Research

Accuracy of Ultrasound Estimates of Urine Volume

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In the hospitalized patient, catheterization is a major risk factor for urinary tract infections (UTIs). Each year in the United States more than 1 million UTIs associated with catheterizations occur (Marchiondo, 1998). Unnecessary catheterization for small residual volumes greatly increases the risk of UTIs. More importantly, UTIs are the leading cause of infections in hospitalized patients and can lead to increased mortality from secondary septicemia. Infections associated with catheterizations can increase the length and cost of hospitalizations and cause the patient additional discomfort.

Significance

Recently, bladder scans have been used as a noninvasive method to estimate urine volume in the bladder. If bladder scan results can be used as a noninvasive reliable determination of urinary volume, patients will be at a lower risk for UTIs from unnecessary catheterizations. Institutional cost will be significantly decreased by using bladder-scanning technology (Moore & Edwards, 1997) since the risk for nosocomial UTIs and the subsequent expense of treating these infections will be reduced.

Purpose

When our institution began using the Bladder Scan BVI 2500 device as a noninvasive method to estimate volume, staff expressed concern about the accuracy of the scanned volumes.

Hence, the purpose of this study was to compare bladder scans and actual bladder volumes, from intermittent catheterization, on general surgery and rehabilitation patients with suspected urinary retention. The following hypothesis was proposed: There will be no significant difference between bladder scan volumes and catheterization urinary volumes on postoperative surgical and rehabilitation patients.

Literature Review

While studies reported in the literature show that discrepancies do occur between scan (estimated volume) and residual catheterization volumes (actual volume), the inaccuracies usually occur with large bladder volumes (>500 ml). Coombs and Millard (1994) compared two different models of the Bladder Scan BVI 2500 and found a high correlation between the scan volume and actual volumes with both models. However, the BVI 2500+ model produced more consistent readings regardless of the amount of urine present. The older model was less accurate with larger bladder volumes.

Moore and Edwards (1997) showed less accuracy with higher volumes. The difference score between the scan and actual volume increased substantially when bladder volume rose above 645 ml (+/- 100 ml) compared to volumes less than 325 ml (+/- 25 ml). No statistical comparisons were done on the data.

Marks, Dorey, Macairan, Park, and deKernion (1997) also compared the two models of the BVI 2500 for accuracy. Actual bladder volumes ranged from 0 to 1,015 ml. Using 100 ml as the reference point for clinical significance, they found only six patients with a difference greater than 100 ml between the scan and catheterization volumes. All six had large, actual bladder vol-

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Table 1  
Comparison of Men and Women on Actual and Scanned Volumes

<table>
<thead>
<tr>
<th>Volume</th>
<th>Men</th>
<th></th>
<th>Women</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Min</td>
<td>Max</td>
</tr>
<tr>
<td>Actual</td>
<td>489.0</td>
<td>189.9</td>
<td>140-900</td>
<td></td>
</tr>
<tr>
<td>Scan</td>
<td>494.2</td>
<td>217.0</td>
<td>117-969</td>
<td></td>
</tr>
</tbody>
</table>

Table 2.  
Comparison of Scanned Urine In Men and Women

<table>
<thead>
<tr>
<th>Gender</th>
<th>Mean Volume in ml</th>
<th>Standard Deviation</th>
<th>Minimum to Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td>489.9*</td>
<td>189.9</td>
<td>140-900</td>
</tr>
<tr>
<td>Women</td>
<td>493.7*</td>
<td>253.1</td>
<td>75-800</td>
</tr>
</tbody>
</table>

* Not significant at .05

umes. The scan devices underestimated catheter volume in both men and women.

Revod Opitz, Murtagh, and Harris (1993) measured scan volumes 400 times prior to 100 episodes of intermittent catheterization on 24 men with neurogenic bladder dysfunction. The mean error of the scan measurements was -26 cc and the mean absolute error was 44 ml. The bladder scan measurements detected the presence of residual volumes of > 100 ml with a sensitivity of 90% and a specificity of 81%.

Scan technique and patient position were examined for their effect on accuracy of the ultrasound reading (Massaglia, Cardenas, & Kelly, 1989). The results showed that little training was necessary to use this ultrasound device and the inter-user reliability was precise whether the patient was in the seated or supine position. Marks et al. (1997) also found that minimal training was necessary to obtain reliable measures of bladder volume.

Method

Measures: The Bladder Scan BVI 2500 is a portable, battery-operated ultrasonic device intended for the noninvasive measurement of urinary bladder volume. After selecting the appropriate gender mode, a mechanical sector scanning transducer is used to provide cross-sectional images of the bladder from 12 scan planes. The machine automatically calculates the estimated bladder volume in milliliters and displays it on a screen. A printout can be obtained of the scanned bladder volume. No routine calibration or alignment operations are required prior to use. Diagnostic Ultrasound Corporation certifies that the scan is in compliance with all applicable standards and regulations both national and international. It has received FDA approval.

Data were collected by registered nurses validated on using the Bladder Scan BVI 2500. Inter-user reliability, precision, and accuracy have been supported in the literature (Massaglia et al., 1989).

Demographic data included age in years, type of surgery, and gender. A difference score was calculated by subtracting the actual volume from the scan volume.

Catheterization protocol. Urinary catheterization is the insertion of a catheter through the urethra into the bladder to drain urine. The procedure can be used in cases of urinary retention or to determine the post void residual.

For this study, catheterization was performed only on patients with a physician’s order requiring the procedure be done during the postoperative period or as part of routine toileting. The catheterization was done immediately after the scan was completed.

Subjects. Forty-eight patients on general surgery and rehabilitation units were included in the sample. Each subject’s actual catheterization volume provided the comparison data. The sample included 39 (83%) men and 8 (17%) women with a mean age of 64.3 years (range 24-93 years). The majority of the patients had urologic surgical procedures (48%) with about equal numbers having general surgery (25%) or rehabilitation (27%) diagnoses. Patients excluded from the sample included pregnant women and patient with suprapubic incisions or wounds.

Results

The mean ultrasound and urinary catheterization volumes were essentially equal (see Table 1). The manufacturer’s recommended criteria to determine equivalence using the Bladder Scan BVI 2500 is 20 ml. The mean difference score for the total sample expressed as a positive integer was 79 ml (SD=68.5) with 50% of the volumes underestimated. Twelve subjects had difference scores of 20 ml or less. This low difference group had a minimum actual volume of 200 ml with a maximum actual volume of 800 ml (Mean=469.75, SD=212.07) and included only one female subject. Ten percent of the subjects (N=5) had difference scores greater than 100 ml, with minimum and maximum actual volumes of 375 ml to 900 ml (Mean=665 ml, SD=216.2). This large difference group also
included one female subject. Exactly half of the subjects had scan volumes that underestimated the actual bladder volume.

**Discussion**

Results of the comparison of scanned urine volume based on gender should be interpreted with caution because there were so few women in the sample. Means, standard deviations, minimum and maximum volumes for men and women were relatively equal (see Table 2). No pattern was apparent when diagnosis was examined in relation to either the small or large difference groups.

Several authors reported the calculation of Pearson’s correlation between scan and actual volume. In our sample the correlation was $r=.94 (<.01)$. While this high a correlation is rarely obtained in clinical research, it must be noted that when explained variance is calculated ($r^2=98\%$), $12\%$ of the variance (unexplained variance 1 – $r^2$) between estimated and actual volumes is not accounted for and could be considered error. The high correlation between the estimated (scan) and actual (catheterization) volumes reinforces the precision of the scan technology.

The question of accuracy is best answered in a clinical rather than purely a statistical context. Only $10\%$ of the sample had scan volumes that differed by greater than 100 ml from the actual bladder volume. While only one subject in our sample had a scan-actual volume difference greater than 130 ml, three of Marks et al. (1997) subjects had scan actual volume differences greater than 130 ml.

**Nursing Implications and Conclusion**

These results show that scan volume is a relatively accurate prediction of actual urine volume. In clinical situations where it is necessary to determine residual urine volume, the bladder scan technology is a good alternative to an invasive catheterization procedure. Reduced risk of infection and patient comfort are two advantages for hospitalized patients. Institutional benefit comes from the decrease in UTIs and subsequent decrease in length of stay. It is recommended that scan estimates of urine volume are accurate and should only be questioned if the scan volume contradicts the clinical symptoms. Therefore, the clinically prudent action would be to use a noninvasive method of determining urine volume whenever possible, to reduce the risk of infection and increase patient comfort.

**References**


