

Authors: S. Carter, J. Ockrim, M. Kojima, T. Miki, A. Marronaro, R. Renzetti, A. Tubaro
Institution: Departments of Urology, Imperial College School of Medicine, Kyoto Prefectural University of Medicine, L'Aquila University
Title: THE STANDARDISATION OF BLADDER VOLUME MEASUREMENT BY ULTRASONOGRAPHY.

Aims of Study:

The measurement of bladder volume (BV) is an important parameter in the evaluation of lower urinary tract function. Many critical clinical decisions are made on the measurement of capacity or residual volume (PVR). It is recognised that PVR is a variable figure depending on the individual void and also because the techniques of measurement are unsatisfactory. There are 4 possible opportunities for error of measurement: 1) Inaccurate imaging, 2) Inaccurate measurement, 3) Imprecise computation of the volume, 4) Inaccurate measurement of the residual by catheter as the comparator. As part of an our effort to set standards in imaging of the urinary tract as it refers to function, we evaluated some of the errors associated with measurement of BV.

Methods :

A total of 125 male patients were studied, during formal urodynamic testing. At the end of the study the bladder was filled by a random volume. Images of the midline sagittal and largest transverse sections of the bladder were obtained 3 times by an individual observer (intraobserver test) in 100 patients and by 3 different observers (interobserver test) in 25 patients. The actual bladder volume (BV CATH) was measured by aspiration through the 8 Fr urodynamic catheter, until the bladder was shown to be empty by ultrasound. All ultrasound pictures were digitised, the cranio-caudal, latero-lateral and antero-posterior diameters were obtained using the Scion graphic package by a single investigator. The cranio-caudal diameter of the bladder was measured on the midline sagittal section in two different ways: as the distance from the internal meatus to the apex and as a true distance relative to the anterior abdominal wall. Two different ultrasound estimated bladder volumes were derived (BV-USS A and BV-USS B, respectively) using the ellipsoid formula (bladder height x width x length x 0.52).

Results:

Bladder volume values, as measured by in-and-out catheterisation under ultrasound control, covered the entire physiological range of residual urine volume (20 to 650 mls).

Table I -	Mean	SD	Minimum	Maximum
BV cath (mls)	240.5	121.5	20.0	650
BV-USS A (mls)	242.1	132.2	29.5	1008.9
BV-USS B (mls)	230.1	117.4	32.2	839.2

No significant difference was found between the mean bladder volume values obtained 3 times by a single

observer and by 3 independent observers to investigate intra-observer and interobserver variability, respectively.

Table II	Variability	Volume 1	Volume 2	Volume 3	#p≤
	Intraobserver	229 +/- 113	231 +/- 112	234 +/- 127	0.5787
	Interobserver	131 +/- 73	129 +/- 66	143 +/- 94	0.1222

Anova test for repeated measures

Ultrasound estimated bladder volumes estimated with the two different cranio-caudal values, were found to be significantly different. Analysis of variance suggested that the BV-USS estimated measuring the cranio-caudal diameter distance from the internal meatus to the apex was, overall, a more accurate estimation of BV.

Table III	Mean Diff. (mls)	#P-Value	95% C.I. (mls)	Range (mls)
BV CATH minus BV USS A	-3.1	0.4523	-11.3 to 5.1	-309.6 to 92.1
BV CATH minus BV USS B	10.2	0.0084	2.6 to 17.7	-357.7 to 89.7
BV USS A minus BV USS B	-14.6	<0.0001	-18.6 to -10.6	

Student's t-test for paired data

Although the mean difference between BV-cath and BV-USS A or B was found to be not significantly different, the range of the observed difference suggest how the ultrasound estimation can be significantly different from the real bladder volume in an individual patient. The higher accuracy of BV-USSB was particularly evident for BV-cath values of 150 mls or greater. Ultrasound estimation of bladder volume was in the range of ± 50 mls of the real value obtained by in-and-out catheterisation in >87% of patients.

Conclusions:

We were able to effectively standardise several of the errors of measurement. In this study we have reduced the error of catheterised bladder volume measurement by using simultaneous ultrasound to check emptying. It seems that there are few if any errors to be made by taking the two images of the bladder provided that the operator is properly trained. Errors of measurement between different observers are also likely to be minimal (to be tested in a separate study). It is evident that the bladder is not an ellipsoid and indeed at some levels of filling the bladder assumes a triangular section or conical shape and as a result the technique of measurement of cranio-caudal length seems important.

If simple standards for measurement of bladder volume are adhered to the accuracy can be increased. At least these practices should be specified in clinical trials but probably ought also be used in clinical practice.

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