Catheter-Related Bladder Discomfort: How Can We Manage It?

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The urethral catheter is used in various clinical situations such as diagnosing urologic disease, urine drainage in patients after surgery, and for patients who cannot urinate voluntarily. However, catheters can cause numerous adverse effects, such as catheter-associated infection, obstruction, bladder stones, urethral injury, and catheter-related bladder discomfort (CRBD). CRBD symptoms vary among patients from burning sensation and pain in the suprapubic and penile areas to urinary urgency. CRBD significantly reduces patient quality of life and can lead to several complications. CRBD is caused by catheter-induced bladder irritation due to muscarinic receptor-mediated involuntary contractions of bladder smooth muscle and also can be caused by mechanical stimulus of the urethral catheter. Various pharmacologic studies for managing CRBD, including antimuscarinic and antiepileptic agents and botulinum toxin injections have been reported. If urologists can reduce patients' CRBD, their quality of life and recovery can improve.

Keywords: Urinary catheter; Urinary bladder; Muscarinic antagonist

INTRODUCTION

The urethral catheter is used in various approaches for diagnosing and treating urologic diseases. For diagnostic purposes, it is used to obtain urine specimens for urinalysis or urine culture and to measure postvoid residual urine for urodynamic or radiographic studies (voiding cystourethrography, retrograde urethrography, etc.). For treatment purposes, when injecting Bacillus Calmette-Guerin or anticancer drugs into the bladder to treat bladder cancer, or to decompress the bladder after general anesthesia, short-term catheterization will be performed for acute urinary retention, while long-term catheterization and periodic catheter replacement are required in neurogenic bladder cases. It is known that about 15%–25% of hospitalized patients in general hospitals indwell and maintain urethral catheters according to various needs, and about 50% of patients living in long-term care facilities or nursing home continuously keep urethral catheters [1-3]. Many patients with neurogenic

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bladder maintain a long-term urethral catheter due to the inconvenience of clean intermittent catheterization. The urethral catheter can act as a foreign body in the human body, causing many adverse effects, such as blockage, infection (cystitis or pyelonephritis due to bacterial infection in urine), bladder cancer (mainly squamous cell carcinoma), hematuria, bladder stones, urethral trauma, and catheter-related bladder discomfort (CRBD) [4-8].

Definitions of CRBD and urinary catheter-related pain (URCP) are confusing. URCP is defined as pain results from involuntary bladder spasm caused by irritation of the bladder wall [9,10]. CRBD refers to discomfort in pelvic area or urgency sensation, which is similar to overactive bladder (OAB) [11,12]. The incidence of CRBD in catheterized patients reaches 47%–90%. CRBD symptoms vary from burning sensation and pain in the suprapubic and penile area to urinary urgency [13-15]. CRBD can trigger serious behavioral reactions such as confusion and agitation, which can lead to traumatic attempts to remove the urethral catheter, causing urethral injury and subsequent urethral stricture [12,16-18]. CRBD can also cause severe pain and prolonged hospital stays after surgery [19,20].

Herein we review the underlying etiology of CRBD and clinical management, focusing primarily on medical treatments for CRBD.

CRBD ETIOLOGIES

CRBD symptoms are similar to those of OAB. CRBD is caused by catheter-induced bladder irritation due to muscarinic receptor-mediated involuntary contractions of bladder smooth muscle. The bladder receives adrenergic innervation from the hypogastric nerve and cholinergic innervation from the pelvic nerve. Catheterization stimulates the bladder's afferent nerve to secrete acetylcholine, causing detrusor muscarinic receptor-mediated involuntary contractions [15,21]. The bladder exhibits heterogeneous populations of muscarinic receptors with a predominance of M2 muscarinic receptors and a minor population of M3 receptors. M2 receptor activation causes contraction of detrusor smooth [22]. Detrusor contraction of the bladder by acetylcholine released from activated cholinergic nerves, mediated by muscarinic receptors located in the urothelium/suburothelium is the main pathophysiology of OAB and CRBD [23, 24]. For this reason, it is helpful to use antimuscarinic agents to treat CRBD.

CRBD can also be caused by mechanical stimulus of the ure-

thral catheter. When the catheter and urine bag are connected, bladder urine is drained and the catheter tip comes into contact with the bladder wall, causing irritation and erosion of the bladder wall. The tip of the suprapubic catheter causes severe pain when it comes into contact with the bladder trigone. "Catheter cramp" refers to the pain caused by bladder and urethral spasms, which are caused by irritation of the bladder wall and trigone by the catheter. Bladder spasms can be strong enough to push on the catheter's inflated balloon and can cause bladder neck and urethral erosion [9,25,26]. CRBD may intensify when the catheter balloon is close to the trigone or the balloon is too large. Moreover, CRBD can caused by urethral stimulation. In their prospective study, Binhas et al. [13] demonstrated that catheter diameter can influence CRBD, especially in men, if the catheter is 18F or larger. The authors insisted that the fact that men's urethras are longer than those of women could explain these findings. However, studies on CRBD as a result of urethral pain is insufficient, and more research is needed.

METHODS FOR MEASURING CRBD

There is no widely used questionnaire for measuring CRBD. In most papers, the intensity of CRBD was classified as mild, moderate, and severe, and in some papers, the pain scale from 1 to 10 was used, and in other studies, the OAB questionnaire was used. Therefore, development of accurate questionnaire which can evaluate patient's symptom precisely is needed. Then, discomfort from CRBD was measured using the following 4-point scoring system, which was firstly devised by Agarwal et al. [17]. Since then, many researches have used this scoring system to measure CRBD [12,15,18]. Table 1 summarizes the content of the questionnaire. However, since this scoring system has a limitation because it has not been properly validated, a convenient and well-validated scoring system for CRBD measurement is required.

CRBD MANAGEMENT

Various studies of medications to modulate CRBD have been conducted, however, many studies compared CRBD improvement after surgery using drugs before or during surgery in patients who underwent surgery under anesthesia and urethral catheterization. Few studies have been conducted on CRBD in patients with short- or long-term catheterization for urologic disease. Among previously published research results included

Table 1. Scoring system for catheter-related bladder discomfort measurement

Score	Symptom
0	No discomfort
1	Mild discomfort only reported upon questioning
2	Moderate discomfort, urge to pass urine reported by the patient without questioning
3	Severe discomfort, urge to pass urine accompanied by behavioral responses, such as flailing limbs, strong verbal responses, or attempt to pull out the catheter

in this review, catheter type, mechanism, effect of therapeutic drugs, and adjustment of catheter balloon size in CRBD patients after surgery were described.

Antimuscarinic Agents

Antimuscarinic agents reduce spontaneous detrusor overactivity in the storage phase by reducing the frequency and intensity of detrusor contraction. Additionally, they increase bladder capacity by inhibiting the bladder-afferent mechanism during bladder filling. Because of these effects, antimuscarinic agents can be used to treat CRBD. Adverse effects of antimuscarinic agents include dry mouth, constipation, somnolence, drowsiness, and blurred vision, which impact both persistence and compliance with long-term treatment because muscarinic receptors mediate the excitatory and inhibitory actions of acetylcholine in the central and peripheral nervous system [27,28].

Solifenacin

Solifenacin selectively blocks the M3 muscarinic receptor to inhibit bladder detrusor contraction and is an antimuscarinic agent with little salivary gland secretion inhibition [29-33].

Solifenacin: To reduce CRBD that occurs after transurethral resection of bladder tumors (TURBT), patients (N = 116) are were given 5 mg of solifenacin (n = 58) or placebo (n = 58) 6 hours before surgery and CRBD was measured 6, 12, 24, 48, 72 hours after surgery. Drug administration was continued for 2 weeks after surgery, and OAB symptom scores in the 2 groups were compared. In the solifenacin group, CRBD incidence and severity decreased significantly (P < 0.05) and OAB symptoms decreased significantly (P < 0.001) compared with placebo. Side effects ranged from mild to severe. The most common side effects were dry mouth (10.3% vs. 6.9%, P = 0.743) and constipation (8.6% vs. 3.4%, P = 0.438) with solifenacin and placebo, respectively [18].

Chung et al. [34] divided patients who underwent TURBT (N = 148) into 2 groups and compared their symptoms: one group took 5 mg of solifenacin (n = 72) the day before surgery, the day of surgery, and the day after surgery, and the other group (n = 76) took no medication. They measured the CRBD of patients 1–2 hours after surgery using the visual analogue scale (VAS) score for 3 days after surgery. The CRBD incidence rate did not differ between the solifenacin and no-medication groups (P = 0.34 at 1 hour, P = 0.08 at 2 hours). CRBD severity was not different between the 2 groups. VAS scores did not differ between the 2 groups at 6 hours, or 1, 2, and 3 days after surgery (P = 0.082, P = 0.350, P = 0.163, P = 0.287). In this study, solifenacin did not reduce CRBD after TURBT.

Solifenacin vs. darifenacin: Darifenacin is an antimuscarinic agent with higher affinity and specificity for the M3 receptor subtype than other subtypes [35]. Darifenacin has also displayed significantly higher affinity for muscarinic receptors in the submaxillary gland of rats than in the bladder and heart [36].

Patients (N = 90) who underwent catheterization after undergoing spinal surgery were divided into 3 groups: 5 mg of solifenacin (n = 30), 7.5 mg of darifenacin 7.5 mg (n = 30), and placebo (n = 30). Drugs were administered 1 hour before anesthesia, and CRBD was measured until 6 hours after surgery in the postanesthesia care unit (PACU). CRBD prevalence and severity were significantly less in the solifenacin and darifenacin groups compared with the placebo group at all time intervals (P < 0.05). Solifenacin and darifenacin both reduced CRBD without clinically significant side effects [14].

Oxybutynin

Oxybutynin may be effective for treating OAB, not only through suppression of muscarinic receptor-mediated detrusor muscle contractions, but also by blocking muscarinic receptors in bladder-afferent pathways [37]. A number of side effects inherent in all anticholinergic agents, including dry mouth, dizziness, constipation, and confusion, have been commonly reported and are responsible for frequent withdrawal from treatment [38].

Newer antimuscarinic agents have similar effects as oxybutynin with better tolerability, and physicians are beginning to prefer these newer antimuscarinic agents as the first-line treatment option for OAB [39].

Patients (N=46) undergoing radical retropubic prostatectomy were divided into either a sublingual oxybutynin (5 mg; n=23) or placebo (n=23) group and were administered these treatments for 24 hours at 8-hour intervals. The authors assessed the pain score at rest using VAS after surgery. The incidences of catheter-related bladder pain and "urge to void" symptoms were significantly higher in the placebo group (P<0.05). Patients in the oxybutynin group did not report dry mouth [40].

Tolterodine

Tolterodine was developed as a nonselective antagonist of muscarinic receptor subtypes to treat OAB [41]. It is as strong as oxybutynin for suppressing bladder contraction and is a significantly less potent salivation inhibitor. Low tolterodine doses may exert an inhibitory effect on C-fiber afferent nerves, which can improve bladder storage function [42].

Tolterodine: Agarwal et al. [17] divided patients (N=215) who underwent endoscopic or open urologic surgery into 2 groups: 2 mg of tolterodine (n=50) or placebo (n=165) 1 hour before anesthesia. The degree of bladder discomfort in each patient was evaluated after 1, 2, and 6 hours after arriving at the PACU. Severity of bladder discomfort was recorded as mild (reported by the patient only on questioning), moderate (reported by the patient without questioning; not accompanied by any behavioral responses), or severe (reported by the patient and accompanied by behavioral responses). Behavioral responses observed were flailing limbs, strong vocal response, and attempts to remove the catheter.

The overall incidence of bladder discomfort was significantly less in the tolterodine group compared with the placebo group [17]. At 1 hour, dry-mouth incidence was 66% in the tolterodine group versus 47% in the placebo group (P<0.05). There was no difference in the incidence of other adverse events between the groups at any time. In a meta-analysis, tolterodine was ranked best in decreasing the severity of CRBD during the 6 hours after surgery [43].

Tolterodine vs. oxybutynin: Patients (N=234) undergoing percutaneous nephrostomy were divided into 3 groups: 5 mg of oxybutynin (n=78), 2 mg of tolterodine (n=78), or placebo (n=78) 1 hour before surgery. Bladder discomfort was assessed at 0, 1, 2, and 6 hours after the patient arrived at PACU, and bladder discomfort severity was rated as mild, moderate, or severe. Significant reductions in incidence and severity were observed in the oxybutynin and tolterodine groups compared with the placebo group (P<0.05). The incidence of dry mouth was significantly higher in the tolterodine and oxybutynin groups compared with the placebo group (P<0.05) [12].

Gabapentin

Gabapentin: Gabapentin is an antiepileptic and analgesic agent and is a ligand of the α2δ subunit of the voltage-sensitive calcium channels involved in activation of afferent C and αδ fibers. Upregulation of bladder C-fiber afferent nerve function has also been hypothesized to play a role in certain cases of urge incontinence and OAB [24]. Gabapentin appears to inhibit peripheral sensitization by its inhibitory activity on afferent C-fibers and may be helpful to treat OAB and CRBD [44,45]. Gabapentin probably regulates detrusor overactivity by controlling afferent input from the bladder and excitability of the sacrum reflex center [45]. Gabapentin is effective at reducing OAB symptoms and improving urodynamic parameters in patients with neurogenic detrusor overactivity or refractory idiopathic OAB [46].

Patients (N=108) undergoing percutaneous nephrolithotomy were divided into 2 groups: 600 mg of gabapentin (n=54) or placebo (n=54), which were administered 1 hour before surgery. CRBD was measured 1, 2, and 6 hours after arrival to the PACU. Gabapentin significantly reduced the frequency and severity of CRBD compared with placebo (P<0.05). There were no differences in postoperative sedation or headache between the 2 groups (P<0.05). The authors concluded that the combined peripheral and central action of gabapentin could account for the observed decrease in CRBD incidence and severity [47].

Bala et al. [15] evaluated the effect of gabapentin on CRBD in patients who underwent TURBT. TURBT patients were divided into 3 groups: group I received placebo (n=33), group II received 600 mg of gabapentin (n=33), and group III received 1,200 mg of gabapentin (n=34). Treatments were administered 1 hour before surgery and CRBD frequency and severity were compared 24 hours after surgery. CRBD incidence was 90% in group I, 66% in group II, and 26% in group III. The incidence of bladder discomfort was significantly lower in group III at all timepoints compared with group I and at 4, 6, 12, and 24 hours compared with group II. CRBD severity was lower in groups II

and III patients compared with group I patients. The most common side effects were drowsiness, dizziness, ataxia, and fatigue. No significant side effects were reported in any patient group. The authors concluded that 1,200 mg of gabapentin administered before surgery was more effective at reducing CRBD incidence after surgery than 600 mg. In a meta-analysis, the authors demonstrated that gabapentin 1,200 mg per oral was ranked best in decreasing the overall incidence of CRBD [43].

Gabapentin vs. tolterodine: Patients (N = 170) undergoing percutaneous nephrolithotomy were randomized and divided into 3 groups: 2 mg of tolterodine (n = 50), 600 mg of gabapentin (n = 50), or placebo (n = 70) 1 hour before surgery, and CRBD severity was compared 1, 3, 12, and 24 hours after surgery. The frequencies of severe CRBD 1, 12, and 24 hours after surgery were 4%, 4%, and 6% in the tolterodine group vs. 4%, 0%, and 2% in the gabapentin group vs. 47%, 14%, and 6% in the placebo group (P < 0.001). The authors concluded that preoperative administration of tolterodine or gabapentin reduced postoperative CRBD after surgery [48].

Pregabalin

Pregabalin is an antiepileptic and analgesic agent. It is similar to gabapentin in its mechanism of action and is an analogue of the inhibitory neurotransmitter GABA, but it does not interact with gamma-aminobutyric acid (GABA) receptors or mimic the actions of GABA [49]. Pregabalin interacts with the auxiliary subunit (alpha2-delta subunit) of voltage-gated calcium channels. Potent bindings at this site attenuate depolarization-induced calcium influx at nerve terminals, with a subsequent reduction in the central release of excitatory neurotransmitters [50,51]. Peripheral release may lead to subsequent inhibition of bladder smooth muscle contraction and to decreased amplitude of detrusor contraction [52]. Pregabalin's ability to inhibit the release of excitatory neurotransmitters is probably responsible for its analgesic properties. This analgesic effect may help increase bladder capacity by increasing the interval between emergency episodes [53]. Pregabalin and gabapentin have similar efficacy, but pregabalin can be administered at significantly lower doses than gabapentin due to its higher bioavailability, faster adsorption, and greater efficacy [49].

Patients (N = 60) undergoing spinal surgery were randomly assigned and divided into 2 groups: 50 mg of pregabalin (n = 30) or placebo (n = 30) 1 hour before anesthesia induction. CRBD was measured and compared at 1, 2, and 6 hours after surgery. CRBD incidence was significantly lower in the pregabalin group compared with the placebo group at all time intervals (P < 0.05). CRBD severity was reduced in the pregabalin group compared with the control group at all time intervals except 6 hours postsurgery [54].

Botulinum Toxin Injection

Intravesical injection of B Botulinum toxin (BotN) is an effective treatment for detrusor overactivity that does not respond to oral medication [55-60]. Young et al. [61] performed intravesical injection of BotN in 54 patients with refractory bladder pain and catheter bypass leakage who also had an indwelling urethral or suprapubic catheter for at least 12 weeks. Intravesical BotN was injected at 100 U or 200 U. After treatment, symptoms were controlled in 51 patients (94%), but 15 patients (28%) developed urinary tract infections. Intravesical injection of BotN is an effective treatment for patients with refractory bladder pain and catheter bypass leakage, but urine culture should be confirmed before treatment and appropriate preoperative antibiotic treatment is necessary.

Adjusting Catheter Balloon Size

CRBD was measured in patients (N = 49) undergoing surgery who had urologic disease (transurethral resection of bladder tumor, transurethral resection of prostate, nephrectomy, etc.). Urethral catheter balloon volume was reduced by 50% and then CRBD was measured 2 hours later. All questionnaires were completed between 12 and 24 hours after insertion of an indwelling urethral catheter and the authors compared the difference in CRBD before and after balloon volume reduction. Patient CRBD reduced significantly after volume reduction (P < 0.05) [21].

CONCLUSIONS

Urethral catheters are used in a variety of situations to excrete urine from patients. However, CRBD makes patients uncomfortable, deteriorates quality of life, and causes postsurgical complications. Several studies of drug treatments to reduce CRBD have been published, but most of these studies were conducted after catheterization of patients under anesthesia after taking medications. There have been few studies on CRBD treatment in patients with short- to long-term catheters for urologic disease, and no prospective studies in these patients have been reported. Urologists have used urethral catheters in many ways as a diagnostic and treatment tool, but the issue of

CRBD has been simultaneously neglected. Future prospective studies are needed to reduce CRBD and improve patient quality of life.

AUTHOR CONTRIBUTION STATEMENT

· Conceptualization: *SYP, YTK, YEY, HSM*
· Data curation: *SHH, HSM*
· Formal analysis: *SHH, HSM*
· Funding acquisition: *HSM*
· Methodology: *KSK, SYP, HSM*
· Project administration: *KSK, HSM*
· Writing-original draft: *EBJ, HSM*
· Writing-review & editing: *EBJ, YTK, YEY, HSM*

REFERENCES

1. Platt R, Polk BF, Murdock B, Rosner B. Mortality associated with nosocomial urinary-tract infection. N Engl J Med 1982;307:637-42.

2. Lo E, Nicolle L, Classen D, Arias KM, Podgorny K, Anderson DJ, et al. Strategies to prevent catheter-associated urinary tract infections in acute care hospitals. Infect Control Hosp Epidemiol 2008; 29 Suppl 1:S41-50.

3. Smith PW, Bennett G, Bradley S, Drinka P, Lautenbach E, Marx J, et al. SHEA/APIC guideline: infection prevention and control in the long-term care facility, July 2008. Infect Control Hosp Epidemiol 2008;29:785-814.

4. Garcia MM, Gulati S, Liepmann D, Stackhouse GB, Greene K, Stoller ML. Traditional Foley drainage systems--do they drain the bladder? J Urol 2007;177:203-7; discussion 7.

5. Stickler DJ, Feneley RC. The encrustation and blockage of long-term indwelling bladder catheters: a way forward in prevention and control. Spinal Cord 2010;48:784-90.

6. Samson G, Cardenas DD. Neurogenic bladder in spinal cord injury. Phys Med Rehabil Clin N Am 2007;18:255-74, vi.

7. Kashefi C, Messer K, Barden R, Sexton C, Parsons JK. Incidence and prevention of iatrogenic urethral injuries. J Urol 2008;179: 2254-7; discussion 7-8.

8. Kohler-Ockmore J, Feneley RC. Long-term catheterization of the bladder: prevalence and morbidity. Br J Urol 1996;77:347-51.

9. Wilson M. Causes and management of indwelling urinary catheter-related pain. Br J Nurs 2008;17:232-9.

10. Nazarko L. Bladder pain from indwelling urinary catheterization: case study. Br J Nurs 2007;16:511-2, 4.

11. Lim N, Yoon H. Factors predicting catheter-related bladder discomfort in surgical patients. J Perianesth Nurs 2017;32:400-8.

12. Agarwal A, Dhiraaj S, Singhal V, Kapoor R, Tandon M. Comparison of efficacy of oxybutynin and tolterodine for prevention of catheter related bladder discomfort: a prospective, randomized, placebo-controlled, double-blind study. Br J Anaesth 2006;96:377-80.

13. Binhas M, Motamed C, Hawajri N, Yiou R, Marty J. Predictors of catheter-related bladder discomfort in the post-anaesthesia care unit. Ann Fr Anesth Reanim 2011;30:122-5.

14. Srivastava VK, Nigam R, Agrawal S, Kumar S, Rambhad S, Kanaskar J. Evaluation of the efficacy of solifenacin and darifenacin for prevention of catheter-related bladder discomfort: a prospective, randomized, placebo-controlled, double-blind study. Minerva Anestesiol 2016;82:867-73.

15. Bala I, Bharti N, Chaubey VK, Mandal AK. Efficacy of gabapentin for prevention of postoperative catheter-related bladder discomfort in patients undergoing transurethral resection of bladder tumor. Urology 2012;79:853-7.

16. Tauzin-Fin P, Stecken L, Sztark F. Catheter-related bladder discomfort in post-anaesthesia care unit. Ann Fr Anesth Reanim 2012;31: 605-8.

17. Agarwal A, Raza M, Singhal V, Dhiraaj S, Kapoor R, Srivastava A, et al. The efficacy of tolterodine for prevention of catheter-related bladder discomfort: a prospective, randomized, placebo-controlled, double-blind study. Anesth Analg 2005;101:1065-7, table of contents.

18. Zhang Z, Cao Z, Xu C, Wang H, Zhang C, Pan A, et al. Solifenacin is able to improve the irritative symptoms after transurethral resection of bladder tumors. Urology 2014;84:117-21.

19. Jeffery N, Mundy A. Innovations in indwelling urethral catheterisation. BJU Int 2020;125:664-8.

20. Bai Y, Wang X, Li X, Pu C, Yuan H, Tang Y, et al. Management of catheter-related bladder discomfort in patients who underwent elective surgery. J Endourol 2015;29:640-9.

21. Zugail AS, Pinar U, Irani J. Evaluation of pain and catheter-related bladder discomfort relative to balloon volumes of indwelling urinary catheters: a prospective study. Investig Clin Urol 2019;60:35-9.

22. Yamanishi T, Chapple CR, Chess-Williams R. Which muscarinic receptor is important in the bladder? World J Urol 2001;19:299-306.

23. de Groat WC. Anatomy and physiology of the lower urinary tract. Urol Clin North Am 1993;20:383-401.

24. Yoshimura N, Chancellor MB. Current and future pharmacological treatment for overactive bladder. J Urol 2002;168:1897-913.

25. Sulzbach LM. Patients who experience the common but uncomfortable sensation of "needing to void". Crit Care Nurse 2002;22:84-7.

26. Robinson J. Fundamental principles of indwelling urinary catheter selection. Br J Community Nurs 2004;9:281-4.

27. Andersson KE, Wein AJ. Pharmacology of the lower urinary tract: basis for current and future treatments of urinary incontinence. Pharmacol Rev 2004;56:581-631.

28. Andersson KE. Antimuscarinics for treatment of overactive bladder. Lancet Neurol 2004;3:46-53.

29. Ikeda K, Kobayashi S, Suzuki M, Miyata K, Takeuchi M, Yamada T, et al. M(3) receptor antagonism by the novel antimuscarinic agent solifenacin in the urinary bladder and salivary gland. Naunyn Schmiedebergs Arch Pharmacol 2002;366:97-103.

30. Kobayashi S, Ikeda K, Miyata K. Comparison of in vitro selectivity profiles of solifenacin succinate (YM905) and current antimuscarinic drugs in bladder and salivary glands: a Ca2+ mobilization study in monkey cells. Life Sci 2004;74:843-53.

31. Choi H, Bae JH, Oh CY, Jeong SJ, Ko WJ, Choi JB, et al. Clinical efficacy of solifenacin in the management of diabetes mellitus-associated versus idiopathic overactive bladder symptoms: a multicenter prospective study. Int Neurourol J 2018;22:51-7.

32. Hsiao SM, Wu PC, Chang TC, Chen CH, Lin HH. Urodynamic and bladder diary factors predict overactive bladder-wet in women: a comparison with overactive bladder-dry. Int Neurourol J 2019;23:69-74.

33. Tae BS, Park TY, Jeon BJ, Chung H, Lee YH, Park JY, et al. Seasonal variation of overactive bladder symptoms in female patients. Int Neurourol J 2019;23:334-40.

34. Chung JM, Ha HK, Kim DH, Joo J, Kim S, Sohn DW, et al. Evaluation of the efficacy of solifenacin for preventing catheter-related bladder discomfort after transurethral resection of bladder tumors in patients with non-muscle invasive bladder cancer: a prospective, randomized, multicenter study. Clin Genitourin Cancer 2017;15:157-62.

35. Yamada S, Ito Y, Nishijima S, Kadekawa K, Sugaya K. Basic and clinical aspects of antimuscarinic agents used to treat overactive bladder. Pharmacol Ther 2018;189:130-48.

36. Yamada S, Maruyama S, Takagi Y, Uchida S, Oki T. In vivo demonstration of M3 muscarinic receptor subtype selectivity of darifenacin in mice. Life Sci 2006;80:127-32.

37. Kim Y, Yoshimura N, Masuda H, de Miguel F, Chancellor MB. Antimuscarinic agents exhibit local inhibitory effects on muscarinic receptors in bladder-afferent pathways. Urology 2005;65:238-42.

38. Jirschele K, Sand PK. Oxybutynin: past, present, and future. Int Urogynecol J 2013;24:595-604.

39. Biardeau X, Campeau L, Corcos J. We should not use oxybutynin chloride in OAB. Neurourol Urodyn 2017;36:822-3.

40. Tauzin-Fin P, Sesay M, Svartz L, Krol-Houdek MC, Maurette P. Sublingual oxybutynin reduces postoperative pain related to indwelling bladder catheter after radical retropubic prostatectomy. Br J Anaesth 2007;99:572-5.

41. Guay DR. Tolterodine, a new antimuscarinic drug for treatment of bladder overactivity. Pharmacotherapy 1999;19:267-80.

42. Yokoyama O, Yusup A, Miwa Y, Oyama N, Aoki Y, Akino H. Effects of tolterodine on an overactive bladder depend on suppression of C-fiber bladder afferent activity in rats. J Urol 2005;174:2032-6.

43. Hur M, Park SK, Yoon HK, Yoo S, Lee HC, Kim WH, et al. Comparative effectiveness of interventions for managing postoperative catheter-related bladder discomfort: a systematic review and network meta-analysis. J Anesth 2019;33:197-208.

44. Sasaki K, Smith CP, Chuang YC, Lee JY, Kim JC, Chancellor MB. Oral gabapentin (neurontin) treatment of refractory genitourinary tract pain. Tech Urol 2001;7:47-9.

45. Carbone A, Palleschi G, Conte A, Bova G, Iacovelli E, Bettolo CM, et al. Gabapentin treatment of neurogenic overactive bladder. Clin Neuropharmacol 2006;29:206-14.

46. Kim YT, Kwon DD, Kim J, Kim DK, Lee JY, Chancellor MB. Gabapentin for overactive bladder and nocturia after anticholinergic failure. Int Braz J Urol 2004;30:275-8.

47. Agarwal A, Dhiraaj S, Pawar S, Kapoor R, Gupta D, Singh PK. An evaluation of the efficacy of gabapentin for prevention of catheter-related bladder discomfort: a prospective, randomized, placebo-controlled, double-blind study. Anesth Analg 2007;105:1454-7, table of contents.

48. Maghsoudi R, Farhadi-Niaki S, Etemadian M, Kashi AH, Shadpour P, Shirani A, et al. Comparing the efficacy of tolterodine and gabapentin versus placebo in catheter related bladder discomfort after percutaneous nephrolithotomy: a randomized clinical trial. J Endourol 2018;32:168-74.

49. Marencak J, Cossons NH, Darekar A, Mills IW. Investigation of the clinical efficacy and safety of pregabalin alone or combined with tolterodine in female subjects with idiopathic overactive bladder. Neurourol Urodyn 2011;30:75-82.

50. Clarke H, Bonin RP, Orser BA, Englesakis M, Wijeysundera DN, Katz J. The prevention of chronic postsurgical pain using gabapentin and pregabalin: a combined systematic review and meta-analysis. Anesth Analg 2012;115:428-42.

51. Thorpe AJ, Offord J. The alpha2-delta protein: an auxiliary subunit

of voltage-dependent calcium channels as a recognized drug target. Curr Opin Investig Drugs 2010;11:761-70.

52. Kavoussi R. Pregabalin: from molecule to medicine. Eur Neuropsychopharmacol 2006;16 Suppl 2:S128-33.

53. Loutochin O, Al Afraa T, Campeau L, Mahfouz W, Elzayat E, Corcos J. Effect of the anticonvulsant medications pregabalin and lamotrigine on urodynamic parameters in an animal model of neurogenic detrusor overactivity. Neurourol Urodyn 2012;31:1197-202.

54. Srivastava VK, Agrawal S, Kadiyala VN, Ahmed M, Sharma S, Kumar R. The efficacy of pregabalin for prevention of catheter-related bladder discomfort: a prospective, randomized, placebo-controlled double-blind study. J Anesth 2015;29:212-6.

55. Ko KJ, Jenkins B, Patel A, Lee KS. A Korean postmarketing study assessing the effectiveness of onabotulinumtoxinA for the treatment of neurogenic detrusor overactivity or idiopathic overactive bladder using a validated patient-reported outcome measure. Int Neurourol J 2019;23:30-9.

56. Elbaset MA, Taha DE, El-Hefnawy AS, Zahran MH, Shokeir AA. Assessment of anticholinergic use after fading of btX-A effects in refractory idiopathic overactive bladder: a prospective blinded randomized trial. Int Neurourol J 2019;23:240-8.

57. Kuo HC. Urodynamic evidence of effectiveness of botulinum A toxin injection in treatment of detrusor overactivity refractory to anticholinergic agents. Urology 2004;63:868-72.

58. Samal V, Krhut J, Paldus V, Mullerova J, Mecl J. Intravesical loss of onabotulinumtoxinA during endoscopic intradetrusor injection - a multicenter experience. Int Neurourol J 2020;24:59-65.

59. Li GP, Wang XY, Zhang Y. Efficacy and safety of onabotulinumtoxina in patients with neurogenic detrusor overactivity caused by spinal cord injury: a systematic review and meta-analysis. Int Neurourol J 2018;22:275-86.

60. Trinh H, Irish V, Diaz M, Atiemo H. Outcomes of intradetrusor onabotulinum toxin A therapy in overactive bladder refractory to sacral neuromodulation. Int Neurourol J 2019;23:226-33.

61. Young MJ, Osman NI, Phillips L, Mangera A, Reid SV, Inman RD, et al. Another therapeutic role for intravesical botulinum toxin: patients with long-stay catheters and refractory bladder pain and catheter bypass leakage. Eur Urol Focus 2020;6:339-43.