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Original Article

Obstetrics and Gynaecology Section

# Diagnostic Accuracy of Urine Volume Estimation by Ultrasound to Prevent Unnecessary Catheterisation in the Intrapartum Period: A Cross-sectional Study

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## ABSTRACT

**Introduction:** Catheterisation for urinary retention could cause bacteriuria and even frequent Urinary Tract Infection (UTI), especially in a traumatised urethra and bladder wall. Currently, there are no recommended non invasive ways to assess urinary retention in laboring women other than clinical estimation by palpation. Ultrasonography (USG) is a good non invasive diagnostic aid for measuring bladder volume in the intrapartum period, thereby avoiding unnecessary urinary catheterisation.

**Aim:** To assess the diagnostic accuracy of USG, estimation of urine in comparison to actual catheterised volume in antenatal women in labour and not in labour.

**Materials and Methods:** This was a cross-sectional study done in the Department of Obstetrics and Gynaecology at Christian Medical College, Vellore, Tamil Nadu, India, from February 2018 to August 2021. The present study was done on 405 females out of which 211 women, who were not in labour and 194 women who were in labour. Bladder volume was measured by using an abdominal portable basic ultrasound machine. A palpable bladder was also assessed clinically, by palpation and percussion and both these measurements were compared to the actual volume of urine at catheterisation. The Intraclass Correlation Coefficient (ICC) for methods of estimation of urine volume was done. To find the association between groups and study variables. Chi-square test and Fisher's-exact test were used.

**Results:** The mean age of the study participants was 28.29±4.6 (group 1) and 25.95±4.2 (group 2). A total of 405 women were recruited with 211 women in group 1 (not in labour) and 194 women in group 2 (in labour). Clinical examination for predicting palpable bladder with urine volume of more than 150 mL showed a sensitivity of 80-90% and a specificity of 3-5%. Comparison of ultrasound estimation of bladder volume and actual urine volume showed an intraclass correlation of 0.88 (95%CI:0.86-0.90, p<0.001) in both not in labour and in labour group.

**Conclusion:** Estimation of urine volume by USG revealed an excellent association with catheter measurement for the prediction of a significant bladder volume, requiring catheterisation.


**Keywords:** Bladder scan, Bladder volume, In labour, Not in labour

## INTRODUCTION

Bladder dysfunction and UTIs are commonly seen in women during pregnancy, especially in the intrapartum and postpartum periods [1,2]. It is known that, massive distension of the urinary bladder impairs its contractility and function [3]. Women in established labour are encouraged to void frequently, in order to avoid overdistension and damage of the detrusor muscle [3,4]. Catheterisation for urinary retention could cause bacteriuria, especially in a traumatised urethra and bladder wall [5]. The use of regional/epidural anaesthesia can make micturition difficulties more pronounced [6,7]. Emptying the bladder before instrumental delivery is a prerequisite. Urinary catheterisation remains a gold standard for measurement and monitoring of bladder volume, but this is invasive and uncomfortable and may lead to UTI [8].

Currently, there are no recommended non invasive diagnostic tools to diagnose urinary retention in laboring women. Ultrasound can serve as a good non invasive alternative for measuring bladder volume in the intrapartum period. Many studies have documented the accuracy of ultrasound estimation of bladder volume [8-10]. Very few studies have been done in the intrapartum period [10,11]. No studies have been done in Vellore, Tamil Nadu region. Moreover, ultrasound estimation of urine before catheterisation to avoid unnecessary catheterisation is not commonly practiced. Therefore, the objective of the present study was to compare the ultrasound estimation of urine with the actual volume of urine obtained after catheterisation. The efficacy of clinical diagnosis of urinary retention, the method currently used to diagnose residual urine in most delivery suites, was also assessed in the present study.

## MATERIALS AND METHODS

This was a cross-sectional study conducted in the Department of Obstetrics and Gynaecology at Christian Medical College, Vellore, Tamil Nadu, India, from February 2018 to August 2021. The study was approved by the Institutional Ethical committee {IRB Min. No. 11104 (OBSERVE) dated 10.01.2018} Women at term with a single viable foetus and cephalic presentation were counseled about the study and consented to the same.

**Sample size calculation:** The required sample size to show a association of about 0.65 units in the urine volume between US and actual bladder volume was found to be 211 women with 90% power and 5% level of significance. Agreement of urine output also showed a similar sample size of about 210 women with 90% power and 5% level of significance when the anticipated ICC was considered to be 0.65 units. Hence, it was decided to study 215 women for each group in the present study.

**Inclusion criteria:** The authors included two groups, group 1 comprised of antenatal women not in active labour requiring elective catheterisation before caesarean section, or women needing urinary output monitoring, while administering $MgSo_4$ for the management of severe preeclampsia. Group 2 included women, who required urinary

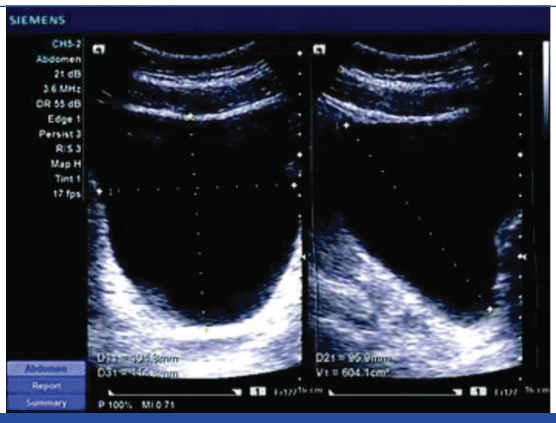
catherisation prior to operative vaginal delivery, for a prolonged period of more than 4 hours after the last void, inability to void or for a clinically diagnosed distended bladder. These two groups were included in the study to assess the use of ultrasound, to estimate the urine volume in women in labour, and those not in labour.

**Exclusion criteria:** Preterm pregnancies, multiple gestations, malpresentations, caesarean sections for emergency conditions such as, foetal distress, abruption, placenta previa, or impending scar dehiscence and women with multiple scars on the abdomen, preventing easy estimation of urine with ultrasound were excluded.

### Study Procedure

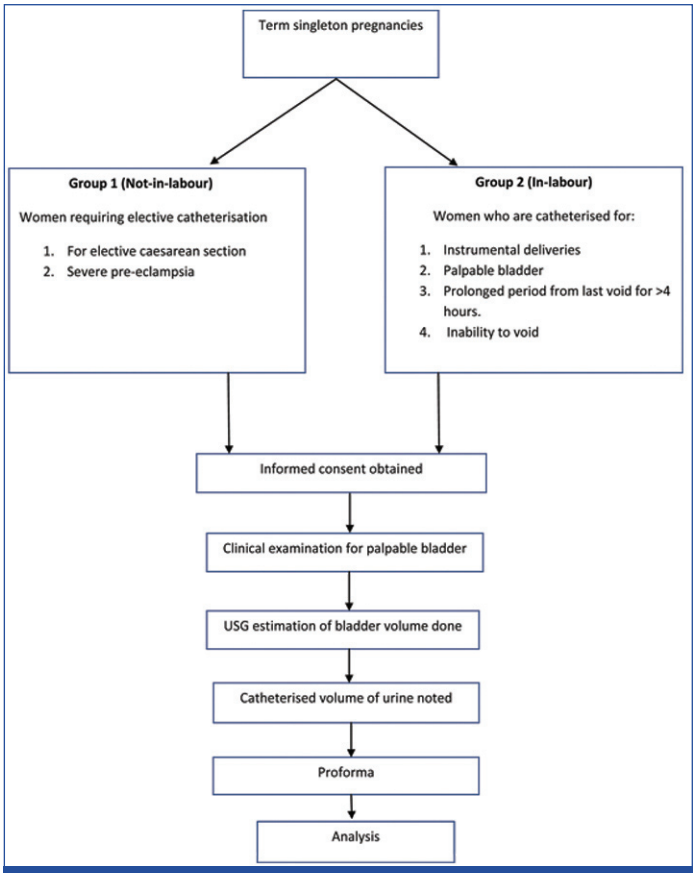
All women who fulfilled the inclusion criteria and who were planned for catheterisation due to any of the above reasons underwent a clinical examination of bladder volume, involving palpation and percussion. This was followed by catheterisation and measuring the actual volume. It has been described that in the general population, 15% of women have Post-void Residual Volume (PVR) greater than 50 mL, 6% greater than 149 mL, and 4% greater than 200 mL [12,13]. The first urge to void is felt when bladder volume reaches 150 mL. A similar study in the past have analysed urinary volumes above 300 mL and its association [11]. However, the recent International Federation of Gynecology and Obstetrics (FIGO) group guidelines [14], recommended that volumes greater than 150 mL should be considered as abnormal, hence, the cut-off of 150 mL was taken as a normal PVR in the present study. The bladder volume by ultrasound and the actual urine volume were divided into categories of <150 mL, 150 mL to 300 mL, 300 mL to 600 mL, and >600 mL instead of measuring urine as absolute quantity to make the inference more clinically relevant. Method of bladder volume estimation: Clinical method used for the diagnosis of palpable bladder was identifying a bogginess in the suprapubic area of the abdomen. This was confirmed by the presence of dullness on percussion, which was absent if the bladder was empty.

The bladder volume by ultrasound was measured using a 3.5 Hz transducer and a curvilinear probe in a split-view image with transverse and sagittal planes. In the transverse view, the probe was adjusted and the volume was measured to get the maximum longitudinal (L) and horizontal (W) diameter. Then the probe was rotated 90°, to measure the height of the bladder in the sagittal plane giving the antero-posterior diameter (H). The total volume of the bladder (V=LxWxH) was calculated using the prolate ellipsoid formula which was in-built in the ultrasound machine. [Table/Fig-1] shows the ultrasound image used to calculate bladder volume. [Table/Fig-2] represents the flowchart of the methodology.




**[Table/Fig-1]:** Total volume of bladder measurement by ultrasound.

In order to avoid interobserver variation, two doctors with basic ultrasound scanning experience received training from an experienced senior obstetrician in the use of ultrasound in the labour ward. The first 20 patients were scanned by both the junior doctor and the senior obstetrician in order to ensure consistency and diagnostic accuracy.




**[Table/Fig-2]:** Recruitment of women included in the two groups of the study.

## STATISTICAL ANALYSIS

Description of the continuous variable was presented with mean and standard deviations, categorical variable with frequencies and percentages. To compare the mean difference between the groups Independent t-test was used. To find the association between groups and study variables Chi-square test and Fisher's-exact test were used. ICC was calculated to assess the agreement of ultrasound assisted urine volume and actual urine output. Bland-Altman plot was used to show agreement between ultrasound diagnosis and actual urine output. All the statistical analysis was performed using Statistical Package for Social Sciences (SPSS) version 21.0.

## RESULTS

A total of 405 women were recruited with 211 women in group 1 (Not in labour) and 194 women in group 2 (In labour). The baseline characteristics are elaborated in [Table/Fig-3]. The women in

| Baseline characteristics | Group 1 n=211 (%) | Group 2 n=194 (%) |
|---|---|---|
| Age in years (mean±SD) | 28.29±4.6 | 25.95±4.2 |
| BMI in kg/m$^2$ (mean±SD) | 27.01±5.27 | 25.17±5.38 |
| Parity | | |
| Primi | 5 (2.4) | 2 (1.0) |
| Multiparous | 206 (97.6) | 192 (99.0) |
| Gestational age (in weeks) (mean±SD) | 38.1±1.2 | 39.0±1.0 |
| Medical risk factors | 68 (32.2) | 39 (20.1) |
| Obstetric risk factors | 136 (64.45) | 114 (58.7) |
| Previous LSCS | 177 (85.5) | 10 (7.0) |
| Duration of labour (in hours) {(median (IQR)} | NA | 12 (6.1,15.87) |
| Membrane rupture | NA | 175 (90.2) |
| Duration of rupture of membrane in hours {(median (IQR)} | NA | 9,75 (4.37,14) |

**[Table/Fig-3]:** Baseline characteristics of both groups (N=405).
Descriptive statistics such as mean (SD) for age and BMI were used. Categorical variables were presented as frequencies and percentages

group 1 had a previous Lower Segment Caesarean Section (LSCS) in 177/211 (85.5%) of the total women studied whereas, in group 2 there were 10/194 (7%). More women in group 1 had medical risk factors 68/211 (32.2%) whereas, 39/194 (20.1%) in group 2 had medical risk factors. The medical risk factors were thyroid disorders, hypertension, diabetes, obesity, seizure disorders, asthma, heart disease, renal disease autoimmune disease and others. The obstetric risk factors were gestational diabetes, hypertensive diseases of pregnancy, previous caesarean section, infertility, intrauterine growth restriction, fibroids complicating pregnancy, antiphospholipid antibody syndrome and others. This was seen in 136 (64.45%) in group 1 and 114 (58.7%) in group 2. Characteristics specific to group 2, such as instrumental delivery, prolonged period from last void, and palpable bladder, are elaborated in [Table/Fig-4]. The commonest reason for catheterisation was prolonged period from last void seen in 40% of women and other common causes were palpable bladder seen in 32% and instrumental delivery in 25%.

| Variables | n=194 (%) |
|---|---|
| Instrumental delivery | 49 (25.2) |
| Prolonged period from last void | 77 (39.7) |
| Palpable bladder | 62 (31.9) |
| Epidural | 6 (3%) |

**[Table/Fig-4]:** Indication for catheterisation in women with active labour (group 2).

Accuracy of clinical diagnosis is described in [Table/Fig-5]. The sensitivity of clinical estimation of bladder volume of >150 mL was between 80%-90% in both groups and specificity was extremely low ranging between 3%-5%.

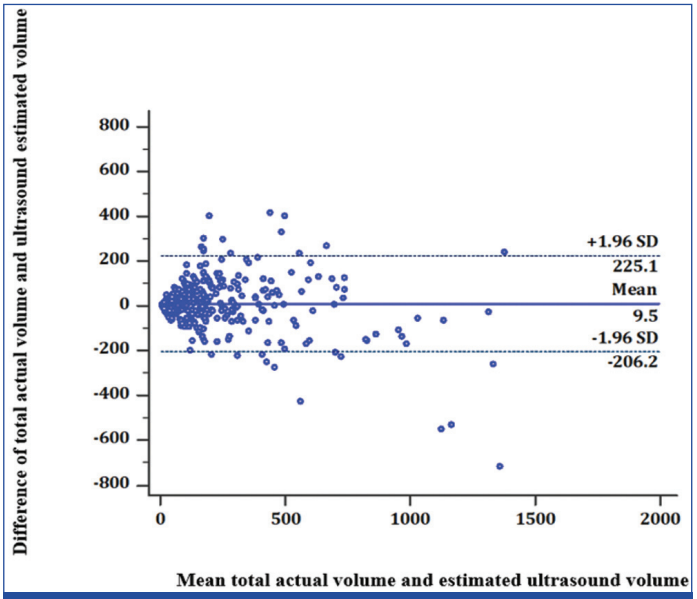
| Groups | Bladder volume | | Number (n) | |
|---|---|---|---|---|
| **Group 1** | **>150 mL** | **≤150 mL** | **n=211** | |
| Bladder+ | 47 | 150 | 197 | |
| Bladder - | 6 | 8 | 14 | |
| Total | 53 | 158 | 211 | |
| **Group 2** | **>150 mL** | **≤150 mL** | **n=194** | |
| Bladder+ | 113 | 75 | 188 | |
| Bladder - | 3 | 3 | 6 | |
| Total | 116 | 78 | 194 | |
| **Overall** | **>150 mL** | **≤150 mL** | **Total (N=405)** | |
| Bladder+ | 160 | 225 | 385 | |
| Bladder- | 9 | 11 | 20 | |
| Total | 169 | 236 | 405 | |
| Clinical examination | | | | |
| | S | SP | PPV | NPV |
| Group 1 | 89% | 5% | 24% | 57% |
| Group 2 | 97% | 4% | 60% | 50% |
| Overall | 95% | 5% | 42% | 55% |

**[Table/Fig-5]:** Accuracy of clinical examination for significant bladder.
s: Sensitivity; sp: Specificity, PPV: Positive predictive value; NPV: Negative predictive value

The number of women with similar categories of volume of urine estimated by ultrasound versus actual urine volume following catherisation in groups 1 and 2 are described in [Table/Fig-6]. Irrespective of the category which comprised of volumes namely 150 mL, 150-300 mL, 300-600 mL and >600 mL, the correlation showed high level of accuracy in the estimates by ultrasound. The ICC between total catheter volume and predicted volume was 0.88 (0.86, 0.90) (p<0.001). The Bland-Altman plot in [Table/Fig-7], represents the mean (SD) bias was 9.5 (112.23). The limits of agreements were (-206.2, 225.1). The precision of was 219.9 and the percentage error was 1.12%.

| Urinary volume in aliquots | Group 1 n=211 | | | Group 2 n=194 | | |
|---|---|---|---|---|---|---|
| | USG estimated volume (n) | Cathe-terised volume actual | Difference | USG predicted volume (n) | Cathe-terised volume (n) | Difference |
| <150 mL | 155 | 158 | -0.02 (-0.10 -0.06 | 89 | 78 | 0.06 (-0.04-0.16) |
| 150-300 mL | 39 | 38 | 0.004 (-0.07-0.08) | 45 | 52 | -0.04 (-0.13-0.05) |
| 300-600 mL | 16 | 14 | 0.009 (-0.04 -0.06) | 35 | 37 | -0.01 (-0.09-0.07) |
| >600 mL | 1 | 1 | 0 (-0.01 -0.01) | 25 | 27 | -0.01 (-0.08 -0.06) |

**[Table/Fig-6]:** Women with similar category of urinary volume by ultrasound and actual catheterised volume in group 1 and 2.




**[Table/Fig-7]:** The Bland-Altman plot representing the mean (SD) bias of 9.5 (112.23) and the limits of agreements of (-206.2, 225.1).
Good agreement between actual urinary volume and ultrasound estimated volume was seen

## DISCUSSION

Urinary catheterisation can introduce bacteria leading to UTI and is a concern especially in tertiary centers where overcoming antibiotic resistance is a challenge. Preventing hospital infection, by avoiding catheterisation can have a significant impact on postpartum care of the mother. In the past decade, several studies [8-10] have shown that estimation of urine by ultrasound is accurate, and a desirable alternative to urinary catheterisation to measure bladder volume. Griffiths CJ, et al., showed the accuracy for measuring bladder volume by scan for volumes more than 150 mL was 90% for actual bladder volume ±15% [8]. Jensen JT et al., confirmed that, diagnostic accuracy for volume more than 150 mL was good [9]. A scoping review [15] showed eight of the eleven included studies that looked at bladder scanning in maternity care, to be accurate. They highlighted that several factors could influence its accuracy. Studies done in the intrapartum period by Barrington JW et al., and Gyampoh B et al., are both small studies but have shown ultrasound to be accurate [10,11]. The first study included 50 women in active labour with some of the women having ruptured membranes [10]. The correlation between bladder volume by ultrasound and actual volume was weak only when the membranes were not ruptured.

The second study recruited 49 women who needed catheterisation [11]. They showed a sensitivity of 77% and a specificity of 86%. However, when they used a new equation to calculate bladder volume in order to improve sensitivity to 100 the specificity dropped to 36%. Unlike the above studies, the present study, done almost a decade later and is larger and has used the new model of portable ultrasound which has a volume calculation formula incorporated

into the system. Unlike other studies [10,11] urine volume were studied both in women who were not in labour and those in labour. The diagnostic accuracy was marginally inferior when the woman was in labour but was definitely superior to the clinical estimation of urinary volume. The use of a basic portable model of ultrasound by inexperienced doctors with a short period of training was sufficient to diagnose bladder volume accurately.

### Limitation(s)

Though, the inclusion criteria were broad, and women with previous LSCS scar and women in labour were included, the authors were unable to comment on the effects of increased BMI, scars and phase of labour in predicting urinary volume.

## CONCLUSION(S)

The present study has reiterated that, ultrasound measurement of bladder volume is an accurate method of estimation and is superior to conventional clinical diagnosis both in labour and not in labour. The association of actual volume of urine and ultrasound estimation was similar irrespective of the bladder volume. These findings have significant implications for change in practice in labour wards, especially in large tertiary centres, where an ultrasound is usually available onsite.

**Authors contributions:** VM, RST, VND, JEM, BK, and SR were involved in the design, planning, conduct and manuscript writing. MT, was involved in the data analysis and manuscript writing.

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