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Original Article

Evaluation of the relationship between urodynamic examination and urinary tract infection based on urinalysis results

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Abstract

Objective: To determine risk factors for urinary tract infection (UTI) after urodynamic examination by evaluating patients' clinical characteristics and urodynamic parameters.
Materials and methods: Two hundred and sixty-one female patients (mean age 58.7 ± 12.3 years) from May to December 2011 who had lower urinary tract symptoms or needed definite diagnosis before pelvic floor reconstruction or anti-incontinence surgery received urodynamic examination. All patients received urinalysis on the scheduled day of urodynamic examination and 3 days after urodynamic examination. Mid-stream urine samples were obtained for urinalysis before urodynamic examination. If patients had UTI based on our urinalysis criteria before urodynamic examination, the investigation was postponed until the patient had a 3–7-day course of antibiotic treatment and urinalysis showed no UTI.
Results: Among 261 patients, 19 and 51 patients had UTI before and after urodynamic examination, respectively. Our data suggest that urodynamic examination causes significantly increased incidence of UTI. Increased number of vaginal births, UTI before investigation, diabetes and decreased average flow rate are risk factors for UTI after urodynamic examination.
Conclusion: When the prevalence of UTI after urodynamic examination is higher than 10%, we recommend that prophylactic antibiotics should be given for high-risk patients with parameters such as older age, diabetes and multipara (>3). Those who have UTI before urodynamic examination and who are found to have a low average flow rate of less than 7 mL/second should take prophylactic antibiotics after examination.

Keywords: antibiotic; urinary tract infection; urodynamic study

Introduction

Urodynamic examinations have evolved since 1927 with D.K. Rose's first introduction of the cystometrograph, which was an instrument designed to determine filling and voiding bladder pressure [1]. Urodynamic tests evaluate lower urinary tract and pelvic floor function and dysfunction, and also provide objective information about manometric, sensorimotor and neurophysiological parameters related to the bladder and pelvic floor [2]. Urodynamic examination is currently the best diagnostic investigation for female lower urinary tract dysfunction. It comprises uroflowmetry, cystometry or measurement of bladder pressure during bladder filling and voiding, urethral pressure profile, electromyography of the external urethral sphincter, pressure flow studies and video urodynamics.

However, urodynamic examination is still an invasive procedure that involves urethral catheterization; it has been shown that catheterization leads to a higher prevalence of urinary tract infections (UTIs) in female patients [3]. There is still no consensus on whether prophylactic antibiotics should be given before or after urodynamic examination. Yip et al [3] reported that age greater than 70 years, previous continence

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surgery and UTI before urodynamic investigation were three independent risk factors for UTI caused by urodynamic examination and suggested that prophylactic antibiotics should be given to high-risk patients. Almallah et al [4] addressed the finding that risk of bacteriuria after flexible cystoscope and urodynamic examination was low and prophylactic antibiotics were not routinely indicated. Moreover, Tong and Cheon's [5] study showed that the incidence of UTI after urodynamic examination was low, and bacteriuria were transient and asymptomatic in most cases. Furthermore, multichannel urodynamics were shown to be well-tolerated procedures; the risk of symptomatic UTI and complications after urodynamic examination was relatively low, based on a questionnaire study [6]. There is still no consensus on whether prophylactic antibiotics are necessary, even though in some studies prophylactic antibiotics were given to high-risk patients [3,7].

In the present study, we wish to determine the exact risk factors for UTI caused by urodynamic examination based on urinalysis tests, and also to evaluate if it is necessary to give prophylactic antibiotics.

Materials and methods

Dipstick urinalysis is the most widely used diagnostic tool for UTIs. Urine microscopic results of more than 10 white blood cells (WBCs) per high power field in centrifuged urine is regarded as significant pyuria. Faro and Fenner [8] reported that traditional bacteriuria was defined as $\geq 10^5$ uropathogens per mL of a voided mid-stream clean catch and cystitis could be defined as $\geq 10^3$ bacteria per mL of a mid-stream voided urine specimen. There was no certain definition for UTI based on urinalysis. Similarly, Mehnert-Kay [9] found that uncomplicated UTI occurs in patients who have a normal, unobstructed genitourinary tract, who have no history of recent instrumentation, and whose symptoms were confined to the lower urinary tract. In our study, the patients who had UTI after urodynamic examination belonged to uncomplicated UTI.

According to Mehnert-Kay's [9] report, leukocyte esterase was specific (94–98%) and reliably sensitive (75–96%) for detecting uropathogens equivalent to 100,000 colony-forming units per mL of urine and nitrite had sensitivity ranging from 35% to 85%, but 95% specificity. The absence of four markers (blood, leukocyte esterase, nitrite and protein) on the urine dipstick at the point of care had a 98% negative predictive value, with sensitivity of 98.3% and specificity of 19.2% [10]. It suggests a high suspicion of the presence of bacteriuria or UTI if either leukocyte esterase or nitrite in urinalysis is positive. Therefore, in the present study, we designed the criteria to define UTI based on WBCs $> 15/\mu L$ plus at least two out of three positive factors: leukocyte esterase, nitrite, and bacteria in urinalysis.

We performed a prospective study, which included 261 female patients (mean age 58.7 $\pm$ 12.3 years) from May to December 2011. All patients received urodynamic examination owing to lower urinary tract symptoms or if they needed a definite diagnosis before pelvic floor reconstruction or anti-incontinence surgery. Informed consent on the risk and complication of the procedure was obtained. Data included age, height, weight, body mass index (BMI), obstetric history, menopausal status, hormone replacement therapy or not, hysterectomy or not, surgical history of urinary incontinence, and personal medical history.

All patients received urinalyses on the scheduled day before urodynamic examination. All urodynamic examinations were performed by the same technician. Mid-stream urine samples were obtained for urinalyses before urodynamic examination. If patients had UTI based on our urinalysis criteria before urodynamic examination, the investigation was postponed until the patient had a 3–7-day antibiotic treatment and urinalysis results appeared normal. All women were evaluated with urodynamics using a standardized protocol in accordance with the Good Urodynamic Practices Guidelines of the International Continence Society [11], which corresponds with the urodynamic procedure in Chen et al's study [12]. Patients who did not follow our protocol were excluded. All patients received urinalysis evaluation 3–7 days after urodynamic examination.

Analyses were performed by using SPSS 15 (SPSS Inc., Chicago, IL, USA). Characteristics of the patients were compared by UTI before and after urodynamic examination, respectively. These variables were expressed either as median with range (for continuous variable) or number with percentage (for categorical variable), and compared by using the Mann–Whitney U-test or Fisher's exact test as appropriate. To investigate the risk factor for UTI after the investigation, those variables whose p-value is less than 0.1 in former bivariate analyses were included in the multivariable stepwise logistic regression analysis. Noticeably, age was dichotomized with the cut-off point of 70 years rather than a continuous variable in the regression. With regard to the high correlation between parity and vaginal births, only the latter was used in the multivariable regression model. For those variables significant in multivariable analysis, receiver operating characteristic (ROC) analyses were further conducted to discriminate UTI after investigation and to show various cut-off points.

Results

Two hundred and sixty-one female patients were enrolled in this study. They all received standard urodynamic examination. Among 261 patients, 51 had a UTI after investigation.

Background information

The characteristics before urodynamic examination by UTI history are summarized in Table 1. Most characteristics were alike between groups except for age, BMI, hormone use (ever or currently on hormone replacement therapy) and hypertension. Patients with UTI history tended to be elderly. The median age of patients with UTI history was 64 years, ranging from 42 to 85 years, whereas that of patients without UTI history was 58 years, ranging from 23 to 84 years ($p = 0.048$). Accordingly, a higher proportion of the elderly was found in patients with UTI history (42.1% vs. 20%, $p = 0.039$). In addition, patients with UTI history tended to have higher BMI

Table 1
Background information[a].

Variable	With UTI (n = 19)	Without UTI (n = 242)	p
Age (y)	64 (42–85)	58 (23–84)	0.048
Height (cm)	152 (142–166)	157 (136–170)	0.056
Weight (kg)	60 (50–74)	57 (41–124)	0.174
BMI (kg/m^2)	25.4 (19–33)	23.6 (18–47)	0.004
Parity (n)	3.1 (1–7)	3.1 (0–8)	0.232
Vaginal births (n)	3.0 (0–7)	2.9 (0–8)	0.181
Cesarean births (n)	0.1 (0–1)	0.2 (0–3)	0.925
Age >70 y (%)	42.1	20.0	0.039
Menopausal (%)	84.2	73.8	0.418
Hormone use (%)	5.3	30.4	0.017
Hysterectomy (%)	36.8	22.9	0.172
Surgery of urinary incontinence (%)	26.3	18.8	0.380
Hypertension (%)	68.4	33.9	0.005
Diabetes (%)	21.1	14.0	0.494
Heart disease (%)	5.3	7.9	1.000
Renal disease (%)	0.0	1.2	1.000
Spinal disease (%)	0.0	1.2	1.000

BMI = body mass index; UTI = urinary tract infection.
[a] Categorical variables were presented as percentage; continuous variables were presented as median (range); continuous variables were compared by using the Mann–Whitney U-test; categorical variables were compared by using Fisher's exact test.

values (25.4 vs. 23.6, $p = 0.004$), a higher proportion of hypertension (68.4% vs. 33.9%, $p = 0.005$) and a lower proportion of hormone use (5.3% vs. 30.4%, $p = 0.017$) than patients without UTI history (Table 1).

UTI after urodynamic examination

Table 2 illustrates the characteristics after urodynamic examination stratified by UTI groups. Those with UTI after examination tended to be elderly (69 years vs. 57 years, $p < 0.001$), had higher parity (4 vs. 3, $p < 0.001$) and a higher number of vaginal births (4 vs. 3, $p < 0.001$), had a higher proportions of menopausal cases (86% vs. 71.8%, $p = 0.046$), UTI before investigation (21.6% vs. 3.8%, $p < 0.001$) and diabetes (29.4% vs. 11%, $p = 0.002$) than those without UTI after examination (Table 2).

For urodynamic parameters, those with UTI after examination had a slower maximal flow rate (17 vs. 21 mL/second, $p = 0.001$) and average flow rate (5 vs. 8 mL/second, $p < 0.001$), a smaller voided volume (199 vs. 277 mL, $p = 0.003$), first desire to void (134 vs. 157 mL, $p = 0.028$) and a larger volume of residual urine (53 vs. 33 mL, $p = 0.010$). Nevertheless, no difference was detected in terms of maximum capacity, maximum urethral closure pressure and functional urethral length. Generally speaking, the variation ranges of the parameter mentioned above were wider in the patients without UTI rather than in the patients with UTI (Table 2).

Risk factors for UTI after urodynamic examination

In the multivariable analysis, number of vaginal births, UTI before examination, diabetes and average of flow rate were significantly associated with UTI after examination. An increase in the number of vaginal births was associated with an elevated risk for UTI after examination by 1.46-fold odds ratio [95% confidence interval (CI) = 1.13–1.88, $p = 0.004$]. UTI before examination (UTI history) and diabetes were associated with increased risk of UTI after examination with an odds ratio of 5.49 (95% CI = 1.74–17.29, $p = 0.004$) and of 3.10 (95% CI: 1.35–7.14, $p = 0.008$), respectively. By contrast, a standard deviation increase of average flow rate was associated with a decreasing risk of UTI after examination (odds ratio = 0.52, 95% CI = 0.33–0.82, $p = 0.005$) (Table 3).

Predictors for discriminating UTI after urodynamic examination

Fig. 1 illustrates the ROC curves of the number of vaginal births and average flow rate for UTI after examination. Table 4 lists selected sensitivity and specificity of number of vaginal births and average flow rate for discriminating UTI after examination. A compromise cut-off point of number of vaginal

Table 2
Comparison of clinical characteristics and urodynamic parameters between patients with and without UTI after urodynamic examination[a].

Variable	With UTI (n = 51)	Without UTI (n = 210)	p
Clinical characteristic			
Age (y)	69 (34–85)	57 (23–84)	<0.001
Height (cm)	156 (142–170)	157 (136–168)	0.153
Weight (kg)	58 (45–80)	58 (41–124)	0.820
BMI (kg/m^2)	24.2 (19–31)	23.6 (18–47)	0.176
Parity (n)	3.9 (1–8)	3.0 (0–7)	<0.001
Vaginal births (n)	3.7 (0–8)	2.8 (0–7)	<0.001
Cesarean births (n)	0.2 (0–2)	0.1 (0–3)	0.463
Age ≥70 y (%)	46.0	15.8	<0.001
Menopausal (%)	86.0	71.8	0.046
Hormone use (%)	22.0	30.1	0.298
Hysterectomy (%)	16.0	25.8	0.196
Surgery of urinary incontinence (%)	16.0	20.1	0.690
UTI before urodynamic investigation (%)	21.6	3.8	<0.001
Hypertension (%)	49.0	33.3	0.051
Diabetes (%)	29.4	11.0	0.002
Heart disease (%)	11.8	6.7	0.241
Renal disease (%)	0.0	1.4	1.000
Spinal disease (%)	2.0	1.0	0.481
Urodynamic parameters			
Maximal flow rate (mL/s)	17 (3–50)	21 (4–91)	0.001
Average flow rate (mL/s)	5 (1–15)	8 (1–24)	<0.001
Voided volume (mL)	199 (15–585)	277 (8–760)	0.003
Residual urine (mL)	53 (0–420)	33 (3–622)	0.010
First desire to void (mL)	134 (67–271)	157 (1–356)	0.028
Maximum capacity (mL)	322 (203–509)	343 (105–515)	0.421
Maximum urethral closure pressure (cmH_2O)	58 (15–169)	69 (2–165)	0.082
Functional urethral length (cm)	2.8 (1.0–4.7)	2.8 (1.2–6.6)	0.866

BMI = body mass index; UTI = urinary tract infection.
[a] Categorical variables were presented as percentage; continuous variables were presented as median (range); continuous variables were compared by using the Mann–Whitney U-test; categorical variables were compared by using Fisher's exact test.

Table 3
Multivariable logistic regression model for risk factors for UTI after urodynamic examination[a].

Predictors	OR	95% CI of OR	*p*
Number of vaginal births	1.46	1.13–1.88	0.004
UTI before urodynamic study	5.49	1.74–17.29	0.004
Diabetes	3.10	1.35–7.14	0.008
Average flow rate (per SD)	0.52	0.33–0.82	0.005

CI = confidence interval; OR = odds ratio; SD, standard deviation; UTI = urinary tract infection.
[a] $n = 248$.

births was equal to or greater than three with an acceptable sensitivity of 79.2% and poor specificity of 36.9%. By contrast, when favoring sensitivity, the cut-off point was chosen as equal to or greater than two with an outstanding sensitivity of 95.8% and poor specificity of 13.6%.

A compromise cut-off point for average flow rate was equal to or below seven with an acceptable sensitivity of 73.5% and fair specificity at 52.2%. By contrast, when favoring sensitivity, the cut-off point was chosen as ≤ 10 with a good sensitivity of 89.8% and poor specificity of 30.0%.

Discussion

Urodynamic examination has been recommended as a routine procedure to confirm voiding dysfunctions both in men and women, especially before any surgical therapy [7]. UTI is the most common morbidity after urodynamic examination and its incidence ranges from 3.6% to 20% [3–5,7,13]. The prevalence of UTI before and after urodynamic examination in our study was 7% and 20%, which is a significant result based on our definition criteria of UTI. It implies that urodynamic examination, an invasive procedure, could indeed result in

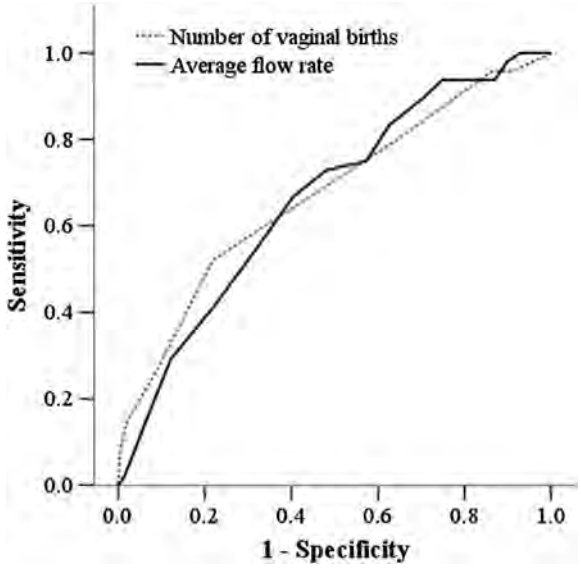

Fig. 1. ROC curve analysis for number of vaginal births and average flow rate in discriminating UTI after urodynamic investigation. ROC = receiver operating characteristic; UTI = urinary tract infection.

UTI. Most studies use urine culture as their diagnostic tool for UTI [5,13,14]. However, urine culture and sensitivities add cost and laboratory workload and make little difference in the treatment of uncomplicated UTI [10], because most UTIs caused by urodynamic examination tend to be uncomplicated. When the predictors for UTI after urodynamic examination in the urodynamic investigation are known, high-risk patients could be treated as soon as possible with prophylactic antibiotics after such examinations and would decrease morbidity related to urodynamic examination.

The finding of UTI before urodynamic examination is a predictor for UTI after urodynamic examination under the confirmation of normal analysis of mid-stream urine, which is compatible with Yip et al's finding [3]. Therefore, preurodynamic investigation consultation should be made for patients who have UTIs. With an increasing number of vaginal births, there is an increased incidence of UTI after urodynamic examination (Fig. 1). If the number of vaginal births is greater than four, there is sensitivity of 52.1% and specificity of 78.2% for UTI after urodynamic examination. More vaginal births would cause more pelvic floor trauma. With age, pelvic floor relaxation may result from old pelvic floor trauma, whereas pelvic floor relaxation is related to urine retention and UTI.

Poor bladder emptying may result in UTI. Bombieri et al [14] reported that maximal urinary flow rate (Q_{max}) < 15 mL/second was associated with bacteriuria after urodynamic examination in three of 13 patients, although the result was not significant, but it constituted a trend. There was no significant correlation between voiding volume, post-voided residual urine volume or Q_{max} and UTI after urodynamic examination in our study. The non-significant result may be due to limited cases; more research and data collected will be needed in future studies.

Decreased average urinary flow rate (Q_{ave}) was a predictor for UTI after urodynamic examination in our study. The less Q_{ave} patients had, the higher the incidence of UTI after urodynamic examination patients contracted. This suggests that UTI was more likely to happen in patients who had poor urinary stream and the reason might be related to bladder outlet obstruction or detrusor underactivity. The etiologies of female bladder outlet obstruction may vary [15]. Detrusor underactivity increases with age. Underactive detrusor function can predict the possibility of urinary retention and symptoms of obstruction. In one study, the relative loss of urethral wall compliance may be responsible for obstruction in the urethra in postmenopausal women [16].

Diabetic patients tend to have UTI. Invasive procedures involving multiple catheterizations result in more UTI in these patients [17].

In addition, some studies showed advancing age was a predicting factor for UTI [3,14]. Age is a known risk factor for catheter-associated bacteriuria [14]. Overall, detrusor underactivity, catheter-associated bacteriuria and relative loss of urethral wall compliance are all related to older age. Thus, age appears to be an important factor in predicting UTI after urodynamic examination. Bombieri et al [14] reported that menopausal status was not associated with bacteriuria and

Table 4
Sensitivity and specificity of the number of vaginal births and average flow rate as predictors for UTI after urodynamic examination.

Predictor/cut-off	Sensitivity, %	Specificity, %	*p*	AUC (95% CI)
Number of vaginal births				
≥1	95.8	8.7	<0.001	0.67 (0.59–0.76)
≥2	95.8	13.6		
≥3	79.2	36.9		
≥4	52.1	78.2		
≥5	27.1	90.8		
Average flow rate (mL/s)				
≤4	40.8	77.8	<0.001	0.67 (0.58–0.75)
≤5	55.1	67.1		
≤6	65.3	59.9		
≤7	73.5	52.2		
≤8	75.5	43.0		
≤9	83.7	37.7		
≤10	89.8	30.0		

AUC = area under the ROC curve; CI = confidence interval; ROC = receiver operating characteristic; UTI = urinary tract infection.

hormone replacement therapy was not protective. Neither did our study show a significant association between menopausal status and hormone replacement therapy with UTI after urodynamic examination.

As far as prophylactic antibiotics are concerned, Baker and colleagues reported their experience in a blind, randomized study in 124 female patients and showed that prophylactic antibiotics were not effective in preventing UTI caused by urodynamic examination.[18] Kartal et al recommended antibiotic prophylaxis for patients undergoing urodynamics in their blind, randomized study [19]. Even though some studies did point out that prophylactic antibiotics could be given to high-risk patients such as older patients, with a previous history of urinary incontinence and UTI before urodynamic examination, prophylactic antibiotics are not routinely indicated [3,4]. In a systemic review which evaluated the effectiveness and safety of prophylactic antibiotics in urodynamic examination, the use of prophylactic antibiotics in urodynamic examination reduced the risk of significant bacteriuria; however, its value in reducing symptomatic UTI remains unknown [20]. In recent studies, antibiotic prophylaxis was not recommended for urodynamic examination in women at low risk, unless the incidence of UTI after urodynamic examination was greater than 10% [21,22].

In conclusion, when the prevalence of UTI after urodynamic examination is higher than 10%, we recommend that prophylactic antibiotics may be given to high-risk patients with parameters such as older age, diabetes, and multiparity (>3). It is suggested that patients who have had a UTI before urodynamic examination and are found to have low $Q_{ave} < 7$ mL/second may take prophylactic antibiotics after examination.

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