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Definition of prostatic urethral obstruction

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Abstract Prostatic urethral obstruction as defined by urodynamic criteria is only present in about 70% of patients undergoing surgical treatment for benign prostatic hyperplasia (BPH). Infravesical obstruction can only be diagnosed by simultaneous recording of detrusor pressure (intravesical pressure minus abdominal pressure) and urinary flow rate. The interpretation of these recordings should be based upon the pressure-flow relationship. The possible clinical implications of the objective diagnosis of prostatic urethral obstruction in BPH are discussed.

Key words Urodynamics · Benign prostatic hyperplasia Prostate · Obstruction · Voiding · Voiding symptoms Pressure flow

Infravesical obstruction has historically been a basic ingredient in the concept of clinically important benign prostatic hyperplasia (BPH). As long as the presence of infravesical obstruction had to be proved by either urinary retention or upper urinary tract deterioration before any serious treatment was considered, no one bothered to diagnose or define the condition of prostatic urethral obstruction itself.

Along with the improvement in surgical and anaesthetic procedures during this century, even uncomplicated BPH has been treated surgically, resulting in 70% of prostatectomies now being performed for uncomplicated BPH [15]. It has, however, been shown in many series that 30% of patients undergoing prostatectomy for uncomplicated BPH are urodynamically unobstructed [12, 19, 21].

Obstruction in a fluid-transporting system can be defined as being present if the fluid pressure proximal to a relative narrowing must be raised to transmit the usual rate of flow through this area (R. H. Whitaker as cited by D. Griffiths). This definition makes it mandatory to measure both pressure and flow to make the diagnosis of obstruction, thus focusing on the pressure. This means that in prostatic urethral obstruction both the driving detrusor pressure and the resulting urinary flow rate must be measured if the condition is to be diagnosed.

The basic relationship between the force of a muscle contraction (detrusor) and speed of shortening of the muscle (flow rate) is described by the Hill relation (Fig. 1) [11], which was transformed to the lower urinary tract by Griffiths (Fig. 2) [7]. He called this relation the bladder output relation (BOR), which is the fundamental basis for all later work in this area. The BOR shows how a given bladder can operate at a given time. If outflow resistance is low a high maximum flow rate and a low corresponding detrusor pressure at the lower right-hand end of the curve will be the result. If outflow resistance increases, corresponding values of detrusor and maximum flow rate move upwards to the left on the curve. It is important to realise that the BOR only represents on detrusor with a given strength. If the detrusor becomes weaker, the whole curve moves left and downwards (Fig. 3). Griffiths also introduced another important feature, the urethral resistance relation (URR), which represents corresponding values of detrusor pressure and flow rate throughout the micturition. When micturition starts detrusor pressure begins to rise and the URR will follow the y-axis until at a certain pressure the urethra opens and the URR will move to the right. If the patient is unobstructed the opening pressure is low and the resistance to further openings is almost negligible, resulting in an almost horizontal URR. If the outlet is rigid, the opening pressure will be elevated and because the resistance to further opening is also greater the slope of the URR will be steeper (Fig. 4). The opening pressure and the closure pressure are seldom identical, and the URR therefore has the shape of a loop rather than that of a single line. Events cannot be determined in terms of temporal duration since there is no time axis on the graph. BOR and URR are the basics of modern urodynamics. Once these

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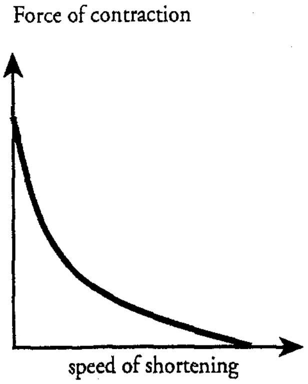

Fig. 1 Hill's relation shows the interdependence of contraction force and contraction speed

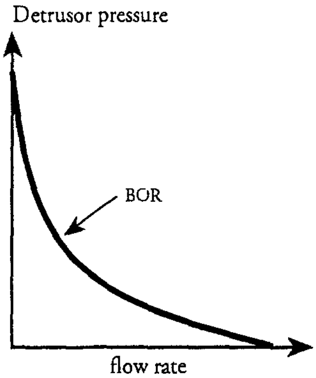

Fig. 2 The bladder outlet relation (*BOR*). Note its resemblance to Hill's relation

relationships are understood the whole concept of using pressure/flow relatioships for analyzing micturition is simplified.

Interpretation of pressure/flow studies

As there has so far been no way the URR can be expressed in one single term, both detrusor pressure and urinary flow rate must be included in the interpretation. If the patient presents a high detrusor pressure (e.g. 120 cm H_2O) and corresponding low maximum flow rate, e.g. 7 ml/s, it is not difficult to classify him as being obstructed.

Also if detrusor pressure is low (e.g. 25 cm H_2) and maximum flow rate high (e.g. 25 ml/s), the patient can immediately be classified as being unobstructed. But in most cases it will be necessary to draw *the pressure/flow relationship*, which is the same as the URR. With some urodynamic equipment this is done automatically, but otherwise it can be done by hand, which is often safer since artefacts are better avoided. The simplest way is to plot the maximum flow rate and the corresponding detrusor pressure. Even better is to select several points of corresponding detrusor pressures and flow rates and draw a line between them.

Since the point of maximum flow rate and corresponding detrusor pressure during increasing obstruction moves upwards to the left on the BOR, it will always be more or less arbitrary where the limit between obstructed and unobstructed is drawn. This is actually the main difference between existing classification systems, and the differences are in reality quite small since they all share the same basic principles.

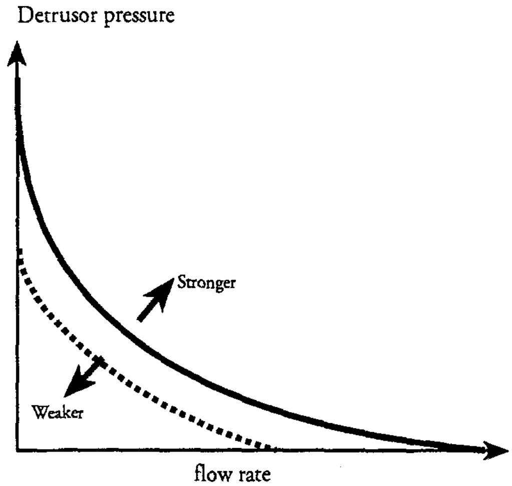

Fig. 3 The BOR shows how a given bladder operates depending on the degree of outlet obstruction. If bladder strength is changed the BOR moves as demonstrated. ▬ Normal BOR; •••• weak detrusor BOR

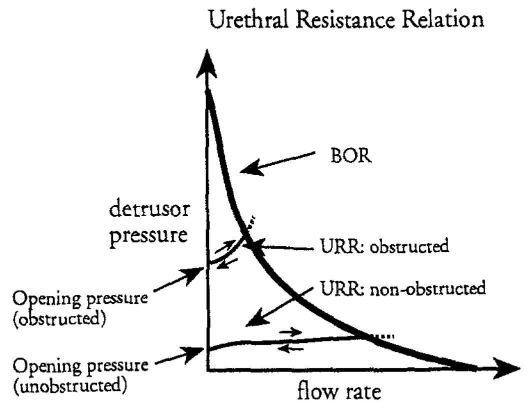

Fig. 4 The urethral resistance relation (*URR*). Both obstructed (*upper*) and unobstructed voiding (*lower*) are shown

The simplest system is the Abrams-Griffiths nomogram (Figs. 5, 6) [2], which has stood the test of time and can be recommended for clinical use. Plots may fall into three zones: obstructed, equivocal or unobstructed. If the point of maximum flow rate and corresponding detrusor pressure falls in the equivocal zone, the whole pressure/flow plot (the URR) must be analysed using the criteria in Table 1. The slope of the plot as mentioned above is an expression of prostatic stiffness. The more force needed to further distend an already open urethra the steeper the slope. With this simple analysis, it is possible to divide a population of BPH patients into obstructed and unobstructed categories with a high degree of certainty. More advanced methods such as Schäfer's nomogram [20], the URA [9] and fully computerized methods such as CLIM [19] and Spångberg's urethral

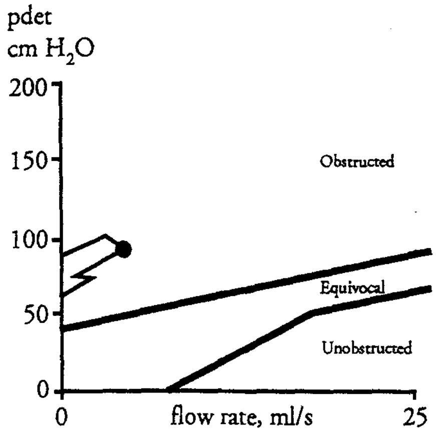

Fig. 5 Abrams-Griffiths nomogram with superimposed continuous pressure/flow plot obstructed micturition

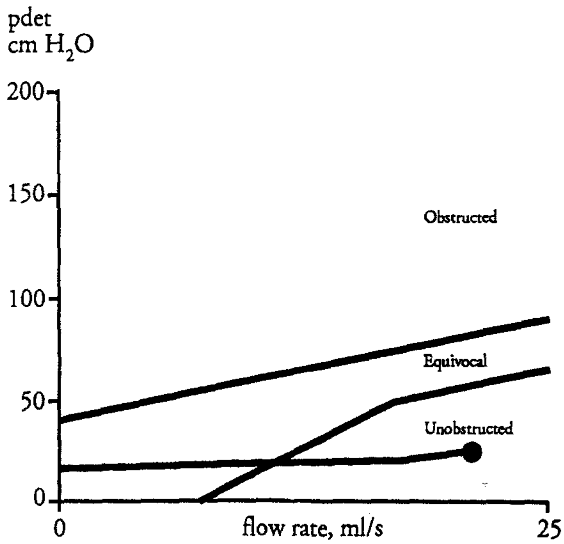

Fig. 6. For comparison with Fig. 6, the Abrams-Griffiths nomogram is shown with an unobstructed pressure/flow plot

pressure/area relation [22] allow obstruction to be further subdivided but as mentioned above share the same basic principles.

Clinical implications

Infravesical prostatic obstruction can only be diagnosed by pressure/flow investigations. But such investigations are time consuming, expensive and demand a high degree of expertise. It is therefore reasonable to ask if it is of clinical value to diagnose infravesical obstruction in the evaluation of patients with BPH. After all, the patient is troubled by the symptoms, which are relieved to a large extent after prostatectomy. No one can answer this question with certainty today, but considering the effect of prostatectomy on the three fundamental aspects of BPH [10] (lower urinary tract symptoms, infravesical obstruction, benign prostatic hyperplasia) may be helpful.

Table 1 Criteria for classification of obstruction in the equivocal zone

Closing pressure >40 cm H_2O	Obstructed
Slope of pressure/flow relationship ≤ 2 cm H_2O per ml/s	Unobstructed
Slope of pressure/flow relationship >2 cm H_2O per ml/s	Obstructed

Table 2 Symptomatic outcome after TURP in relation to preoperative obstruction on pressure/flow investigation

Ref.	Patients (*n*)	Unobstructed (%)	Symptomatic failure after TURP	
			Obstructed (%)	Unobstructed (%)
[12]	123	29	7	21
[17]	217	14	24	43
[19]	29	34	10	70

Table 3 The success rate in placebo-controlled drug studies in patients with prostatism

Ref.	Patients (*n*)	Placebo (%)	Active treatment (%)
[7]	20	90	90
[13]	38	56	71
[1]	52	62	60
[4]	38	76	76
[3]	40	42	90

Symptoms

We know that prostatectomy has a pronounced beneficial effect on symptomatology. Only few studies have compared outcome in relation to urodynamically proven obstruction (Table 2) [12, 17, 19]. From these studies it is evident, however, that symptomatic outcome is less favorable in the unobstructed patients, although a success rate of 78% in the unobstructed group as seen in Jensen's study also seems satisfactory. Complicating the interpretation of symptomatic outcome, however, is the enormous placebo effect of any treatment for symptomatic uncomplicated BPH (Table 3) [1, 3, 4, 8, 13].

A placebo effect after drug treatment of 50% is confusing, and invasive procedure such as prostatectomy must have a much stronger impact on the patient than tablets. In a double-blind study comparing balloon dilatation with cystoscopy, Lepor found a marked symptomatic improvement in 63% of the patients 3 months after cystoscopy and a moderate to marked symptomatic effect in 60% after balloon dilatation [14]. Two studies comparing balloon dilatation and transurethral reaction of the prostate (TURP) also found no difference in symptomatic outcome between dilatation and TURP (Table 4)

Table 4 Symptomatic outcome and effect on Q_{max} in three randomised studies comparing balloon dilatation of the prostate with either cytoscopy or TURP. Symptomatic outcome is almost identical independent of treatment modality. Q_{max} is only improved significantly after TURP

Ref.		Patients (n)	Symptom score		Q_{max}	
			Initial	After 3 months	Before	After 3–6 months
[14]	Balloon dilatation	15	12.4	7.5	9.2	11.5
	Cystoscopy	16	11.9	8.8	10.5	12.9
[6]	Balloon dilatation	26	14.1	7.3	11.8	14.8
	TURP	25	13.6	6.2	12.3	19.2
[18]	Balloon dilatation	10	12.5	6.0	9.5	12.5
	TURP	10	10.0	4.5	7.3	18.0

Table 5 Pre- and postoperative urodynamic parameters in BPH patients classified as infravesically obstructed and unobstructed preoperatively (from [21])

		Preoperative	Postoperative
Obstructed	Q_{max} (ml/s)	7.5 (2–21)	15.8 (5.5–46)
	Residual urine (ml)	120 (0–1000)	40 (0–435)
	P_{det}, Q_{max} (cm H_2O)	73 (30–157)	27 (5–65)
Unobstructed	Q_{max} (ml/s)	10.8 (2.5–52)	19 (7.5–37)
	Residual urine (ml)	73 (0–572)	21 (0–255)
	P_{det}, Q_{max} (cm H_2O)	27 (0–57)	24 (8–35)

[6, 18]. So the difference in symptomatic outcome after cystoscopy and TURP is not very clear. To add to the confusion a recent study has demonstrated a 69% decrease in symptom score lasting at least 3 months after treatment, which was only insertion of a 22F catheter for 1 h [5].

A symptomatic effect comparable to that seen after prostatectomy might in other words be accomplished using much cheaper and less traumatic treatment modalities. So one must be very careful if focusing only on symptoms as the outcome parameter in symptomatic BPH.

Obstruction

Prostatectomy is a very efficient treatment for infravesical prostatic obstruction [12, 16, 19]. In the obstructed patient detrusor pressure decreases and flow rate increases substantially (Table 5) [12]. In the unobstructed patient detrusor pressure only decreases marginally, while flow rate increases because the patient is already on the almost horizontal part of the BOR (Table 5) [12]. The effects of other treatments both invasive and non-invasive have been poorly documented because of the lack of properly performed pressure/flow investigations.

Hyperplastic prostate

A prostatectomy will remove prostatic adenomas. We do not know if this is of relevance per se. It might be that prostatic adenomas although not causing infravesical obstruction might cause voiding symptoms by themselves. The beneficial effect of thermotherapy on symptoms but not on obstruction might indicate this. But as mentioned previously, symptomatology is a parameter to be interpreted with caution.

Conclusion

The diagnosis of prostatic urethral obstruction must be made by pressure/flow investigations using the pressure-flow relationship (the URR) as the diagnostic basic. Thirty percent of males being admitted for prostatectomy without preoperative pressure-flow investigation are urodynamically unobstructed and the symptomatic outcome in this group is statistically significantly worse than in the obstructed group. The nevertheless high success rate in the unobstructed group may at least partly be due to a placebo effect, since similar good results are seen after cystoscopy or just insertion of a 22F catheter for 1 h. Patients with infravesical prostatic obstruction show significant urodynamic improvement after prostatectomy, while unobstructed patients only improve marginally.

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