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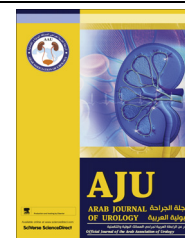
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VOIDING DYSFUNCTION/FEMALE UROLOGY
ORIGINAL ARTICLE

A quantitative comparison between free uroflow variables and urodynamic data, and the effect of the size of urodynamic catheters on its interpretation



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KEYWORDS

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Free uroflow;
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ABBREVIATIONS

PFS, pressure-flow
study;
 Q_{max} , maximum urin-
ary flow rate;
 Q_{maxP} , Q_{max} on PFS;
PVR, postvoid residual
volume;
LUT, lower urinary
tract;

Abstract Objective: To assess the effect of the urodynamic catheter on the urinary flow rate and residual volume in various urodynamic diagnoses, and compare the outcome when using a smaller catheter, as the effect of this catheter on free uroflow variables is mostly studied in patients with bladder outlet obstruction (BOO) and little is known about its effect in other urodynamic diagnoses.

Patients and methods: In all, 319 men undergoing a pressure-flow study (PFS) with a 5 F filling and 5 F measuring bladder catheter were subdivided into three groups based on a urodynamic diagnosis, i.e. normal PFS (group 1), BOO (group 2) and detrusor underactivity (DU, group 3). Another group (4) comprised 61 patients who had a PFS with the filling catheter removed before the voiding phase. The effect of the catheters on the maximum urinary flow rate (Q_{max}) and the post-void residual volume (PVR) was analysed statistically and compared among the groups. We also compared the free-flow variables with the clinical and urodynamic variables.

Results: Groups 1–3 (with two catheters) had a significantly lower Q_{max} and higher PVR than those voiding with one catheter (group 4). The reduction in Q_{max}

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DU, detrusor underactivity;
UDS, urodynamic study

was highest in group 3 (41.9%) and least in group 2 (21%). Group 4 showed no significant change in Q_{\max} in cases with BOO and a normal PFS but a significant decline in those with DU (19.6%). The PVR was positively associated with the bladder capacity and negatively with detrusor contractility, but no association with a urodynamic diagnosis of BOO or any specific symptom.

Conclusion: Detrusor contractility was the strongest predictor of the obstructive effect caused by the catheter. This study justifies the use of a single 5 F catheter at the time of voiding, although that can also cause a reduction in flow in patients with DU.

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Introduction

The effect of the urodynamic catheters used in a pressure-flow study (PFS) on the maximum urinary flow rate (Q_{\max}) is well known but the exact mechanisms are not yet fully understood [1]. Several studies have shown the effect of the catheter in terms of a reduced Q_{\max} and increased postvoid residual volume (PVR), but the methods and patient demographics are quite variable [2]. Most studies were done on men with probable BOO and there are still insufficient data on the effect of urodynamic catheters in patients with detrusor failure [3–6].

Similarly the PVR has been clinically associated with voiding phase problems, particularly lower urinary tract (LUT) obstruction. However, the relationship between the PVR and other urodynamic variables has not been convincingly established by available reports [7]. The cause is varied, ranging from an organic obstruction to detrusor failure.

The primary objective of the present study was to further analyse quantitatively the effect of urodynamic catheters on Q_{\max} and to determine whether this change was consistent across various urodynamic diagnoses. Second, we also assessed the effect of catheter calibre by comparing flow rate measurements in patients undergoing PFS using differently sized (two 5 F vs. one 5 F) urethral catheter assemblies.

Patients and methods

With the approval of the institutional review board all men (total 486) who had a PFS between 2007 and 2012 were reviewed, and 167 excluded, comprising those with known neurological disease, with a voided volume of < 150 mL on a free-flow measurement, and those with incomplete data. All clinical and urodynamic data were entered into an institutional urodynamics database.

Based on a final urodynamic study (UDS), 319 consecutive men who satisfied the inclusion criteria were divided into three groups; group 1 (78 men) with normal UDS (no abnormality detected), group 2 (145 men) with a UDS diagnosis of BOO (based on the bladder contractility index and Abrams-Griffiths nomogram), and

group 3 (96 men) with a UDS diagnosis of detrusor underactivity (DU; a detrusor pressure of < 20 cmH₂O with a Q_{\max} of < 15 mL/s, and incomplete emptying). All had a PFS using 5-F filling and 5-F measuring catheters *in situ*. A 10 F rectal balloon catheter was used to measure the abdominal pressure. Another 61 patients (group 4) with a mixed diagnosis were prospectively included, to undergo PFS with one 5-F (filling) catheter removed at the time of initiation of voiding.

All other urodynamic equipment and methods (free uroflowmetry, PVR measured with bladder catheterisation, and PFS) used were identical across all groups.

The chi-square test was used to compare dichotomous/categorical variables. Any statistical association was assessed between a significant PVR (> 20%) on free flow and the clinical and urodynamic variables. Values of Q_{\max} on a free urinary flow rate and the PFS flow rate (Q_{\max}^P) were compared using a paired Student's *t*-test. An unpaired *t*-test was used to detect the difference between two continuous variables, with $P < 0.05$ considered to indicate significance, and the various groups were compared using anova.

Results

The mean (range) age of the patients was 56.5 (22–89) years, with no statistically significant differences among the groups. As expected, the normal group (1) had the highest Q_{\max} , with a mean (range) of 22.5 (13.5–26) mL/s, which was significantly ($P < 0.01$) more than in the other two groups. There was no significant difference in Q_{\max} between men with BOO and those with DU ($P > 0.10$).

Due to the effect of the catheter, the Q_{\max}^P in groups 1–3 showed a mean reduction of 32.5% compared to the Q_{\max} from 'free' uroflowmetry ($P < 0.05$; Table 1) The free Q_{\max} was higher than Q_{\max}^P in 83.3% of men overall ($P = 0.02$). However, on a sub-analysis of the normal PFS group it was higher in 95% of men, and for the BOO and DU groups 62% and 93%, respectively. Although all three groups using the larger catheter assembly had a significant reduction in Q_{\max} with the

catheters *in situ*, this effect was most marked in those with DU (group 3), with group 1 > group 2.

A high PVR after a free uroflow was associated with a higher PVR on PFS. The PVR was significantly higher after PFS in groups 1–3 (Table 1). The change in PVR was highest for group 3 and least for group 1. Although patients with a significant PVR had a positive association ($P < 0.05$) with overall voiding difficulties, there was no statistically significant association with any specific symptom, including a sense of incomplete voiding or persistent suprapubic discomfort.

In both groups 2 and 3, cystomanometry showed a larger bladder capacity in men with a significant PVR. There was no association of PVR with the filling pressure or detrusor overactivity. The PVR had no association with a urodynamic diagnosis of LUT obstruction. The PVR had a negative association ($P < 0.05$) with the opening detrusor pressure, suggesting that the larger the opening pressure, the lower the PVR. Voided volumes were not significantly different when a free uroflow was compared with the PFS, although there was a measurable decline in group 1 and increase in the other groups.

The results were noticeably different in group 4, where the filling catheter was removed, with an overall decline in the flow rate of 11% (Table 2). On subdividing these patients, those with a normal PFS and with BOO had a statistically insignificant reduction in Q_{\max} , while those with DU had a significant reduction in Q_{\max} .

Discussion

Klingler et al. [5] reported similar findings to those in the present study in 41 men with symptomatic benign prostatic enlargement. They reported that urinary flow rates measured with a large (10 F/5 F) urethral catheter assembly *in situ* were reduced by a mean of 55%. This effect appears to have several causes and was not simply

Table 2 The subanalysis in group 4 (single 5 F catheter during voiding).

Variable	Normal	BOO	DU	Total
% decline of Q_{\max}	9	6.5	19.6	11
P	0.06	0.10	0.02	0.05

a result of the ‘obstructing’ effect of the urethral catheter.

The present results are consistent with those of other studies, with an overall 32.5% reduction in Q_{\max} compared to a free flow rate, with the use of two 5-F catheters. Detrusor contractility was the most significant determining factor, as those with the lowest detrusor pressures (group 3) had the greatest reduction and largest increase in PVR compared with men who had a normal PFS (group 2), followed by those with BOO (group 3, least reduction). In group 2, only 62% of men had a reduced flow rate, while a third of the men had an increase. There are other possible explanations for the smallest effect in men with BOO, i.e., some stenting effect of the catheter around the already obstructed outlet, and a lower margin for change with an already very low flow rate. The reduction in Q_{\max} was more consistent in groups 1 and 3, where 97% and 93% of patients, respectively, had a reduced flow during PFS.

The presence of a significant PVR (> 20%) was more common with voiding difficulties but it was not specific to any particular symptom. There was no statistically significant association between the PVR and an overactive detrusor, or abnormal bladder compliance. This means that the PVR can neither be a cause or effect of detrusor overactivity.

With only one 5 F catheter in the voiding phase, there was a statistically insignificant decline in men with a normal PFS and in those with BOO. However, there was up to a 20% decline (statistically significant) in men with DU even with a 5 F catheter. The practice

Table 1 The effect of the catheter assembly on Q_{\max} , PVR and voided volume. There were two 5 F catheters in group 1–3 and one 5 F catheter in group 4 during voiding.

Group	1	2	3	4
Mean (range) variable				
Q_{\max} (mL/s)	22.5 (14.5–26)	8.0 (3.7–13.2)	11.7 (3.3–15.7)	13.2 (4.5–28)
$Q_{\max P}$ (mL/s)	15.4 (8.5–19.8)	6.3 (2.8–9.4)	6.8 (2.7–12.1)	11.7 (4.3–22.2)
% reduction	34.5	21	41.9	11
P	< 0.05	< 0.05	< 0.05	> 0.05
PVR (mL)	12 (0–33)	91 (64–106)	141 (65–361)	87(0–267)
PVR on PFS (mL)	21 (0–67)	126 (111–196)	198 (144–488)	103(0–280)
% change	75	38.5	40.4	18
P	< 0.05	< 0.05	< 0.05	> 0.05
Voided volume (mL)				
Free flow	286 (152–397)	183 (151–256)	296 (155–446)	256 (177–398)
PFS	257 (239–424)	197 (181–280)	330 (210–465)	277 (164–388)
P	> 0.05	> 0.05	> 0.05	> 0.05

of removing one catheter before the voiding phase has inherent limitations, like the inconvenience of interrupting the procedure, the possibility of dislocating both catheters, and men with DU still had a 20% decline in Q_{\max} and further fill/void cycles would need recatheterisation. We used a three-way stop cock if refilling was required after the filling catheter had been removed, in case of failed voiding at that volume, but it compromised the further recording of filling variables.

Apart from quantitative variables (flow rate, voided volume or PVR) the presence of a catheter also affected qualitative variables, like the voiding pattern. However, an analysis of the voiding pattern is quite subjective, poorly reproducible and difficult to analyse statistically, and hence was not included in the objectives of this study. Although the catheter was observed to cause straining, this finding was difficult to compare amongst the groups.

With the known limitations of invasive conventional PFS, there has been a continuous effort to develop a noninvasive urodynamic model, ranging from mathematical formulae to specialised devices [8–12]. Noninvasive measurements of bladder/detrusor wall thickness [8], intravesical prostatic protrusion [9], or isovolumetric bladder pressure [10] might replace invasive PFS in the future, if only information about BOO is needed. However, urodynamic investigations are still indicated in patients requiring detailed information about the bladder filling and voiding phases, and to assess the precise cause of LUTS [13]. However, there is as yet insufficient evidence to justify the replacement of invasive voiding cystometry by these investigational approaches [14].

In conclusion, urodynamically the PVR was more a measure of detrusor contractility than a variable of LUT obstruction or any specific clinical finding. With larger catheters the reduction in the flow rate is remarkable, and thus in cases of a significant reduction in flow on PFS, values of the free flow rate must guide the diagnosis, as examining the urodynamic flow rate alone could carry a 20–40% error in measuring Q_{\max} . The present study justifies the use of one 5 F catheter at the time of voiding, although even that can cause a reduction in flow in men with DU.

Conflict of interest

None.

Source of funding

None.

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