

## ADJUSTING FOR THE EFFECT OF 24-HOUR VOLUME IMPROVES BLADDER DIARY DETECTION OF DECREASED VOIDED VOLUME IN DETRUSOR OVERACTIVITY

### Hypothesis / aims of study

Voided volume decreases with age and increases with increasing 24-hour volume ( $V_{24}$ ) [1,2]. We have developed a new method of removing the influence of both age and  $V_{24}$  on voided volume when comparing a patient's voided volume to a reference population. This study's objective was to determine if adding voided volume to the age adjustment improves the "detection" of decreased voided volume in women with detrusor overactivity ("DO").

### Study design, materials and methods

We report average voided volume ( $V_{avg}$ ) as representative of the bladder diary voided volume measurement. Three-day bladder diaries were collected from a "reference population" of 161 asymptomatic (by questionnaire) women (Age: median = 47; range = 20-82 years) and 29 female patients with DO demonstrated by provocative cystometry (Age: median = 57; range = 29-80 years). We also selected from the reference population a "control group" of 29 age- and race-matched asymptomatic women. An electronic bladder diary system that uses intelligent character recognition to enter data from handwritten paper diaries into a computer (Life-Tech, USA) was used to analyze the data. Our method of adjusting a patient's voided volume for its relationship to age and  $V_{24}$  was as follows: (1) a "regression equation" expressing the reference measurement's relationship to age and  $V_{24}$  was obtained by multiple regression; (2) a frequency distribution of the differences between the actual reference measurements and their values predicted by the regression equation (the "reference residuals") was constructed; (3) the difference between the patient's voided volume and its value predicted by the regression equation (the "patient residual") was calculated; (4) the patient's measurement was reported as a percentile within the reference population by determining the patient residual's position within the frequency distribution of the reference residuals. To test the efficacy of adding  $V_{24}$  to the age adjustment, percentiles of patient voided volumes adjusted only for age were also obtained.

### Results

As Figure 1 shows, adjusting for the effect of  $V_{24}$  on  $V_{avg}$  produced a dramatic decrease in  $V_{avg}$  percentiles within the DO patient population. With the  $V_{24}$  adjustment, 48.3% of the  $V_{avg}$  percentiles in the DO population were below the tenth reference percentile compared to only 13.8% of the unadjusted DO percentiles. As Figure 2 shows, the strong tendency for  $V_{avg}$  to increase with increasing  $V_{24}$  seen in asymptomatic subjects is also present in the DO population. However, the DO data points tend to lie below the control data points.

### Interpretation of results

Figure 2 provides insight into why adjusting for the  $V_{24}$  relationship increases detection of decreased  $V_{avg}$  in DO patients. The  $V_{avg}$  vs.  $V_{24}$  relationship in DO patients tends to push the  $V_{avg}$ s of DO patients with high  $V_{24}$ s well up into the range of reference  $V_{avg}$  values. However, if the  $V_{avg}$  vs.  $V_{24}$  relationship is removed, the  $V_{avg}$  measurements from DO patients with high  $V_{24}$ s tend to lie near the bottom of the reference range. Arrow # 1 in Figure 2, which identifies the data point of a DO patient with classical urge incontinence symptoms, illustrates this effect. This patient's high  $V_{24}$  (3,276 ml) pushed her unadjusted  $V_{avg}$  into the control group's 65<sup>th</sup> percentile, thus producing a "false-negative" result. In contrast, when adjustment removes the  $V_{avg}$  vs.  $V_{24}$  relationship, the patient's  $V_{avg}$  lies near the fifth control group percentile (the lower dashed line). As demonstrated by arrow # 2 in figure 2, removing the  $V_{avg}$  vs.  $V_{24}$  relationship's effect on  $V_{avg}$  also decreased the incidence of false positives among asymptomatic subjects who happened have a low  $V_{24}$ . The asymptomatic volunteer's data point identified by arrow # 2 is below the fourth percentile of the raw control population, but after adjusting for the fact that the subject's  $V_{24}$  is only 700 ml, the her data point is only a little

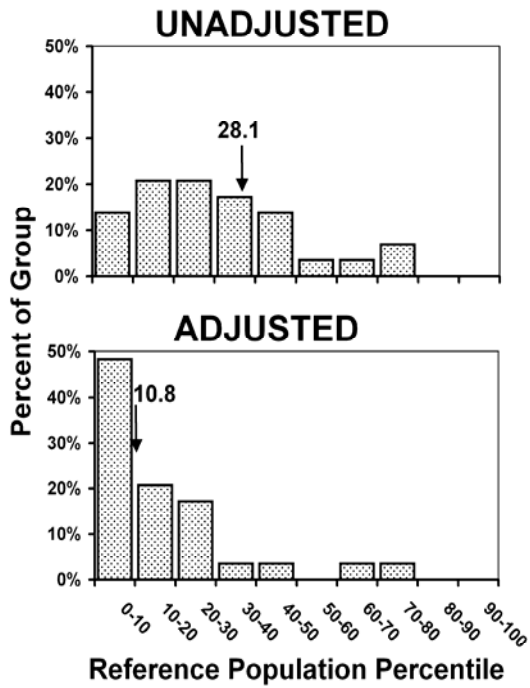
below the control group's 50<sup>th</sup> percentile line.

### Concluding message

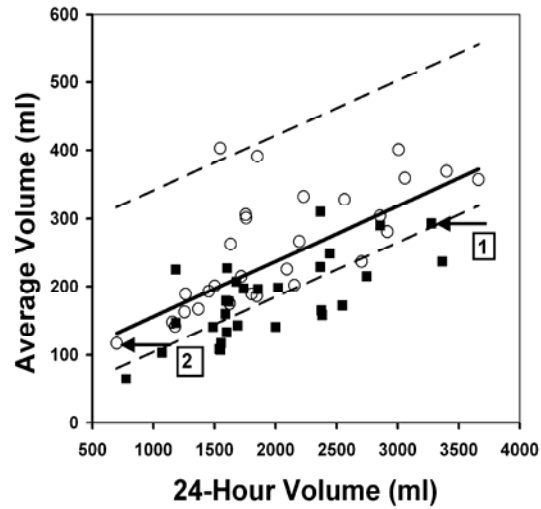
Removing the strong relationship between voided volume and 24-hour volume increased both the sensitivity and specificity with which voided volume measurements from our DO patients were separated from reference measurements. However, even with this adjustment, only 48% of  $V_{avg}$  measurements from our DO patients fell below the 10th percentile of the reference population. Therefore, we suggest that the  $V_{24}$ - and age-adjusted bladder diary voided volume measurements be reported as reference population percentiles, as is the custom with clinical measures, such as height and weight, that do not separate "normal" from "abnormal" very effectively.

### References

1. BJU International **93**: 1257, 2004
2. [www.icsoffice.org/publications/2005/PDF/0138.PDF](http://www.icsoffice.org/publications/2005/PDF/0138.PDF).



**Figure 1:** Effect of adjusting patients'  $V_{avg}$  reference percentiles for their  $V_{24}$  relationships. The arrows show median percentiles.



**Figure 2:** Scatter plots of  $V_{avg}$  vs.  $V_{24}$  data-points from 29 DO patients (solid squares) and age-matched controls (open circles) with superimposed control 50<sup>th</sup> (solid) and 5<sup>th</sup> and 95<sup>th</sup> (dashed) percentile lines. Data points identified by arrows are discussed in the text.

percentile lines. Data

**FUNDING:** Life-Tech

**DISCLOSURES:** Parsons: Research grant from Life-Tech. Amundsen: Research grant from Life-Tech. Cardozo: Research grant from Life-Tech. Vella: None. Webster: Consultant to Life-Tech

**HUMAN SUBJECTS:** This study was approved by the Duke University Medical Center, Institutional Review Board and Kings College Hospital Ethics Committee and followed the Declaration of Helsinki Informed consent was obtained from the patients.