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Original Research

Significance of Prolapse Reduction in Measurement of Postvoid Residual Urine Volume in Pelvic Organ Prolapse Patients: A Prospective Study

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Abstract

Background: This study compared postvoid residual (PVR) urine volume by ultrasonography in pelvic organ prolapse (POP) patients before and after prolapse reduction to evaluate the need for prolapse reduction in accurately assessing PVR in women with POP. **Methods**: This was a prospective study including 128 patients. Both standard methods for measuring PVR urine volume, urethral catheterization, and portable abdominal ultrasound machines were used. An examination was performed by one urogynecologist within five minutes after the patients self-voided. The patients were divided into two groups according to pelvic organ prolapse quantification (POP-Q) stage, early prolapse stage, and advanced prolapse stage, and comparative analysis was performed. **Results**: Before prolapse reduction, the Pearson correlation coefficient of PVR urine volume measured by ultrasonography and PVR urine volume measured through urethral catheterization was 0.708 in the early prolapse stage and 0.949 in the advanced prolapse stage. After prolapse reduction, the Pearson correlation coefficient of PVR urine volume measured by ultrasonography and PVR urine volume measured through urethral catheterization was 0.895 in the early prolapse stage and 0.982 in the advanced prolapse stage. **Conclusions**: These study results showed that prolapse reduction when measuring PVR urine volume by ultrasonography in POP patients is acceptable and essential for enhancing accurate patient assessment.

Keywords: postvoid residual urine volume; pelvic organ prolapse; prolapse reduction

1. Introduction

The prevalence of Pelvic Organ Prolapse (POP) is 3~8% of the population and approximately 20% of women will undergo surgery for incontinence or POP during their lifetime [1]. POP is associated with voiding dysfunction, decreased urinary flow rate, and increased Postvoid Residual (PVR) urine volume, and secondary outlet obstruction [2]. The American College of Obstetricians and Gynecologists (ACOG) recommends including history taking, physical examination, urine analysis, and PVR urine volume in the basic workup for lower urinary tract or prolapse patients. POP patients may have occult Stress Urinary Incontinence (SUI), and following surgery de novo SUI may be present. Assessment for occult SUI can be performed before surgery. Where present a concomitant SUI surgery can be considered when performing POP surgery [3]. POP reduction was first introduced in the 1980s, when it was suggested that occult SUI was a predictor of postoperative de novo SUI [4]. A stress test is performed during the preoperative assessment of POP. A previous study showed that a patient with initial negative stress test results but positive results in a stress test re-executed after POP reduction is considered to be a case of occult SUI [3]. POP reduction eliminates, urethral pressure by bringing the surrounding structures, including the vagina, into a corrected anatomical position. In this study, a speculum was used for POP reduction, and urethral pressure profilometry was measured with an inserted catheter. POP reduction artificially deteriorates the urethral closure mechanism [5]. It is very important to measure PVR urine volume in patients with lower urinary tract symptoms or pelvic floor dysfunction. Traditionally urethral catheterization was used to measure PVR [6]. Improvements in pain, urinary tract infection, and patient discomfort were observed in ultrasonography compared with urethral catheters [7–10].

In 1967 ultrasound was introduced to measure PVR urine volume. Its effectiveness has been proven in several papers. In 1988, ultrasonography was proposed as the standard for reducing various complications caused by a urethral catheter when measuring PVR urine volume [6,7]. Recently, several studies have confirmed the accuracy of ultrasonic equipment, and the use of ultrasonography for measuring PVR urine volume [10–16]. Nonetheless, ultrasonography in POP patients may show inaccurate PVR urine volume results due to anatomical deformation when the uterus and bladder descend towards the vagina. With the anterior compartment prolapse, the bladder is brought caudally, making it difficult for the suprapubic transducer to measure PVR accurately. Reportedly, the greater the uri-

nary volume and residual urine volume, and the more advanced prolapse stage, the more errors in PVR urine volume measured by ultrasonography due to urethra kinking. In previous studies, when the PVR urine volume of advanced prolapse stage patients as measured by ultrasonography, is more than 100 mL, urethral catheterization should be used to measure PVR urine volume [17,18]. Advanced prolapse stage patients may experience discomfort with the same urethral catheterization method, even though ultrasonography, is a non-invasive method.

There is an ultrasonography method that can substitute urethral catheterization for PVR urine volume measurement, but research indicates that urethral catheterization is better for advanced prolapse stage patients because ultrasonography accuracy is poor. Notably, an approach for improving the accuracy of PVR urine volume with ultrasonography for POP patients is needed [18,19]. This study was planned because advanced prolapse stage patients can use ultrasonography without urethral catheterization, but there is no other way to increase accuracy. We hypothesized that the PVR urine volume in POP patients would be inconsistent with the bladder ultrasound scanned volume and urethral catheterization volume due to anatomical deformations.

Therefore, POP patients especially the advanced prolapse stage patients need a different method than general patients to measure PVR urine volume with ultrasonography [18,19]. This study aimed to understand the need for prolapse reduction when measuring PVR urine volume by ultrasonography in patients with POP. Our primary outcome was the absolute difference between bladder ultrasound scan PVR urine volume measured before and after prolapse reduction and urethral catheterization PVR urine volume between the two groups.

2. Materials and Methods

This was a prospective cohort study conducted at the Chonnam National University Medical Hospital. After approval by the Institutional Review Board at Chonnam National University Medical Hospital (IRB No. CNUH-2017-211), 128 females with POP who visited the Obstetrics and Gynecology department at the Chonnam National University Medical Hospital from December 2017 to December 2018 were enrolled in this study. The procedure described below was performed after obtaining informed consent form from all of the patients.

We recruited patients who sought treatment in our outpatient clinic due to a symptomatic anterior or posterior vaginal wall prolapse regardless of their continence status. All of the patients were in a postmenopausal state and had never received hormone replacement therapy. They underwent physical examination, pelvic ultrasonography, bladder ultrasound scan before and after prolapse reduction, and urethral catheterization for PVR urine volume. Subject characteristics were recorded from the electronic medical record, including age, parity, body mass index (BMI), previous abdominal surgery, and past medical history (diabetes mellitus and hypertension). POP staging was evaluated with the pelvic organ prolapse quantification (POP-Q) system [20]. All examinations, including physical examination, pelvic ultrasonography, bladder ultrasound scan, POP-Q system staging, prolapse reduction, and urethral catheterization were performed by a special urogynecologist with 20 years of experience.

All of the patients underwent pelvic ultrasonography to assess pelvic and bladder pathology. In the previous studies, patients with pelvic mass were excluded from ultrasonography due to anatomical abnormalities such as uterine myoma, ovarian cyst and bladder diverticulum, which impaired the accuracy of bladder ultrasound scan PVR urine volume measurement [17,21]. Patients who underwent hysterectomy were excluded because bladder ultrasound scan PVR urine volume estimation was limited [10]. Patients with chronic indwelling urinary catheters, active urinary tract infection, and a history of urethral surgery were excluded could [17,18]. Patients with neurological diseases causing urination disorders or patients who could not speak Korean fluently were excluded.

Fig. 1. Portable bladder ultrasound scanner Biocon-700™.

PVR urine volume was measured using a portable abdominal ultrasound machine (Bicon-700, Mcube Technology, Seoul, Korea) (Fig. 1). This portable abdominal ultrasound machine model study is commonly used in clinical practice, has been validated in research studies, and provides generalizable results. The Bicon-700 bladder ultrasound scanner was routinely calibrated and maintained according to the manufacturer's recommendations. The ultrasound transducer was placed superior to the patient's pubic bone in the midline and directed toward the spine at an angle between 0 and 60° from the horizontal in an inferior direction. The PVR urine volume using bladder ultrasound scanner in one patient was measured three times and set as the largest value to increase accuracy. All patients self-voided for PVR urine volume and the measurements were performed within five minutes. A urogynecologist used a portable abdominal ultrasound machine with the patient ly-

ing on the lithotomy position on an obstetrics and gynecology armchair. Each bladder volume was measured before and after prolapse reduction, and the difference was compared. In a previous study, a Sims speculum was used for prolapse reduction [17]. A standardized method for uterine prolapse reduction has not yet been established. In our study, digital reduction was used to reduce the anterior compartment, the posterior compartment, and the apex compartment. Second and third fingers were introduced where required, as much as was comfortable and acceptable to the patient. During prolapse reduction by finger, examining the inside of the vagina was examined for reduction.

Urethral catheterization was performed immediately using a 12 F soft nelaton catheter by the standard maneuvers method and sterile technique. Methods such as urethral catheter twisting, advancing, and suprapubic pressure was applied routinely to improve the accuracy of nelaton PVR urine volume measurement. We recorded the bladder ultrasound scan PVR urine volume before and after POP reduction, and urethral catheterization PVR urine volume.

Although the standardized range for normal PVR urine volume has not yet been established, some studies consider a PVR urine volume of less than 100 mL as normal [22], while other studies consider a PVR urine volume of less than 50 mL as normal and 100 mL as elevated. The prevalence of elevated PVR urine volume among POP patients is approximately 6~30% [23]. Previous research has confirmed, a relationship between symptoms of elevated PVR urine volume in POP patients, the apex compartment prolapse, and elevated PVR urine volume was confirmed [24]. There was no support from the portable abdominal ultrasound machine company. The patients were divided into two groups, early stage (stage I and II) and advanced stage (stage III and IV) according to the POP-Q classification. POP stage I and II patients, who experienced discomfort when urinating were included. History taking, physical examination, pelvic and bladder ultrasonography, and urethral catheterization were performed, and the results were recorded when the patients initially visited the hospital.

The Student's *t*-test was used for comparison between each group, and Pearson's correlation coefficient statistical method was used for comparison between the PVR urine volume measured by bladder ultrasound scan and that measured by urethral catheterization. All of the statistical analyses were performed using SPSS version 23.0 (IBM, New York, USA), and $p < 0.05$ was indicated statistical significance.

3. Results

A total of 128 patients were included in the analysis. Patients were divided into an early prolapse stage patients group (stage I and II) and an advanced prolapse stage group (stage III and IV) according to the degree of POP. The characteristics of the two groups are summarized as follows: Among all of the patients, 60 were in the early prolapse stage group and 68 were in the advanced prolapse stage group. Patient characteristics were with descriptive statistics. The average ages of the patients in the early prolapse stage group and advanced prolapse stage group were 67.6 and 66.7 years, respectively, and the parity was 3.6 and 3.5, respectively with no statistically significant differences. The BMI was 24.0 in the early prolapse stage group and 24.1 in the advanced prolapse stage group, showing no statistical difference. There were 39 (65%) and 29 (42.6%) patients with previous abdominal surgery history (cesarean section, myomectomy, salpingoophrectomy, an ovarian cystectomy) in the early and advanced prolapse stage groups, respectively, with no difference between the two groups. Past medical history (diabetes mellitus and hypertension) also showed no difference between the two groups (Table 1).

Table 1. Patient characteristics.

Characteristics	Early stage group (n = 60)	Advanced stage group (n = 68)	*p*-value
Age (years)	67.6 ± 8.8	66.7 ± 7.9	0.411
BMI* (kg/m^2)	24.0 ± 2.2	24.1 ± 2.9	0.355
Parity	3.6 ± 1.2	3.5 ± 1.4	0.272
Previous abdominal surgery	39 (65.0%)	29 (42.6%)	0.390
Past medical			
Diabetes mellitus	22 (36.6%)	23 (33.8%)	0.469
Hypertension	33 (55.0%)	30 (44.1%)	0.738

Mean ± Standard deviation (range or %).

*BMI body mass index.

The Pearson correlation coefficient of the PVR urine volume measured via bladder ultrasound scan before prolapse reduction and the PVR urine volume measured via urethral catheterization was 0.708 ($R^2 = 0.90$) in the early prolapse stage patients and 0.949 ($R^2 = 0.50$) in the advanced prolapse stage patients. The Pearson correlation coefficient of the PVR urine value measured through bladder ultrasound scan after prolapse reduction and the PVR urine value measured through urethral catheterization was 0.895 ($R^2 = 0.96$) in the early prolapse stage patients and 0.895 ($R^2 = 0.96$) in the advanced prolapse stage patients. In both groups, we observed a further increase in the consistency of the PVR urine volume and urethral catheterization volume measured by bladder ultrasound scan after the prolapse reduction (Fig. 2).

In each group, the degree of agreement between the PVR urine volume and urethral catheterization volume measured by bladder ultrasound scan before and after reduction was compared based on a residual urine volume of 50 cc. In the early prolapse stage patients, when the PVR urine volume was less than 50 cc, the Pearson Correlation coefficient of the PVR urine volume and urethral catheterization volume increased from ($R^2 = 0.12$) to ($R^2 = 0.64$) before and after prolapse reduction, respectively. When the

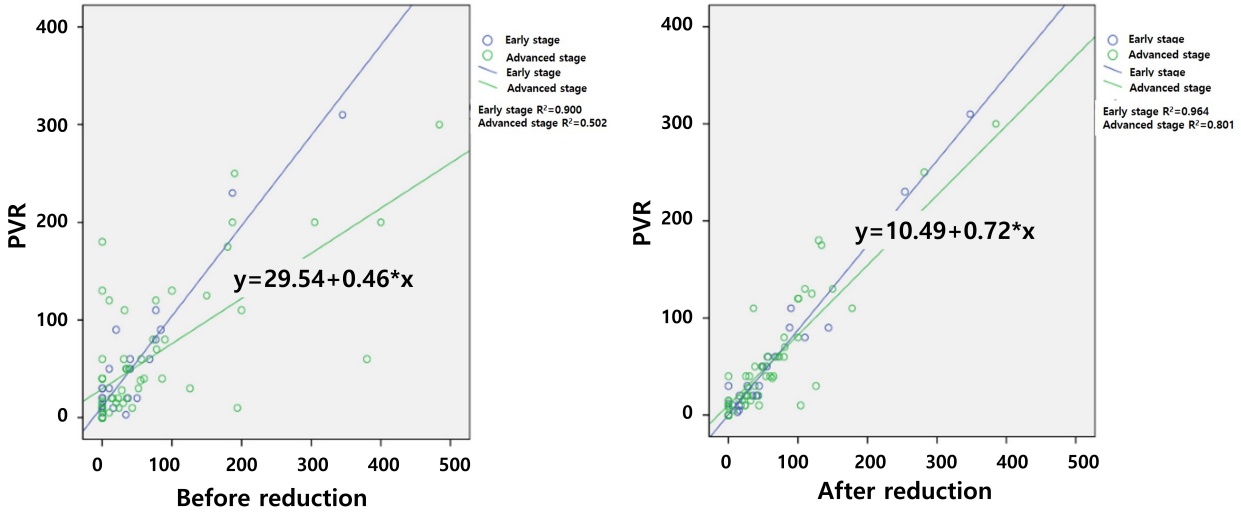

Fig. 2. Correlation between scanned volume and catheterization volume in early-stage and advanced-stage patients.

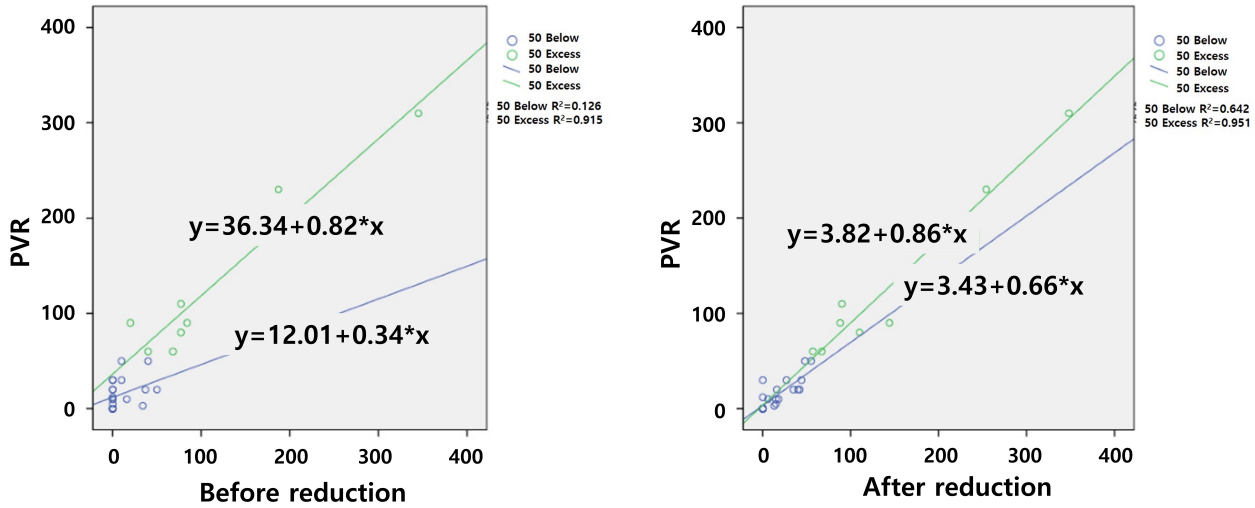

Fig. 3. Correlation between scanned volume and catheterization volume examined in early-stage using residual urine 50 cc.

PVR urine volume was more than 50 cc, the Pearson correlation coefficient increased from (R^2 = 0.91) to (R^2 = 0.95) before and after prolapse reduction, respectively (Fig. 3). In the advanced prolapse stage patients, the consistency increased further from (R^2 = 0.07) to (R^2 = 0.29) when the PVR urine volume was less than 50 cc and from (R^2 = 0.33) to (R^2 = 0.71) when the PVR urine volume was more than 50 cc before and after the prolapse reduction, respectively (Fig. 4).

4. Discussion

ACOG recommends measuring PVR urine volume when examining POP patients [3]. Historically, urethral catheterization was used to measure PVR urine volume in patients with pelvic floor dysfunction. A portable bladder ultrasound scanner can be brought to the patient's bedside the scan performed in real-time, and the process requires only basic training [15].

There is no universally accepted definition for PVR urine volume, but based on the current literature, we consider 100 mL or more to be elevated PVR and defined it as voiding dysfunction [17,22]. Elevated PVR urine volume mimics other lower urinary tract symptoms, such as urinary urgency, frequency, and incontinence, leading to misdiagnosis and improper treatment [24]. Elevated PVR urine volume is associated with recurrent urinary tract infection due to incomplete bladder emptying and is a potential marker of disease [2]. Elevated PVR urine volume is associated with anterior compartment prolapse [19]. However, only a few studies have examined the relationship between the degree

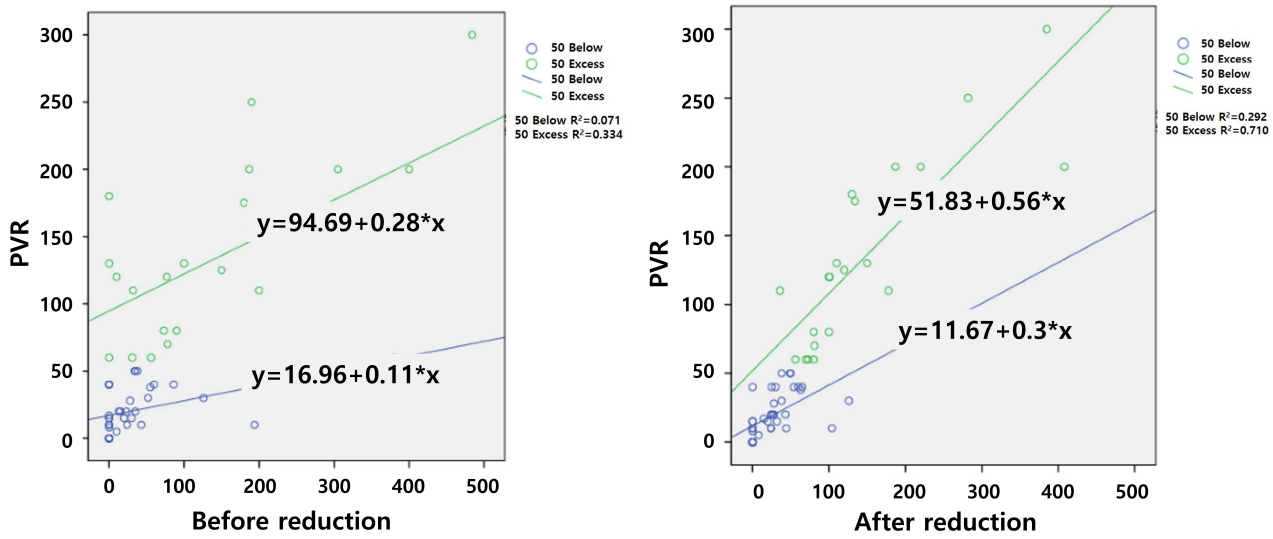

Fig. 4. Correlation between scanned volume and catheterization volume examined in advanced stage using residual urine 50 cc.

of the anterior compartment pelvic prolapse and PVR urine volume [13].

Therefore, in this study, the bladder ultrasound scanned volume and urethral catheterization volume were measured and compared before and after the prolapse reduction. An increase in the correction coefficient value was observed after prolapse reduction in both groups. Furthermore, when the amount of PVR urine volume in each group was more than 50 cc, the correlation coefficient value was increased further after prolapse reduction. POP patients have an anterior compartment anatomical abnormality, and a bladder further out of position, resulting in an error in the bladder ultrasound scanned volume when the PVR urine volume is large. In previous study, PVR urine volume in patients with advanced prolapse stage showed a tendency to increase in error when measured by bladder ultrasonography [18]. For these patients, measurement of the PVR urine volume using the bladder ultrasound scanned volume after prolapse reduction could reduce measurement error. Measuring the PVR urine volume more accurately, can help explain occult SUI after POP surgery.

The strength of this study is that one special urogynecologist performed a series of procedures, including physical examination pelvic and bladder ultrasonography, and PVR urine volume measurement alone. All examinations were performed by a professional urogynecologist with a history of approximately 5000 surgeries over 20 years. This eliminated the errors resulting from measurements by several inspectors and consequently enhanced accuracy. This study was also prospective. The bladder scanned volume was measured in all patients when the urethral catheterization was performed, and the values were compared. Also, this is the first case using a special urogynecologist's finger instead of a speculum for prolapse reduction. This process insured increased accuracy of the prolapse reduction.

The limitations of this study are the small scale nature of the study and the small study population. Future research involving more patients is warranted. In addition, this study was conducted on patients who were transferred to a tertiary hospital, and further work should involve general patient groups. Other studies have suggested that high-frequency ultrasound can be used to measure full bladder wall thickness and bladder wall blood circulation (Resistive Index) together to help diagnose bladder pathology [25]. Ultrasound can be used as a non-invasive clinical tool to perform structural and hemodynamic assessment of bladder. In this study, only PVR urine volume was measured using a portable bladder ultrasound scanner. Future studies should collect bladder hemodynamic data to measure bladder contractility using high-frequency ultrasound and doppler ultrasound.

5. Conclusions

Prolapse reduction is a potential enhancing approach in ultrasonography to measure PVR urine volume in POP patient regardless of POP stage and PVR urine volume. When measuring PVR in the advanced prolapse stage patients, prolapse reduction is a method to increase accuracy. Accurate PVR urine volume measurement will be clinically helpful in determining future treatment methods for patients with advanced prolapse stage.

Author Contributions

TYK, MKC, and CHK designed the study and developed the project. TYK collected data, analyzed statistics, and edited the manuscript. MKC and CHK revised the manuscript. All authors read and approved the final manuscript.

Ethics Approval and Consent to Participate

Written informed consent for the publication of this case was obtained from the patients. The study was conducted in accordance with the Declaration of Helsinki and was approved by the Institutional Review Board at Chonnam National University Medical Hospital (IRB No. CNUH-2017-211). All methods were carried out in accordance with relevant guidelines and regulations.

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Conflict of Interest

The authors declare no conflict of interest.

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