

## VOIDING EFFICIENCY: A NEW METHOD OF ASSESSING BLADDER EMPTYING FUNCTION IN WOMEN

### Hypothesis / aims of study

Assessment of bladder emptying is an important component in evaluating the emptying phase function of the lower urinary tract. Traditionally, post-void residual volume (PVR) has been used as one of the key parameters to assess bladder emptying. To our knowledge, it has never been established that an absolute value of PVR is an accurate and consistently reliable measurement of adequate bladder emptying. We define voiding efficiency (VE) as a percentage of volume voided compared to the pre-void bladder volume. The primary aim of this study of normal pre-menopausal women was to determine if voiding efficiency represents a clinically meaningful way of assessing bladder emptying function. Secondly, we evaluated voids during the proliferative and secretory phases of the menstrual cycle to observe differences in VE during these two phases, and to compare VE with the widely used PVR.

### Study design, materials and methods

Premenopausal volunteers were recruited for this prospective cohort study. Included were women between 18-45 years old with no previous anti-incontinence/urinary tract surgery, previous hysterectomy, reported urinary tract infections during the previous 3 months, previously identified abnormalities of the lower urinary tract (e.g., congenital anomalies) and no systemic hormonal birth control. Uninstrumented uroflowmetry studies were performed. During the first visit (proliferative phase), immediately upon completion of a spontaneous void (void I), the participants underwent catheterization to measure the post-void residual urine volume. The catheter was retained in the bladder which was filled with 400mL of normal saline. The catheter was removed, and the subjects were instructed to void for a second time (void II) in the uroflowmeter. The same sequence was repeated at a second visit (secretory phase), which allowed for a total of four voids per subject.

### Results

Median VE's for both voids were consistently over 90% (void I = 91.7% and void II = 94.8%). Medians for PVR's were less than 50mL (void I = 35mL and void II = 25mL). When comparing void I in both phases to void II, there was a significant difference in voiding efficiencies (92% versus 95%, respectively,  $p=0.01$ ). A similar trend was found for the PVR's: a significantly lower PVR was found for void II as compared to void I (40.3mL versus 60.9mL,  $p=0.03$ ) respectively. Voiding efficiencies by phase of menstrual cycle showed no differences when comparing phases ( $p=0.57$ ). There were no statistically significant differences in maximal flow rates, average flow rates, time-to-maximal flow, and voiding times when comparing phases and individual voids by sequence (void I to void II).

### Interpretation of results

To date there are no universally accepted parameters to assess efficiency of the emptying phase of the lower urinary tract (LUT). Historically, the PVR of urine has been used to determine any degree of urinary retention and /or incomplete bladder emptying. However, use of the PVR has been purely anecdotal and without scientific substantiation. Moreover, abnormally elevated PVR have been expressed in absolute terms, such as greater than 50mL or 100mL. Unfortunately, this approach does not take into account this PVR as compared to the volume of urine in the bladder at the start of micturition. More recently several studies have proposed more methodical ways to assess the normalcy of bladder emptying. Although the term "voiding efficiency" (VE) has been proposed previously, it has described the PVR as a percent of residual urine in men with various obstructive conditions and irritative symptoms[1]. Other investigators proposed bladder voiding efficiency (BVE). They described BVE to be a product of bladder contractility against urethral resistance and measured according to the degree of bladder emptying[2,3]. In this study we propose a simple, accurate, reliable and clinically applicable measurement of bladder emptying function. Our approach intentionally seeks to avoid the inclusion of more complex indices, such as detrusor muscle contractility. Thus, we define VE as follows:

$$VE (\%) = \text{voided volume (mL)} / \text{pre-micturition volume (mL)} \times 100$$

The denominator in this equation is determined by the sum of the volume of urine voided plus the PVR. To establish normative data we recruited healthy volunteers with no known pathologic conditions of the LUT, or situations that might have impacted negatively on LUT function, such as use of hormonal contraception, post-menopausal status, irregular menstrual cycles, diabetes, etc.

### Concluding message

In conclusion, our findings have persuaded us that bladder VE is a clinically meaningful method of assessing bladder emptying function. We consider women with a VE of greater than or equal to 90% to be normal. We acknowledge that further studies would be helpful to help us understand how VE can be used to differentiate between normal and non-normal subjects.

### References

1. Bosch R, Kranse R, et al. Dependence of male voiding efficiency on age, bladder contractility and urethral resistance: Development of a voiding efficiency nomogram. *J. Urol* 1995;154:190-194.
2. Abrams P. Bladder outlet obstruction index, bladder contractility index and bladder voiding efficiency: three simple indices to define bladder voiding function. *BJU International* 1999;84:14-15.
3. Abrams P, Griffiths D. The assessment of prostatic obstruction from urodynamic measurements and from residual urine. *Br J Urol*. 1979;51:129-134.

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|   | department of OB/Gyn.   |
| <i>Is this a clinical trial?</i>                        | No  |
| <i>What were the subjects in the study?</i>             | HUMAN   |
| <i>Was this study approved by an ethics committee?</i>  | Yes   |
| <i>Specify Name of Ethics Committee</i>                 | Research Subjects Review Board of the University of Rochester |
| <i>Was the Declaration of Helsinki followed?</i>        | Yes   |
| <i>Was informed consent obtained from the patients?</i> | Yes   |