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Evaluation of Detrusor Contractility Parameters Help to Analyze Consequences of Steady Abdominal Pressure Changes during Voiding in Women

Françoise A. Valentini [a*], Brigitte G. Marti [a] and Gilberte Robain [a]

[a] Sorbonne Université and Physical Medicine and Rehabilitation Department, Hôpital Rothschild, 5 Rue Santerre 75012-Paris, France.

Authors' contributions

This work was carried out in collaboration among all authors. Author FAV contributed to concept and design of the study, data collection, analysis of data, manuscript preparation. Author managed BGM data collection, analysis of data. Author GR managed data collection, manuscript preparation. All authors reviewed the results and approved the final version of the manuscript.

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ABSTRACT

Introduction: Urodynamic study interpretation leading to urodynamic diagnosis is mainly based on pressure recordings and the value of detrusor pressure at maximum flow ($p_{det.Qmax}$). Detrusor pressure is calculated by subtracting the abdominal pressure (p_{abd}) from the vesical pressure (p_{ves}). Hence, there is a critical role for p_{abd} in this process. The goal of our study was evaluate the contribution of detrusor contractility parameters (DCP) to confirm and to correct urodynamic misdiagnosis (UmD) due to steady abdominal pressure changes during voiding in women.

**Corresponding author: E-mail: favalentini@gmail.com;*

Materials and Methods: Urodynamic tracings of 271 non-neurologic women referred for investigation of various LUTS were retrospectively analyzed. UmD could be bladder outlet obstruction (BOO) and normal (N) for decreased p_{abd}, normal (N) and detrusor underactivty (DU) for increased p_{abd}. Detrusor contractility parameters were VBN parameter **k** and PIP1.
Results: Among the whole population 125 women had a significant change (≥5 cmH_2O) of p_{abd} during voiding (73 decrease, 52 increase).
In the "decrease" sub-group, only 3 N became DU with decreased DCP values; in the "increase" sub-group 1 N and 1 DU patients gained BOO diagnosis with increased DCP values.
In total, analysis of changes in abdominal pressure leads to 5/271 (1.8%) changes in urodynamic diagnosis; no correlation between previous surgery of incontinence or main complaint.
Conclusion: A high percentage of the non-neurologic female population has steady changes of abdominal pressure during voiding, that condition leads to few changes in urodynamic diagnosis; evaluation of detrusor contractility parameters values help to verify the new conclusions.

Keywords: Abdominal pressure; detrusor contractility; urodynamic diagnosis; voiding; non-neurologic women.

1. INTRODUCTION

After completion of a voiding cystometry, the study interpretation leading to a urodynamic diagnosis (UD) is mainly based on pressure recordings and the value of detrusor pressure at maximum flow ($p_{det.Qmax}$). Detrusor pressure is calculated by subtracting the abdominal pressure p_{abd} (assumed equal to rectal) from the vesical pressure (p_{ves}). Hence, there is a critical role for abdominal pressure in this process.

According to the report of Good Urodynamic Practice guidelines [1], abdominal pressure is recorded using a punctured intrarectal balloon catheter filled with 2 mL of saline. During voiding, the changes in abdominal pressure can be threefold, decreased, unchanged, or increased (generally from straining efforts). Two of these three processes, increase or decrease in abdominal pressure, can have an effect on the final urodynamic diagnosis, especially for the diagnoses of detrusor underactivity (DU) or bladder outlet obstruction (BOO) which rely primarily on $p_{det.Qmax}$ [2-4].

The goal of this study was to analyze the consequences of steady changes in abdominal pressure during voiding in women on urodynamic diagnosis, and the contribution of analysis of detrusor contractility parameters (DCP) to confirm and to correct urodynamic misdiagnosis (UmD).

2. MATERIALS AND METHODS

Urodynamic tracings of 271 non-neurologic women age range [20-88 years old] who were referred for investigation of various lower urinary tract symptoms (LUTS) to our specialized unit, run by the same team over time were retrospectively analyzed. Exclusion criteria, in addition of neurological condition, were advanced cognitive impairment (MMSE ≤ 20), diabetes mellitus, grade ≥ 2 pelvic organ prolapse, complete urinary retention and/or severe mobility impairment. Each patient file comprised demographic data, medical history, 3-day bladder diary, and current medications. Main complaint was categorized as stress urinary incontinence (SUI), urge urinary incontinence (UUI) mixed urinary incontinence (MUI), and "OTHER" (dysuria-frequency complaint, meaning LUTS but no urinary incontinence). Each analyzed file included a filling cystometry followed by a voiding study with an intubated flow (IF). Cystometry was performed with the patient in a sitting position with a 7-F triple-lumen urethral catheter perfused with saline at room temperature using a medium filling rate of 50 mL/min. Abdominal pressure was recorded using a punctured intrarectal balloon catheter filled with 2 mL of saline according to the report of Good Urodynamic Practice guidelines [1]. Post-void residuals (PVR) were measured using bladder-scan after the IF.

After completion of the urodynamic session, the tracings were interpreted to reach a urodynamic diagnosis which conformed to the ICS/IUGA recommendations [5]. UD included: bladder outlet obstruction (BOO), detrusor hyperactivity with impaired contractility (DHIC), detrusor overactivity (DO), detrusor underactivity (DU). Some investigations were found "normal" (N) and others related to urethral dysfunction (intrinsic sphincter deficiency (ISD) and voiding triggered by urethral relaxation (URA)). Some combined diagnoses were observed between DO, DU or DHIC with ISD.

If we look at the cut-off criteria for urodynamic diagnosis a detrusor pressure value is only required for BOO and DU. These two diagnoses are based on the following criteria:

1. for BOO: $p_{det.Qmax} \geq 25$ cm H_2O and $Q_{max} \leq 12$ mL.s^{-1} proposed by Defreitas et al. [4].
2. for DU the cutoff criteria, usable for all women, proposed by Gammie et al. [2] were used: $p_{det.Qmax} < 20$ cm H_2O, $Q_{max} < 15$ mL.s^{-1} and BVE (bladder voiding efficiency) < 90%.

To add more consistency, an evaluation of detrusor contractility was obtained from the VBN detusor contractility parameter [6] **k** and the projected isovolumetric pressure PIP1 [3] (PIP1 = $p_{det.Qmax} + Q_{max}$). Parameters necessary for **k** computation include initial bladder volume V_{ini} (voided volume + post void residual) with voided volume ≥ 100 mL, intubated maximum flow (Q_{max}) and detrusor pressure at maximum flow ($p_{det.Qmax}$) [7]. It had been demonstrated that **k** and PIP1 gave consistent evaluations of detrusor contractility for females [8].

After evaluation of p_{abd} at maximum flow, a correction of $p_{det.Qmax}$ erasing the artificially increase of $p_{det.Qmax}$ was applied; when p_{abd} decreased during voiding; a similar scheme for correction of $p_{det.Qmax}$ was used.

Then, after evaluation of the real value of $p_{det.Qmax}$, we investigated possible changes in urodynamic diagnosis and, to check the validity of the proposed changes, we computed values of detrusor contractility parameters.

2.1 Statistical Analysis

Data are presented as mean ± SD and range. Analysis of variance (ANOVA), and the Chi-square test were used as appropriate. All statistical results were considered significant at $p < 0.05$. Statistical analyses were performed using SAS, version 5.0 (SAS Institute, Inc., Cary, NC).

3. RESULTS (TABLES 1-3)

3.1 Steady Decrease of Abdominal Pressure during Voiding (Fig. 1) (Tables 1-2)

Among the whole population, 145 women (53.5%) had a steady decrease of abdominal pressure from baseline to the time of Q_{max} during the intubated flow among which 73 (26.9%) had a significant decrease (≥5 cmH_2O).

After new evaluation of $p_{det;Qmax}$ taking into account the decrease of $p_{abd.Qmax}$:

- all BOO remained BOO
- among 51 N, 3 had criteria following Gammie's criteria [2] (p_{det}, Q_{max} and BVE) and then gained DU diagnosis.

For these patients with initial UD "normal" the complaint and the decrease of values of contractility characteristics (**k** and PIP1) were as follow:

- complaint UUI, age 75y, from **k** =.326, PIP1 = 33 to **k**=.070, PIP1=21
- complaint MUI, age 72y, from **k** = .257 , PIP1 = 30 to **k**=.153, PIP1= 25
- complaint OTHER, age 68y,from k = .253 , PIP1 = 40 to **k**=.030, PIP1= 22

The decrease of p_{abd} for these three patients was respectively -12, -5 and -18 cm H_2O.

Decrease in **k** and PIP1 values was consistent with DU diagnosis [7, 8].

Change of UD was 3/271 (1.11%) for the whole population and 3/145 (2.07%) for the patients with steady decreasing abdominal pressure during voiding.

3.2 No Change of Detrusor Pressure during Voiding (Tables 1-2)

Forty five (35.7%) patients had no change of detrusor pressure during voiding and thus no change in urodynamic diagnosis.

3.3 Steady Increase of Abdominal Pressure during Voiding (Fig. 1) (Tables 1-2)

Among the whole population, 81 women (53.5%) had an steady increase of abdominal pressure from baseline to the time of Q_{max} during the intubated flow and 52 women (19.2%) had a significant increase (≥5 cmH_2O) in p_{abd} from baseline to the time of Q_{max} resulting in artificially decrease in $p_{det.Qmax}$.

After correction of abdominal pressure and withdrawal of patients who strained, among 5

patients with N diagnosis, 1 gained BOO diagnosis and among 3 patients with DU diagnosis, 1 gained BOO diagnosis.

For these 2 patients the complaint and the changes of values of contractility characteristics (**k** and PIP1) were as follow:

- patient with initial UD "normal":complaint MUI, age 69 y, from **k**=.410, PIP1 = 38 to **k**=.565, PIP1=45
- patient with initial UD "detrusor underactivity" : complaint SUI, age 37y, from **k**=.103, PIP1 =21 to **k**=.472, PIP1=41

Their correction of p_{det} was respectively +7 and +20cm H_2O.

Increase in **k** and PIP1 values was consistent with BOO diagnosis [7, 8].

In total, among 81 patients with steady increase of abdominal pressure during voiding 2 (0.6%) had change in urodynamic diagnosis and mainly gain of BOO diagnosis.

3.4 Influence of Previous Surgery of Incontinence

Thirty eight women had surgery for urinary incontinence: 31 TVT or TOT, 1 Burch while 6 had TVT ablation.

Among these women 9 had significant decrease and 9 significant increase of p_{det} during voiding. None had change in urodynamic diagnosis after correction of $p_{det.Qmax}$.

In total, analysis of changes in abdominal pressure led to 5/271 (1.8%) changes in urodynamic diagnosis.There were no correlation between previous surgery of incontinence and changes in urodynamic diagnosis due to changes in abdominal pressure during the voiding phase. Changes in values of detrusor contractility parameters were consistent with usual values of the new urodynamic diagnoses [8] (Figs. 2-3).

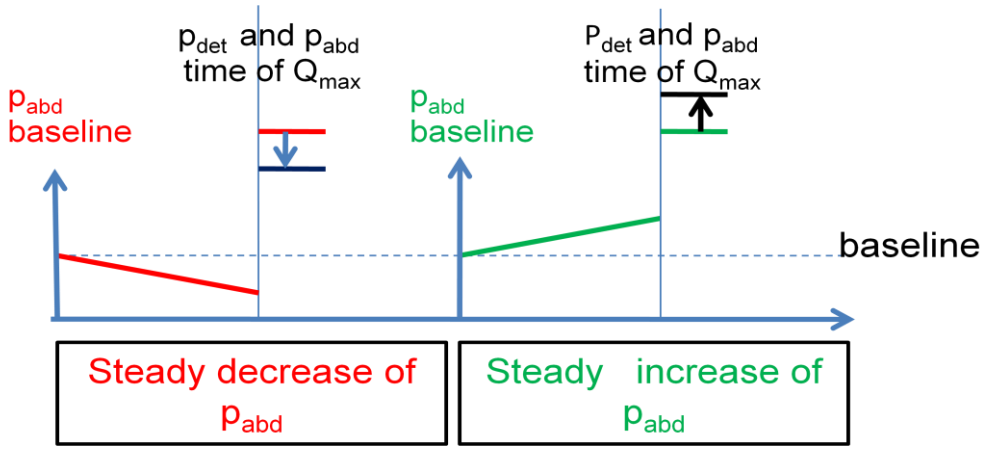

Fig. 1. Steady changes of p_{abd} from baseline during voiding and correction which must be made for p_{det}.

Table 1. Changes of abdominal pressure during voiding

Nbr (number of patients with decrease in p_{abd}) (%) **145 (53.5%)**	**Decrease in p_{abd}** **Unit : cm H_2O**	**Nbr (number of patients with incease in p_{abd}) (/%)** **81 (29.9%)**	**Increase in p_{abd}** **Unit : cm H_2O**
72 (49.6%)	-1 → -4 cm H_2O	29 (35.8%)	1 → 4 cm H_2O
36 (24.8%)	-5 → -9 cm H_2O	17 (21.0%)	5 →9 cm H_2O
22 (15.2%)	-10 → -14 cm H_2O	9 (11.1%)	10→14 cm H_2O
8(5.5%)	-15 → -19 cm H_2O	9 (11.1%)	15→19 cm H_2O
7 (4.8%)	≥ -20 cm H_2O	17 (20.9%)	≥20 cm H_2O

Table 2. Number of patients with change of abdominal pressure during voiding *vs.* main complaint

DAP/IAP	SUI	MUI	UUI	OTHER	P
IAP (81)	10	25	31	15	.6552
No (45)	13	11	11	10	.1167
DAP(145)	32	44	39	30	.6971

DAP: decrease of abdominal pressure; No: unchanged; IAP: increase of abdominal pressure. SUI: stress urinary incontinence; MUI: mixed urinary incontinence: UUI: urge urinary incontinence; OTHER: voiding dysfunction without incontinence

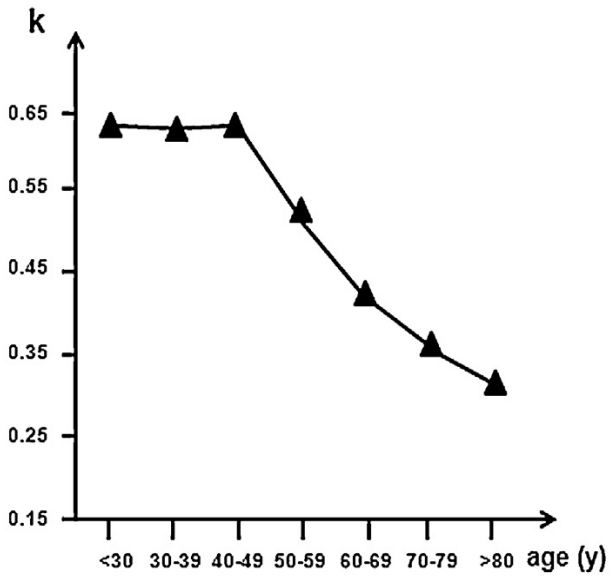

Fig. 2. VBN detrusor contractility k vs. Age

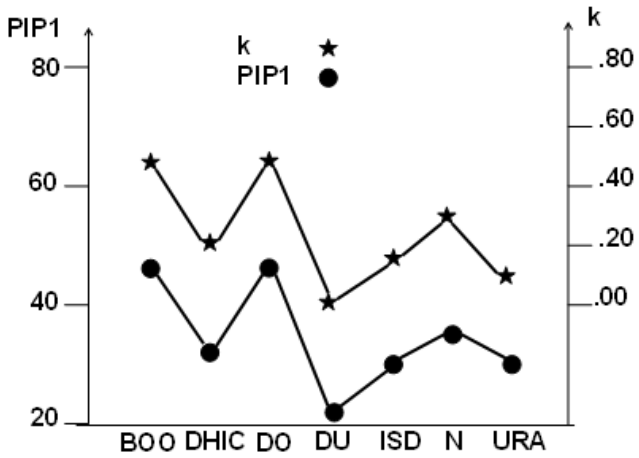

Fig. 3. Values of detrusor contractility parameters (k without unit and PIP1 in cm H_2O) vs urodynamic diagnoses

BOO bladder outlet obstruction; DHIC detrusor hyperactivity with impaired contractility, DO detrusor overactivity, DU detrusor underactivity; N investigations found "normal"; investigations related to urethral dysfunction: intrinsic sphincter deficiency (ISD) and voiding triggered by urethral relaxation (URA)

Table 3. Number of women with changes with steady change of abdominal pressure (increase of abdominal pressure = IAP or decrease of abdominal pressure = DAP; No = no change) *vs.* urodynamic diagnosis (BOO bladder outlet obstruction; DHIC detrusor hyperactivity with impaired contractility, DO detrusor overactivity, DU detrusor underactivity; N investigations found "normal"; investigations related to urethral dysfunction: intrinsic sphincter deficiency (ISD) and voiding triggered by urethral relaxation (URA))

DAP/IAP	BOO	DHIC	DO	DU	ISD	N	URA	p
IAP (Nbr=81)	8	5	20	9	16	16	7	.0344
No (Nbr=45)	8	3	8	5	6	12	3	.8433
DAP(Nbr=145)	18	2	30	13	26	51	5	.7220

4. INTERPRETATION OF THE RESULTS - DISCUSSION

Changes of abdominal pressure during voiding are very frequent in women whether it is decrease or increase. Small fluctuations are frequently due to live signals and are rubbed out with acute examination of the traces. Straining is easily identified and implies pelvic floor contraction.

Our study is interested in the permanent and regular variations during voiding. Muscular relaxation causes decrease of abdominal pressure with consequence a rise of detrusor pressure while rectal contraction causes increase in abdominal pressure with consequence a decrease in detrusor pressure. It is the first study which assesses the exact variations in abdominal pressure during voiding between baseline and the time of maximum flow and, then evaluates the consequences on urodynamic diagnoses. In their study, Valdevenito et al. [9-10] only evaluate the changes due to a decrease of abdominal pressure.

Some decreases and increases are of low amplitude consequently without effect. Due to accuracy of static pressure measurement in urodynamic system [11], a gap of +5 to -5 cm H_2O between the beginning of voiding and the time of Q_{max} is considered as irrelevant. Note that for URA urodynamic diagnosis, after the initial urethral relaxation which triggers voiding, the three options (decrease, statu quo and increase) for evolution of abdominal pressure during voiding can be observed.

In our non neurologic female population, 145 (53.5%) have a decrease of abdominal pressure without association with one complaint and 81 (29.9%) an increase. However, 50.3% of the population with decrease and 64.2% of the population with increase doesn't need detrusor pressure correction; more care should be taken in the population with increase because there are possible straining episodes.

Whereas the different urodynamic diagnoses, two depend of the evaluation of detrusor pressure at maximum flow: bladder outlet obstruction and detrusor underactivity. So, between the urodynamic diagnosis proposed in the initial analysis of the urodynamic testing bladder outlet obstruction and normal urodynamics can be revised with a correction of abdominal pressure in case of abdominal pressure decrease during voiding while normal urodynamics and detrusor underactivity can be revised in case of abdominal pressure increase during voiding. PIP1 and **k** values are of the order of magnitude expected for age and urodynamic diagnosis whether it is a steady decrease or an steady increase of abdominal pressure during the voiding phase [7].

The first limitation of our study is that it is retrospective which induces a bias due to the recruitment of our urodynamic laboratory. Recordings were reviewed independently by two investigators. In case of discrepancy (about10% of the files) an additional interpretation was made jointly to reach a single conclusion.

Other limitation is the use of the VBN contractility parameter k [3, 6] as a detrusor contractility index, and those are primarily related to the voiding performance. As already alluded to, they include a non-interrupted flow until reaching Q_{max} and no significant abdominal straining. These two conditions are applied in the mathematical computation of the **k** index.

5. CONCLUSION

A high percentage of the non-neurologic female population has steady changes of abdominal pressure during voiding the consequence of which may be a urodynamic misdiagnosis. If the

correction of these changes leads to few changes, an evaluation of detrusor contractility parameters values helps to verify the new findings.

CONSENT

As per international standard or university standard, patient(s) written consent has been collected and preserved by the author(s).

ETHICAL APPROVAL

This study was conducted in accordance with the Declaration of Helsinki. According to the local practice of Ethics Committee, there is no formal Institutional Review Board approval required for retrospective studies.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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