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ORIGINAL ARTICLE

Symptomatic urinary tract infections after surgery for prolapse and/or incontinence

Gary Sutkin · Marianna Alperin · Leslie Meyn · Harold C. Wiesenfeld · Rennique Ellison · Halina M. Zyczynski

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Abstract
Introduction and hypothesis The purpose of our study was to estimate the frequency and risk factors for symptomatic urinary tract infection (UTI) after surgery for stress urinary incontinence (SUI) and/or pelvic organ prolapse (POP).
Methods Case-control study of 389 consecutive women who underwent surgery for POP and/or SUI. Cases were defined as a symptomatic, culture-confirmed UTI within 6 weeks of surgery. Multivariable logistic regression was used to determine independent risk factors.
Results Thirty five (9%) women developed a UTI. The risk of UTI was significantly increased by previous history of multiple UTIs (adjusted OR: 3.7, CI 1.4–10.1), increased distance between the urethra and the anus (adjusted OR: 1.4, CI 1.1–1.9), and prolonged duration of catheterization (adjusted odds ratio (OR) for ≥10 days: 4.2, 95% CI 1.5–11.6); 94.6% of catheterizing women were prescribed daily nitrofurantoin.
Conclusions UTI is an important postoperative morbidity after urogynecologic surgery and is common in catheterizing women despite antibiotic prophylaxis.

Keywords Urinary tract infection · Pelvic organ prolapse · Urinary incontinence · Surgical complications · Urinary catheterization

Introduction

Urinary tract infections (UTIs) are the most common morbidity after surgery for stress urinary incontinence (SUI) or pelvic organ prolapse (POP) [1, 2]. These conditions are common in women, with one in nine expected to pursue surgical treatment by the age of 80 years [3, 4]. The SISTEr trial of Burch vs. autologous sling for treatment of stress urinary incontinence reported a UTI rate of 48% in the sling cohort and 32% in the Burch cohort during the first 24 months of follow-up [1]. In a recent analysis of 1,356 sling procedures performed in a Medicare population, 33.6% of the women developed a UTI within 3 months after surgery [5]. Forty five percent of older women pursuing obliterative surgery for advanced prolapse developed a urinary tract infection within 3 months of surgery [2]. The reported frequency of this adverse event is alarmingly high but understandable, given that urogenital tract surgery involves urinary tract instrumentation from cystoscopy and transurethral or suprapubic catheters. Most surgical outcome studies lack a consistent definition of UTI or asymptomatic

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G. Sutkin (✉) · R. Ellison · H. M. Zyczynski
Division of Urogynecology and Reconstructive Pelvic Surgery, Department of Obstetrics, Gynecology, and Reproductive Sciences, Magee-Womens Hospital, University of Pittsburgh, Pittsburgh, PA, USA
e-mail: gsutkin@mail.magee.edu

M. Alperin
Division of Female Pelvic Medicine and Reconstructive Surgery, Department of Obstetrics and Gynecology, Kaiser Permanente, West Los Angeles, CA, USA

L. Meyn
Department of Obstetrics, Gynecology, and Reproductive Sciences, Magee-Womens Hospital, University of Pittsburgh, Pittsburgh, PA, USA

H. C. Wiesenfeld
Division of Reproductive Infectious Diseases and Immunology, Department of Obstetrics, Gynecology, and Reproductive Sciences, Magee-Womens Hospital, University of Pittsburgh, Pittsburgh, PA, USA

bacteriuria, and empiric treatment, antibiotic administration, or billing codes often serve as surrogates for the diagnosis. A research directive from a National Institutes of Health-sponsored female pelvic floor disorders terminology workshop recommended that future research on the surgical treatment of urinary incontinence include the description of adverse events such as UTIs [6].

UTIs result in 3.6 million office visits by women annually [7], require antibiotics that can be expensive, and can cause adverse events. Their association with systemic illnesses, such as pyelonephritis and acute respiratory distress syndrome, emphasizes the magnitude of their potential morbidity in an aging population. The presence of a UTI carries an almost threefold risk of mortality in patients after controlling for comorbid conditions [8]. Targeted strategies to reduce the rate of postoperative UTI require the identification of modifiable risk factors.

The objective of our study was to estimate the frequency of symptomatic UTI after surgery for SUI and/or POP and to explore potential risk factors for development of this morbidity in a large consecutive case series.

Materials and methods

After obtaining approval from the institutional review board at the University of Pittsburgh, we conducted a retrospective chart review of 394 consecutive women who underwent surgery for POP and/or SUI at Magee-Womens Hospital (MWH) on a teaching service supervised by five attending physicians between May 2005 and December 2006. Subjects were excluded if they had a pre-existing neurogenic bladder. The time interval studied was the first 6 weeks after surgery.

Office and hospital medical records were reviewed for demographic variables including age, gravidity, parity, body mass index, race, smoking status, menopausal status, estrogen use, and sexual activity. Clinical variables extracted included self-report of liquid or solid fecal incontinence, self-report of a preoperative history of multiple UTIs, and chronic use of immune mediating medications. Physical exam variables included values from a pre-operative Pelvic Organ Prolapse Quantification (POP-Q) examination, the urethral anal distance (UAD), which is the distance between the mid-urethra and the mid-anus (calculated by adding the genital hiatus and the perineal body measures of the POP-Q exam), ordinal stage of prolapse, leading edge of prolapse, and the post-void residual (PVR) urine volume.

Surgical variables included the primary surgeon, indication for the surgery (POP, SUI, or both), the surgical procedures, the route of surgery (abdominal, vaginal, or both), type of anesthesia, estimated blood loss, use of perioperative prophylactic intravenous antibiotics, and the need for urethral catheterization at discharge. All women underwent voiding trials prior to discharge. If their PVR urine volume exceeded 100 cm^3 or more than one-third of their total bladder volume, they were instructed to perform clean intermittent self-catheterization (CISC). If they could not master CISC, they were discharged with an indwelling transurethral Foley catheter. We recorded the duration and method of post-operative catheterization (CISC, indwelling transurethral Foley catheter, or Foley catheter on discharge followed by learning CISC on an outpatient basis), antibiotic prophylaxis during catheter use, and any procedure performed to improve post-operative urinary retention.

Subjects were divided into cases or controls based upon our definition of UTI. To meet our study's criteria for a UTI, a woman had to report irritative voiding symptoms such as dysuria, worsening urgency, frequency, or nocturia and have a documented positive urine culture. Urine cultures were considered positive if they were from a catheterized specimen with growth of a single organism at $\geq 10^3$ cfu/ml or from a clean catch specimen with growth of ≤ 2 organisms at $\geq 10^5$ cfu/ml [9].

Controls were women who did not have the above symptoms and either had no culture sent or had a negative culture report on record. An unclassified group included those women who had a positive urine culture but no documented urinary symptoms (asymptomatic bacteriuria) and those who were treated empirically without culture confirmation of infection (Fig. 1). The most common reason for sending a culture in a woman without symptoms was in response to an abnormal urine dip. The charts of the asymptomatic bacteriuria subjects were independently reviewed by two investigators to confirm the absence of any reported urinary symptoms.

In order to better understand the impact of the unclassified group, preliminary analyses were performed, comparing them with both the cases and the controls. This group significantly differed from the other two groups by numerous variables: age, previous history of multiple UTIs, UAD, route of surgery, voiding trial results, and duration of catheter use (data not presented). We concluded that the unclassified group was a heterogeneous group containing both unconfirmed cases and controls. Therefore, these women were excluded from final analyses (Fig. 1).

Differences between cases and controls were evaluated using Fisher's exact, Chi-square, Student's *t*, and Mann–Whitney U tests, where appropriate. Data was presented as mean ± standard deviation (SD) or median with range for continuous variables and as frequency (percentage) for categorical variables. Multivariable logistic regression modeling was then utilized to determine which factors were independently associated with the development of a post-operative UTI. Variables with p values less than 0.1

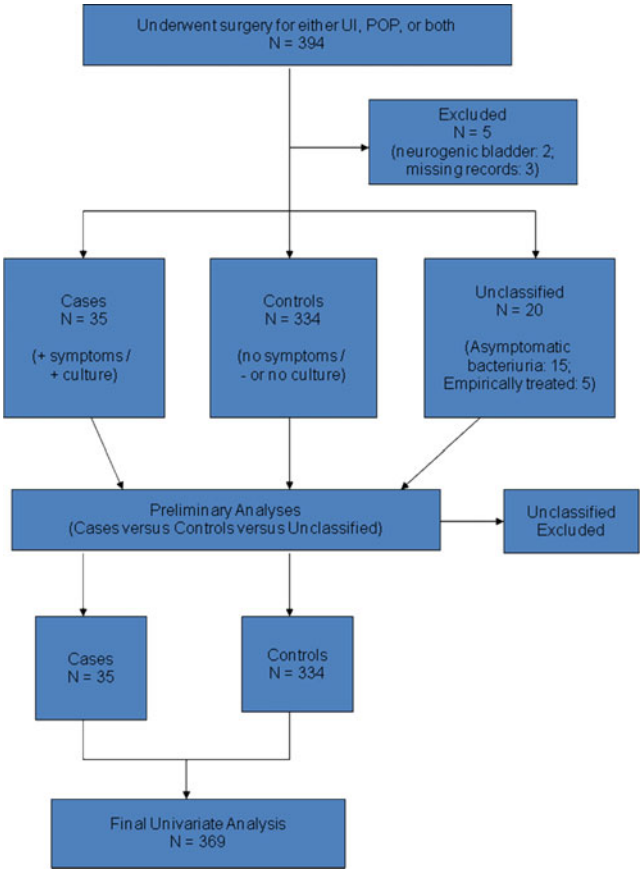

Fig. 1 Flow chart showing exclusion of subjects, group assignment, preliminary analysis of groups, and exclusion of unclassified group

were considered for inclusion and models were developed using forward stepwise regression based on the likelihood ratio test statistic. Variables were retained in the model if the Wald chi-squared test statistic had a p value of 0.05 or less. Odds ratios (OR) for independent risk factors were calculated, along with the corresponding 95% confidence intervals (CI). All statistical analyses were considered significant at the level of 0.05.

Results

A total of 394 charts were reviewed from women who underwent corrective surgery for SUI, POP, or both. Five cases were excluded from analyses due to a pre-existing diagnosis of neurogenic bladder in two (0.5%), and an inability to locate complete medical records for three (0.8%) patients. Of the remaining 389 subjects, reconstructive or obliterative surgery for prolapse was performed in 149 (38.3%), urinary incontinence surgery in 92 (23.7%), and 148 (38.0%) women underwent both types of surgery. One hundred three (26.5%) women underwent concurrent hysterectomy. The surgical approach was vaginal in 255 (65.6%), open abdominal in 131 (33.7%), and laparoscopic in 3 (0.8%).

All women received preoperative antibiotics (usually Cefazolin or Cefotetan). All subjects underwent a post-operative voiding trial before their discharge from the hospital. Of the 167 women (42.9%) who failed their voiding trial, 107 (27.5%) successfully learned CISC, while 44 (11.3%) used an indwelling transurethral Foley catheter. An additional 16 (4.1%) women were initially discharged using a Foley catheter and transitioned to self-catheterization about 1 week after surgery.

Records confirmed that 94.6% of those discharged using a catheter received a script for prophylactic oral antibiotics with instructions to take them daily while using the catheter. Nitrofurantoin 100 mg daily was the most commonly prescribed prophylactic antibiotic, followed by single-strength trimethoprim sulfamethoxazole for those with contraindications. Because of the nearly universal administration of prophylactic antibiotics in women who required assisted bladder drainage, we left this variable out of our analysis.

Thirty five women (9.0% of the initial 389 subjects) met our strict definition for a UTI and were counted as cases. Three hundred and thirty-four (85.9%) without a UTI were categorized as controls. Twenty (5.1%) were identified as unclassified and were excluded from the analyses. The most common organisms isolated from the positive cultures of our cases included *E. coli* (n=14), *Proteus mirabilis* (n=4), *Pseudomonas aeruginosa* (n=3), *Klebsiella pneumoniae* (n=3), *Enterobacter* (n=3), and *Streptococci* (n=3).

Univariate analysis comparing cases (n=35) and controls (n=334) (Table 1) showed that women with post-operative UTIs were significantly older, were more likely to use transvaginal estrogen, were more likely to have a previous history of multiple UTIs, were more likely to undergo surgery by vaginal route, and had a longer UAD. Failure to adequately empty the bladder at the time of discharge from the hospital and the duration of subsequent use of any type of transurethral catheter were also highly associated with the development of a post-operative UTI (Table 2). The UTI rate was 16.8% for all women who failed their voiding trial, regardless of method of catheterization, vs 6.0% for those spontaneously voiding at discharge. The rate of UTI did not differ significantly between methods of bladder drainage (transurethral Foley catheter 14.6% vs CISC 12.4%), although the rate was higher (26.7%) in women who were taught CISC on an outpatient basis about a week after being discharged with a Foley catheter. This latter group also employed catheters for the longest duration (17.2±13.7 days vs 6.0±6.7 days for Foley, 9.4±9.7 days for CISC).

There was a trend for cases to report liquid fecal incontinence more frequently, have a greater perineal body

Table 1 Selected demographic, medical, and operative characteristics of urinary tract infection cases and controls

Characteristic	# (%) UTI cases (n=35)[a]	# (%) Controls (n=334)[a]	P value[b]
Age (years, mean ± SD)	68.3±11.7	62.7±12.2	0.01
Body mass index (kg/m^2, mean ± SD)	28.8±7.8	28.1±5.2	0.61
Race			0.59
White	34 (97%)	315 (94%)	
Non-white	0	10 (3%)	
Unknown	1 (3%)	9 (3%)	
Gravida (median, range)	3 (0–6)	3 (0–13)	0.60
Parity (median, range)	3 (0–6)	3 (0–13)	0.57
Smoker			0.73
Never	22 (63%)	216 (64%)	
Past	10 (29%)	79 (24%)	
Current	3 (9%)	40 (12%)	
Post-menopausal	31 (89%)	272 (81%)	0.36
Any E2	7 (20%)	73 (22%)	>0.99
Transvag E2	5 (14%)	16 (5%)	0.04
Oral E2	1 (3%)	47 (14%)	0.07
Patch E2	1 (3%)	11 (3%)	>0.99
Hypertension	19 (54%)	146 (44%)	0.28
Diabetes	2 (6%)	33 (10%)	0.56
Sexually active	12 (35%)	169 (52%)	0.07
History of UTIs	10 (29%)	37 (11%)	0.01
Liquid fecal incontinence	14 (41%)	79 (25%)	0.06
Solid Fecal Incontinence	4 (12%)	37 (12%)	>0.99
Pre-operative post-void residual (median, range)	50 (0–450)	40 (0–800)	0.21
Urethral anal distance (cm)	7.5±1.9	6.8±1.5	0.02
Surgical category			0.67
POP	16 (46%)	128 (38%)	
UI	7 (20%)	83 (25%)	
Both	12 (34%)	123 (37%)	
Abdominal or vaginal			0.01
Abdominal	5 (14%)	119 (36%)	
Vaginal	30 (86%)	212 (64%)	
Anesthesia			0.12
Local/sedation	5 (15%)	55 (17%)	
GETA	13 (39%)	176 (55%)	
Regional	15 (45%)	91 (28%)	
Length of stay (days, mean ± SD)	1.8±1.1	1.6±1.1	0.32
Estimated blood loss (ml, median, range)	150 (25–1,500)	150 (10–1,100)	0.98

SD standard deviation

[a] Some numbers do not add up to total (n=369) because of missing values

[b] P value from Fisher's exact, chi-square, Student's t, or Mann–Whitney U test where appropriate

at rest, use oral estrogen supplements less frequently, and be less sexually active. We found no statistically significant differences in ordinal stage or leading edge of prolapse.

Multivariable logistic regression modeling confirmed the risk of UTI to be independently associated with duration of catheterization (adjusted odds ratio for >10 days: 4.2, 95% CI 1.5–11.6), a previous history of multiple UTIs (adjusted odds ratio: 3.7, 95% CI 1.4–10.1), and a greater distance between the urethra and the anus (adjusted odds ratio: 1.4, 95% CI 1.1–1.9) (Table 3).

Table 2 Post-operative voiding factors associated with the development of a urinary tract infection after surgery for prolapse and/or stress urinary incontinence

Voiding factor	# (%) UTI cases (n=35)[a]	# (%) Controls (n=334)[a]	P value[b]
Failed voiding trial	22 (63%)	131 (39%)	0.011
Catheter			0.016
Self voiding	13 (37%)	203 (61%)	
Foley	6 (17%)	35 (10%)	
CISC	12 (34%)	85 (25%)	
Foley and CISC	4 (11%)	11 (3%)	
Total catheter days			0.004
None	13 (39%)	203 (63%)	
1–4	3 (9%)	42 (13%)	
5–9	8 (24%)	45 (14%)	
10 or more	9 (27%)	31 (10%)	

[a] Some numbers do not add up to total (n=369) because of missing values

[b] P value from Fisher's exact, chi-square, chi-square for linear trend test where appropriate

Discussion

The overall risk for developing a symptomatic urinary tract infection within 6 weeks of prolapse or incontinence surgery in our study was 9.0%. Nearly one in ten women from this well characterized cohort of consecutive surgeries met our strict definition of a UTI (bothersome UTI symptoms plus the presence of a uropathogen on culture). This is comparable to findings of the SISTEr trial, where 16.7% of study subjects were treated for a UTI's within 6 weeks of surgery [10].

The risk of developing a post-operative UTI was significantly increased by incomplete bladder emptying and transurethral catheterization, despite the use of prophylactic antibiotics. Failure to pass a voiding trial with resultant catheter use for more than 10 days conferred more than a fourfold increased risk for a post-operative UTI in our study. Transient urinary retention after pelvic floor surgery is common [11] and interferes with the bladder's defense against UTIs through mechanical emptying [12]. Potential causes for transient post-operative urinary retention include vascular denervation, tissue edema, narcotics, and anesthetics. Catheter use to manage urinary stasis is a well known risk factor for the development of a UTI [13]. Failure to pass voiding trials after incontinence surgery with resultant catheter use conferred a 2.2-fold increased risk for an early post-operative UTI in the SISTEr trial [10].

In our study, 153 of 369 (41.5%) of our case and control cohorts failed their voiding trials and were discharged with intermittent or an indwelling urethral catheter. This rate of transient urinary retention is consistent with other pelvic surgical cohorts that include outpatient slings [11, 14] and advanced prolapse repairs [15]. In the absence of normative data, the determination of when a non-neurologically impaired surgical patient has "adequately" emptied her bladder after pelvic surgery is subjective. The PVR range of 75–150 cm^3 is commonly used in clinical practice to define a "passing" voiding trial. This range may be too conservative for some women being treated for advanced prolapse who have pre-operative PVRs in the 200-to-300-ml range or those who are discharged the same day of surgery. Shorter post-operative hospitalization may not provide enough time to resolve transient urinary retention. To address this challenge, we attempt to avoid the negative sequelae of acute urinary retention in the community setting by teaching our patients CISC when their PVR exceeds the threshold of 100 ml. It is possible that this conservative threshold results in more women using catheters than necessary. Research is needed to determine if PVRs in excess of 100 ml increases the risk for a UTI.

Table 3 Multivariable analysis: predictors of a urinary tract infection after surgery for prolapse and/or stress urinary incontinence

	Adjusted[a] OR	95% CI	P value
History of urinary tract infections	3.8	1.4–10.1	0.010
Duration of catheterization			
No catheterization	1.0	Referent	
1–4 days	0.8	0.2–3.8	0.786
5–9 days	2.6	0.9–7.3	0.065
10+ days	4.2	1.5–11.6	0.006
Urethral anal distance	1.4	1.1–1.9	0.007

OR odds ratio, *CI* confidence interval

[a] Adjusted for all factors shown

Our findings did not support the theory that CISC conveys a protective effect against UTIs when compared to indwelling Foley catheter use [16, 17]. It is possible that the relatively small number of cases in our study precluded us from detecting a potential difference between these two groups. Women performing CISC are routinely instructed to terminate catheterization as soon as they reach their PVR goal of less than 100 ml on two consecutive voids. There is a risk that patients will retain an indwelling Foley longer than they need due to the practicalities of scheduling a visit to the office or from a visiting nurse for removal and voiding reassessment.

Our study did not address the question of whether replacement of the transurethral Foley vs learning CISC in the event of a repeat failed voiding trial during the outpatient follow up visit carries equivalent risk of a UTI.

We were unable to review the impact of prophylactic antibiotics on the risk of UTI in the post op setting of urethral catheterization for transient urinary retention. Our study was performed in a practice that routinely administers antibiotic prophylaxis to women requiring assisted bladder drainage after surgery and allows each physician to determine when a urine culture is sent. Nearly all catheterizing women received a prescription at discharge. Experts generally recommend against the routine use of antibiotics to prevent symptomatic UTI in women with catheter-related asymptomatic bacteriuria [18–21]. Nitrofurantoin prophylaxis was shown to significantly decrease the rate of symptomatic UTIs in a randomized placebo controlled trial of women managed with suprapubic catheters for incomplete emptying after urogenital surgery (18.9% in the Nitrofurantoin group) [22]. Our transurethral catheter users had a UTI rate of 16.8% despite almost universal use of Nitrofurantoin. For patients with intolerance to Macrodantin, we commonly use Bactrim or Keflex. Further research is needed to explore the adjuvant use of non-antibiotic prophylaxis measures such as vaginal estrogen, urine acidifiers, and other nutriceuticals.

Paradoxically, we found that a larger urethral anal distance enhanced the risk for UTI (adjusted OR 1.4). This sum of perineal body and genital hiatus measures of the POP-Q examination enabled us to test the hypothesis that a shorter distance would facilitate bladder colonization with enteric flora. Although it might seem counterintuitive that a greater distance between the source and destination of enteric urinary pathogens would predispose a woman to a post-operative UTI, we postulate that a higher UAD is a proxy for global neuromuscular compromise manifesting as pelvic and perineal descent [23]. Although the UAD decreases post-operatively, the global pelvic floor dysfunction remains, and these women are possibly at risk for urinary stasis and subsequent UTI development.

Liquid fecal incontinence approached statistical significance in our univariate analysis. Fecal incontinence can indeed predispose a woman to auto-inoculation of enteric bacteria into her urine; however, we did not include this variable into our final multivariable model due to the very small prevalence in our cohort.

Risk factors for UTI in post-menopausal women without recent surgery are well known and include vaginal atrophy, incomplete bladder emptying, catheter use, pelvic floor prolapse, type I diabetes mellitus, and history of UTIs [13, 24, 25]. Our population's risk factors were similar, and many of the variables found to be significant in the preliminary analyses were linked to advancing age. Transvaginal estrogen is commonly prescribed for the treatment of atrophy. It is also employed by us in a multimodal strategy to prevent recurrent urinary tract infections in the elderly. Additionally, the vaginal route for surgery is preferentially selected for our older patients because the morbidity and associated recovery is generally less difficult than laparotomy. None of these variables were found to be independent risk factors for a UTI in our analyses.

A strength of this study is that the subjects were selected consecutively, thus reducing the selection bias. Both hospital and office charts were reviewed, providing data for the analysis of numerous patient and procedural characteristics. There were very few missing data points. The multiple surgeons and variety of incontinence and prolapse procedures through both vaginal and abdominal routes enhances the generalizability of our findings.

Limitations of our study include the intrinsic weaknesses of a retrospective study. Patient reports of prior UTIs are subject to recall bias and liquid fecal incontinence may be underreported due to embarrassment. Furthermore, some of our patients may have received treatment for acute UTI symptoms from other health care sources without notifying us. We consider this unlikely as it is our practice to schedule women for 2- and 6-week post-operative visits, during which time they are screened for UTI symptoms.

In summary, we characterized the risk for UTI in a population of consecutive women undergoing surgery for POP and/or SUI. We found the need for post-operative catheterization and prolonged duration of catheterization, despite antibiotic prophylaxis, as well as previous history of multiple UTIs, and an increased distance between the urethra and the anus to be significant independent risk factors for the development of symptomatic UTI in the immediate post-operative period. There is a pressing need to generate an evidence-based approach to the management of transient post-operative urinary retention, as well as to identify effective UTI prevention strategies in this population.

Conflicts of interest None.

References

1. Albo ME, Richter HE, Brubaker L, Norton P, Kraus S, Zimmern PE et al (2007) Burch colposuspension versus fascial sling to reduce urinary stress incontinence. N Engl J Med 356:2143–2155
2. FitzGerald MP, Richter HE, Bradley CS, Ye W, Visco AC, Cundiff GW, Zyczynski HM, Fine P, Weber AM (2008) Pelvic support, pelvic symptoms, and patient satisfaction after colpocleisis. Int Urogynecol J 19:1603–1609
3. Bump RC, Norton PA (1998) Epidemiology and natural history of pelvic floor dysfunction. Obstet Gynecol Clin North Am 25:723–746
4. Olsen AL, Smith VJ, Bergstrom JO, Colling JC, Clark AL (1997) Epidemiology of surgically managed pelvic organ prolapse and urinary incontinence. Obstet Gynecol 89:501–506
5. Anger JT, Litwin MS, Wang Q, Pashos CL, Rodriguez LV (2007) Complications of sling surgery among female medicare beneficiaries. Obstet Gynecol 109:707–714
6. Weber AM, Abrams P, Brubaker L, Cundiff G, Davis G, Dmochowsji RR et al (2001) The standardization of terminology for researchers in female pelvic floor disorders. Int Urogynecol J 12:178–186
7. Fihn SD (2003) Acute uncomplicated urinary tract infection in women. N Engl J Med 349:259–266
8. Platt R, Polk F, Murdock B, Rosner B (1982) Mortality associated with nosocomial urinary-tract infection. N Engl J Med 307:637–642
9. Hooten TM, Stamm WE (1997) Diagnosis and treatment of uncomplicated urinary tract infection. Infect Dis Clin North Am 11:551–581
10. Chai TC, Albo ME, Richter HE, Norton P, Dandreo KJ et al (2007) Analysis of adverse events from the stress incontinence surgical treatment efficacy trial (Sister). J Pelvic Medicine & Surgery 13:259, abstract
11. Mutone N, Brizendine E, Hale D (2003) Factors that influence voiding function after the tension-free vaginal tape procedure for stress urinary incontinence. Am J Obstet Gynecol 188:1477–1483
12. Cox CE, Hinman F (1961) Experiments with induced bacteriuria, vesicle emptying and bacterial growth on the mechanism of bladder defenses to infection. J Urol 83:739
13. Foxman B, Brown P (2003) Epidemiology of urinary tract infections: transmission and risk factors, incidence, and costs. Infect Dis Clin N Am 17:227–241
14. Barron KI, Savageau JA, Young SB, Labin LC, Morse AN (2006) Prediction of successful voiding immediately after outpatient mid-urethral sling. Int Urogynecol J 17(6):570–575, Nov
15. Benson JT, Lucente V, McClellan E (1996) Vaginal versus abdominal reconstructive surgery for the treatment of pelvic support defects: a prospective randomized study with long-term outcome evaluation. Am J Obstet Gynecol 175:1418–1421
16. Mohler JL, Cowen DL, Flanigan RC (1987) Suppression and treatment of urinary tract infection in patients with an intermittently catheterized neurogenic bladder. J Urol 138:336–340
17. Dobbs SP, Jackson SR, Wilson AM, Maplethorpe RP, Hammond RH (1997) A prospective, randomized trial comparing continuous bladder drainage with catheterization at abdominal hysterectomy. Br J Urol 80:554–556
18. Trautner BW, Darouiche RO (2004) Catheter-associated infections. Arch Intern Med 164:842–850
19. Saint S, Chenowith CE (2003) Biofilms and catheter-associated urinary tract infections. Infect Dis Clin N Am 17:411–432
20. Wyndeale JJ (2002) Complications of intermittent catheterization: their prevention and treatment. Spinal Cord 40:536–541
21. Galloway A, Green HT, Windsor JJ, Menon KK, Gardner BP, Krishnan KR (1986) Serial concentrations of C-reactive protein as an indicator of urinary tract infection in patients with spinal injury. J Clin Pathol 39:851–855
22. Rogers RG, Kammer-Doak D, Olsen A, Thompson PK, Walters MD, Lukcz ES, Qualls C (2004) A randomized, double-blind, placebo-controlled comparison of the effect of nitrofurantoin monohydrate macrocrystals on the development of urinary tract infections after surgery for pelvic organ prolapse and/or stress urinary incontinence with suprapubic catheterization. Am J Obstet Gynecol 191:182–187
23. DeLancey JO, Hurd WW (1998) Size of the urogenital hiatus in the levator ani muscles in normal women and women with pelvic organ prolapse. Obstet Gynecol 91:364–368
24. ACOG Practice Bulletin No. 91 (2008) Treatment of Urinary Tract Infections in Non-Pregnant Women. Obstet Gynecol 111:785–794
25. Stamm WE, Raz R (1999) Factors contributing to susceptibility of postmenopausal women to recurrent urinary tract infection. Clin Infect Dis 28:723–725