Smart Bladder White Paper

Automated Bladder Volume Measurement

mindray
NORTH AMERICA

Background

Bladder volume is often measured for various clinical reasons, most commonly to assess for signs of urinary retention. The incidence of acute urinary retention has been estimated as 3.0 to 6.8 cases per 1000 person-years in the general male population.[1] Causes of urinary retention include obstruction, infection, pharmacologic, iatrogenic, and neurogenic processes, with prostatic enlargement being the most common cause of acute urinary retention.[1] In critically ill patients, bladder volume may also be measured as a way to evaluate for signs of urine production.

Indication	Note
Concern for Urinary Retention	Usually performed as a pre and post void residual
Evaluation of Urine Production	Usually performed in critical ill patients to monitor for urine production

Figure 1: Clinical Indications for Bladder Volume Estimation

Cause	Examples
Obstruction	Narrowing or compression of the urinary tract ex. BPH, malignancy, calculi, stricture
Infectious	Genitourinary infections such as bacterial or sexually transmitted diseases
Neurogenic	Compression of nerve roots or spinal cord, post ischemic stroke, detrusor areflexia
Iatrogenic	Recent surgery, urinary strictures
Pharmacologic	Anticholinergics, antihistamines, antipsychotics, etc.

Figure 2: Causes of Urinary Retention[1]

Traditionally, a foley catheter would be inserted to measure bladder volume. However, this procedure is painful, invasive and carries a risk of infection.[2] Ultrasound has since become a valuable tool for assessing urinary retention by estimating post-void residual bladder volume. Two methods of using ultrasound are through the use of an automated bladder scanner and point of care ultrasound (POCUS).[2] With an automated bladder scanner, the operator places a transducer over the patient's anterior pelvis, and the device automatically estimates the bladder volume.[2] However, the challenge with this method is the requirement of a separate device requiring additional training and maintenance. Additionally, these devices have limited visualization of what is being measured; potentially leading to inaccurate volume measurements. POCUS, on the other hand, is a noninvasive and safe way to estimate bladder volume. Studies have shown good intra- and inter-reliability with ultrasound measurement of bladder volume.[3] However, there is a gap in training amongst medical professionals, an area where automation could offer valuable assistance.

Clinical Values

The bladder volume is clinically estimated using the ellipsoid formula for volume, which involves multiplying depth, width, height, and a constant factor of 0.52.[3] A curvilinear probe is placed transversely just above the pubic symphysis with the indicator towards the patient's right. The bladder is identified as a distinct anechoic structure, and the probe is fanned through the pelvis to obtain the largest transverse view of the bladder. The height and width of the bladder are then measured. Next the probe is rotated to the sagittal position with the indicator positioned towards the patient's head and fanned left to right to obtain the largest sagittal view of the bladder. The depth of the bladder is measured from this view. The measurements are then entered into the formula. Alternatively, dual-screen mode on the ultrasound can be used to obtain measurements simultaneously.

Elliptical Volume: Height x Width x Depth x 0.52

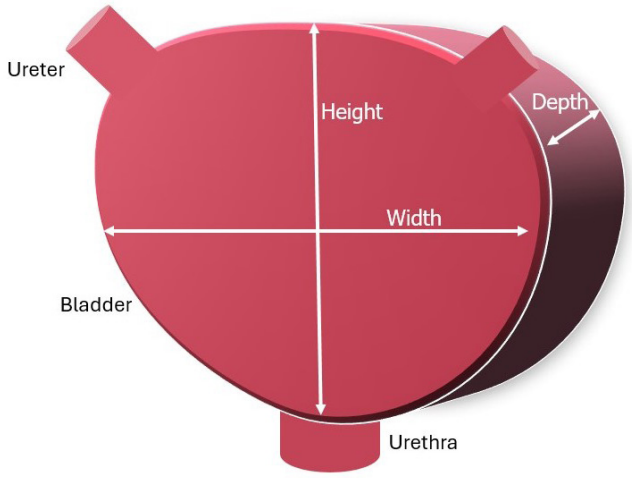

Figure 3: Bladder Volume Measurement

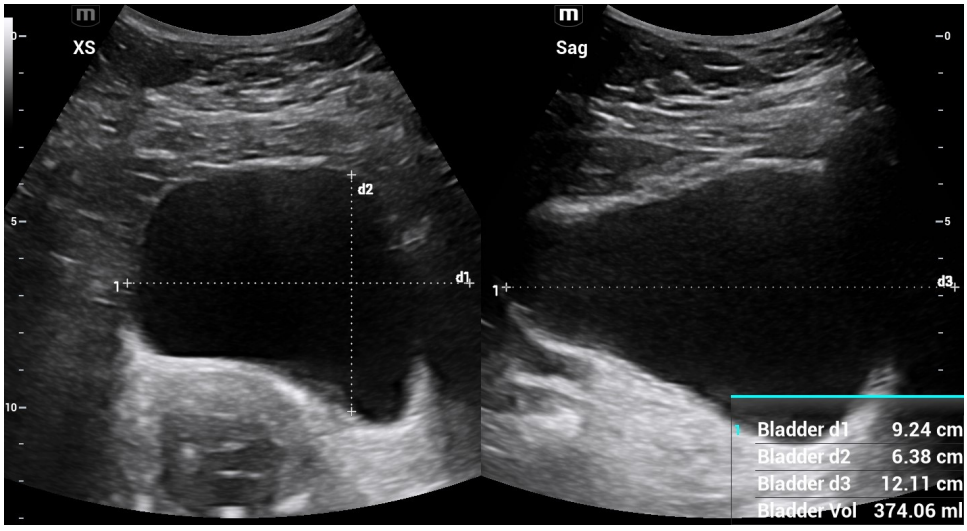

Figure 4: Dual screen image of the bladder in transverse and sagittal plane

There is no universally accepted definition of urinary retention. However, acute obstruction usually defined by a post void residual >200 mL.[2] The American Urologic Association consensus statement on chronic urinary retention describes >300 mL to be significant.[1]

Technology Introduction

Smart Bladder automatically positions the calipers for the bladder dimensions. The outline of the bladder in both the transverse and sagittal orientation is used by pattern recognition method in a still B mode image. The algorithm automatically acquires the measurements for the bladder height, width and depth in a still B mode image. Smart Bladder supports both single and dual image measurements.

Data Collection Methodology

We evaluated the Smart Bladder function in comparison to the traditional bladder scanner in 50 emergency department patients with a body mass index (BMI) over 30. This BMI threshold was selected to represent a more technically challenging assessment.

Analysis

We found that the mean measurement error for the Smart Bladder was below the 100 mL threshold, and at lower, clinically relevant bladder volumes, it showed greater accuracy. While there was no significant difference in measurement accuracy compared to the traditional bladder scanner, Smart Bladder proved more efficient than POCUS, reducing the steps needed to obtain a bladder volume from 10 to six. Additionally, users reported that it was user-friendly and benefited the department by eliminating the need to learn and maintain a separate device for bladder volume assessment.

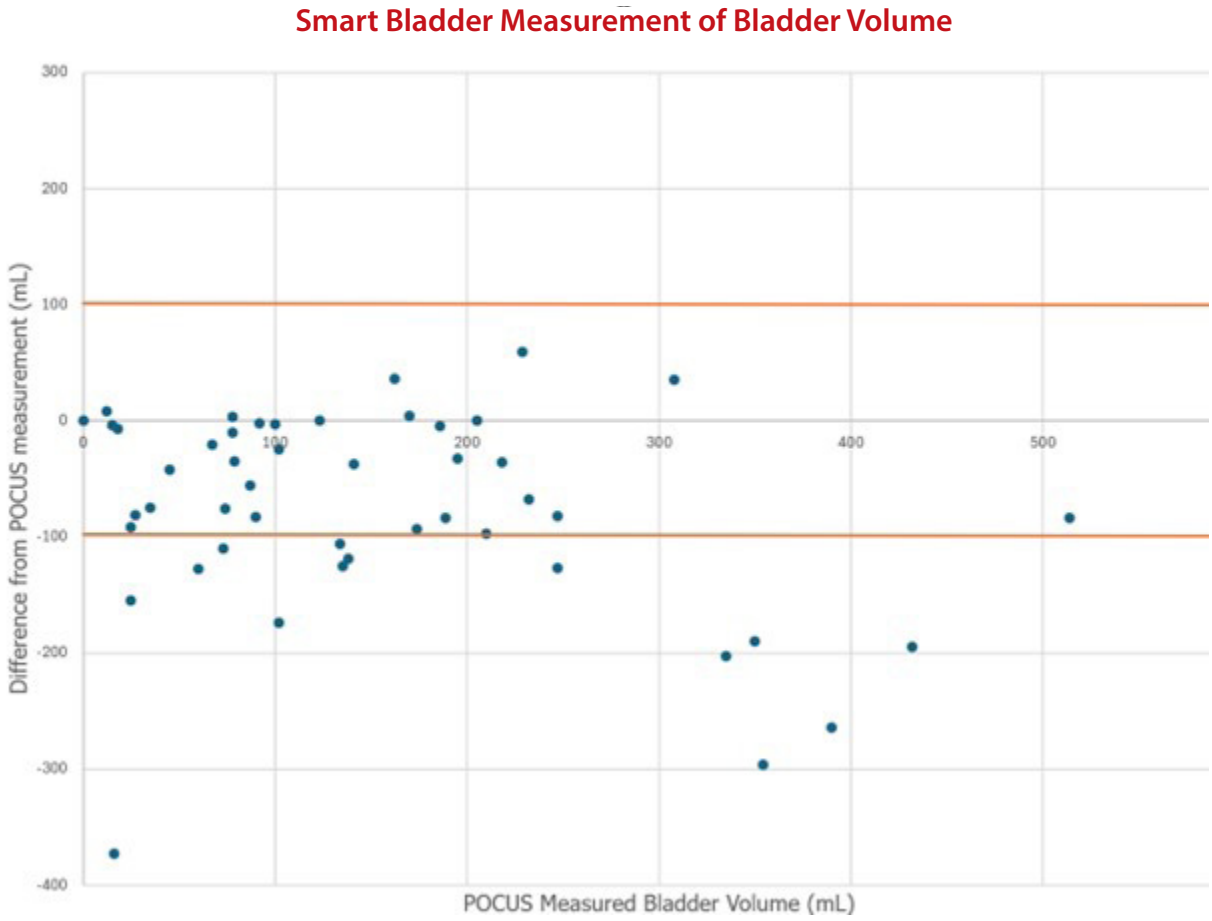

Figure 5: Bland-Altman Chart

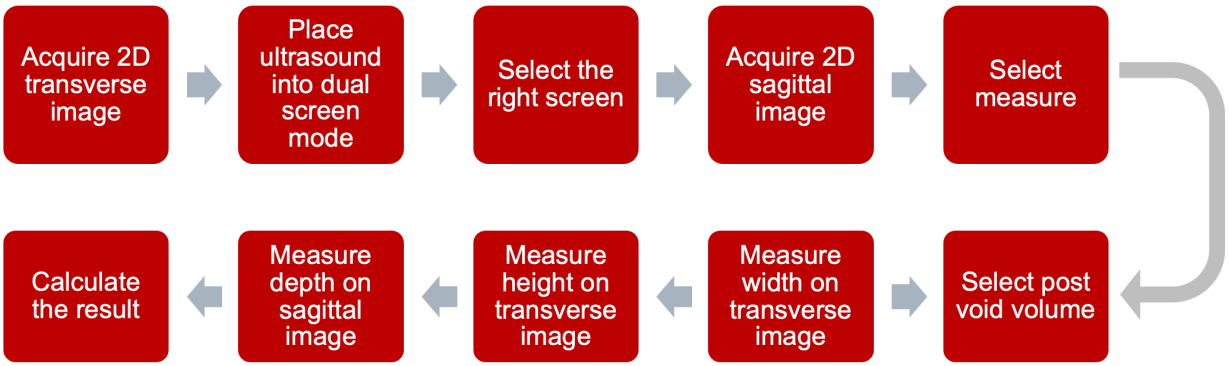

Figure 6: Traditional ultrasound bladder volume measurements

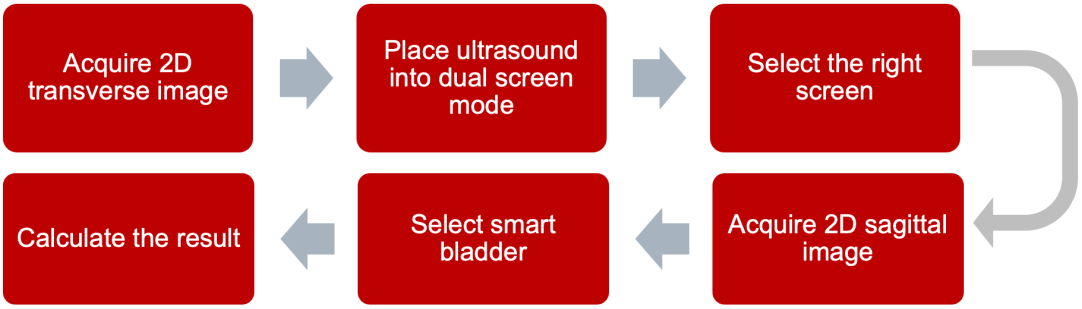

Figure 7: Procedure through Smart Bladder

Smart Bladder calculates and displays the bladder volume in milliliters. It is essential to review caliper placement, as we observed an increase in error with obscured bladder borders leading to an overestimation of bladder volume. To ensure accurate measurement, users are advised to obtain a clear image and adjust the caliper lines to measure the widest portion of the bladder in both the transverse and sagittal views.

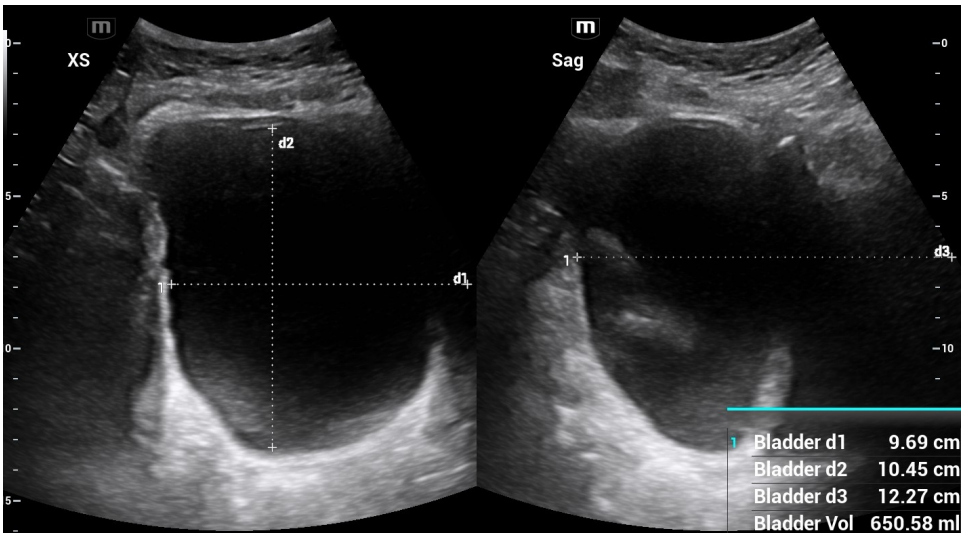

Figure 8: Smart Bladder overestimation with obscured boarder in the sagittal view

Conclusion

- Smart Bladder Technology demonstrated no statistically significant difference compared to a traditional bladder scanner but offered advantages in efficiency and reduced equipment needs within the department
- Evaluate post void bladder volume when there is concern for urinary retention
- Use Smart Bladder in single or dual screen mode
- Smart Bladder decreases steps for bladder volume measurement as compared to POCUS

Acknowledgments

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References

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