

Predictors of Voiding Dysfunction after Mid-urethral Sling Surgery for Stress Urinary Incontinence

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Purpose: Postoperative voiding dysfunction is a bothersome complication after mid-urethral sling surgery. The current study presents multiple repeated postoperative voiding trials against a urine load of preoperative functional bladder capacity, as estimated by a preoperative frequency volume chart, to identify the relevance of preoperative and immediate factors to the outcome.

Methods: A total of 180 patients were enrolled from August 2008 to August 2011. Patients received mid-urethral sling surgery with a transobturator tape, with or without concomitant cystocele repair. Patients reported relevant medical histories and a 3-day frequency volume chart and underwent urodynamic studies. After surgery, patients were filled to their maximum bladder capacity as dictated by their frequency volume chart and performed the first voiding trial. Two subsequent voiding trials were performed after natural filling. Failure of any single voiding trial was considered failure. Patients who failed the final voiding trial received intermittent catheterization to follow-up. After screening for relevant factors with the use of univariate analyses, preoperative, surgical, and postoperative factors predicting outcome were estimated by logistic regression analysis.

Results: The urine load at the voiding trial and the peak flow rate immediately preceding the voiding trial predicted voiding trial success in the multivariate analysis. Urine load and previous trial peak flow rate were relevant when tested against each individual voiding trial. Preoperative and surgical factors, such as age, parity, and concomitant cystocele repair, showed significance in the univariate analysis. Overall, 16.1% of patients who passed the first voiding trial failed on subsequent trials, whereas 36.8% of patients who failed the first voiding trial succeeded.

Conclusions: Postoperative voiding dysfunction is transient and is associated with the immediate voiding conditions following surgery. Close observation against urine overload in the bladder is important when weaning patients back to normal voiding conditions.

Keywords: Suburethral slings; Urinary retention; Urinary incontinence

INTRODUCTION

Postoperative voiding dysfunction following a mid-urethral sling procedure is a bothersome complication that occurs in approximately 3 to 10% of patients who undergo the procedure [1,2]. Temporary voiding dysfunction manifests as transient urinary retention or incomplete bladder emptying, which may require prolonged or intermittent catheterization and is associ-

ated with an increased risk of urinary tract infection and patient inconvenience [3].

Several retrospective studies have evaluated patient characteristics in an attempt to predict which patients are at higher risk for postoperative voiding dysfunction according to preoperative factors. Commonly, objective or subjective preoperative variables from the patient history and urodynamic variables that may predict the possibility of low bladder functionality have

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been the focus of investigation [1,2,4,5]. However, recent studies have also shown that single estimation of postoperative voiding function is not reliable in predicting maintenance of good functionality and that such preoperative factors do not necessarily ensure against subsequent successful voids [3].

Urinary retention in itself is not a unique occurrence pertaining to incontinence surgery in the context of postoperative voiding dysfunction. Several studies have highlighted the importance of fluid load in predicting the occurrence of postoperative retention [6-9]. Although the frequent use of catheterization during and after incontinence surgery may have abated the concern of fluid load, failure of preoperative measures in predicting the outcome of repeated voiding trials may signify the importance of the immediate voiding conditions surrounding postoperative voiding.

Whereas preoperative factors are of no doubt important for successful postoperative voiding after mid-urethral sling surgery, the presence of urine overflow during each voiding trial may be as important in weaning the postoperative bladder to a functional voiding condition. The current study presents multiple repeated postoperative voiding trials against a urine load of preoperative functional bladder capacity, as estimated by a preoperative frequency volume chart, to identify the relevance of preoperative and immediate factors in dictating the outcome.

MATERIALS AND METHODS

Patient Recruitment and Preoperative Investigations

Institutional Review Board approval and written informed consent were obtained. Patients undergoing incontinence surgery with a mid-urethral sling were prospectively enrolled from August 2008 to August 2011.

Demographic data and pelvic surgical history were obtained. Subjective symptom severity of stress urinary incontinence was stratified by Stamey grade. Physical examination was performed to identify concurrent prolapse. Patients were required to fill out a 3-day frequency volume chart, by which the maximum voided volume was identified and the presence of mixed urinary incontinence was noted. Urinalysis and urine cultures were performed to rule out urinary tract infection.

Preoperative urodynamic studies were performed, documenting uroflowmetry, filling cystometry, pressure flow study, and measurement of Valsalva leak point pressure. The studies were performed with the patient in a birthing chair at a 45-degree angle. After catheterizing for post-void residual (PVR), cysto-

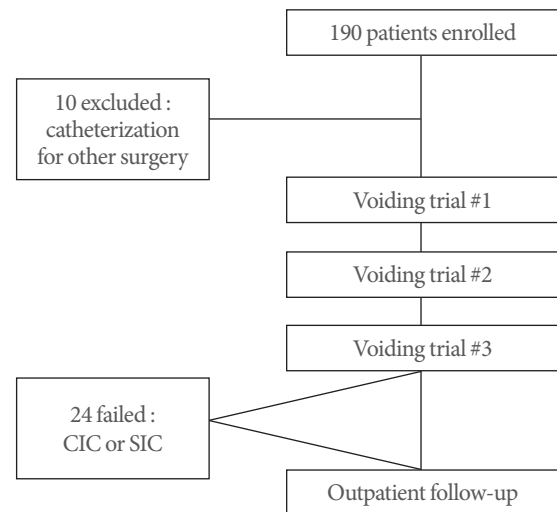


Fig. 1. Patient enrollment and study. CIC, clean intermittent catheterization; SIC, self intermittent catheterization.

metrics were performed with a Laborie 8 Fr twin lumen urodynamic catheter (Laborie Bonito Urodynamics 64 unit, LIT 1000 Series, Laborie Medical Technologies, Williston, VT, USA) at a fill rate of 50 mL per minute. First desire, strong desire, and maximal bladder capacity were recorded. Pelvic organ prolapse quantification stage II or greater prolapse was reduced with ring forceps before obtaining Valsalva leak point pressures at 150 mL, 200 mL, and maximal bladder capacity. Data collected from post-cystometrogram uroflowmetry with the catheter removed included flow pattern (intermittent/fluctuating or continuous), maximum flow rate, average flow rate, voiding time, time to peak flow, voided volume, and PVR volume. Pressure flow studies were performed and maximum detrusor pressure and detrusor pressure at maximal flow were obtained (Fig. 1).

Surgical Methods

All patients received general anesthesia. The mid-urethral slings and concurrent vaginal repairs were performed by a single surgeon. All mid-urethral sling procedures were performed with a transobturator tape (TOT). All patients were catheterized with an 18 Fr Foley catheter until the first postoperative day. All postoperative pain control was performed with intramuscular ketorolac or enteral acetaminophen as needed.

Voiding Trials

Voiding trials were performed beginning on the first postoperative day. The bladder was filled with normal saline and a corresponding volume of the maximum voided volume as noted on

the 3-day frequency volume chart. After instruction to refrain from Valsalva-assisted voiding, patient voiding was measured with uroflowmetry and a residual volume was estimated by ultrasonography. Failure of a single voiding trial was defined as the presence of a residual volume over 150 mL. Overall failure was defined as failure of any single voiding trial during three consecutive voids.

The second and third voiding trial was performed at the next consecutive normal voiding sensation after natural filling, also under uroflowmetry measurements.

Patients who failed were discharged home and were instructed to perform self-intermittent catheterization until PVR reached less than 50 mL. These patients underwent a repeat voiding trial at the clinic within 7 days.

Statistical Analysis

Univariate analysis of all patient baseline and operative characteristics was performed between patients who failed in any voiding trial and patients who succeeded in all voiding trials. Because the overall success of three voiding trials was defined by success in all three attempts, the largest voiding trial urine volume load at the voiding trial and smallest maximum flow of the previous voiding trial were also included in the analysis. Because voided volume was dependent on residual volume, which was the dependent factor determining voiding trial success, it was excluded from prediction.

Chi-square analyses were used to test for association between the outcome and categorical or ordinal predictors. Simple logistic regression models were used to test for association between the outcome and continuous predictors. Based on the recommendations of Hosmer and Lemeshow [10], the results from the univariate analyses were used in a screening approach to reduce the number of predictors included in the multivariable logistic regression model. Under this screening procedure, a sample size of 180 observations provides 80% power to detect an odds ratio of 1.589 or greater (or 0.629 or less) when examining the association between the probability of passing the first voiding trial and a continuous predictor. Variables with a P-value of 0.10 or less were included in the model. Backward selection methodologies were used to construct a parsimonious multivariable logistic model to predict passing each voiding trial and the logical sum of all voiding trials. Statistical analyses were performed by using R ver. 2.12.2 (R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

Patient Characteristics

A total of 190 patients were enrolled from August 2008 to June 2011. Ten patients were excluded because they had received other combined abdominal surgery requiring indwelling catheterization and prolonged bed rest. A total of 180 patients underwent a TOT procedure and were followed up for three voiding trials before being discharged. The average age of the patients was 57.46 ± 10.17 years and the patients' average body mass index was 25.33 ± 3.32 kg/m². Overall, 36 patients (20.0%) had a history of previous pelvic surgery, but no patients were undergoing repeat incontinence surgery. Forty-one patients (22.7%) underwent surgery for a concomitant cystocele, whereas all other patients received TOT only. Seventy-five patients (41.7%) underwent surgery for mixed urinary incontinence.

Immediate Voiding Trial Results

Three voiding trials were performed before discharge. Overall, 45 patients (25.0%) failed at least one voiding trial, whereas 20 patients (11.1%) failed a single voiding trial, 19 patients (10.6%) failed two voiding trials, and 6 patients failed all three voiding trials (3.3%). Nineteen patients (10.6%) failed the first voiding trial when filled to the maximum voided capacity dictated by their 3-day frequency volume chart. Thirty-three patients (18.3%) failed the second voiding trial when voiding after natural filling. Twenty-four patients (13.3%) who failed the third voiding trial were discharged with an indwelling Foley catheter. At the outpatient follow-up at 1 week, all patients voided successfully.

Of note, 16.1% (26/161) of patients who passed the first voiding trial subsequently failed one or more of the subsequent voiding trials, whereas 36.8% (7/19) of patients who failed successfully voided on both subsequent trials. The negative predictive value of the first trial for the second was 57.9% (11/19), and the positive predictive value was 86.3% (139/161). The negative predictive value of the second trial for the third was 57.6% (19/35), and the positive predictive value was 96.6% (142/149).

Risk Factors for Voiding Trial Failure

The univariate analysis identified 5 potential predictive variables using $P < 0.10$ for passing all voiding trials (Table 1). Model building via backward stepwise logistic regression found maximum urine load at the voiding trial and minimum urine flow of the previous voiding trial to be significant.

Classification of cases on the basis of this model showed a

Table 1. Preoperative, surgical, and postoperative factors of voiding trial success as estimated by univariate and multivariate analyses

Variable	Overall	Success	Fail	Univariate	Multivariate	Odds ratio	95% CI
No.	180 (100)	135 (75.0)	45 (25.0)	0.25			
Age (yr)	57.46 ± 10.17	56.54 ± 9.71	60.30 ± 11.12	0.04	0.11		
BMI (kg/m ²)	25.33 ± 3.32	25.47 ± 3.45	24.90 ± 2.91	0.36			
Pelvic surgery	36 (20.0)	29 (21.5)	7 (15.6)	0.26			
Menopause	128 (71.5)	93 (68.9)	35 (79.5)	0.12			
Parity (3)	30 (16.7)	18 (13.6)	12 (26.3)	0.08	0.29		
SUI Grade				0.61			
1	77	58	19				
2	103	72	31				
Mixed UI	75 (41.7)	60 (44.4)	15 (33.3)	0.13			
Urodynamic study							
Qmax (mL/sec)	25.20 ± 11.13	25.91 ± 10.86	23.09 ± 11.75	0.15			
Residual urine	22.61 ± 24.96	21.38 ± 23.99	26.25 ± 27.58	0.27			
Max capacity (mL)	344.45 ± 46.26	344.39 ± 42.95	344.64 ± 55.34	0.98			
PdetQmax (cmH ₂ O)	19.47 ± 13.02	19.95 ± 14.30	18.07 ± 8.20	0.41			
Pdetmax (cmH ₂ O)	138.00 ± 25.00	25.58 ± 14.53	23.27 ± 8.83	0.32			
VLPP, 200 mL (cmH ₂ O)	54.95 ± 25.39	55.52 ± 25.52	53.15 ± 25.23	0.61			
Voiding diary							
Frequency	7.87 ± 3.57	7.80 ± 3.38	8.06 ± 4.12	0.72			
Nocturnal frequency	1.05 ± 1.12	1.06 ± 1.17	1.03 ± 0.95	0.91			
Max volume (mL)	352.06 ± 128.49	354.54 ± 132.05	345.00 ± 119.35	0.71			
Min volume (mL)	101.27 ± 62.84	103.85 ± 62.23	93.82 ± 64.95	0.43			
Surgery							
Cystocele repair	41 (22.7)	21 (17.0)	20 (39.5)	0.01	0.10		
Voiding trial							
Urine load (mL)	363.10 ± 127.30	336.74 ± 111.06	436.34 ± 141.51	<0.01	<0.01	0.989	0.984-0.995
Qmax previous (mL/sec)	14.58 ± 7.39	15.92 ± 7.14	10.56 ± 6.69	<0.01	<0.01	1.236	1.115-1.369

Only the postoperative factors of urine load and previous voiding trial peak flow remained predictive in the multivariate analysis.

Values are presented as number (%) or mean ± SD.

BMI, body mass index; SUI, stress urinary incontinence; UI, urinary incontinence; Qmax, maximum urine flow rate; VLPP, Valsalva leak point pressure.

positive predictive value of 82.6% (128/155) and a negative predictive value of 76.0% (19/25). The separate areas under the curve (AUC) for a maximum urine load and minimum urine flow predicting overall voiding trial success were 0.709 and 0.740, respectively (Fig. 2).

DISCUSSION

The highest predictive factors for postoperative voiding dysfunction following mid-urethral sling surgery for stress urinary in-

continence in 180 patients were the urine flow rate of the immediate preceding voiding trial and the urine load of the current voiding trial. These factors, which describe the immediate voiding function at the time of the voiding trial, were more significant than preoperative predisposing factors. Fluid retention has been shown to be a prominent patho-etiological factor in the investigation of other surgical procedures [7,9]. Tammela et al. [9,11,12] showed that intraoperative fluid load and the volume of primary urinary retention were the most significant factors predicting postoperative urinary retention in 5,520 patients

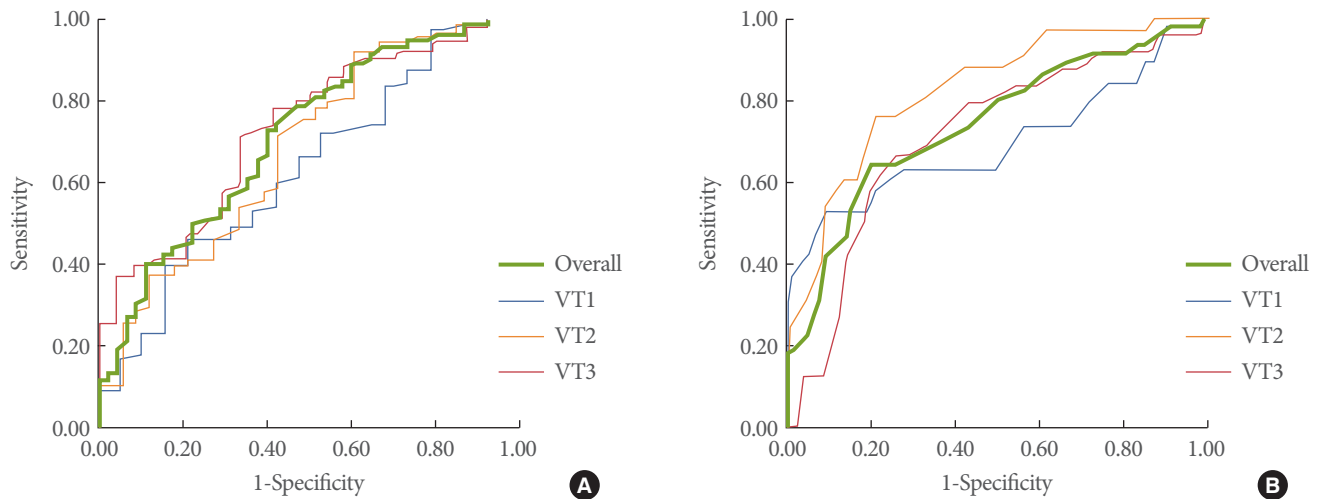


Fig. 2. The receiver operator curve and area under curve for (A) urine load of each trial and (B) urine flow of the previous trial predicting the outcome of each trial. (A) Urine load at each trial predicting voiding trial success. Area under the curve (AUC) for overall success was 0.709, 0.631, 0.681, and 0.730 for each consecutive trial, respectively. (B) Peak urine flow at each trial predicting voiding trial success. AUC for overall success was 0.740, 0.697, 0.823, and 0.711 for each consecutive trial, respectively. VT, voiding trial.

undergoing urologic surgery. These factors were more relevant than the type of anesthesia or previous cholinergic medications the patients were receiving; however, the type of surgery was not clearly described. Petros et al. [7] also found the amount of perioperative fluid given to be the most significant predictive factor for urinary retention in patients undergoing herniorrhaphy. Although the volumes in these studies were generally overt retention in the range of 500 to 1,200 mL, Tammela et al. [12] also found that retention occurred in 13.6% of retention patients with volumes smaller than 500 mL. The current study demonstrated voiding dysfunction developing following a series of similar procedures under the same type of anesthesia. Despite being assisted by immediate catheterization following surgery, significant voiding dysfunction developed at the urine loads usually managed before surgery, demonstrating an increased susceptibility to developing urinary retention in the postoperative setting.

Despite these studies indicating urine load as a significant factor in postoperative voiding dysfunction, studies investigating mid-urethral sling procedures have mostly focused on preoperative parameters [2-5,13,14]. Kleeman et al. [2] initially showed that a high PVR urine amount before surgery was significant in predicting the development of postoperative voiding dysfunction. Miller et al. [13] associated these events with a low preoperative detrusor pressure on urodynamic studies, and Hong et al. [14] suggested that a low preoperative urine flow rate was the only predictive preoperative factor. In contrast, Minas-

sian et al. [5] presented data suggesting that smaller preoperative PVR urine predisposed to postoperative voiding dysfunction, whereas Barron et al. [4] associated the patho-etiology with preoperative Valsalva leak point pressure greater than 60 cmH₂O in addition to psychological factors and patient surgical history. Our own data from the univariate analysis agree with the former position that poor preoperative voiding dysfunction is more dominant in patients who develop voiding dysfunction.

However, these studies focused on the initial event of voiding dysfunction, whereas both in the study by Wheeler et al. [3] and in the present study, voiding dysfunction developed in a significant proportion of patients who had passed the first voiding trial. The study by Wheeler et al. [3] showed that 16.4% of patients who passed the initial voiding trial failed on the second. Our study also showed similar results, with 16.1% failing one or more of the subsequent voiding trials. Furthermore, whereas the study by Wheeler et al. [3] excluded patients who failed at any point, our study showed that even among patients who failed the initial voiding trial, 36.8% successfully voided on subsequent trials. In the analysis of postoperative voiding trials, we showed that factors more immediately predisposing to the voiding trial, such as the immediate urine load and the peak flow rate of the previous voiding trial, were more significant in influencing the outcome than were preoperative factors, which suggests a more transient patho-etiology in the development of voiding dysfunction in the postoperative setting. Furthermore, the strength of predicting the failure of the following trials simply on the basis

of failure, i.e., the negative predictive value of individual voiding trials, remained at 57.6 to 57.9%, indicating that 42.3 to 42.1% of patients who failed at each voiding trial succeeded in the subsequent trial. The transient nature of these voiding trial failures were more prominent when considering that all patients successfully voided at the 1-week follow-up and show the necessity of assessing voiding function multiple times despite initial failure.

With the lack of specific definitions for postoperative voiding dysfunction in patients undergoing mid-urethral sling procedures, it is difficult to directly compare results between several studies. The definition of voiding trial failure varies between studies, from proportional definitions of 20 to 50% of the urine load to clearly defined levels of 100 to 150 mL [1-5,15]. Furthermore, the urine load is less clearly described. Kleeman et al. [2] suggested filling of 300 mL or by subjective fullness, whereas Barron et al. [4] suggested filling of at least 200 mL. Other studies did not specify or analyze the urine volume of the voiding trial. Our study opted to define failure by a specific amount of residual urine, because the focus was more heavily dependent on urine load. Urine load was allowed to fill naturally if possible, and the first volume trial also used saline infusion to the bladder capacity as described in the patient's maximum bladder capacity on the frequency volume chart. Although these volumes were small compared with volumes that usually instigate acute urinary retention in the clinical setting, the recovery from failure to void in these patients was also relatively shorter than that which would be expected when overloaded with grossly large volumes. Also, although this method lacks rigorous standardization between patients, it also accounts for the variability in the patient's natural voiding habits, which may be difficult to stratify with only those factors represented on a urodynamic study.

By demonstrating the transient nature of voiding dysfunction in the postoperative setting, with its risk increasing with the immediate voiding conditions, this study demonstrates the importance of managing urine volume to prevent overloading in these patients. Close observation of patient urine load following catheter removal is important in weaning the patient to the unfamiliar voiding conditions following mid-urethral sling surgery. Although identification of an ideal cutoff for urine load is beyond the scope of this study, the AUC of the overall voiding trial suggests 400 mL as an estimate of the cutoff for ensuring the preservation of voiding function. Further study may be required to determine the individual level of urine load for each patient. A more stringent stratification of preoperative parameters would

also improve our findings.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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