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ORIGINAL ARTICLE

Post-reduction stress urinary incontinence rates in posterior versus anterior pelvic organ prolapse: a secondary analysis

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Abstract
Introduction/hypothesis Stress incontinence with vaginal prolapse reduction is less common in women with posterior-predominant prolapse (rectocele) compared with those with anterior-predominant prolapse (cystocele).
Methods This was a secondary analysis of a cohort of prospectively enrolled women with symptomatic pelvic organ prolapse at or beyond the hymen and prolapse-reduced stress urinary incontinence (SUI) testing. Subjects were included if they had anterior- or posterior-predominant prolapse with at least a 1 cm difference in pelvic organ prolapse quantification (POP-Q) points *Ba* and *Bp* (N=214). We evaluated the prevalence and risk factors of post-reduction SUI between the two groups.
Results Comparing posterior (n=45) and anterior (n=169) prolapse groups, we identified similar rates of post-reduction SUI (posterior: 6/45, 13.3 %; anterior:18/169, 10.7 %; p=0.52) and SUI without reduction (posterior:4.4 %; anterior:11.2 %; p=0.26). Maximum prolapse size was slightly larger in anterior than in posterior patients (+3.1 vs +2.0 cm beyond the hymen, p=0.001), while a higher proportion of posterior subjects reported a prior hysterectomy (p=0.04). Among posterior subjects, lower maximum urethral closure pressure values (MUCP; p=0.02) were associated with post-reduction SUI. In contrast, among anterior-predominant prolapse, larger prolapse measured at POP-Q point *Ba* (p=0.003) and maximum POP-Q measurement (p=0.006) were each associated with higher rates of post-reduction SUI and were highly correlated with each other (R=0.90).
Conclusions We observed similar rates of post-reduction SUI in women with anterior- and posterior-predominant pelvic organ prolapse. Factors affecting the anterior and posterior prolapse groups differed, suggesting different mechanisms of continence protection. These findings suggest that reduction incontinence testing for operative planning would be as relevant to posterior-predominant prolapses as it is to anterior prolapse.

Keywords Post-reduction · Occult stress urinary incontinence · Rectocele

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Introduction

Pelvic organ prolapse (POP) and urinary incontinence (UI) are highly prevalent in women and significantly impair quality of life [1]. Wu et al. reported that 166,000 surgeries were performed in the United States for POP in 2010 and project that this number will likely increase to 310,050 per year by 2050 [2]. The goal of operative management is to improve vaginal bulge symptoms as well as associated quality of life for these patients. Prior studies suggest that between 10 % and 60 % of POP patients without concurrent baseline stress urinary incontinence (SUI) can develop de novo SUI after reconstructive surgery [3–6]. It is theorized that anterior vaginal wall prolapse can lead to urethral obstruction from "kinking" and thus mask SUI [7]. Reconstructive surgery that corrects anterior prolapse is thought to straighten the urethra, sometimes revealing SUI. Preoperative prolapse reduction testing can help identify such women with post-reduction SUI a priori [8–10]. While studies have observed substantial rates (approximately 30 %) of post-reduction SUI among patients with anterior-predominant prolapse [9, 10], little is known about post-reduction SUI in women with posterior-predominant prolapse, and no prior studies have compared the two cohorts.

The aim of this study was to compare anterior- and posterior-predominant prolapse groups and determine the associated risk factors for post-prolapse reduction SUI in a prospective cohort. Our subject population had been previously recruited based on their bothersome symptoms of prolapse and significant prolapse on examination, and were therefore seeking active management for their disease process. This cohort was felt to be an appropriate population to study owing to the subjects' inherent risk of developing de novo SUI following treatment. Based on prior studies focusing on anterior prolapse and the proposed mechanism regarding the pathophysiology of SUI, we hypothesized that the prevalence of demonstrable post-prolapse reduction SUI would be higher in anterior than in posterior prolapse patients.

Patients and methods

Population

Following approval by the University of Michigan Medical School Institutional Review Board, we performed a secondary analysis of two cohorts of prospectively enrolled women between November 2000 and August 2011 with symptomatic POP at our institution. The first cohort has been described previously [11]. The remaining women were more recently recruited in a similar fashion and had symptomatic rectoceles. Briefly, inclusion criteria were age >18 years, willingness to undergo a pelvic examination, and English speaking. Women who had undergone hysterectomy were eligible if the surgery had been carried out at least 2 years before enrollment and if the indication for surgery did not include pelvic floor dysfunction (e.g., pelvic organ prolapse, urinary incontinence, or fecal incontinence). Medical history parameters were obtained by patient report. For this secondary analysis, additional inclusion criteria were:

1. Anterior- *or* posterior-predominant prolapse, defined as at least 1 cm difference in *Ba* (most distal position of the anterior vaginal wall compared with *Bp* (most distal position of the remaining upper posterior vaginal wall) [12] with apical support above the hymen.
2. Anterior or posterior prolapse at least to the hymen or beyond.
3. Stress urinary incontinence testing performed with vaginal prolapse reduction. Women who had equal anterior and posterior prolapse (i.e., $Ba = Bp$) were excluded.

Clinical examination

Clinical evaluation included a focused gynecological examination and complex urodynamics [11]. The physical examination included a pelvic organ prolapse quantification (POP-Q) examination [12], which was performed in a semi-recumbent position. These findings established if the subject status was anterior- or posterior-predominant prolapse. Filling cystometrograms were stopped at a volume of 300 cc or maximum bladder capacity if the patient could not tolerate continued filling of normal saline and were performed with a dual-tip microtransducer (Gaeltek™MMI, Hackensack, NJ, USA) simultaneously recording urethral and bladder pressures. Urethral pressure profiles were performed and the maximum urethral closure pressure (MUCP) was calculated as the mean difference between the maximum urethral pressure and the resting bladder pressure across three pulls without prolapse reduction. At maximum bladder capacity, a semi-recumbent Valsalva stress urinary incontinence test was performed first at baseline, and then again after prolapse reduction, which was done using a large cotton swab or disarticulated speculum. Patients were asked to perform three coughs and three Valsalva maneuvers, each time with increasing force. Women were considered to have stress incontinence if they visibly leaked urine during at least one of the stress maneuvers. Testing was carried out by one of the authors or a urogynecology fellow.

The primary outcome was the occurrence of SUI, with and without prolapse reduction, in the anterior compared with posterior prolapse groups. This was defined as a positive stress test via either type of stress test (at 300 cc or at maximum bladder capacity if less), in the semi-recumbent position.

Statistical analysis

Wilcoxon rank-sum and Chi-squared tests were used to compare distributions of continuous and categorical variables between anterior and posterior prolapse groups. Logistic regression was used to assess the association between post-reduction SUI and the independent variables that were significantly associated in univariate analysis ($p<0.05$) or clinically important, with odds ratios and confidence limits calculated from model estimates, all in SPSS Version 18 (Chicago, IL, USA). Methods, definitions, and units conformed to the standards jointly recommended by the International Urogynecological Association (IUGA) and the International Continence Society (ICS), except where specifically noted [13].

Results

A total of 214 subjects were included, 45 of whom were in the posterior group and 169 in the anterior group. We observed no significant differences between the groups with regard to age, body mass index (BMI), parity, or menopause status. Maximum prolapse severity was greater in the

anterior group (lowest point of prolapse a mean of +3.1 cm in the anterior vs +2.0 cm in the posterior groups; $p=0.001$; Table 1). There were marginally more post-hysterectomy subjects in the posterior group ($p=0.04$) and mean baseline MUCP was higher in the anterior group, although not significant (57.7 cm H_2O in the anterior vs 49.9 cm H_2O in the posterior groups, $p=0.06$; Table 1). The POP-Q points for the two groups are shown in Table 2.

A baseline SUI rate (stress incontinence without prolapse reduction) of 9.8 % was found in our total population. Baseline SUI rates were 4.4 % in the posterior group and 11.2 % in the anterior group ($p=0.26$) (Table 3). Overall, we found a post-reduction SUI rate of 11.2 % in our study. Post-reduction SUI rates for the two groups were similar, 13.3 % for the posterior and 10.7 % for the anterior group ($p=0.52$) (Table 3). There were two patients, one from each group, who demonstrated SUI on baseline testing but not with their prolapse reduced. They were included in the baseline SUI group for analysis.

In univariate analysis, among posterior-predominant patients, lower MUCP values were associated with post-reduction SUI (mean: 53.1 cm H_2O continent with reduction vs 31.3 cm H_2O in the post-reduction SUI group; $p=0.02$). There was no difference in MUCP between the post-reduction continent and incontinent groups in the anterior cohort (mean: 57.7 cm H_2O continent with reduction versus 57.7 cm H_2O in the post-reduction SUI group; $p=0.28$).

Prolapse size also affected continence after reduction. Among the anterior-predominant group, women who had a larger mean prolapse at point *Ba* tended to have higher rates of leakage with reduction (+2.6 cm continent with reduction vs +4.2 cm in the post-reduction SUI group; $p=0.003$). Similarly, the mean maximum measurements at any POP-Q point (+2.9 vs +4.5 cm in the post-reduction SUI; $p=0.006$) were each associated with post-reduction SUI. *Ba* values and the maximum prolapse size were highly positively correlated ($r=0.90$).

To identify risk factors independently associated with post-reduction SUI, we used multivariate logistic regression modeling, including factors considered clinically important or that were significantly associated in the univariate analysis ($p<0.05$). Specifically, for the posterior group, these were age (univariate $p=0.22$) and MUCP (univariate $p=0.02$). Neither age nor MUCP remained significantly associated with post-reduction SUI in multivariate models; however, the odds ratio for a lower MUCP and post-reduction SUI in the posterior-predominant group was OR=0.90, but this was not statistically significant (95 %CI 0.80–1.01, $p=0.07$). A similar model was not completed for the anterior group owing to co-linearity between the variables of maximum prolapse and point *Ba*.

Table 1 Baseline characteristics of the study groups

	Anterior predominant ($n=169$)	Posterior predominant ($n=45$)	p value
Age (years)[a]	56.6 (12.0)	58.0 (11.3)	0.59
BMI (kg/m^2)[a]	26.7 (5.1)	28.1 (5.9)	0.19
Parity[a]	3.0 (1.8)	3.0 (1.8)	0.44
Hysterectomy[b]	31 (18.5)	15 (33.3)	0.04
Menopause[b]	100 (59.2)	33 (73.3)	0.09
Maximum prolapse (cm)[a]	3.1 (1.9)	2.0 (1.3)	0.001
Mean MUCP (cmH_2O)[a]	57.7 (27.2)	49.9 (21.5)	0.06

Data reported as either mean (SD) or *n* (%)

[a] Wilcoxon rank-sum test (nonparametric *t* test)

[b] Chi-squared test

Discussion

In clinical practice, we have noted that a number of patients undergoing isolated posterior compartment reconstruction have developed de novo SUI; however, published data regarding the prevalence of post-reduction SUI among such patients are limited. In this study, post-reduction bladder testing revealed that women with posterior-predominant prolapse were as likely as those with anterior-predominant prolapse to demonstrate incontinence once the prolapse had been reduced. Prior studies have gained insight into prolapse symptomatology by comparing patients with cystoceles with those with rectoceles, but our understanding of post-prolapse reduction SUI remains limited to studies evaluating patients with single-compartment prolapse [14]. Although a few studies have evaluated women with posterior prolapse only [15, 16], no prior study has compared anterior with posterior prolapse groups with respect to post-reduction SUI in a prospective cohort enabling relative comparisons.

Prior multicenter studies have demonstrated the role of preoperative prolapse-reduction testing in patients with anterior and apical prolapse; this is based on the theory that anterior vaginal prolapse causes urethral obstruction and masks incontinence. The goal of reduction testing is to identify and potentially treat that problem, maximizing patient satisfaction. In the CARE trial, continent women undergoing abdominal sacrocolpopexy for prolapse stages 2–4 were randomized regarding a concomitant Burch colposuspension, and a significant decrease in de novo SUI was seen in the Burch subjects [17]. Preoperatively, only approximately 4 % of these women showed SUI *without* their prolapse being reduced. However, following reduction, up to 30 % of the subjects demonstrated SUI. Furthermore, the women who demonstrated post-reduction SUI preoperatively were at a higher risk of postoperative SUI [9]. The OPUS

Table 2 Median pelvic organ prolapse quantification (POP-Q) points of the groups

POPQ point D data include only those patients who had not undergone a prior hysterectomy

POPQ measurement (medians)	Aa	Ba	C	D	Ap	Bp
Anterior predominant	+1	+2	−2	−6	−1	−1
Posterior predominant	−1	−1	−5.5	−7	+1	+2
p value	<0.001	<0.001	0.01	<0.001	<0.001	<0.001

Trial (outcomes following vaginal prolapse repair and mid-urethral sling), presented at the International Continence Society Meeting in 2011, reported a rate of post-reduction SUI of 33.5 % and found that a prophylactic TVT during prolapse surgery resulted in superior continence rates at both 3 and 12 months, regardless of the subjects' preoperative post-reduction SUI testing [10, 18]. They also reported a trend toward a better continence outcome for those patients with a positive prolapse reduction stress test. Based on these prior studies, we hypothesized that the prevalence of demonstrable post-reduction SUI would be higher in anterior- than in posterior-predominant prolapse women. In contrast, we observed essentially equal rates of post-reduction SUI in posterior and anterior cases.

Compared with these studies, our post-reduction SUI rate of approximately 11 % in the anterior group was comparatively lower, likely because of the testing technique and patient characteristics [9]. The reduction technique has been shown to significantly affect the prevalence of post-reduction SUI and can be considered a weakness of our study and any others evaluating occult SUI with regard to reproducibility and effectiveness [9, 10, 18]. However these tests are far from consistent. Experienced clinicians recognize that even with a single technique (e.g., swab reduction), incontinence can be demonstrated or not demonstrated by varying the amount of upward pressure applied. Our examiners were allowed to choose between a speculum or a swab for the reduction based on vaginal examination and prolapse type. It is possible that there was less "overcorrection" of prolapse in our cohort when the swab was used, thereby preventing levator muscle retraction, prompting more SUI. Additionally, we did not perform testing in the standing position, which may have unmasked more SUI as found in the OPUS trial [10, 18]. Our patients were tested with a transurethral catheter in place, which was not removed despite failure to leak, thereby possibly leading to lower detected rates of SUI. Cohort differences should be noted as well. The CARE trial subjects had more severe prolapse (87 % stages 3–4 versus 68 % stages 3–4 herein), which as our findings associating prolapse severity and post-reduction SUI among anterior prolapse patients suggest, may account for this difference.

Myers et al. evaluated 90 subjects with varying degrees of posterior prolapse, comparing urodynamic findings between the controls (posterior prolapse above the hymen, grades 0–2) and women with grade 3 posterior prolapse. They observed post-reduction stress incontinence only in the grade 3 group, with a prevalence of 14.3 % [15], similar to our findings of 13 %. Nguyen et al. evaluated 54 patients with stage 2 or greater posterior prolapse, comparing them with a similar group of nonprolapsed controls. They reported a higher rate of occult SUI (54 %) than we found, despite a younger population, with less prolapse and higher MUCP values [16]. These findings may reflect the "over-retraction" of the posterior wall with the speculum, eliciting more SUI. This cohort also had a higher rate of prior incontinence surgeries, possibly leading to changes in urethral function. A strength of our study is that none of our patients had undergone prior genitourinary surgery (other than hysterectomy), and urethral function was likely unaltered from an iatrogenic perspective in our population.

Additionally, we observed a difference in risk factors for post-reduction SUI between the anterior and posterior groups. In women with anterior-predominant prolapse, women who demonstrated post-reduction SUI had a prolapse that was 1.5 cm lower than those who did not. Few studies have evaluated prolapse severity as a predictor of occult or de novo SUI in subjects with cystoceles. Reena et al. found a trend toward more de novo SUI with more severe prolapse postoperatively in a prospective cohort, although their population included only a small number of stage 2 prolapses and nonstandardized postoperative evaluation [8].

Myers et al. and Nguyen et al. observed that rectocele severity was associated with higher rates of occult SUI, the former concluding that women with grade 3 posterior wall defects should undergo urodynamic evaluation with reduction [15, 16]. In our posterior cohort, we did not observe that severity of prolapse was associated with post-reduction SUI. However, each study defined prolapse differently and the

Table 3 Stress urinary incontinence rates between groups

[a]Data reported as *n* (%)

	Anterior-predominant[a]	Posterior-predominant[a]	*p* value
SUI *without* reduction (baseline)	19/169 (11.2 %)	2/45 (4.4 %)	0.26
SUI *with* reduction only (occult)	18/169 (10.7 %)	6/45 (13.3 %)	0.52

prior two studies included women with relatively normal vaginal support for comparison. Not surprisingly, Nguyen et al. found that patients with POP-Q stages 2–4 were at a higher risk of post-reduction SUI compared with stages 0–1. Myers et al. used the Baden–Walker system and found that only grade 3 prolapse (descent halfway beyond the hymen) conveyed an increased risk. In this study, we included only patients with prolapse to the hymen or beyond; we may have also seen a difference in prolapse severity as a risk factor if we compared them with women with relatively normal support. It could also be hypothesized that there was a significant difference in urethral function among these cohorts; however, our mean MUCP for the posterior group when not reduced fell between the Myers and Nguyen cohorts, with the latter demonstrating an even higher MUCP average (MUCP mean: Myers et al. =39−47 cm H_2O, present study =49 cm H_2O, Nguyen et al. =62 cm H_2O).

We also found that older subjects were at a greater risk of post-reduction SUI in both groups (greater in the posterior group) in our univariate analysis. This may be related to the age effect of urethral sphincter function, as both age and menopausal status have been positively correlated with intrinsic sphincter deficiency [19, 20]. Because this association was stronger in our posterior group, we included age and MUCP in our posterior multivariate regression analysis and found not only an association with persistent MUCP effect, but also, not surprisingly, that age was likely associated as well.

It is not surprising that with more severe prolapse, greater urethral obstruction may occur. This is consistent with data showing that the prolapse of either compartment can elevate MUCP and that reduction significantly lowers MUCP [15, 21]. Our anterior group showed higher MUCP values than the posterior group in general (Table 1) and had more severe prolapse. In addition, both anterior groups, whether or not they leaked with reduction, had higher MUCP values than both posterior groups, but were more similar to the posterior group that did not leak (Table 4). Finally, the lowest MUCP values were found in the posterior prolapse women who suffered leakage. Based on these findings and in keeping with prior theories [7, 22], we propose that prolapse severity leading to urethral hypermobility and obstruction plays the predominant role for continence in women with cystoceles. In contrast, in women with rectoceles, the continence mechanism relies on urethral obstruction by posterior wall buttressing only in those patients with poor urethral function. In other words, if a patient's urethral sphincter mechanism is relatively normal, removing the posterior bulge is less likely to result in occult SUI. A limitation of our study is that we did not collect post-reduction MUCP values and therefore cannot comment on the accuracy of MUCP measurements in this prolapse population.

Our population is otherwise representative of women who suffer from pelvic organ prolapse and incontinence. Other studies have shown that cystoceles have a higher incidence than rectoceles in the general population and that they are typically more severe [14, 20]. Furthermore, it has been shown that patients with cystoceles are more likely to have concomitant apical prolapse than women with rectoceles [23, 24]. Our cohort had more anterior predominant prolapse, which was also more severe than the posterior predominant group and associated with more apical prolapse. Importantly, the posterior group still demonstrated similar rates of post-reduction SUI despite having less severe prolapse; therefore, we do not think that this demographic imbalance significantly biased our results. A final limitation of our study is that we did not have validated subjective measures of urinary incontinence.

Table 4 Univariate analysis comparing predictors of post-reduction SUI between anterior- and posterior-predominant groups

	Anterior-predominant			Posterior-predominant		
	PRSUI -	PRSUI +	*p* value	PRSUI-	PRSUI +	*p* value
Age (years)	56.2 (12.1)	60.1 (10.9)	0.31	57.1 (11.6)	61.7 (8.0)	0.22
BMI (kg/m^2)	26.7 (5.0)	27.6 (6.0)	0.90	27.8 (6.0)	29.3 (6.4)	0.68
Parity	2.9 (1.7)	3.1 (2.2)	0.90	2.7 (1.7)	2.7 (1.2)	0.24
Hysterectomy	26 (17.3 %)	5 (27.8 %)	0.51	13 (34.2 %)	2 (33.3 %)	0.77
Menopause	85 (56.7 %)	14 (77.8 %)	0.16	26 (68.4 %)	6 (100 %)	0.22
Maximum prolapse (cm)	2.9 (1.8)	4.5 (2.2)	0.006	2.0 (1.3)	2.5 (1.4)	0.31
POP-Q point *Ba*	2.6 (1.6)	4.2 (2.0)	0.003	−1.0 (1.1)	−1.7 (0.8)	0.27
POP-Q point *Bp*	−0.9 (1.7)	−1.1 (1.2)	0.70	1.9 (1.3)	2.5 (1.4)	0.31
MUCP (cmH_2O)	57.7 (25.3)	57.7 (41.2)	0.28	53.1 (21.3)	31.3 (7.1)	0.02

PRSUI = post-reduction stress urinary incontinence

Values reported as mean (SD) or *n* (%)

Nonparametric *p* values reported

In conclusion, we observed similar rates of post-reduction stress urinary incontinence in women with anterior- compared with posterior-predominant prolapse. Prolapse severity was associated with post-reduction SUI in women with anterior-predominant prolapse. In contrast, urethral function was more predictive of post-reduction SUI in patients with posterior-predominant prolapse. These findings may highlight an important difference in continence mechanisms between women with cystoceles versus rectoceles. Larger prospective studies with more detailed urodynamic testing are needed to shed further light on these possible mechanistic differences in continence in the prolapse population. Despite divergence of opinion regarding management of post-reduction SUI when identified, this study demonstrates the importance of testing not only women with cystoceles, but also women with rectocele for operative planning.

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