



# Do Foley Catheters Adequately Drain the Bladder? Evidence from CT Imaging Studies

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## ABSTRACT

**Introduction:** The Foley catheter has been widely assumed to be an effective means of draining the bladder. However, recent studies have brought into question its efficacy. The objective of our study is to further assess the adequacy of Foley catheter for complete drainage of the bladder.

**Materials and Methods:** Consecutive catheterized patients were identified from a retrospective review of contrast enhanced and non-contrast enhanced computed tomographic (CT) abdomen and pelvis studies completed from 7/1/2011-6/30/2012. Residual urine volume (RUV) was measured using 5mm axial CT sections as follows: The length (L) and width (W) of the bladder in the section with the greatest cross sectional area was combined with bladder height (H) as determined by multiplanar reformatted images in order to calculate RUV by applying the formula for the volume (V) of a sphere in a cube:  $V = (\pi/6) * (L * W * H)$ .

**Results:** RUVs of 167 (mean age 67) consecutively catheterized men (n=72) and women (n=95) identified by CT abdomen and pelvis studies were calculated. The mean RUV was 13.2 mL (range: 0.0 mL-859.1 mL, standard deviation: 75.9 mL, margin of error at 95% confidence: 11.6 mL). Four (2.4%) catheterized patients had RUVs of >50 mL, two of whom had an improperly placed catheter tip noted on their CT-reports.

**Conclusions:** Previous studies have shown that up to 43% of catheterized patients had a RUV greater than 50 mL, suggesting inadequacy of bladder drainage via the Foley catheter. Our study indicated that the vast majority of patients with Foley catheters (97.6%), had adequately drained bladders with volumes of <50 mL.

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## INTRODUCTION

The Foley catheter has been a staple of medical care since its inception in 1935 by American urologist Frederic Foley (1). Though there have been modifications in the 80 years since its creation, the Foley catheter has withstood the test of time and is considered an acceptable means for bladder drainage in the appropriate setting. One

of the main complications of its use is catheter-associated urinary tract infection (CAUTI).

The prevalence of CAUTI is high, as up to 40% of catheterized patients in the acute hospital care setting develop CAUTI (2). This, in conjunction with the fact that up to 25% of patients admitted to hospitals have a urinary catheter placed at some point during their stay highlights the healthcare burden generated by CAUTI (3). Although

the cost of each CAUTI is estimated to be less than \$600, the additive cost to hospitals for lack of Medicare and Medicaid reimbursement of a “preventable complication” is considerable (4, 5).

For each day that a catheter is in place, 3-7% of patients may develop a CAUTI (6). By the 30th day of catheterization, the incidence of CAUTI or catheter-associated asymptomatic bacteriuria (CAASB) is almost 100% (7). Failure to keep the urinary collection bag in a gravity dependent position is the most commonly violated catheter care-related recommendation, and can double the relative risk of developing CAUTI or CAASB (8).

One potentially modifiable factor to impact the incidence of CAUTI is inadequate drainage of the bladder. Stoller et al. suggested that Foley catheters do not consistently and constantly drain urine from the bladder, with 43% of patients found to have a residual urine volume >50 mL (8). A previous study found that clinically asymptomatic men with a post-void residual volume (PVR) of >180 mL are at high risk for developing bacteriuria (9). Further, PVR >150 mL in a non-catheterized patient is associated with an increased risk of developing a urinary tract infection (10). Taking these findings together, it would seem logical that we can reduce the incidence of CAUTI by addressing the problem of inadequate bladder drainage by Foley catheters. As such, the purpose of our study was to evaluate the efficacy of the Foley catheter in bladder drainage.

## MATERIALS AND METHODS

After obtaining approval from our Institutional Review Board (approved protocol #330937-1), we retrospectively identified 167 consecutively catheterized patients via contrast enhanced and non-enhanced abdominal and pelvic CT studies from 7/1/2011-6/30/2012. Patients with suprapubic bladder drainage catheters were excluded.

We assessed residual urine volume (RUV) by utilizing the 5mm axial section demonstrating the greatest bladder cross sectional area. Using coronal multiplanar reformatted images to determine maximum bladder height, RUV was calculated by means of the formula for the volume (V) of a sphere in a cube with a given length (L), width (W), and height (H):  $V=(\pi/6)*(W*L*H)$ .

## RESULTS

Patients were stratified into three groups: RUV =0 (n=68, 40.7%), RUV >0 and <50 mL (n=95, 56.9%, mean=6.7 mL, standard deviation (st dev) =7.9 mL), and RUV ≥50 mL (n=4, 2.4%, mean=394.7 mL, st dev=345.3 mL). Two of the four patients with RUV ≥50 mL were found to have improperly placed catheters by CT. The overall mean RUV was 13.2 mL with a st dev of 75.9 mL and margin of error of 11.6 mL for a 95% confidence interval.

We further stratified patients by gender. Thirty nine women (41%) had RUV =0 mL, 54 (57%) had a RUV >0 mL and <50 mL (mean=8.0 mL, st dev=8.3 mL), and 2 (2%) had RUV ≥50 mL, (mean=301.4 mL, st dev=172.6 mL). The overall mean RUV for women was 10.9 mL with a st dev of 50.0 mL. Twenty nine men (40.3%) had RUV=0 mL, 41 (57%) had a residual urine volume of >0 mL and <50 mL, (mean=4.9 mL, st dev =7.0 mL), and 2 (2.8%) had RUV >50 mL (mean=488.1 mL, st dev=362.8 mL). The overall mean RUV for men was 16.2 mL, with a st dev of 100.2 mL. A summary of our data analysis is provided in Table-1.

## DISCUSSION

Contrary to the study performed by Stoller et al., we found that the vast majority of our patients (97.6%) had a RUV of <50 mL. Further, 40.7% of our patients were found to have no residual volume at all. This contrast may be attributed to differences in study design. In Stoller’s study, bladder sonography was performed at the bedside whereas in the present cohort, the patient was transported to the CT department. It is possible that during transport, manipulation and movement of the Foley, as well as changes in abdominal pressure during transfer resulted in drainage in urine from the bladder. Since patients either move or are turned/moved frequently while in hospital beds, we feel that CT-derived measurement of bladder volume still represents a “real world” situation amongst catheterized inpatients. Further, sonographic measurement of the bladder is less precise when the bladder is collapsed (11, 12).

**Table 1 - Summary of Data.**

| Group              | 0 mL  | >0 mL & <50 mL | ≥50 mL      |
|--------------------|-------|----------------|-------------|
| N women            | 39    | 54             | 2           |
| %women             | 41.1% | 56.8%          | 2.1%        |
| Mean/SD Women (mL) | --    | 8.0/8.3        | 301.4/172.6 |
| N men              | 29    | 41             | 2           |
| %men               | 40.3% | 56.9%          | 2.8%        |
| Mean/SD Men (mL)   | --    | 4.9/7.0        | 488.1/362.8 |
| N total            | 68    | 95             | 4           |
| % total            | 40.7% | 56.9%          | 2.4%        |
| Mean/SD total(mL)  | --    | 6.7/7.9        | 394.7/345.3 |

mL = milliliters, N = number, SD = standard deviation

In the present study, while only 2% of patients had a RUV of >50 mL, 59% of patients a RUV of >0 mL, indicating that for most patients the Foley catheter does not completely drain the bladder. Though some of the smaller volumes may be considered negligible, 16% of our patients (n=26) had a RUV of >10 mL.

We found that half (2/4) of the patients with a RUV >50 mL had an improperly placed catheter, emphasizing the importance of catheter placement technique and urine output monitoring. Hence, the vast majority of properly placed catheters appear to drain the bladder at least moderately well with an arbitrary "cut point" of 50 mL. The importance of finite RUV <50 mL in catheterized patients has yet to be determined.

## CONCLUSIONS

In summary, our retrospective study provides three principal findings:

- 1) For the vast majority of patients the Foley catheter adequately drained the bladder;
- 2) There were no gender differences in the efficacy of the Foley catheter in bladder drainage;
- 3) Improper placement of a Foley catheter can lead to significant urinary retention.

## ABBREVIATIONS

CAUTI = catheter-associated urinary tract infection

CAASB = catheter-associated asymptomatic bacteriuria

PVR = post-void residual volume

RUV = residual urine volume

L = length

W = width

H = height

V = volume

St dev = standard deviation

## CONFLICT OF INTEREST

None declared.

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