_{max}, mL/s	0.169	1.184 (1.014-1.382)	<.05
Pdet@Q_{max}, cm H_2O	0.031	1.032 (1.012-1.052)	<.01
Urodynamic PVR, mL	−0.002	0.998 (0.996-1.000)	<.05
Abdominal straining to void	−1.010	0.363 (0.110-1.192)	.095
BCI (Pdet@Q_{max} + 5 × Q_{max})	0.024	1.024 (1.010-1.038)	<.01
BCI < 100	−1.980	0.138 (0.030-0.635)	<.05
BOOI (Pdet@Q_{max} − 2 × Q_{max})	0.028	1.028 (1.008-1.049)	<.01
BOOI > 40	1.722	5.595 (1.685-18.575)	<.01

AUA, American Urological Association; β, logistic regression beta coefficient; BCI, bladder contractility index; BOOI, bladder outlet obstruction index; CI, confidence interval; OR, odds ratio; Pdet@Q_{max}, detrusor pressure at maximum flow; PVR, post void residual; Q_{max}, maximum flow rate; SD, standard deviation; UTI, urinary tract infection.

generalizing the findings of our study include the comparator group for men with a weak bladder contraction (BCI < 100). We do not present baseline characteristics and outcomes in men who underwent UDS and did not subsequently undergo a de-obstructive outlet procedure. Recently, additional signs and symptoms of UAB have been reported by Gammie et al[17] in their assessment of 1788 men and women with DU. For future studies, a group of men with a weak bladder contraction (BCI < 100), who are simply observed and do not undergo an outlet procedure would be an important comparator group to those who undergo an intervention. In lieu of this, we selected men with a strong bladder contraction (BCI ≥ 100) to serve as a comparator to men with DU (BCI < 100).

From our study population, we also found that elevated preoperative PVR alone was significantly, albeit weakly, associated with reduced odds of spontaneous void after a de-obstructive outlet procedure (Table 2). The threshold for actionable PVR upon which a surgical de-obstructive intervention should be performed has been the subject of much debate. Chronic non neurogenic urinary retention was the topic of a recent AUA quality improvement and patient safety committee which was tasked to create a consensus definition, treatment algorithm and outcome endpoints.[21] In this white paper report sponsored by the AUA, chronic urinary retention was defined as "*an elevated PVR greater than 300 mL that persisted for at least 6 months and documented on 2 or more separate occasions.*" Urinary retention was categorized according to high vs low risk, and the presence or absence of symptoms. High-risk factors include hydronephrosis, stage 3 chronic kidney disease, and recurrent culture-proven UTI or urosepsis. Upon consensus of the panel, the decision to treat chronic urinary retention should be mandated if any of the high-risk factors are present. In the absence of high-risk factors, symptoms which would warrant treatment of chronic urinary retention include the presence of moderate/severe symptoms on the AUA symptom index, and/or history of requiring

TABLE 3 Outcomes stratified by bladder contractility index (BCI)

	BCI < 100 (n = 66)	BCI ≥ 100 (n = 56)	*P* value
Baseline characteristics			
Age (y, mean ± SD)	69 ± 12	68 ± 10	.629
Diabetes (n, %)	13 (20%)	14 (25%)	.482
Preoperative UTI (n, %)	11 (17%)	17 (30%)	.073
Alpha blocker (n, %)	52 (79%)	47 (84%)	.469
5α reductase inhibitor (n, %)	29 (44%)	21 (38%)	.471
Preoperative spontaneous voiding (n, %)	45 (68%)	46 (82%)	.078
AUA symptom score (mean ± SD)	18 ± 8.1	17 ± 7.5	.537
AUA quality of life score (mean ± SD)	4.1 ± 1.5	3.4 ± 1.5	<.05
Preoperative Q_{max} (mL/s, mean ± SD)	7.2 ± 6.6	8.5 ± 4.6	.261
Preoperative voided volume (mL, mean ± SD)	172 ± 147	176 ± 145	.892
Preoperative PVR (mL, mean ± SD)	219 ± 221	198 ± 222	.624
Preoperative urodynamics			
Bladder capacity (mL, mean ± SD)	507 ± 353	381 ± 239	<.05
Detrusor overactivity (n, %)	26 (39%)	33 (59%)	<.05
Urodynamic Q_{max} (mL/s, mean ± SD)	3.7 ± 3.9	7.2 ± 4.6	<.001
Pdet@Q_{max} (cm H_2O, mean ± SD)	38 ± 22	100 ± 36	<.001
Urodynamic PVR (mL, mean ± SD)	315 ± 303	185 ± 213	<.05
Abdominal straining to void (n, %)	15 (23%)	5 (9%)	<.05
BCI (Pdet@Q_{max} + 5 × Q_{max}, mean ± SD)	56 ± 31	135 ± 35	<.001
BCI < 100 (n, %)	66 (100%)	56 (100%)	...
BOOI (Pdet@Q_{max} − 2 × Q_{max}, mean ± SD)	30 ± 22	85 ± 40	<.001
BOOI > 40 (n, %)	21 (32%)	52 (93%)	<.001
Postoperative follow-up			
Follow-up (mo, mean ± SD)	6.5 ± 11	6.3 ± 9.6	.922
Postoperative UTI (n, %)	7 (11%)	6 (11%)	.985
Postoperative spontaneous voiding (n, %)	52 (79%)	54 (96%)	<.01
AUA symptom score (mean ± SD)	15 ± 9.3	9.8 ± 7.3	<.05
AUA quality of life (mean ± SD)	3.2 ± 1.8	2 ± 1.8	<.05
Postoperative Q_{max} (mL/s, mean ± SD)	11 ± 6.5	16 ± 12	<.05
Postoperative voided volume (mL, mean ± SD)	176 ± 121	185 ± 172	.777
Postoperative PVR (mL, mean ± SD)	100 ± 125	70 ± 112	.189
Postoperative change in PVR (mL, mean ± SD)	−113 ± 180	−133 ± 180	.580

Abbreviations: AUA, American Urological Association; BCI, bladder contractility index; BOOI, bladder outlet obstruction index; Pdet@Q_{max}, detrusor pressure at maximum flow; PVR, post void residual; Q_{max}, maximum flow rate; SD, standard deviation; UTI, urinary tract infection.

catheterization for symptomatic inability to void. While the 300 mL PVR cutpoint was the consensus of this AUA white paper, the panel admits that this volume for PVR was only selected because 300 mL is reported as the volume at which the bladder first becomes palpable.[10] Of course, an elevated PVR can be symptomatic at lower volumes and intervention is commonly performed to improve emptying for this reason.

Additional major findings include that in the absence of UDS, the only baseline non-urodynamic characteristic that was significantly different between groups when stratified by contractility (BCI < 100 vs BCI ≥ 100) was the AUA quality of life score (Table 3). As outlined by Alan Wein's 1981 seminal paper on voiding dysfunction, the mechanistic failure to empty urine is a result of dysfunction of the bladder, dysfunction of the outlet, or a combination of both a weak bladder and obstruction of the bladder outlet.[22] Further mechanistic and epidemiologic classification of the factors which result in UAB need to be identified to improve the detection of DU and guide treatment. Existing noninvasive assessments of lower urinary tract function include PVR, uroflowmetry,

TABLE 4 Outcomes for BCI < 100 (n = 66) stratified by bladder outlet obstruction index (BOOI)

	BOOI ≤ 40 (n = 45)	BOOI > 40 (n = 21)	*P* value
Baseline characteristics			
Age (y, mean ± SD)	67 ± 12	72 ± 11	.203
Diabetes (n, %)	9 (20%)	4 (19%)	.928
Preoperative UTI (n, %)	8 (18%)	3 (14%)	.723
Alpha blocker (n, %)	35 (78%)	17 (81%)	.769
5α reductase inhibitor (n, %)	22 (49%)	7 (33%)	.236
Preoperative spontaneous voiding (n, %)	31 (69%)	14 (67%)	.857
AUA symptom score (mean ± SD)	18 ± 9	18 ± 6.2	.921
AUA quality of life score (mean ± SD)	3.8 ± 1.8	4.6 ± 1	.093
Preoperative Q_{max} (mL/s, mean ± SD)	6.9 ± 7.5	7.9 ± 4.2	.567
Preoperative voided volume (mL, mean ± SD)	184 ± 167	146 ± 87	.276
Preoperative PVR (mL, mean ± SD)	238 ± 241	179 ± 172	.338
Preoperative urodynamics			
Bladder capacity (mL, mean ± SD)	545 ± 400	429 ± 213	.136
Detrusor overactivity (n, %)	14 (31%)	12 (57%)	<.05
Urodynamic Q_{max} (mL/s, mean ± SD)	4.4 ± 4.4	2.3 ± 2.1	<.05
Pdet@Q_{max} (cm H_2O, mean ± SD)	27 ± 17	60 ± 13	<.001
Urodynamic PVR (mL, mean ± SD)	350 ± 351	252 ± 176	.167
Abdominal straining to void (n, %)	13 (29%)	2 (10%)	.080
BCI (Pdet@Q_{max} + 5 × Q_{max}, mean ± SD)	49 ± 34	72 ± 16	<.01
BOOI (Pdet@Q_{max} − 2 × Q_{max}, mean ± SD)	19 ± 15	55 ± 14	<.001
Postoperative follow-up			
Follow-up (mo, mean ± SD)	7.9 ± 13	3.7 ± 2.6	.066
Postoperative UTI (n, %)	6 (13%)	1 (5%)	.292
Postoperative spontaneous voiding (n, %)	33 (73%)	19 (90%)	.113
AUA symptom score (mean ± SD)	15 ± 9.1	15 ± 10	.882
AUA quality of life (mean ± SD)	3.3 ± 1.8	3 ± 1.9	.724
Postoperative Q_{max} (mL/s, mean ± SD)	12 ± 6.4	11 ± 6.8	.745
Postoperative voided volume (mL, mean ± SD)	201 ± 139	142 ± 84	.086
Postoperative PVR (mL, mean ± SD)	115 ± 142	72 ± 78	.159
Postoperative change in PVR (mL, mean ± SD)	−128 ± 196	−86 ± 147	.440

Abbreviations: AUA, American Urological Association; BCI, bladder contractility index; BOOI, bladder outlet obstruction index; Pdet@Q_{max}, detrusor pressure at maximum flow; PVR, post void residual; Q_{max}, maximum flow rate; SD, standard deviation; UTI, urinary tract infection.

detrusor wall thickness, near-infrared spectroscopy, and penile compression release.[23,24] While suggestive of BOO, there is a very limited assessment of these measures in a prospective approach to determine their ability to discriminate DU from BOO.

Invasive urodynamic pressure-flow evaluation of voiding function remains the reference standard test used to diagnose BOO and DU. In our study population of men who underwent UDS followed by an outlet de-obstruction procedure, we found that a reasonable likelihood of spontaneous voiding existed postoperatively despite the presence of DU. Surprisingly, in those men with a BCI < 100 and unable to void before surgery, 12 out of 21 men (57%) were able to benefit from a de-obstruction procedure (Table 5). Based on our findings, it may be reasonable to offer men who demonstrate poor contractility on UDS a de-obstructive outlet procedure, even if the outlet does not meet the urodynamic threshold for obstruction (BOOI > 40). In men with a normal bladder contraction (BCI ≥ 100), the higher likelihood of spontaneous void in the presence of obstruction (BOOI > 40), supports higher success rates after de-obstruction. The difference in outcomes in patients with suspected obstruction and DU vs normal contractility supports the use of pressure-flow UDS in the evaluation of men with higher suspicion of DU to inform counseling.

TABLE 5 Outcomes for men unable to void before surgery with BCI < 100 (n = 21), stratified by postoperative spontaneous voiding

	No spontaneous voiding (n = 9)	Spontaneous voiding (n = 12)	*P* value
Baseline characteristics			
Age (y, mean ± SD)	69 ± 12	70 ± 15	.850
Diabetes (n, %)	4 (44%)	2 (17%)	.163
Preoperative UTI (n, %)	3 (33%)	2 (17%)	.375
Alpha blocker (n, %)	7 (78%)	11 (92%)	.368
5α reductase inhibitor (n, %)	4 (44%)	7 (58%)	.528
Preoperative spontaneous voiding (n, %)	0 (0%)	0 (0%)	...
AUA symptom score (mean ± SD)	17 ± 12	14 ± 7.6	.727
AUA quality of life score (mean ± SD)	4 ± 1.7	3.7 ± 1.2	.795
Preoperative Q_{max} (mL/s, mean ± SD)	...	1.8 ± 3.3	...
Preoperative voided volume (mL, mean ± SD)	...	82 ± 122	...
Preoperative PVR (mL, mean ± SD)	...	352 ± 242	...
Preoperative urodynamics			
Bladder capacity (mL, mean ± SD)	667 ± 241	695 ± 635	.897
Detrusor overactivity (n, %)	3 (33%)	6 (50%)	.445
Urodynamic Q_{max} (mL/s, mean ± SD)	3.6 ± 5.6	1.2 ± 2.1	.254
Pdet@Q_{max} (cm H_2O, mean ± SD)	26 ± 21	38 ± 26	.269
Urodynamic PVR (mL, mean ± SD)	665 ± 172	450 ± 375	.204
Abdominal straining to void (n, %)	2 (22%)	5 (42%)	.350
BCI (Pdet@Q_{max} + 5 × Q_{max}, mean ± SD)	43 ± 39	44 ± 31	.988
BOOI (Pdet@Q_{max} − 2 × Q_{max}, mean ± SD)	19 ± 22	36 ± 26	.126
Postoperative follow-up			
Follow-up (mo, mean ± SD)	12 ± 23	13 ± 15	.939
Postoperative UTI (n, %)	5 (56%)	0 (0%)	<.01
Postoperative spontaneous voiding (n, %)	0 (0%)	12 (100%)	<.001
AUA symptom score (mean ± SD)	17 ± 12	7 ± 5	.235
AUA quality of life (mean ± SD)	4 ± 1.4	1.3 ± 0.6	.053
Postoperative Q_{max} (mL/s, mean ± SD)	...	11 ± 5.3	...
Postoperative voided volume (mL, mean ± SD)	...	162 ± 86	...
Postoperative PVR (mL, mean ± SD)	...	56 ± 38	...
Postoperative change in PVR (mL, mean ± SD)	...	−270 ± 164	...

Abbreviations: AUA, American Urological Association; BCI, bladder contractility index; BOOI, bladder outlet obstruction index; Pdet@Q_{max}, detrusor pressure at maximum flow; PVR, post void residual; Q_{max}, maximum flow rate; SD, standard deviation; UTI, urinary tract infection.

5 | CONCLUSION

The decision for a man with lower urinary tract symptoms to pursue a de-obstructive outlet procedure should be individualized. Counseling should take into account the presence of preoperative spontaneous voiding, obstructive parameters, flow, and bladder contractility and should provide patients with guidance for the expectation of spontaneous voiding after surgery. Whereas recovery of spontaneous voiding is higher in patients with normal bladder contractility and obstruction, outlet procedures are still an option with a reasonable chance of success in men with DU.

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CONFLICT OF INTERESTS

The authors declare that there are no conflict of interests.

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