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● *Original Contribution*

ASSESSMENT OF POSTOPERATIVE POSTVOID RESIDUAL BLADDER VOLUME USING THREE-DIMENSIONAL ULTRASOUND VOLUMETRY

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Abstract—The aim of our prospective study was to assess the concordance between postvoid residual volumes (PVR) of the urinary bladder obtained by two different three-dimensional (3-D) ultrasound (US) volumetric methods (VOCAL and XI VOCAL) and with measurement by the catheter in postoperative patients who have undergone radical hysterectomy. The 3-D sonographic volume-determination of PVR with both methods correlated significantly with the actual amount of PVR by the catheter. The accuracy of both 3-D US volumetric methods was significantly higher under 300 mL of PVR. Bland–Altman plots were generated to examine limits of agreement. Both noninvasive 3-D sonographic methods are appropriate for the correct volume-determination of PVR following radical hysterectomy. Thus, we may avoid routine, albeit often unnecessary, catheterization to measure postoperative residual bladder volumes and subsequently the incidence of lower urinary tract infection may be reduced and better postoperative comfort for patients may be permitted. (E-mail: szabolcs.bozsa@aok.pte.hu) © **2011 World Federation for Ultrasound in Medicine & Biology.**

Key Words: **Three-dimensional ultrasound, Volumetry, VOCAL, XI VOCAL, Urinary bladder, Radical hysterectomy.**

INTRODUCTION AND LITERATURE

Radical hysterectomy with bilateral pelvic lymphadenectomy is the operative treatment of early stage malignancies of the uterine cervix. Radical interventions affect autonomic nerve innervation of the urinary bladder and may result in lower urinary tract (LUT) dysfunction with an incidence of 8% to 80% (Zullo et al. 2003).

Early LUT dysfunction may be caused by decreased bladder capacity, diminished bladder sensation causing dysfunction of voiding and by decreased activity of the detrusor muscle. Early type LUT dysfunction is mainly dependant on the severity of damage to autonomic innervation of the bladder and is often transient. Urinary incontinence, difficulty of voiding with straining, detrusor hyperactivity, as well as decreased bladder compliance are responsible for late type LUT dysfunction that usually persist for 6 to 12 months (Chen et al. 2002; Manchana at al. 2010).

Early postoperative dysfunction of the LUT may cause urinary retention. Catheterization to drain and measure postvoid residual volumes (PVR) is an accepted and common method following gynecologic procedures but it may cause discomfort to the patient and increase the risk of urethral injury and the incidence of iatrogenic LUT infection (Meares 1991; Schaeffer 1992; Foxman 2003; Hashmi et al. 2003). The duration and costs of hospitalisation is increased in patients with LUT infection (Krieger et al. 1983). According to Horowitz et al. (2003) and to Ghezzi et al. (2007), recatheterization is indicated at more than 100 mL and 150 mL of PVR, respectively. Sonographic assessment of the residual volume of the urinary bladder is a noninvasive, painless, cost-effective, reliable and repeatable method (Poston et al. 1983; Beacock et al. 1985; Haylen et al. 1989).

Previously published reports suggest many alternative methods for the evaluation of PVR. Groshar et al. (1987) found good correlation between the assessment of PVR by the radionuclide method and catheterization ($r = 0.98$), however, this technique is expensive and

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requires special instrumentation and well-trained personnel. Haylen et al. (1989) recommended the application of transvaginal sonography for the assessment of urinary bladder volume because it was found to be more accurate than the conventional transabdominal two-dimensional (2-D) sonography. Serial transvaginal US examinations may cause discomfort to the patient. For this reason, transabdominal three-dimensional (3-D) ultrasound (US) volumetry may be the optimal technique for the exact, noninvasive, painless and reproducible assessment of the PVR. Several studies investigated the efficacy of volume estimation of the PVR by the transabdominal 2-D US technique with different equations and with conflicting correlation (Poston et al. 1983; Beacock et al. 1985). Two-dimensional US-volumetry calculates volume of regular shaped geometric objects with ellipsoid or spheric volume-equations. With respect to irregular shaped objects, 2-D sonographic volumetry is rather inaccurate, although it may be refined with different measurement techniques (Knorr et al. 1990; Bis and Slovis 1990). Amole et al. (2004) detected exact correlation ($r = 0.98$) between the PVR estimated by transabdominal sonography and the actual volume of the retained urine measured by the catheter following prostatic operations. In their study, Lertbunnaphong et al. (2006) found significant correlation between the PVR estimated by transabdominal sonography and the actual residual catheter-volume of the urinary bladder following radical abdominal and conventional vaginal hysterectomy ($r = 0.93$, $p < 0.001$).

The main objective of our prospective study was to assess the concordance between the volumes of postvoid retention of the urinary bladder measured by the Virtual Organ Computer-aided AnaLysis (VOCAL) and eXtended Imaging Virtual Organ Computer-aided AnaLysis (XI VOCAL) 3-D US volumetric methods and by catheterization in patients after radical hysterectomy.

MATERIALS AND METHODS

Between October 1, 2007 and March 31, 2008, we prospectively measured the amount of postoperative PVR by 3-D transabdominal sonographic volumetry in patients with cervical cancer operated on by type III radical abdominal hysterectomy with bilateral lymphadenectomy at the Department of Obstetrics and Gynecology of the Faculty of Medicine of the University of Pécs. Seventeen patients were enrolled in the study. Clinical characteristics of the enrolled patients are listed in Table 1. At the time of the operation the age of patients ranged between 29 and 79 years (mean 45.4 years, SD 13.7). Mean body mass index of patients was 25.2 kg/m^2 (SD 5.9). The study protocol was approved by the Institutional Review Board of the University of Pécs and written informed consent was obtained from each patient prior to the operation.

Table 1. Clinical characteristics of patients undergone type III radical hysterectomy (n = 17)

Clinical data	n = 17
Age (year)	
Mean ± SD	45.4 ± 13.7
Range	29.2–79.4
Height (m)	
Mean ± SD	1.6 ± 0.06
Range	1.5–1.7
Weight (kg)	
Mean ± SD	67.0 ± 17.0
Range	32.0–96.0
Body mass index (kg/m^2)	
Mean ± SD	25.2 ± 5.9
Range	14.2–33.7
Parity	
Mean ± SD	2.5 ± 1.5
Range	1–6
Previous abdominal surgery	
Appendectomy	2 (11.8%)
Cesarean section	2 (11.8%)
Laparoscopic/open gynecologic surgery	0 (0.0%)
Miscellaneous	2 (11.8%)
Diagnosis - Carcinoma cervicis uteri in stadio	
1a2	1 (5.9%)
1b1	3 (17.6%)
1b1 post irrad. praeop. HDR-AL	2 (11.8%)
1b2	2 (11.8%)
1b2 post irrad. praeop. HDR-AL	1 (5.9%)
2a	1 (5.9%)
2a post irrad. praeop. HDR-AL	2 (11.8%)
2a post radio-chemotherapy	1 (5.9%)
2b	1 (5.9%)
2b post irrad. praeop. HDR-AL	3 (17.6%)
Hospitalisation (day)	
Mean ± SD	7.9 ± 3.5
Range	4.0–20.0

During the radical hysterectomy, an indwelling catheter was inserted into the urinary bladder that was removed on postoperative day (POD) 3. Since July, 2006 in our evidence-based postoperative gynecologic protocol, the estimated PVR cut-off value for recatheterization after removal of the preoperatively-inserted catheter is 100 mL. After the first spontaneous voiding on POD 3 and on POD 4, as well as in one patient on POD 5, 3-D volume-datasets were acquired by the observer (S. B.) and then immediately stored in the US machine at our 3-D US unit for later off-line analysis of the PVR. The exact measurement of the true volume of the bladder by the catheter was performed in each patient by licensed nurse practitioners within 5 min after 3-D dataset acquisition. After sterile catheter-drainage of the retained urine, gentle suprapubic manual pressure was applied onto the bladder to be certain of the complete emptying of the PVR (Maymon et al. 1991). The amount of the retained and drained urine was measured in a cylinder and expressed in mL. One patient developed complete urinary retention and the indwelling catheter