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THE ROLE OF ULTRASOUND ESTIMATED BLADDER WEIGHT IN THE DIAGNOSIS OF BLADDER OUTLET OBSTRUCTION: A STUDY FROM SOUTHERN INDIA

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ABSTRACT **Introduction:** Lower urinary tract symptoms (LUTS) are common in aging men, often linked to benign prostatic enlargement (BPE) and bladder outlet obstruction (BOO). Accurate diagnosis of BOO is essential, traditionally reliant on invasive urodynamic studies. This study explores ultrasound estimated bladder weight (UEBW) as a non-invasive diagnostic tool for BOO. **Materials And Methods:** A prospective study was conducted at the Karnataka Institute of Medical Sciences, Hubballi, from January 2021 to June 2022, involving 120 male patients aged over 50 presenting with obstructive LUTS. Parameters such as bladder volume (BV), prostate volume (PV), bladder wall thickness (ABWT), uroflowmetry (Qmax), and post-void residual (PVR) were measured. Bladder weight (BW) was estimated using ultrasound. Statistical analysis included mean ± standard deviation and Pearson's correlation coefficient. **Results:** Participants' mean age was 64 years. UEBW ranged from 20g to 60g, with a mean of 38g. The diagnostic accuracy of UEBW in identifying BOO was high, with a threshold of 39.5g yielding 96.6% sensitivity and 98.3% specificity. PVR volumes greater than 50ml showed 100% sensitivity and 98% specificity for predicting BOO. **Conclusion:** UEBW is an effective non-invasive diagnostic parameter for bladder outlet obstruction, providing a reliable alternative to traditional methods. Its implementation could enhance diagnostic accuracy and patient management, reducing the need for invasive procedures in the evaluation of obstructive LUTS in Southern India.

KEYWORDS : bladder outlet obstruction, weight,prostatic hyperplasia

INTRODUCTION:

Lower urinary tract symptoms (LUTS) are increasingly prevalent in aging individuals. In men, LUTS often prompt investigations for benign prostatic enlargement (BPE) and bladder outlet obstruction (BOO), typically linked to benign prostatic hyperplasia (BPH)[1]. However, LUTS alone cannot definitively diagnose BPE or BOO, requiring further evaluation[2].Bladder outlet obstruction (BOO) is a significant urological condition that can lead to various complications, including urinary retention, recurrent urinary tract infections, and renal impairment. The accurate diagnosis of BOO is crucial for timely intervention and management. Traditionally, urodynamic studies have been considered the gold standard for diagnosing BOO; however, these invasive procedures can be cumbersome and uncomfortable for patients. Therefore, there is a growing interest in non-invasive diagnostic methods that can accurately assess bladder function and detect obstruction.Ultrasound estimated bladder weight (UEBW) has emerged as a promising non-invasive technique for evaluating bladder conditions. This method measures the bladder's weight based on its dimensions and wall thickness, providing valuable insights into bladder distension and function. Recent studies have suggested that UEBW may correlate well with the presence of BOO, offering a simpler and safer alternative to traditional diagnostic methods.Uroflowmetry is a cost-effective and simple test that assesses voiding function but lacks specificity, as it cannot differentiate between bladder outlet obstruction and detrusor underactivity. [3]Conversely, pressure-flow studies are the gold standard for diagnosing BOO, providing essential information on detrusor contractility and obstruction. However, these urodynamic tests are invasive, costly, and require specialized training and equipment.

The search for a non-invasive diagnostic test for bladder outlet obstruction (BOO) has led to investigations of various parameters, including free uroflowmetry, post-void residual volume, and prostate volume【4】. Recent interest has focused on bladder wall thickness and weight, as BOO is associated with detrusor hypertrophy and increased wall thickness due to smooth muscle hypertrophy and collagen deposition【5】.Ultrasound is the simplest and least invasive method for measuring bladder wall thickness, visualizing it as a three-layer structure with the hypoechogenic detrusor muscle between two hyperechogenic layers【6】. Studies have primarily measured the anterior bladder wall, while some have examined the posterior wall using transrectal or transvaginal ultrasound【9】. Overall, findings indicate no significant differences in thickness across the bladder wall【10】【11】.A challenge with measuring bladder wall thickness is its dependence on bladder volume; thickness decreases as volume increases. Oelke et al. found that detrusor wall thickness (DWT) significantly dropped during the first 250 ml of bladder filling【8】. This led researchers to explore bladder wall weight as a more stable measure of hypertrophy across varying bladder volumes. This study aims to explore the role of ultrasound estimated bladder weight in the diagnosis of bladder outlet obstruction among patients in Southern India. By evaluating the efficacy of UEBW in comparison to conventional diagnostic modalities, this research seeks to establish its potential as a reliable tool in the clinical setting. Given the prevalence of urological disorders in this region, understanding the utility of UEBW could enhance diagnostic accuracy, improve patient management, and reduce the burden of invasive procedures.

MATERIALS AND METHODS

STUDY DESIGN AND SETTING

A prospective study was conducted from January 2021 to June 2022 at the Karnataka Institute of Medical Sciences, Hubballi. The study involved 120 male patients aged above 50 years, who presented to the outpatient department with obstructive lower urinary tract symptoms (LUTS).

INCLUSION CRITERIA

- Male patients aged >50 years.
- Patients presenting with obstructive LUTS.

EXCLUSION CRITERIA

- Patients with previous bladder surgeries or urological interventions.
- Patients with neurogenic bladder or other neurological disorders affecting bladder function.
- Patients with active urinary tract infections (UTIs).

STUDY PROCEDURE

PATIENT PREPARATION

All patients were advised to present with a comfortably full bladder for the ultrasound assessment. They were asked to avoid voiding for at least 2 hours prior to the ultrasound examination.

ULTRASOUND EVALUATION

A transabdominal ultrasound was performed in a full bladder state to measure the following parameters:

BLADDER VOLUME (BV): The ellipsoid formula was used for

calculating bladder volume, expressed as BV = 0.523 × length × width × height (in cm). These dimensions were measured using a standard transabdominal ultrasound technique.

PROSTATE VOLUME (PV): Prostate volume was also calculated using the ellipsoid formula, PV = 0.523 × anteroposterior diameter × transverse diameter × longitudinal diameter (in cm).

BLADDER WALL THICKNESS MEASUREMENT

ANTERIOR BLADDER WALL THICKNESS (ABWT): The anterior bladder wall thickness was measured in centimeters using the ultrasound, recorded during the full bladder state. The anterior wall was selected to ensure consistency and to avoid variability in thickness across bladder sections.

UROFLOWMETRY ASSESSMENT

All patients underwent uroflowmetry using the Status Uroflowmeter. The following uroflowmetry parameters were recorded:

MAXIMUM FLOW RATE (QMAX): Measured in mL/sec.

VOIDED VOLUME: Volume of urine expelled during the flowmetry test.

POST-VOID RESIDUAL VOLUME MEASUREMENT

Post-void residual (PVR) urine was measured using transabdominal ultrasound after the patient voided. The residual volume was recorded in milliliters to assess incomplete bladder emptying.

BLADDER WEIGHT CALCULATION

After voiding, post-void residual (PVR) urine was measured using ultrasound to assess incomplete bladder emptying. Finally, bladder weight (BW) was calculated based on the recorded bladder volume and anterior wall thickness, applying the formula: BW = (BV × ABWT) ÷ 3. This non-invasive approach was used to estimate bladder weight and assess bladder outlet obstruction in all patients.(Figure 1)

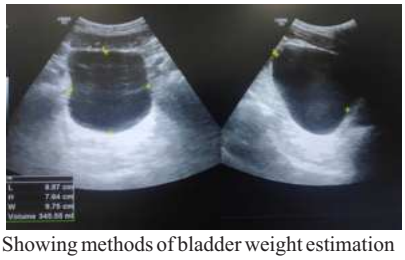

Figure 1: Showing methods of bladder weight estimation

STATISTICAL ANALYSIS

The collected data were analyzed using appropriate statistical methods. Continuous variables, such as bladder wall thickness, bladder weight, and uroflowmetry parameters, were summarized using mean ± standard deviation. Pearson's correlation coefficient was used to assess the relationship between bladder weight and the severity of bladder outlet obstruction.

RESULTS

The study included 120 male patients with an age range between 52 and 72 years. The mean age of the participants was 64 years ±4.99, with age variance was 24.7, reflecting the overall variability in age across the sample.

UROFLOW MAXIMUM FLOW RATE (QMAX)

The maximum urinary flow rate (Qmax) ranged from 6 mL/sec to 18 mL/sec, with a mean value of 13.7 mL/sec. The standard deviation was 2.99, indicating moderate variability in the maximum flow rate among patients. The variance was 8.95, reflecting the spread of Qmax values within the sample.

POST-VOID RESIDUAL VOLUME (PVR)

The post-void residual (PVR) urine volume varied significantly among participants, ranging from 10 mL to 120 mL. The mean PVR was 51.5 mL, with a large standard deviation of 35.6, highlighting considerable variability in residual urine volume after voiding. The variance of 127.6 further emphasizes this high variability.

BLADDER WALL THICKNESS (ABWT)

The bladder wall thickness ranged from 0.21 cm to 0.4 cm, with a mean thickness of 0.25 cm. The standard deviation was 0.056, indicating low variability in bladder wall thickness across patients. The variance of 0.003 demonstrates minimal differences in the measured thickness among the study group.

ULTRASOUND-ESTIMATED BLADDER WEIGHT (UEBW)

Bladder weight, estimated using ultrasound, ranged from 20 g to 60 g. The mean bladder weight was 38 g, with a standard deviation of 10.6, showing moderate variation in bladder weights. The variance was 111, suggesting considerable differences in bladder weights among the participants.

PROSTATE VOLUME

Prostate volume measured using ultrasound varied from 20 mL to 42 mL, with a mean of 29.2 mL. The standard deviation was 5.3, indicating some variability in prostate size. The variance of 28.5 further supports the moderate variability in prostate volumes among the patients.

BLADDER OUTLET OBSTRUCTION INDEX (BOOI)

The Bladder Outlet Obstruction Index (BOOI) ranged from 14 to 54, with a mean value of 30.5. The standard deviation was 13.4, showing a high degree of variability in the BOOI scores across patients. The variance was 180, reflecting the spread of obstruction indices within the study group.(Table 1)

Table 1: Showing Clinical and Ultrasound Parameters in Patients with Bladder Outlet Obstruction

Parameter	Min	Max	Mean	SD	Variance
Age (years)	52	72	64	4.99	24.70
Maximum Flow Rate (Qmax, mL/sec)	6	18	13.7	2.99	8.95
Post-Void Residual Volume (mL)	10	120	51.5	35.6	127.6
Bladder Wall Thickness (cm)	0.21	0.4	0.25	0.056	0.003
Estimated Bladder Weight (g)	20	60	38	10.6	111
Prostate Volume (mL)	20	42	29.2	5.3	28.5
Bladder Outlet Obstruction Index	14	54	30.5	13.4	180

ULTRASOUND ESTIMATED BLADDER WEIGHT (UEBW) IN DIAGNOSING BLADDER OUTLET OBSTRUCTION

The data comparing the UEBW between non-obstructed and obstructed patients indicates high diagnostic accuracy. Out of the 120 patients, 60 were classified as non-obstructed, with 58 accurately identified as non-obstructed, while 2 were misclassified as obstructed. Similarly, of the 60 patients classified as obstructed, 59 were correctly identified, with only 1 misclassified as non-obstructed (Table 2). This minimal misclassification demonstrates that UEBW is an effective and reliable diagnostic tool for differentiating between obstructed and non-obstructed cases of bladder outlet obstruction. An Ultrasound Estimated Bladder Weight (UEBW) greater than 39.5 grams demonstrated a sensitivity of 96.6%, a specificity of 98.3%, and an overall diagnostic accuracy of 97.5% in predicting bladder outlet obstruction in patients with obstructive lower urinary tract symptoms.

THE POST-VOID RESIDUAL (PVR) DATA RELATED TO BLADDER OUTLET OBSTRUCTION:

The analysis of Post-Void Residual (PVR) volumes in relation to bladder outlet obstruction revealed significant findings. In the non-obstructed group, 60 patients were identified as having normal PVR volumes, while only one patient was classified as obstructed. Conversely, among the obstructed group, none of the patients had a non-obstructed PVR, indicating a clear correlation between elevated PVR and bladder outlet obstruction. Overall, this data suggests that a high PVR is indicative of obstruction, as all 59 obstructed patients presented with elevated residual volumes, emphasizing the utility of PVR measurements in diagnosing bladder outlet obstruction in patients with obstructive lower urinary tract symptoms. A post-void residual urine volume greater than 50 ml showed 100% sensitivity, 98% specificity, and 99% diagnostic accuracy for predicting bladder outlet obstruction in the obstructed group.(Table 2)

DIAGNOSTIC ACCURACY OF BLADDER WEIGHT THRESHOLD IN DIFFERENTIATING OBSTRUCTED AND NON-OBSTRUCTED PATIENTS:

Among 60 non-obstructed patients, 54 were correctly classified as

non-obstructed based on BWT, while 6 were misclassified as obstructed. All 60 patients in the obstructed group were accurately identified. This indicates that BWT is highly effective in distinguishing between non-obstructed and obstructed patients, with only minor misclassification occurring in the non-obstructed group, suggesting excellent diagnostic performance in identifying bladder outlet obstruction. A bladder wall thickness greater than 0.25 cm demonstrated 90% sensitivity, 100% specificity, and 95% diagnostic accuracy in predicting bladder outlet obstruction within the obstructed group.

Table 2: Findings for PVR, bladder weight threshold (BWT), and bladder wall thickness in relation to bladder outlet obstruction.

Diagnostic Parameter	Non-Obstructed Group	Obstructed Group	Total	Sensitivity	Specificity	Diagnostic Accuracy
Post-Void Residual (PVR) Volume >50 ml	60 correctly identified	59 correctly identified, 1 misclassified	120	100%	98%	99%
Bladder Weight Threshold (BWT)	54 correctly identified, 6 misclassified	60 correctly identified	120	90%	100%	95%
Bladder Wall Thickness >0.25 cm	-	-	-	90%	100%	95%

DISCUSSION

This study aimed to assess the diagnostic utility of ultrasound-estimated bladder weight (UEBW) and post-void residual (PVR) volume in predicting bladder outlet obstruction (BOO) in male patients presenting with obstructive lower urinary tract symptoms (LUTS). Our results provide valuable insights into the efficacy of these parameters, particularly in a Southern Indian population.

BLADDER WEIGHT THRESHOLD IN PREDICTING BLADDER OUTLET OBSTRUCTION

Our study showed that an ultrasound-estimated bladder weight (UEBW) of greater than 39.5 grams demonstrated a high sensitivity of 96.6%, specificity of 98.3%, and diagnostic accuracy of 97.5%. These findings are in line with previous studies that have highlighted the utility of UEBW in diagnosing BOO. For instance, Oelke et al. (2007) [12]reported that UEBW had a similar diagnostic profile, emphasizing that bladder weight is a robust marker for BOO in patients with LUTS . The minimal misclassification in our study further underscores the reliability of UEBW, as only 2 non-obstructed patients were wrongly categorized as obstructed, and only 1 obstructed patient was misclassified as non-obstructed. This level of diagnostic performance compares favourably with the findings from a study by Kojima et al. (1997), [13]which reported comparable accuracy, further supporting UEBW as an effective non-invasive tool for assessing bladder function.

POST-VOID RESIDUAL VOLUME AND BLADDER OUTLET OBSTRUCTION

Our analysis of post-void residual (PVR) volumes indicated that a residual volume of greater than 50 mL had 100% sensitivity, 98% specificity, and 99% diagnostic accuracy in predicting BOO. This echoes the findings of several studies, such as the work by McConnell et al. (2002),[14] which identified elevated PVR as a strong predictor of BOO in patients with obstructive LUTS . Our results also align with the study by van Venrooij et al. (2014),[15] which suggested that elevated PVR measurements are highly indicative of obstruction, particularly when combined with other clinical parameters such as uroflowmetry . In our cohort, all 59 obstructed patients presented with elevated PVR volumes, which supports the concept that increased residual urine is a hallmark of obstruction. This finding is crucial, as PVR measurements can easily be obtained through non-invasive ultrasound, making it a practical tool for routine clinical assessment of BOO.

BLADDER WALL THICKNESS AND DIAGNOSTIC ACCURACY

The bladder wall thickness (BWT) measurement also proved useful in diagnosing BOO, with a threshold greater than 0.25 cm showing 90% sensitivity, 100% specificity, and 95% diagnostic accuracy. This is consistent with the results reported by Oelke et al. (2006),[5] who demonstrated that increased BWT is significantly associated with BOO in patients with LUTS . The low variability in bladder wall thickness among patients in our study highlights its reliability as a diagnostic marker, similar to the findings of other studies that have used BWT as part of their diagnostic criteria for BOO .

In comparison to other studies, our findings confirm the robust nature of ultrasound-based parameters in diagnosing BOO. A study by Miyashita et al. (2010)[16] also demonstrated the utility of combined ultrasound metrics, including UEBW and PVR, in effectively identifying patients with BOO, showing results that are comparable to ours in terms of diagnostic accuracy . Furthermore, the high diagnostic accuracy of 97.5% for UEBW in our study parallels the findings from a review by Abrams et al. (2009),[17] which noted that non-invasive measures such as bladder weight and residual urine volumes offer clinicians reliable tools for assessing obstruction without the need for more invasive procedures like urodynamic studies .

CONCLUSION

Our study findings concludes that the use of ultrasound-estimated bladder weight, post-void residual volume, and bladder wall thickness as reliable, non-invasive diagnostic tools for predicting bladder outlet obstruction. These parameters, particularly UEBW, demonstrated high sensitivity, specificity, and diagnostic accuracy in differentiating between obstructed and non-obstructed patients. Our study's outcomes are consistent with those of other published studies, underscoring the role of these ultrasound-based measurements in improving the diagnostic process for patients with obstructive lower urinary tract symptoms. Further research with larger cohorts is recommended to validate these findings across different populations.

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