

# **DETERMINING THE IDEAL INDEX FOR ASSESSING DETRUSOR CONTRACTILITY IN WOMEN : INSIGHTS FROM URODYNAMIC DIAGNOSIS AND AGE**

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## **ABSTRACT**

### **Aims**

Detrusor contractility governs the voiding process. Its evaluation in women derived from an intubated flow is obtained from the contractility indices PIP1 and the VBN-derived parameter k. Both values of PIP1 and k are dependent of the urodynamic diagnosis (UD) and decrease with aging. Our goal was to find out if one of these indexes was more informative depending on UD and age.

### **Methods**

Contractility was evaluated from pressure-flow studies of 354 non-neurologic women (age range 20-96 y) who were referred for investigation of various lower urinary tract dysfunctions and who fulfilled criteria for inclusion: non-interrupted flow, voided volume >100 mL and  $Q_{max} > 2\text{mL/s}$ .

UD were bladder outlet obstruction (BOO), detrusor hyperactivity with impaired contractility (DHIC), detrusor overactivity (DO), detrusor underactivity (DU). Some

investigations were found “normal” (N) and other related to urethral dysfunction (intrinsic sphincter deficiency (ISD)) or voiding triggered by urethral relaxation (URA)). Data were interpreted across age-groups with 20 years interval, at least 3 patients with one UD in a given age-group interval.

## **Results**

Among all the UD, only 2 did not have a sufficient number of patients to be reported: DHIC for 20-40y and URA for >80y. For each UD, variations of k and PIP1 demonstrated a decrease with age, which was more important for k in the age group >80y (compared with all age groups). Age-groups 20-40 and 41-60 gave comparable values of k and PIP1 for UD BOO, DO and DU. Analysis of percentage of contractility value variation showed a more important and significant decrease for k vs. PIP1 between age-groups 61-80 and >80 for all UD ( $p=.0028$ )

## **Conclusions**

If both detrusor contractility indexes have values well related to urodynamic diagnosis which decrease with age, use of k is more informative than PIP1 in elderly women.

**Key word: urodynamic diagnosis , elderly women, intravesical pressure ,bladder**

## **INTRODUCTION**

Detrusor contractility governs the voiding process. Definition of detrusor contractility remains confused as its two aspects depend partially of pressure (strength of the detrusor contraction) and partially of flow (contraction adequately sustained). Thus evaluation of detrusor contractility in women remains a great challenge mainly because definition of contractility is not simple and also because first attempts to define a contractility index in women were mostly derived from the evaluation of detrusor contractility in men.

“Assessment of detrusor contractility can be made from isometric testing or pressure-flow studies. Various indexes have been proposed: firstly the Watts factor (WF) introduced by Derek Griffiths well correlated with maximum isovolumetric contraction pressure but needing sophisticated computations and with poor reproducibility, secondly a simplified approach the projected isovolumetric pressure (PIP) based on the linearized bladder output relation which obeys the formula  $PIP = p_{det.Q_{max}} + K \cdot Q_{max}$  where K value is  $5 \text{ cmH}_2\text{O/mL}\cdot\text{s}^{-1}$  proposed by Werner Schafer” [1, 2]. “To obtain a coefficient without dimension, Werner Schafer defined DECO which is the ratio  $PIP/100 \text{ cmH}_2\text{O}$ . PIP was later called bladder contractility index (BCI)” by Paul Abrams [3].

Tan et al. observing that “the PIP index proposed for men led to a great overestimation of detrusor contractility in women introduced a modified projected isovolumetric pressure where K value is  $1 \text{ cmH}_2\text{O/mL}\cdot\text{s}^{-1}$ :  $PIP1 = p_{det.Q_{max}} + Q_{max}$ ” [4]. PIP1 has been defined for “elderly” women (range 53-89 years old) suffering from “urge incontinence”.

The VBN, mathematical model of miction [5] introduced “the parameter k, which characterized detrusor contractility”. “Then a nomogram, based on this mathematical model, was proposed to calculate the detrusor contractility in women from a pressure-flow study (PFs)” [6].

If PIP1 has been proposed for older women, parameter k was defined regardless of age or gender. In addition, evaluation of parameter k takes into account the bladder volume at initiation of voiding.

It has been demonstrated that PIP1 and the VBN-derived parameter k produced comparable and consistent results, that their values decreased with ageing and

were dependent of the urodynamic diagnosis (UD) [6]. Our goal was to find out if one of these contractility indices was more informative depending on UD with age.

## **METHODS**

Of urodynamic studies of women referred for investigation of various lower urinary tract dysfunctions in one practice, contractility was retrospectively evaluated from pressure-flow studies of 354 consecutive non-neurologic women (age range 20-96 y) who fulfilled criteria for inclusion.

Exclusion criteria were diabetes, grade >2 prolapse, previous pelvic floor surgery and MMSE  $\leq$  20.

Detrusor contractility parameters (PIP1 and VBN parameter k) were mainly derived from  $p_{det.Qmax}$  and  $Q_{max}$ , measured during IF; VBN parameter k also needed to know initial bladder volume (Vini). Voided volume was measured during IF and post void residual volume (PVR) using a Bladder-scan. So Vini was calculated by adding the PVR to the voided volume.

Thus, women unable to void during the PFS, with an interrupted flow, a voided volume less than 100 mL or who expelled their urethral catheter during the PFS were excluded.

“Urodynamic investigations were carried out according to the International Continence Society Good Urodynamic Practices, using a urodynamic unit from Laborie (Mississauga Canada). Filling cystometry was performed, with saline at room temperature at a medium filling rate of 50 mL/min“. [7] Filling cystometrogram was obtained via a triple lumen urethral catheter 7F allowing for urethral pressure recording and followed by an intubated flow (IF). PFS started as the patient was

given the “permission to void”; detrusor and urethral pressures, and urine flow rate were recorded during the whole voiding phase.

UD was posed according to the ICS/IUGA recommendations [8]: “bladder outlet obstruction (BOO), detrusor hyperactivity with impaired contractility (DHIC), detrusor overactivity (DO), detrusor underactivity (DU). Some investigations were found “normal” (N) and other related to urethral dysfunction (intrinsic sphincter deficiency (ISD)) or voiding triggered by urethral relaxation (URA)). The data was interpreted across age groups with 20 years interval, unless the UD was present in less than 3 patients in a given age group interval“.

Criteria for urodynamic diagnoses were: BOO:  $Q_{max} < 12$  mL/s and  $p_{detQmax} > 25$  cmH<sub>2</sub>O [9], DO: occurrence of Non-Inhibited Detrusor Contraction  $\geq 5$  cmH<sub>2</sub>O during filling [10], DHIC: same as DO during filling and underactive detrusor during voiding [11], DU: In absence of real consensus  $p_{detQmax} < 20$  cmH<sub>2</sub>O,  $Q_{max} < 15$  mL/s, high  $t_{mic}$  [12], N: no symptom reproduced during the assessment, ISD: low MUCP [13-14], and/or positive VLPP [15], URA: voiding triggered by urethral relaxation.

Main complaints were incontinence: stress (SUI), mixed (MUI), urge (UUI); some complaints did not involve incontinence (OTHER).

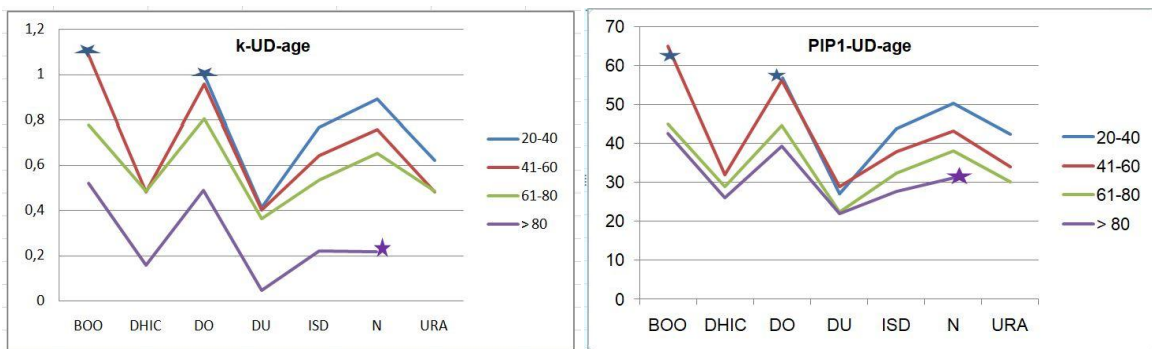
## **STATISTICAL ANALYSIS**

Data were presented as mean  $\pm$  SD. Analysis of variance (ANOVA), *t* test, and the Chi<sup>2</sup> test were used as appropriate. Post-hoc analysis was done to explore differences between multiple groups means. Analyses were performed on the overall study population and stratified by age. All statistical results were considered significant at  $P < 0.05$ . Statistical analyses were performed using SAS, version 5.0 (SAS Institute, Inc., Cary, NC).

## RESULTS

Among all UD, only 2 did not have a sufficient number of patients to be reported: DHIC for 20-40y and URA for > 80y. Variations of k and PIP1 for each UD demonstrated a decrease with age, which was more important for k in the age group > 80y (compared with all age groups). Age-groups 20-40 and 41-60 gave comparable values of k and PIP1 for UD BOO, DO and DU (figure 1).

Analysis of percentage of contractility value variation for all UD showed a decrease for k vs. PIP1 for all age-groups but that decrease was more important and significant only between age-groups 61-80 and >80 (mean  $58.6 \pm 20.1$  vs  $10.4 \pm 5.8$ ,  $P=0.0028$ ).



**Figure 1:** variation of value of detrusor contractility indices with age and urodynamic diagnosis. k is without unit, PIP1 in  $\text{cmH}_2\text{O}$ ; stars show gaps (no DHIC for 20-40 y; no URA for >80 y).

## DISCUSSION

“Recently, Fry and Gammie proposed a detrusor contractility parameter (DCP) also named  $t_{20-80}$  (time interval between detrusor pressure rising from 20 to 80% of its value once the flow starts)” [16]. “Unfortunately, this proposed indice

is seldom relevant because of inherent limitations in the urodynamic tracing, including the need for very high quality urodynamic tracings" [17].

The Watts Factor calculation is difficult without a computer and its value has poor reproducibility.

"In our study, evaluation of PIP1 is obtained from coordinates ( $p_{det.Q_{max}}$  and  $Q_{max}$ ) of a remarkable point of the intubated flow, i.e. the point of maximum flow. Evaluation of the VBN contractility parameter  $k$  is also obtained from the values of the coordinates of this point but take into account the filling volume ( $V_{ini}$ ,  $p_{det.Q_{max}}$  and  $Q_{max}$ ) to use the nomogram. This finding is novel as PIP1 has only been studied so far in a group of elderly females (53-89 years old) suffering from urge urinary incontinence" [4]. "Instead, in our study, 41 of 143 women younger than 55 years complained of urge incontinence. So our study could broaden the age range for which PIP1 can be used for detrusor contractility measurements. Lastly, there are limitations to the use of  $k$  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. Although these two conditions were applied in the mathematical computation of the  $k$  index, to our knowledge they have not been evaluated in the development of PIP1". [4]

## **CONCLUSION**

If both detrusor contractility indexes, PIP1 and VBN parameter  $k$ , have values well related to urodynamic diagnosis which decrease with age, use of  $k$  is more informative than PIP1 in elderly women.

**Ethical Approval:**

As per international standards or university standards written ethical approval has been collected and preserved by the author(s).

**Conflict of interest:** all authors report no conflict of interest

## **REFERENCES**

- 1-Tan TL, Bergmann MA, Griffiths D, Resnick NM. Stop test or pressure-flow study? Measuring detrusor contractility in older females. *Neurourol Urodyn* 2004; 23: 184-9.
- 2- Schäfer W. Analysis of bladder outlet function with the linearized passive urethral resistance relation, linPURR, and a disease-specific approach for grading obstruction: from complex to simple. *World J Urol* 1995; 13: 47–58),
- 3- Abrams P. Bladder outlet obstruction index, bladder contractility index and bladder voiding efficiency, three simple indices to define voiding function. *BJU Int* 1999; 84: 14-5.
- 4- Tan TL, Bergmann MA, Griffiths D, Resnick NM. Stop test or pressure-flow study? Measuring detrusor contractility in older females. *Neurourol Urodyn* 2004; 23: 184-9
- 5- Valentini FA, Besson GR, Nelson PP, Zimmern PE. A mathematical micturition model to restore simple flow recordings in healthy and symptomatic individuals and enhance uroflow interpretation. *Neurourol Urodyn* 2000; 19: 153-76.
- 6- Valentini FA, Marti BG, Robain G, Zimmern PE, Nelson PP. Comparison of indices allowing an evaluation of detrusor contractility in women. *Prog Urol.* 2020; 30: 396-401.

- 7- Rosier PFWM, Schaefer W, Lose G, Goldman HB, Guralnick M, Eustice S, Dickinson T, Hashim H. International continence society good urodynamic practices and terms 2016: urodynamics, uroflowmetry, cystometry, and pressure-flow study. *NeurourolUrodyn* 2017; 36: 1243-1260. doi: 10.1002/nau.23124
- 8- Haylen BT, de Ridder D, Freeman RM, Swift SE, Berghmans B, Lee J, Monga A, Petri E, Rizk DE, Sand PK, Schaer GN. An international urogynecological association (IUGA)/international continence society (ICS) joint report on the terminology for female pelvic floor dysfunction. *NeurourolUrodyn* 2010; 29: 4-20.
- 9-DefreitasGA ,Zimmern PE, Lemack GE, Shariat SF. Refiningdiagnosis of anatomicfemalebladderoutlet obstruction: comparison of pressure-flow studyparameters in clinicallyobstructedwomenwiththose of normal controls. *Urology*. 2004; 64: 675-9 doi: 10.1016/j.urology.2004.04.089.
- 10- Abrams P, Cardozo L, Fall M, Griffiths D, Rosier P, Ulmsten U, van Kerrekroeck P, Victor A, Wein A. The standardisation of terminology of lowerurinary tract function: Report from the Standardisation Sub-committee of the International Continence Society. *NeurourolUrodyn*. 2002; 21: 167-178. doi: 10.1002/nau.10052
- 11-Resnick NM, Yalla SV. Detrusorhyperactivitywithimpaired contractile function. An unrecognized but common cause of incontinence in elderly patients. *JAMA*.1987;257:3076-81. doi: 10.1001/jama.257.22.3076
- 12-Gammie A, Kaper M, Dorrepaal C, Kos T, Abrams P. Signs and symptoms of detrusorunderactivity: An analysis of clinicalpresentation and urodynamic tests from a large group of patients undergoing pressure flow studies. *EurUrol*. 2016;69: 361–369. doi: 10.1016/j.euro.2015.08.014
- 13-Rud T. Urethral pressure profile in continent womenfromchildhood to oldage. *Acta ObstetGynecolScand*. 1980;59: 331-335.

14. Kapoor DS, Housami F, White P, Swithinbank L, Drake M. Maximum urethral closure pressure in women: Normative data and evaluation as a diagnostic test. *Int Urogynecol J.* 2012;23:1613– 1618. doi: 10.1007/S00192-012-1770-7
- 15- Burden H, Warren K, Abrams P. Leak point pressures: How useful are they? *Curr Opin Urol.* 2005;25:317-322
- 16- Fry CH, Gammie A, Drake MJ, Abrams P, Kitney DG, Vahabi B. Estimation of bladder contractility from intravesical pressure-volume measurements. *Neurourol Urodyn* 2017; 36: 1009-14, doi.org/10.1002/nau.23047.
- 17- Valentini FA, Nelson PP. RE: Fry CH, Gammie A, Drake MJ, Abrams P, Kitney DG, Vahabi B. Estimation of bladder contractility from intravesical pressure-volume measurements. *NAU* doi 10.1002/nau.23047. *Urodyn* 2017; 36:1944-45. doi 10.1002/nau.23201