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ORIGINAL PAPER

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# The importance of studying pressure-flow for predicting postoperative voiding difficulties in women with stress urinary incontinence: a preliminary study that correlates low Pdet×Qave with postoperative residual urine

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**Abstract** We evaluated the parameters of preoperative pressure-flow for predicting the postoperative voiding difficulties in women with stress urinary incontinence. The preoperative urodynamic study records of 14 women treated using the tension-free vaginal tape (TVT) procedure were retrospectively analyzed. Of the patients treated with the TVT procedure, urinary retention occurred in one patient, and three had a residual urine volume of more than 30 ml. All patients became completely free of stress urinary incontinence postoperatively. The lowest Pdet max (5 $cmH_2O$) in the preoperative pressure-flow study was found in a patient with a remarkable postoperative residual urine volume of more than 50 ml. The second lowest Pdet max value (8 $cmH_2O$) was seen in a patient with postoperative urinary retention, whose residual urine volume, however, decreased to almost zero 1 year after the operation. The preoperative Pdet max×Qave values were remarkably low for these three patients, including the one with the lowest Pdet max, with a post-void residual urine volume of more than 30 ml. The plots of Pdet max×Qave versus the age of patients show that the Pdet max×Qave values tend to decrease with aging. The preoperative Pdet max×Qave value can be an important parameter for predicting increased residual urine after TVT sling surgery.

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## Introduction

Since 1998, a tension-free vaginal tape (TVT) procedure for treating women with stress urinary incontinence has become one of the most popular surgical techniques for this problem. It was developed by Ulmsten et al., who emphasized the importance of the pubourethral ligament and thus posited that the purpose of the TVT procedure was to support the mid-urethra by a prolene mesh tape without adding any tension, resulting in reinforcement of the suburethral vaginal hammock [9]. A short-term TVT success rate has been reported to be around 90% for complete cure and 10% for significant improvement [10]. Recently, the 5 years follow-up results were published, according to which 84.7% of the patients were completely cured both objectively and subjectively, and 10.6% improved significantly without any long-term voiding difficulties [7].

Although the TVT procedure is supposed to be an easy to learn, safe, and minimally-invasive with a high long-term success rate, troublesome postoperative complications such as urinary retention, difficult voiding, and the new onset of urge symptoms have been reported [3, 4]. Deval et al. reported that of 189 cases treated using the TVT procedure, the major postoperative complications were urinary retention in 6.4%, difficulty in voiding in 10.7%, and new onset urge symptoms in 21.3%. The patients with urinary retention or difficult voiding with residual urine of 150 ml or greater were treated with a temporary intermittent self-catheterization, sling adjustment or tension-free vaginal tape section [4]. These complications may be attributed to the position of the tape, the adjustment of which is the most

difficult part of the TVT procedure, although no elevation of the mid-urethra or addition of tension is supposed to occur in this procedure.

Thus, it is beneficial to predict the possible occurrence of complications, such as urinary retention and post-void residual urine, prior to surgery. In this paper, we emphasize the importance of a preoperative pressure-flow study in order to evaluate the contractility of the detrusor, and we posit that a low Pdet max (maximum detrusor pressure)×Qave (mean urinary flow rate) value can predict the risk of postoperatively increased residual urine.

## Patients and methods

From April 2000 to July 2003, 14 patients with genuine stress urinary incontinence aged of $57.1 \pm 8.6$ (mean ± SD: range 45–72) were assessed urodynamically and then treated with the TVT procedure. All patients underwent a 60 min pad test, free-flow uroflowmetry, measurement of post-void residual urine volume, chain-cystogram, and a pressure-flow study preoperatively. The pressure-flow study was carried out using Griffon Urodynamics Model GR860U (Albyn Medical; Dingwall, Scotland) with an indwelling 8-F double lumen catheter in the urethra. One lumen was used for filling with physiological saline at 37°C at a filling rate of 20 ml/min. Another was connected to the transducer. Intra-abdominal pressure was recorded via an 18-F rectal catheter with a balloon. Intra-vesical and -rectal pressures were recorded simultaneously. The post-void residual urine volume was determined by transabdominal ultrasonography (3.5 MHz; Aloka) after free-uroflowmetry. The Pdet max×Qave value was calculated using the Pdet max from the pressure-flow study and Qave from free-uroflowmetry, performed separately. After surgery, uroflowmetry and the measurement of post-void residual urine volume were performed within 2 weeks. When clinically significant residual urine of more than 30 ml was seen postoperatively, uroflowmetry and the measurement of residual urine volume were performed at least every 6 months. The TVT procedure was performed as described by Ulmsten et al. under local anesthesia by the same urologist or gynecologist [9, 10]. The patients were asked to cough to confirm that continence was achieved and that the adjustment of the tape was not too tight to allow a space between the tape and urethra, preventing the cough-provoked leakage. Usually, no indwelling catheter was used after the operation.

## Results

The characteristics of the patients enrolled are summarized in Table 1. No patient had previously undergone abdominal or intrapelvic surgery with the exceptions of case 6 who had had an hysterectomy and resection of the urethral diverticulum at the ages of 38 and 44, respectively; and case 13 who had undergone Stamey's procedure. Patients with urge incontinence and prolapse were not enrolled. According to the Blaivas' classification, there were eight cases of type I, four of type IIA, and two of type III disease. Neither uninhibited contractions nor abnormal findings indicating neurogenic bladder was found on cystometry. The mean Pdet max was $22.6 \pm 11.1$ $cmH_2O$ and the mean Pdet open (opening pressure) $8.3 \pm 7.3$ $cmH_2O$. As shown in Fig. 1, urinary flow rates decreased from $27.0 \pm 10.8$ to $16.4 \pm 4.1$ ml/sec for the peak flow rate, and from $15.3 \pm 7.8$ to $8.4 \pm 2.7$ ml/sec for the average flow rate, indicating that postoperative urethral resistance increased in all cases.

All patients were completely continent after the TVT operation. In one patient, the urge symptoms developed after 6 months. No patient was treated with intermittent self-catheterization for urinary retention. In case 11, who voided using abdominal pressure and showed the

**Table 1** Characteristics of patients assessed by study of pressure-flow and free-flow uroflowmetry prior to TVT surgery

| Case | Age | Type | Pad test (g) | PVU angle | Cystometry (pressure flow) | | | | Stress test | UFM (max/mean) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | FDV/MDV | LPP | Pdet max | Pves max (cm $H_2O$) | | Before | After |
| 1 | 47 | IIA | 130 | 240° | 141/192 | 37 | 18 | 76 | ++ | 22/15 | (–) |
| 2 | 45 | I | 480 | 170 | 232/392 | 100 | 47 | 92 | ++ | 33/17 | 16/12 |
| 3 | 63 | I | 10 | 200 | 169/252 | 100 | 25 | 33 | – | 17/8 | 11/7 |
| 4 | 53 | I | 8 | 170 | 210/329 | 50 | 26 | 56 | + | 12/8 | 11/5 |
| 5 | 66 | I | 50 | 180 | 124/271 | 30 | 8 | 30 | – | 41/34 | 20/12 |
| 6 | 72 | IIA | 14 | 150 | 362/453 | 44 | 15 | 48 | ++ | 23/13 | 24/12 |
| 7 | 48 | III | 30.3 | 150 | 234/300 | 25 | 19 | 13 | ++ | 36/26 | (–) |
| 8 | 49 | IIA | 9.5 | 200 | 186/265 | 100 | 30 | 18 | + | 19/13 | 16/7 |
| 9 | 65 | I | 43.1 | 160 | 125/320 | 80 | 20 | 34 | + | 24/11 | 16/7 |
| 10 | 59 | I | 3.3 | 160 | 122/302 | 80 | 40 | 77 | | 11/5.5 | (–) |
| 11 | 60 | I | 52.7 | 210 | 77/187 | 50 | 5 | 44 | + | 25/11 | (–) |
| 12 | 58 | III | 68.3 | 144 | 174/299 | 20 | 22 | 33 | | 41/24 | 18/7 |
| 13 | 66 | I | 28.9 | 150 | 107/228 | 80 | 20 | 26 | + | 44/15 | 16/7 |
| 14 | 49 | IIA | 47.6 | 170 | 77/201 | 28 | 21 | 21 | + | 30/14 | (–) |

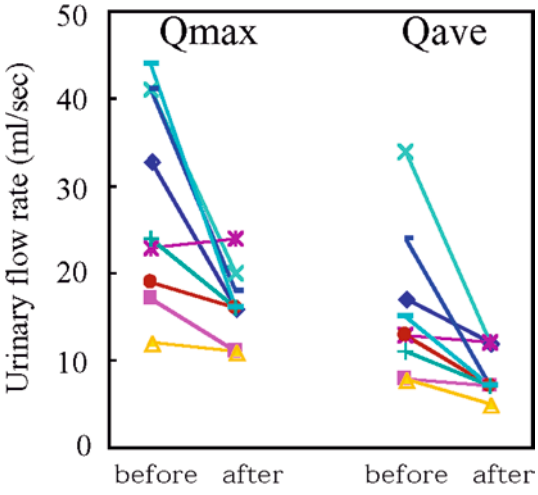


**Fig. 1** Changes in urinary flow rate before and after the TVT procedure. The average flow rate decreased in all patients indicating that the postoperative urethral resistance increased in all cases

lowest detrusor pressure (Pdet max = 5 $cmH_2O$) preoperatively, the postoperative residual urine volume was 150 ml 3 days after the surgery. This patient still voids with a residual urine more than 50 ml and has had suffered repeated cystitis. In case 5, urinary retention occurred on the day following surgery and the tension-free vaginal tape was readjusted with a urethral bougie pulling down to loosen the tape. After this, the patient could micturate with a post-void residual urine of less than 50 ml. One year later, her residual urine volume had decreased to almost zero. Her maximum voiding pressure in the preoperative pressure-flow study was the second lowest (Pdet max = 8 $cmH_2O$) among the patients enrolled, suggesting that detrusor pressure may be an important factor in predicting this complication (Fig. 2). However, Fig. 2 also shows that there were two

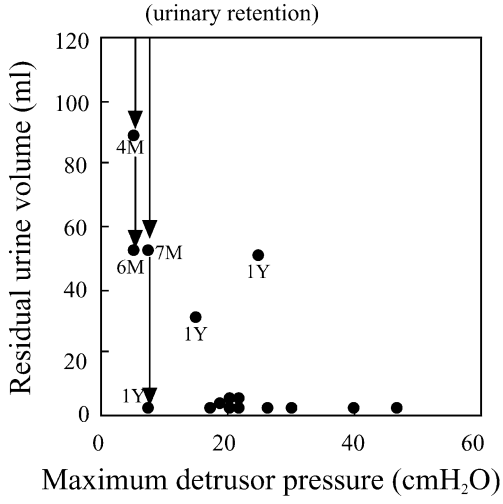


**Fig. 2** A plot of preoperative maximum detrusor pressure (Pdet max) against post-operative residual urine volume. A *closed circle* represents the residual urine volume measured within 2 weeks of sling surgery unless otherwise indicated

cases with significant residual urine volume whose Pdet max values were much higher than the urinary retention case. These are cases 3 and 6, of which the post-void residual urine volume remained at 50 and 30 ml, respectively, 1 year after the operation. In case 3, in particular, the patient still complains of a slight difficulty in voiding after 1 year of follow-up.

Next, we focused on Pdet max×Q values. Figure 3A and B show the correlation of the Pdet max×Q values with residual urine volume. The Q values used were from free-flow uroflowmetry, performed separately from the pressure-flow study because in the pressure-flow study the patients could sometimes not void as they usually do due to the indwelling catheter and embarrassment. In cases 3, 6 and 11, the Pdet max×Q values were very low compared with other patients. Notably, the Pdet

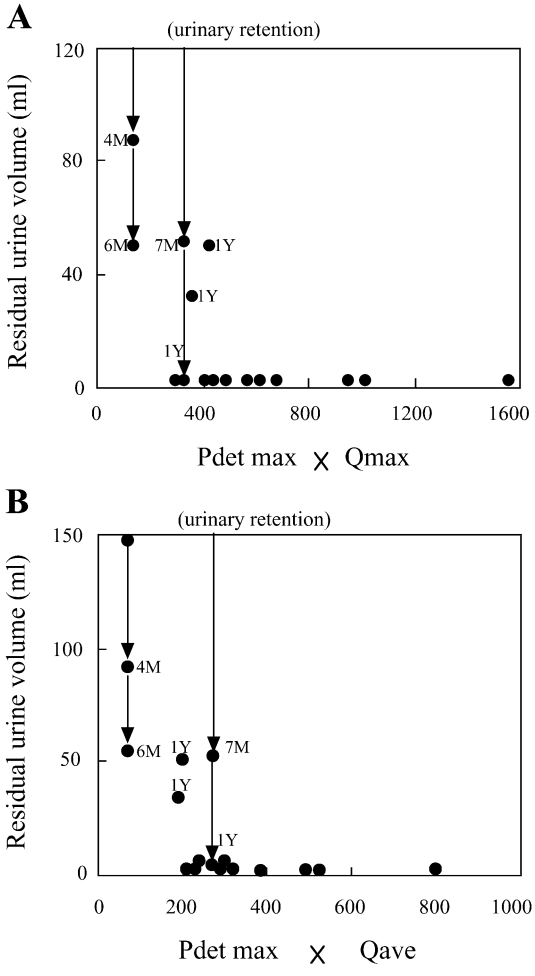


**Fig. 3 A** A plot of preoperative Pdet max×Qmax against postoperative residual urine volume. A *closed circle* represents the residual urine volume of an individual patient measured within 2 weeks of sling surgery unless otherwise indicated. The *closed circle with the time indicated* represents a case with prolonged residual urine of significance. **B** Correlation between preoperative Pdet max×Qave and postoperative residual urine volume indicating that the Pdet max×Qave value represents detrusor contractility and that a low Pdet max×Qave value may predict postoperatively increased residual urine and voiding difficulties

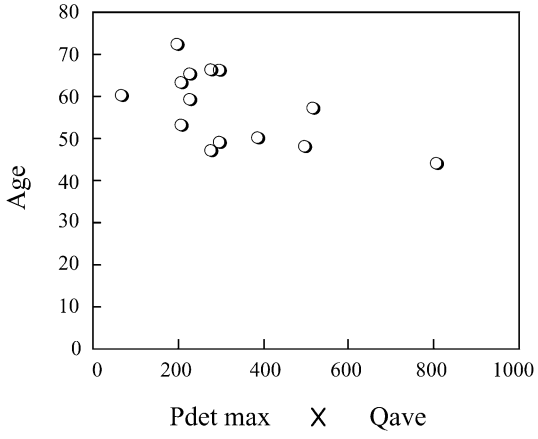


**Fig. 4** A plot of preoperative Pdet max×Qave versus the age of patients showing that the detrusor contractility is decreased in senior patients

max×Qave values in these three cases were lower than in any of the other cases (Fig. 3B), suggesting that Pdet max×Qave can be an important marker for predicting postoperative difficulty in voiding with persistent residual urine of significance. We assume that the Qmax (maximum urinary flow rate) values sometimes include increased flow rates due to abdominal straining, and that Qave more adequately represents the urinary flow caused by isotonic contraction of detrusor. Figure 4 shows the correlation of Pdet max×Qave with the age of the patients. The Pdet max×Qave values were decreased in senior patients 60 or older.

## Discussion

In this paper, we report on the importance of the study of pressure-flow prior to TVT surgery in evaluating detrusor contractility in order to predict postoperative complications such as difficulty in voiding and increased residual urine volume. Although this is a preliminary study with a limited number of cases, we posit that a low Pdet max×Qave value can predict postoperative significantly increased residual urine volume and difficulty in voiding, and thus, in accordance with this preoperative information, that we can determine how loosely or tightly to adjust the TVT sling.

In early studies on the TVT procedure, Ulmsten et al. reported that, among 131 patients treated with TVT surgery, short-term postoperative urinary retention requiring an indwelling catheter for 3 days occurred in three patients and that an additional patient was treated with a readjustment of the tape via the vaginal incision [9]. They later reported, in another study, that two patients needed intermittent catheterization for a couple of days and three needed an indwelling catheter for 7–12 days postoperatively among the 50 patients who underwent surgery [10]. On the other hand, Kuo reported that in a videourodynamic study performed within 2 weeks postoperatively, a slight decrease in Qmax and an increase in bladder neck opening time were observed among the patients treated with either TVT surgery or the pubovaginal sling procedure using the rectus fascia. However, these parameters returned to their preoperative levels 3–6 months postoperatively. Other parameters, such as voiding pressures, cystometric capacities and post-void residual urine volumes were not changed in either group after the incontinence surgery [6]. He concluded that the pubovaginal sling surgery using the rectus fascia or the TVT procedure did not cause outlet obstruction when the surgery was properly performed [5, 6].

Nevertheless, Sander et al. reported that 78% of patients treated with the TVT procedure considered that their voiding had become more difficult 1 year after surgery and that the flow curve patterns had changed to be more obstructive in 40% of the patients with Qmax and Qave being decreased significantly. They also indicated that the mean post-void residual urine volume and the urethral resistance factor increased significantly 1 year after TVT surgery, emphasizing the risk of possible bladder outlet obstruction after the surgery [8].

There have been several studies in which the preoperative parameters were evaluated for predicting postoperative voiding difficulties in patients with stress urinary incontinence. Bergman et al. reported that preoperative data from uroflowmetry and post-voiding residual urine volumes in patients treated with incontinence surgery failed to predict postoperative voiding difficulties [1]. Subsequently, they focused on a group of patients who voided without a detrusor contraction in a preoperative pressure-flow study, and reported that half of the patients regained detrusor contractility postoperatively and that the majority of the rest of the patients needed prolonged postoperative bladder drainage. They also noted that two thirds of the patients voiding without detrusor contraction, but with a normal flow rate regained detrusor contractility postoperatively, suggesting the importance of flow rate as one of the predicting factors for postoperative voiding difficulties [2]. In our study, however, there were no patients who voided without a detrusor contraction during the pressure-flow study. This is possibly due to the examination with an 8F-catheter indwelled in the urethra, causing an increase in urethral resistance.

We postulate that Pdet×Qave, which represents power (defined as a rate of work) in physics, can act as a good marker for potential detrusor contractility. Thus a low Pdet×Qave value predicts significantly increased post-void residual urine after the TVT procedure. Because our urodynamic system (Griffon Urodynamics) cannot show the average detrusor pressure, we used Pdet max on the assumption that the contraction of the detrusor is continuous and isotonic. The reason for using Qave is that the Qmax includes the increased flow rates caused by the momentary abdominal pressure while straining, and that Qave more adequately represents the flow caused by the continuous contraction of detrusor.

Although this is a preliminary study with a limited number of cases, it seems logical to use Pdet×Qave in representing the contractility of the detrusor for predicting the insufficiency of voiding, i.e. residual urine, after TVT surgery. Thus, it is worth performing a large series study using this parameter for predicting the outcome of this particular surgery.

It seems that, in most cases treated with the TVT procedure, no significant post-void residual urine requiring CISC, or voiding difficulties occur, although insignificant obstructive changes in the voiding phase may be found [8]. However, it is also true that some patients with insufficient detrusor contractility will suffer from the above complications postoperatively, thus necessitating the evaluation of the potential detrusor contractility in advance.

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