Urological Research 8, 71-75 (1980)

Urological Research

Clinical Applications of Momentum Flux Measurements with Special Reference to Detrusor Hyperreflexia and Meatal Stenosis

H. H. Meyhoff[1], D. J. Griffiths[2], J. Nordling[1] and T. Hald[1]

[1]Department of Urology, Herlev University Hospital, Copenhagen, Denmark and

[2]Departments of Urology and of Biological and Medical Physics, Medical Faculty, Erasmus University Rotterdam, Holland

Accepted: June 19, 1979

Summary. Distensibility of the meatal part of urethra was studied in 67 patients with detrusor hyperreflexia and in 7 patients with organic meatal stenosis using the momentum flux meter. Statistically significantly higher momentum flux values were found in patients with non obstructive detrusor hyperreflexia compared to normal persons - indicating a tighter meatus than normal. The connection between tight meatus and detrusor hyperreflexia is discussed. Also in patients with organic meatal stenosis momentum flux measurements showed a rigid meatus. Because of its high diagnostic specificity, momentum flux measurement may prove valuable as a screening investigation in male patients with suspected detrusor hyperreflexia or distal urethral stenosis.

Key words: Momentum flux - Flow rate - Detrusor hyperreflexia - Meatal stenosis - Urodynamics.

Momentum flux in the voided urinary stream can easily be measured simultaneously with the flow rate by means of the DISA momentum flux meter. This investigation may be undertaken either as a non-invasive screening procedure or as part of a pressure-flow-electromyography study in male patients.

In vitro testing of this apparatus for steady flow rates has shown its accuracy for both momentum flux and flow rate is acceptable for clinical use (4). A recording from this apparatus gives all the information contained in a flow rate measurement alone. The extra parameter recorded - momentum flux - adds the possibility of evaluation of the distensibility of the meatal part of the urethra (4).

A normal area of momentum flux related to flow rate has previously been delineated (5).

Preliminary clinical results from measurements with this apparatus have suggested high momentum flux values in patients with non-obstructive detrusor hyperreflexia (3).

The present study was therefore undertaken in order to evaluate meatal properties in patients with detrusor hyperreflexia. Our findings in patients with normal cystometry and in patients with previous or present meatal stenosis are also presented.

METHOD[1]

All momentum flux measurements performed in the laboratory were reviewed. Patients with phimosis, epispadias or hypospadias were excluded. Curves with artefacts due to contact of the glans penis with the momentum flux measuring plate or due to off scale recordings for momentum flux or flow rate were rejected. If more than one recording was obtained in each patient, the registration with the highest momentum flux related to maximum flow rate was selected, since deviations in the urinary stream exit angle from the horizontal in both upward and downward directions will reduce the measured momentum flux. All momentum flux values were read at maximum flow rate. None of these voidings was performed in privacy. The DISA momentum flux meter - described in detail previously (3, 4) - was used for all measurements. Most cases were studied using a shelf on the apparatus for penis support and the height over the floor of the apparatus was carefully adjusted to fit each patient.

[1]Methods, definitions and units conform to the standards proposed by the International Continence Society except where specifically noted

0300-5623/80/0008/0071/$ 01.00

CO_2 cystometry was performed at a filling rate of 200 ml/min through a transurethrally introduced Foley 16 F catheter with the patient in the supine position. Detrusor hyperreflexia was diagnosed according to the definitions of the I. C. S. (2).

After cystometry the bladder was filled with saline at body temperature, the catheter removed and the momentum flux-flow registration obtained.

The data from patients with detrusor hyperreflexia, with no history of previous meatal stenosis and with no signs of present organic meatal stenosis as judged from introduction of a Foley 16 F catheter, were compared to the normal distribution of momentum flux values (5) - the data being submitted for computer analysis.

The normal values of momentum flux were obtained from persons who had not previously been catheterised (5). In order to evaluate a possible influence of the catheterisation itself, the recordings of all patients in this study with normal cystometry and without present or previous meatal stenosis, and for whom penis support was used, were compared to recordings from normal persons.

Data from patients with previous or present meatal stenosis, in whom a narrow or rigid meatus during voiding might be expected, were also compared to values from normal persons.

In order to judge whether the meatal part of urethra could be flow-controlling, the effect of meatal dilatation to 28-30 F for 2 minutes using a conical meatus dilatator was studied by pressure - flow - momentum flux registrations in 13 unselected patients. One voiding was obtained from each patient immediately before and after dilatation.

PATIENTS

The details of the patients are given in Table 1. Mean age and range for 67 patients with detrusor hyperreflexia and 28 patients with normal cystometry, all without organic meatal stenosis, were 62.5 (27-78) years and 65.2 (53-76) years respectively. The patients are grouped according to the critical flow rate (Q_c) above which the meatus probably distends with approximately constant stiffness (6).

Seven patients (27-68 years) were suspected of having a rigid meatus: 6 had stenosis in the distal 3 cm of urethra as judged from insertion of 16 F catheter, and 1 patient had had several previous dilatations for meatal stenosis. A small urethral catheter (8-12 F) was introduced for bladder filling in 6 of these patients from whom a spontaneous voiding was not obtained.

Pressure-flow registrations before and after meatal dilatation were obtained in 13 post-prostatectomy patients, 3 of whom had detrusor hyperreflexia, 7 a normal cystometry, and 3 a meatal stenosis.

RESULTS

The best correlation between momentum flux (M) plotted against flow rate (Q) for the 42 patients with detrusor hyperreflexia and a maximum flow rate above or equal to 10 ml/sec was found to be the curvilinear regression: $M = 0.032 \times Q^{1.68}$. For normal persons the curve of regression was (5): $M = 0.082 \times Q^{1.28}$. Figure 1 shows the plots and the curves of regression damarcated with plus and minus one standard deviation.

Table 1. Material

	Flow rate ml/sec	Detrusor hyper-reflexia	Normal cystometry	No cystometry
Organic meatal stenosis	7-35	2(1)	4(2)	1
No present or previous organic meatal stenosis	≥ 10	42(3)[c]	19(7)[b]	0
	< 10	25[a]	9[a]	0

In brackets number of patients that had meatal dilatations.
a, b and c indicate diagnosis:

[a] Prostatic obstruction

[b] Post prostatectomy

[c] Post prostatectomy (15(3) patients)
Slight prostatic obstruction (16 patients). Frequency, urge incontinence, persistent enuresis (11 patients)

These curves of regression were statistically significantly different (Spearman's non-parametric test of correlation, rho = 0.54, P = 0.0002).

Figure 2 indicates that catheterisation was not responsible for these high momentum flux values. All but two patients without detrusor hyperreflexia are placed within the normal area.

Patients with meatal stenosis or rigid meatus and with a wide range of flow rates are all placed at the upper limit of or definitely above the normal area - Figure 3.

With a maximum flow rate below 10 ml/sec momentum flux values from patients with detrusor hyperreflexia are inseparable from those from normal persons and patients with detrusor hyperreflexia - Figure 4. The only exception was a patient with meatal stenosis.

Meatal dilatation was unable to improve the pressure-flow relationship in the non-obstructed direction except in 2 of the 3 patients with meatal stenosis and in 1 patient with normal cystometry. Only in 6 of 13 patients did momentum flux measurement after dilatation show an increased cross-sectional area of the urinary stream, indicating an effective dilatation.

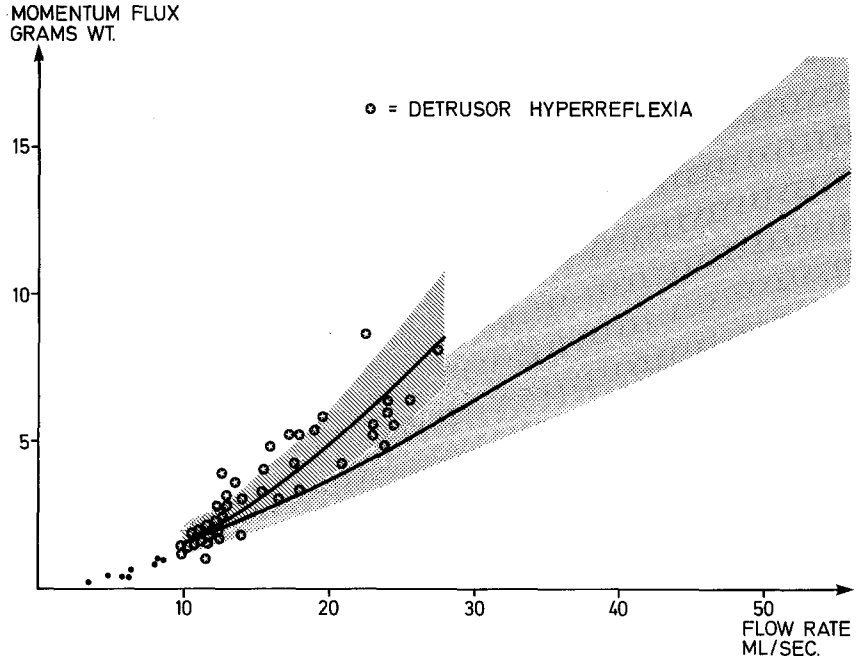

Fig. 1. Curve of regression plus and minus one standard deviation for 42 patients with detrusor hyperreflexia and a maximum flow rate above or equal to 10 ml/sec in relation to the normal curve of regression plus and minus one standard deviation

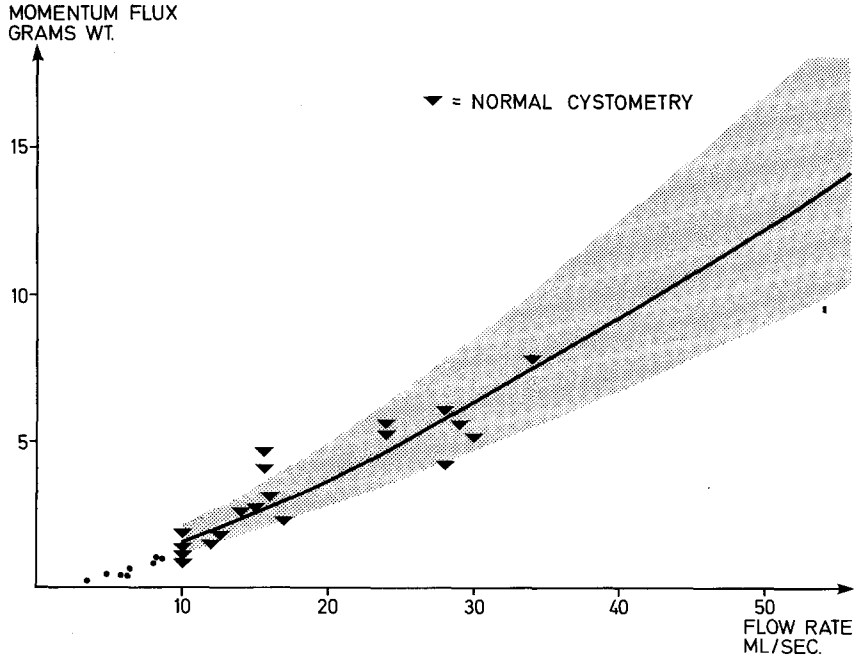

Fig. 2. Plots from 19 patients with normal cystometry in relation to the normal curve of regression plus and minus one standard deviation

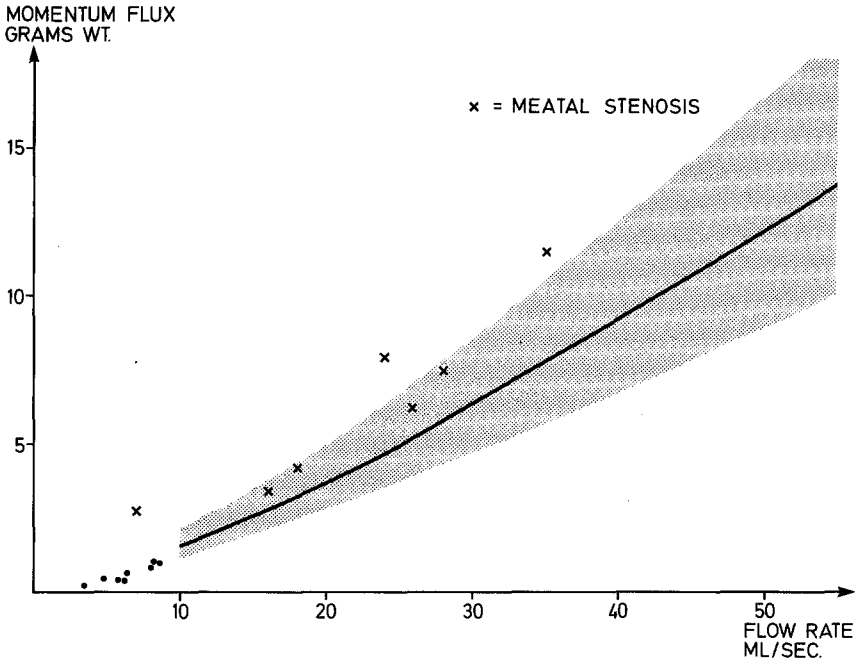

Fig. 3. Plots from 7 patients with organic meatal stenosis in relation to the normal curve of regression plus and minus one standard deviation

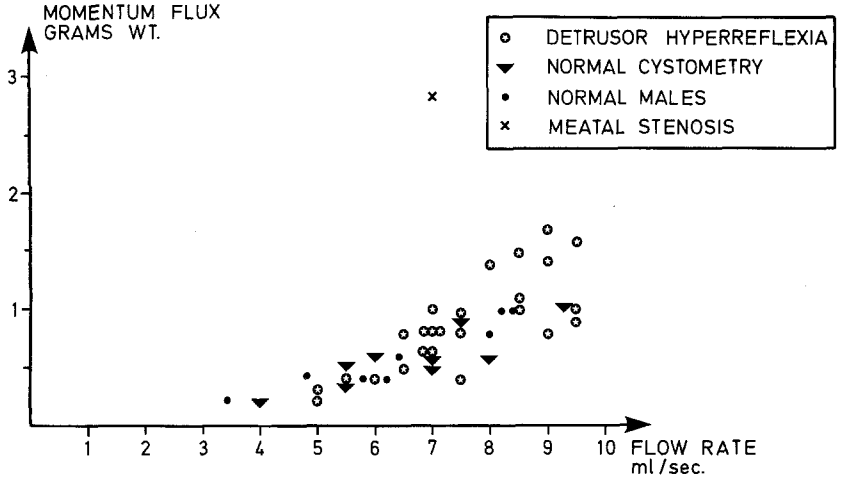

Fig. 4. Plots from 25 patients with detrusor hyperreflexia, 9 patients with normal cystometry, one patient with organic meatal stenosis and from 8 normal persons

DISCUSSION

From a physiological point of view it is interesting to note a statistically significantly steeper line of regression for a group of patients with detrusor hyperreflexia and flow rates above or equal to 10 ml/sec compared to normal persons. It is unlikely (Fig. 2) that this finding is due to the preceding catheterisation or a more correct stream exit angle. Only about half of the patients with detrusor hyperreflexia used the shelf for penis support and uncontrolled changes in exit angle should not be different for patients and normal persons.

This implies that at least some patients with "non-obstructive" detrusor hyperreflexia have tighter meatuses than normal. The connection between detrusor hyperreflexia and tight meatus is not obvious. One could suppose that

1) tight meatus is a result of detrusor hyperreflexia,
2) they are both the result of some third factor,
3) detrusor hyperreflexia is the result of the tight meatus,

The third hypothesis seems most promising. In normal males the compressive zone in the proximal urethra is believed to be the flow-controlling region (1). A narrow meatus will increase the pressure in the distal urethra during voiding, and if this pressure increase is high enough, the meatal part of urethra will control the flow rate. In one patient with a perineal urethrostomy (Leadbetter-I operation for proximal urethral stricture and fairly normal distal urethra) we

have measured the energy loss in the meatal part of urethra to be roughly constant with varying flow rates, of the order of 40 cm H_2O. This implies that, in "non-obstructed" patients with tight meatuses, the pressure in the distal urethra is almost certainly high enough to make the compressive zone no longer the flow-controlling region so that the meatus and distal urethra then becomes flow-controlling. If so, one could suppose either that one was dealing with a previously unrecognised subclinical obstruction, or that the important factor was not the actual obstruction as such, but removal of flow-control from the compressive zone to meatal region. This might then alter a neurogenic feedback mechanism which normally should function during micturition, so causing changes in the control mechanism of the bladder and leading to detrusor hyperreflexia.

Dilatation failed to improve the flow rate in 3 patients with detrusor hyperreflexia. Since less than half of the patients had effective dilatations, as judged from momentum flux - flow rate measurements, we have not at present verified with this technique whether the meatus in these patients is flow-controlling. Perhaps a meatotomy would be able to reverse detrusor hyperreflexia in some patients.

As to clinical applications of momentum flux measurements it must be emphazised that the substantial between-patient variation causes a poor diagnostic sensitivity at low flow rates for detrusor hyperreflexia, but an increasing sensitivity with increasing flow rates (e.g. about 50% at a flow rate of 20 ml/sec). Setting an upper limit for normality as the normal line of regression plus one standard deviation, the diagnostic specificity for flow rates above 10 ml/sec, however, is high (94%). Organic meatal narrowing can be diagnosed at high as well as at low flow rates - Figure 3. As this investigation can be undertaken without instrumentation in addition to an ordinary flow rate measurement, the high diagnostic specificity justifies its use. From this study, however, it may be deduced that a relatively high momentum flux value may indicate either organic meatal stenosis or detrusor hyperreflexia. As part of a pressure-flow study, simultaneous momentum flux measurement will indicate when an infravesical obstruction is located in the meatal part of urethra. A simple pressure-flow study is unable to localize the position of an infravesical obstruction.

Momentum flux measurements might therefore prove valuable as a screening investigation in male patients with persistent enuresis, frequency or urge incontinence, in post prostatectomy incontinence, in the evaluation of infravesical obstruction and perhaps in enuretic boys. A high momentum flux value (relative to flow rate) will indicate a narrow meatus, and if in combination with a high flow rate probably detrusor hyperreflexia. High momentum flux - low flow rate will indicate meatal stenosis.

Acknowledgement: Danish medical research council grant nr: 512-8916 has supported this study.

REFERENCES

1. Griffiths, D. J.: Hydrodynamics of male micturition - I. Theory of steady flow through elastic-walled tubes. Medical and Biological Engineering 9, 581 (1971)
2. International Continence Society: First report on the standardisation of terminology of lower urinary tract. British Journal of Urology 48, 39 (1976)
3. Meyhoff, H. H., Andersen, J. T., Nordling, J., Hald, T.: An apparatus for the recording of momentum in the urinary stream. In: Proceedings of the 7th Annual Meeting of the International Continence Society, Portoroz, Yugoslavia, 1977
4. Meyhoff, H. H., Griffiths, D. J., Nordling, J., Hald, T.: Accuracy and interpretation of results from the DISA momentum flux meter. Urological Research 8, 37 (1980)
5. Meyhoff, H. H., Griffiths, D. J., Nordling, J., Hald, T.: Momentum flux values at maximum flow rate in normal males. Urological Research 8, 67 (1980)
6. Sterling, A. M., Griffiths, D. J.: Measurement of the elasticity of the male urethral meatus by urinary drop spectrometry. Urologia Internationalis 31, 321 (1976)

Dr. H. H. Meyhoff
Urological Laboratory 54G2
Herlev Hospital
DK - 2730 Herlev
Denmark