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Original Article

Does urodynamics predict voiding after benign prostatic hyperplasia surgery in patients with detrusor underactivity?

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Urodynamic study

Abstract *Objective:* We sought to determine if urodynamic study (UDS) predicted voiding outcomes in men with detrusor underactivity (DU) and benign prostatic enlargement (BPE) who underwent photovaporization of the prostate (PVP).
Methods: Between September 2010 and July 2015, 106 male patients with BPE and DU were identified. All patients underwent PVP. Urinary retention was noted by the preoperative necessity for an indwelling or intermittent catheter. Data collection included comorbidities, quality of life (QoL) scores, prostate volume, prostate-specific antigen (PSA), UDS and perioperative outcomes. UDS parameters included volume at first desire to void, volume at first urge to void, volume of severe urge, volume at capacity, compliance, detrusor contractions, maximum urinary flow rate (Q_{max}), and postvoid residual (PVR).
Results: A total of 106 men were included in this analysis, who had urinary retention with a Foley catheter or clean intermittent catheterization (CIC) at the time of surgery. At baseline we found patients who voided had a detrusor pressure at Q_{max} ($P_{det}@Q_{max}$) of 10.05 ± 6.45 cmH_2O compared to 16.78 ± 12.17 cmH_2O in those who did not void ($p = 0.071$). Postoperatively, 96 (90.6%, mean age 76.9 ± 26.2 years) of patients voided successfully while 10 (9.4%, mean age 80.52 ± 9.61 years) of patients remained in urinary retention. Mean baseline Q_{max} was 4.895 ± 5.452 mL/s and 2.900 ± 3.356 mL/s ($p = 0.087$) in those who voided and did not respectively. PVR was 319.23 ± 330.62 mL in those who voided and 276.88 ± 263.27 mL ($p = 0.344$) in

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those who did not void. No UDS parameter predicted who would void postoperatively or improvements in QoL.
Conclusions: The patients with DU and BPE might be able to successfully void after undergoing PVP regardless of UDS findings. All men who voided had improved international prostate symptom score and QoL scores compared to baseline and these parameters were durable up to 12 months.

1. Introduction

Detrusor underactivity (DU) is defined as a weakened detrusor contraction and/or the length of contraction in the absence of bladder outlet obstruction (BOO) [1]. DU results in the incomplete emptying of the bladder. DU is oftentimes unrecognizable from BOO [2]. The current European Association of Urology (EAU) guidelines for males with non-neurogenic lower urinary tract symptoms (LUTS) suggest the underlying prevalence of DU can be as high as 40% [3]. Further studies suggest 48% of elderly males with LUTS demonstrate some evidence of DU [4]. Patients with DU have reduced flow rates. However, this does not distinguish BOO from DU [5]. The current gold standard for diagnosing DU is urodynamic study (UDS) with pressure flow study. UDS is plagued with various limitations due to the cost, invasiveness and possible adverse events including pain, urinary tract infections (UTI), hematuria and embarrassment [6,7].

Unfortunately, there is a paucity of scientific literature detailing the role of preoperative UDS to predict the surgical outcomes particularly for those with DU. Retrospective studies published on this subject demonstrated DU may have an effect on surgical outcomes, however these studies had conflicting results [8,9]. The objective of this study was to evaluate if preoperative UDS in men with DU predicted voiding outcomes following photovaporization of the prostate (PVP).

2. Methods

2.1. Study population

Male patients diagnosed with DU and benign prostatic enlargement (BPE) at a tertiary referral center between September 2010 and July 2015 were included in the study. For the purposes of this study, DU was defined by "low detrusor contractions (less than 30 cmH_2O) or no contraction during the emptying phase" [10]. All patients were in urinary retention with a Foley catheter or clean intermittent catheterization (CIC) and had failed at least one trial void on maximum medical therapy. Patients discontinued anticoagulants when feasible. Patients with repeat surgeries or prostate cancer, urologic injury, pelvic surgery or radiation were excluded from the study. This was a retrospective study based on a de-identified database of subjects. Thus informed consent was not required. Institutional review board approval was gained at each referral center.

2.2. Surgical procedure

Only patients undergoing Greenlight XPS 180 W (Boston Scientific, Boston, MA, USA) were selected to limit surgical variability. PVP was accomplished using the standard method as previously reported by two expert PVP surgeons [11], starting at the 1 o'clock position and completed clockwise to the level of the capsular fibers. The end point was a "transurethral resection of the prostate (TURP)-like" cavity lined by capsular fibers. The prostatic urethra was viewed with a 30-degree lens. A widely open bladder neck was visualized, with no tissue projecting into the visual field. A Foley catheter was inserted postoperatively at the surgeon's discretion. The trial of void (TOV) was done on post operation Day 1. All men had general anesthesia.

2.3. Urodynamics

After patients had a retention episode, pressure flow studies were conducted at a median of 4 weeks. UDS was performed in all men with balloon catheter inserted in the rectum and a 7 Fr catheter passed through the urethra. A detailed description of the urodynamics study process has been described previously by Jamzadeh et al. [10].

The purpose of urodynamics was to assess the function as well as any dysfunctions of the urinary bladder and outlet. Urodynamics were used to diagnose DU as per the International Continence Society (ICS) [1]. DU is defined by detrusor contractions less than 30 cmH_2O and an uroflow of less than 12 mL/s catheterized.

All patients underwent videourodynamic evaluation, including measurement of vesical and abdominal pressure during filling and voiding. Bladder pressure, abdominal pressure, and detrusor pressure were assessed in the seated position. Bladder pressure was monitored using a dual lumen 7 Fr catheter, inserted transurethrally into the bladder. Abdominal pressure was recorded with the use of a standard rectal balloon catheter. Abdominal pressure was subtracted from total vesical pressure to determine detrusor pressure. Medium-fill cystometry was performed at 30 mL/min with normal saline. Urodynamic studies were performed and reviewed without knowledge of American Urological Association symptom index. Studies were reviewed manually to eliminate any testing artifacts and to accurately determine

detrusor over activity, maximum urinary flow rate (Q_{max}), detrusor pressure at maximum urinary flow rate ($P_{det}@Q_{max}$), bladder capacity and postvoid residual (PVR).

2.4. Primary outcomes

Preoperative parameters were divided by disease-specific quality of life (QoL) scores, Q_{max}, PVR, comorbidities and prostate volume, and prostate-specific antigen (PSA) was collected as well as urodynamic parameters. Urinary retention postoperatively was noted by the necessity for an indwelling or intermittent catheter. In addition, patients' comorbidities were recorded by chart review.

2.5. Statistical analysis

Preoperative and postoperative outcomes were continuously distributed and presented as categorical variables. Comparisons with baseline were made using the linear and logistic regressions. Continuous variables reported means, medians and interquartile ranges. Statistical analysis and descriptive statistics were performed using SPSS Version 21 (IBM Corp., Armonk, NY, USA) with $p < 0.05$ considered statistically significant.

3. Results

A total of 106 patients were included in this study. Results were divided based on those who voided following BPH surgery at postoperation day and those who could not. Postoperatively, 96 (90.6%) of patients voided successfully without the need for assistive drainage techniques while 10 (9.4%) of patients could not void and needed a Foley catheter or CIC. Table 1 outlines all the baseline characteristics for the cohorts. The mean age for those who voided was 76.96 ± 9.12 years at the time of surgery, while those that did not void were 80.52 ± 9.61 years ($p = 0.121$). Preoperative PSA was higher for those who voided compared to those who did not void (15.34 *vs.* 8.35 ng/mL), although this was not significant ($p = 0.109$). Comparably, both groups used aspirin ($p = 0.001$). Males who voided following surgery had a higher mean Q_{max} at baseline compared to those who did not void (7.5 *vs.* 5.9 mL/s, $p = 0.042$).

Table 2 shows the UDS parameters for both voiding and non-voiding cohorts. Patients who voided had a lower mean $P_{det}@Q_{max}$, which measures the detrusor pressure at Q_{max} (10.05 cmH_2O *vs.* 16.78 cmH_2O). Although when comparing between the cohorts this was not significant ($p = 0.071$). A

Table 1 All patient baseline characteristics.

Characteristics	Voiding ($n = 96$)	Non-voiding ($n = 10$)	p-Value
Age (year)	76.96 ± 9.12	80.52 ± 9.61	0.121
BMI (kg/m^2)	26.22 ± 3.99	26.71 ± 4.76	0.369
Prostate volume (mL)	155.64 ± 82.40	140.89 ± 55.42	0.256
Preoperation PSA (ng/mL)	15.34 ± 32.62	8.35 ± 9.49	0.109
Medication usage			
ASA (aspirin)	29 (30.2%)	4 (40%)	0.001
Alpha blocker, *n* (%)	52 (54.2%)	5 (50%)	0.407
5-Alpha reductase inhibitors (5-ARIs), *n* (%)	71 (74%)	7 (70%)	1.417
Anticoagulation, *n* (%)	12 (12.5%)	2 (20%)	0.298
Voided volume (mL)	127.50 ± 131.33	79.51 ± 146.78	0.220
IPSS	19.04 ± 8.99	17 ± 7.0	0.377
QoL	4.90 ± 1.41	4.14 ± 1.34	0.097

BMI, body mass index; PSA, prostate-specific antigen; ASA, acetylsalicylic acid; IPSS, International Prostate Symptom Score; QoL, quality of life.

Table 2 UDS parameters for all patients prior to surgery.

UDS parameters	Voiding ($n = 96$)	Non-voiding ($n = 10$)	p-Value
Volume at first desire to void (mL)	166.61 ± 89.92 ($n = 94$)	145.79 ± 66.04	0.189
Volume at first urge to void (mL)	268.92 ± 160.42 ($n = 94$)	335.74 ± 400.07 ($n = 8$)	0.401
Volume at severe urge to void (mL)	372.54 ± 225.67 ($n = 93$)	420.27 ± 392.73 ($n = 9$)	0.364
Bladder capacity (mL)	208 ± 313	521 ± 414	0.471
$P_{det}@Q_{max}$ (cmH_2O)	10.05 ± 6.45 (range 0–32)	16.78 ± 12.17 (range 4–34)	0.071
Bladder compliance	29.4 ± 26.8	36.12 ± 46.95	0.350
Q_{max} (mL/s)	4.895 ± 5.452	2.9 ± 3.4	0.087
PVR (mL)	319.23 ± 330.62	276.88 ± 263.27	0.344
IDC, *n* (%)	35 (36.5%)	4 (40%)	
Abrams–Griffith number	10.46 ± 15.61	-1.20 ± 10.93	0.022
Bladder contractility index	26.70 ± 17.58	19.3 ± 25.74	0.119

UDS, urodynamic study; $P_{det}@Q_{max}$, detrusor pressure at maximum flow; Q_{max}, maximum flow rate; PVR, post void residual volume; IDC, idiopathic detrusor contractions.

total of 56 patients had a $P_{det}@Q_{max}$ of 0 cmH_2O. Interestingly, patients who voided had a lower mean bladder capacity when compared to those who did not void (208 mL *vs.* 521 mL, $p = 0.471$). Similarly, these patients had a higher mean PVR when compared to those that did not void (319.23 mL *vs.* 276.88 mL, $p = 0.344$). However, neither bladder capacity nor PVR reached significance. The bladder contractility index (BCI) for non-voiders was 26.70 ± 17.58 and 19.3 ± 25.7 for voiders ($p = 0.119$). The Abrams–Griffiths number is a simple method to classify patients based on the presence or absence of obstruction. The Abrams–Griffiths number for voiders was 10.46 ± 15.61 and -1.20 ± 10.93 for non-voiders ($p = 0.022$).

Table 3 assesses past medical history and intraoperative surgical characteristics. All patients ($n = 106$) were in retention before undergoing surgery. The top comorbidities were hypertension (65.1%), cardiovascular disease (30.2%), arrhythmia (20.8%), and diabetes mellitus (14.2%). All patients underwent PVP with a mean laser time being 76.45 ± 38.03 min.

Table 4 outlines the uroflowmetry parameters for all patients who voided at baseline and 1, 3, 6, and 12 months postoperatively. QoL improved from 4.90 ± 1.41 at baseline to 1.65 ± 1.73 at 12 months postoperatively ($p < 0.0001$). Similarly, International Prostate Symptom Score (IPSS) decreased from 19.04 ± 8.99 at baseline to 7.31 ± 7.24 at 12 months postoperatively ($p < 0.0001$). Q_{max} increased from 7.57 ± 6.52 mL/s at baseline to 10.43 ± 7.51 mL/s at

Table 3 Previous medical history and surgical characteristics.

Past medical history	Total
Urinary retention	106 (100%)
Valve	13 (12.3%)
Arrhythmia	22 (20.8%)
Myocardial infarction	9 (8.5%)
CHF	3 (2.8%)
PVD	5 (4.7%)
CVD	32 (30.2%)
Dementia	1 (0.9%)
COPD	10 (9.4%)
Mild liver disease	1 (0.9%)
Diabetes mellitus	15 (14.2%) (4 non-voiders; 11 voiders)
Diabetes mellitus with end-stage organ damage	1 (0.9%)
Moderate/severe renal disease	5 (4.7%)
2nd non-metastasis solid tumor	3 (2.8%)
Moderate/severe liver disease	1 (0.9%)
AIDS	1 (0.9%)
Hypertension	69 (65.1%)
Surgical characteristics	
Joules of laser energy	531359.57 ± 289033.79
Number of fibers	2.46 ± 1.23
Laser time (min)	76.45 ± 38.03

QoL, quality of life; CHF, congestive heart failure; PVD, peripheral vascular disease; CVD, cardiovascular disease; COPD, chronic obstructive pulmonary disease; AIDS, acquired immunodeficiency disease.

Table 4 Postoperative characteristics for voiding patients.

Uroflowmetry parameter	Preoperatively, mean ± SD	Postoperatively (1 month)		Postoperatively (3 months)		Postoperatively (6 months)		Postoperatively (12 months)	
		mean ± SD	*p*-Value	mean ± SD	*p*-Value	mean ± SD	*p*-Value	mean ± SD	*p*-Value
QoL	4.90 ± 1.41	3.07 ± 1.98	<0.0001	2.05 ± 1.69	<0.0001	1.74 ± 1.72	<0.0001	1.65 ± 1.73	<0.0001
IPSS	19.04 ± 8.99	13.48 ± 7.55	0.0001	8.95 ± 6.24	<0.0001	8.62 ± 7.36	<0.0001	7.31 ± 7.24	<0.0001
Q_{max} (cmH_2O)	7.57 ± 6.52	12.17 ± 8.60	0.023	11.05 ± 5.91	0.002	11.14 ± 6.95	0.004	10.43 ± 7.51	0.016
PVR (mL)	166.33 ± 182.89	115.87 ± 109.89	0.049	82.78 ± 108.76	0.003	88.04 ± 128.86	0.007	72.92 ± 90.20	0.001

IPSS, International Prostate Symptom Score; Q_{max}, maximum flow rate; PVR, post void residual.

12 months postoperatively ($p = 0.016$), although the best improvement was 1 month postoperatively (12.17 ± 8.60 mL/s) ($p = 0.023$). Lastly, PVR decreased from 166.33 ± 182.89 mL at baseline to 72.92 ± 90.20 mL at 12 months postoperatively ($p = 0.001$).

4. Discussion

In our current study, almost all of men who presented with DU (90.6%) successfully voided at 12 months who underwent PVP with improvement of QoL. Furthermore, urodynamic parameters such as Q_{max} and PVR were similar amongst those who voided and those who did not, suggesting urodynamic did not predict those that voided following surgical intervention for those with obstruction and DU. Current guidelines suggest DU in patients should be ruled out before undergoing surgery in order to maximize outcomes [3,12]. This is because surgery used to alleviate related to BPH is based on the same mechanism of action for BOO.

Surgical intervention with PVP has been known to relieve obstruction from BPH in men with DU. A study by Cho et al. [13] evaluated patients with DU who underwent PVP or holium laser enucleation (HoLEP). DU was defined as a BCI of <100 according to the baseline urodynamic study. A total of 432 and 423 men with DU underwent HoLEP and PVP, respectively. When comparing procedures in terms of IPSS, Q_{max} and voiding symptom score, patients with DU who received HoLEP showed the greatest degree of improvement postoperatively, although none of these values reached statistical significance [13].

Another study by Cho et al. [14] similarly found regardless of preoperative presentation of DU, 145 patients with DU who underwent 120 W higher-power system (HPS) and 105 patients who underwent HoLEP had no difference in surgical outcomes. Patients showed improvements in IPSS, Q_{max} and their LUTS symptoms which maintained durable up to 3 years postoperatively, which is similar in the improvements of our cohort of patients. A study by Ryoo et al. [15] evaluated HoLEP in patients who underwent preoperative UDS with a bladder outlet obstruction index (BOOI) of ≥40 ($n = 117$) or <40 ($n = 57$). Overall, IPSS, QoL, Q_{max} and PVR improved across both groups with those with a BOOI ≥40 having an overall success rate in IPSS and PVR of 93.7% compared to 73.6% with a BOOI <40. Even though surgical outcomes were higher in the BOOI ≥40 group, both cohorts benefited from surgical intervention.

DU has been an important issue when considering surgery due to its overwhelming prevalence in patients with LUTS [4]. This is precisely why preoperative UDS has been suggested to increase the odds of surgical success [12]. However, information currently published in the literature has been conflicting at best. For patients who underwent a TURP procedure, treatment failure was 100% in those presenting without BOO on UDS evaluation [16]. Another study by Gotoh et al. [17] found results contrary to those reported by Javle et al. [16]. They reported patients without BOO as assessed by UDS would have good outcomes and thus would be acceptable surgical candidates [17]. These two conflicting conclusions have caused confusion in regard to the effectiveness of preoperative UDS due to the utilization of these very subjective definitions of success.

A study by Thomas et al. [18] conducted a 10-year retrospective study on DU patients who underwent TURP. A total of 224 men were included in this study. The researchers discovered surgery does not help if patients do not have obstruction. This aligns with our study given all the patients were obstructed. There may be conflicting results in the current literature on postsurgical outcomes in DU due to several reasons. This may be because the definition used in studies differs patients as well may void differently. Some may void Valsalva, whilst others push from the abdomen to void. There were a few limitations associated with our study. As a center that specializes in LUTS, there may have been selection bias in that frail patients may not be referred for urological evaluation based on primary care physician's (PCP) discretion. Even though we included comorbidities, we did not have access to functional status in this cohort. This study has several strengths. This is among the largest cohort of BPH patients with DU who underwent preoperative UDS that had a PVP. In addition, this is the first study, to our knowledge, focusing on patients with preoperative UDS who underwent PVP using the 180 W 532 nm laser fiber. We have follow-up until 12 months, showing the durability of this treatment modality in this patient population.

5. Conclusion

Almost all men with DU were able to successfully void after undergoing PVP. All men who voided had improved IPSS scores and QoL scores, with parameters being durable at 12 months postoperatively. Unfortunately, UDS did not predict which men with DU would not be able to void postoperatively. It is possible that our current definition of DU is inadequate to select those who can and those who cannot void. Further prospective trails are needed to clarify the role of UDS in this population.

Author contributions

Study Concept and design: Bilal Chughtai, Kevin Zorn.
Data Acquisition: Dominique Thomas, Nadir Zaidi, Stephanie Ashley Chen, Yiye Zhang.
Data Analysis: Dominique Thomas, Stephanie Ashley Chen, Yiye Zhang.
Drafting of Manuscript: Dominique Thomas, Kevin Zorn, Nadir Zaidi, Stephanie Ashley Chen, Yiye Zhang, Alexis Te, Bilal Chughtai.
Critical Revision of Manuscript: Dominique Thomas, Kevin Zorn, Nadir Zaidi, Stephanie Ashley Chen, Yiye Zhang, Alexis Te, Bilal Chughtai.

Conflicts of interest

Bilal Chughtai is a consultant for Boston Scientific.

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