Review Article

Postoperative urinary retention (POUR): A narrative review

ABSTRACT

Postoperative urinary retention (POUR) is defined as the inability to void in the presence of a full bladder after surgery. Complications include delirium, pain, prolonged hospitalization, and long-term altered bladder contractility. Comorbidities, type of surgery and anesthesia influence the development of POUR. The incidence varies between 5% and 70%. History and clinical examination, the need for bladder catheterization and ultrasonographic evaluation are three methods used to diagnose POUR. The prevention of POUR currently involves identifying patients with pre-operative risk factors and then modifying them where possible. Bladder catheterization is the standard treatment of POUR, however, further studies are necessary to establish patients who need a bladder catheter, bladder volume thresholds and duration of catheterization.

Key words: Postoperative complications, sugammadex, urinary retention

Introduction

Postoperative urinary retention (POUR) is defined as the inability to void in the presence of a full bladder after surgery.[1] Complications include delirium, pain, prolonged hospitalization, and long-term altered bladder contractility.[2] POUR is readily managed with catheterization, however, a bladder catheter placement can be emotionally traumatic, and it is associated with morbidity including urinary tract infection, trauma, and blockage.[3] Patients with urological pathology are at increased baseline risk of POUR and in these cases, the procedure of catheterization may be difficult.[4] Comorbidities, type of surgery and/or anesthesia influence the development of POUR.[1]

Access this article online	
Website: https://journals.lww.com/sjan	Quick Response Code
DOI: 10.4103/sja.sja_88_24	

Unfortunately, as underlined by Baldini *et al.*[1] in a 2009 review, the non-univocal definition of POUR has led to a difficult establishment of its real impact. Therefore, it is estimated that the incidence varies between 5% and 70% in the different types of surgery.

Physiology of micturition

The bladder is composed of a body and a neck, formed by, respectively, the detrusor muscle and the internal urethral sphincter (IUS), the latter made up of an internal layer of smooth muscle. The adult urinary bladder has a capacity from 400 to 600 ml. A volume of approximately 300 ml creates a sense of fullness. Voluntary bladder control develops in the first few years of life and involves coordination between the

How to cite this article: Cambise C, De Cicco R, Luca E, Punzo G, Di Franco V, Dottarelli A, *et al.* Postoperative urinary retention (POUR): A narrative review. Saudi J Anaesth 2024;18:265-71.

Chiara Cambise[1], Roberto De Cicco[1], Ersilia Luca[1], Giovanni Punzo[1], Valeria Di Franco[1], Alessandra Dottarelli[1], Teresa Sacco[1], Liliana Sollazzi[1,2], Paola Aceto[1,2]

[1]Dipartimento di Scienze dell'emergenza, anestesiologiche e della rianimazione, Fondazione Policlinico Universitario A. Gemelli IRCCS, Largo A. Gemelli, 8, 00168, [2]Dipartimento di Scienze Biotecnologiche di Base, Cliniche Intensivologiche e Perioperatorie, Università Cattolica del Sacro Cuore, Rome, Italy

Address for correspondence: Dr. Ersilia Luca, Dipartimento di Scienze dell'emergenza, anestesiologiche e della rianimazione, Fondazione Policlinico Universitario A. Gemelli IRCCS, Largo A. Gemelli, 8, 00168, Rome, Italy.
E-mail: ersilia.luca@policlinicogemelli.it

Submitted: 16-Feb-2024, **Accepted:** 19-Feb-2024, **Published:** 14-Mar-2024

frontal cortex, pontine centers, and spinal segments. During micturition, two phases can be distinguished, the storage phase and the emptying one.

Urination occurs because of the contraction of the detrusor and the relaxation of the neck, due to the activity of the parasympathetic fibers. On the other hand, the sympathetic fibers influence the relaxation of the detrusor and close the IUS. When any of these control mechanisms are inhibited, because of age or external interventions (such as the administration of anesthetics), improper urine retention may occur.[5]

Diagnosis of POUR

History and clinical examination, the need for bladder catheterization, and ultrasonographic evaluation are three methods used to diagnose POUR.[1]

In the past, anamnestic and objective criteria (pain and discomfort in the lower part of the abdomen, clinical assessment by palpation, and percussion in the suprapubic area) were used to diagnose POUR.[6] The need for bladder catheterization was assessed for both diagnostic and therapeutic purposes. Catheterization is an invasive procedure that may cause complications, including catheter-related infections, urethral trauma, prostatitis, and patient discomfort.[2] Ultrasound evaluation has gained popularity only in the last decade and has allowed a more accurate diagnosis. It also allows us to provide an accurate measure of the residual urinary volume[7,8] and to evaluate patients whose symptoms could be masked by regional anesthesia and/or comorbidities, including patients with spinal cord damage, stroke, or sedated patients unable to communicate symptoms.[6]

Furthermore, clinical evaluation underestimates bladder volume compared to ultrasound. Pavlin *et al.*[9] demonstrated that 61% of day surgery patients admitted to the Post-Anesthesia Care Unit (PACU) after general anesthesia did not report any symptoms of bladder distention, although they had bladder volume on ultrasound greater than 600 ml. Other authors found that a quarter of patients studied with ultrasound for POUR had postoperative bladder hyperdistention, although they had no clinical symptoms.[10] According to Ceratti *et al.*,[11] the incidence of urinary retention was higher when ultrasound was used for the diagnosis, compared to clinical examination. Therefore, ultrasound was shown to be accurate in establishing urinary volume.

Perioperative risk factors

POUR has a higher incidence in men (4.7%) compared to women (2.9%)[2] and it increases with age showing a 2.4 times increased risk in patients over 50, probably due to progressive neuronal degeneration.[12–14]

Benign prostatic hyperplasia and concomitant neurological pathologies such as stroke, poliomyelitis, cerebral palsy, multiple sclerosis, spinal lesions, diabetic and alcoholic neuropathies are predisposing factors for the development of urinary retention, supporting the greater incidence of POUR in the older population usually affected by these comorbidities.[2,15–18]

The presence of lower urinary tract symptoms, such as frequency, urgency, straining and weak stream, significantly increases the risk of POUR, while the preoperative use of alpha-blockers to treat prostatic hypertrophy significantly decreases the incidence.[19] Tamsulosin has recently been reported to be effective in preventing POUR after spine surgery, herniorrhaphy, and pelvic surgery.[20–22]

Some surgeries predispose to a greater risk of POUR and the incidence, as mentioned above, varies widely, according to the cases examined.[2] Studies on arthroplasty show a wide variability (10.7–84%),[23–25] as those on anal-rectal surgery, which vary between 1% and 52%.[14,26] In the latter case, the damage to the pelvic nerves and the evoked reflex pain causes an increase in the tone of the internal sphincter that justifies the high incidence of POUR.[27,28] After hernia repair, the incidence of POUR can vary from 5.9% to 38%.[14,29] Even in gynecological surgery, the results are conflicting. Pavlin *et al.*[9] reported that no patient undergoing routine gynecological surgery developed POUR, probably because 90% of them were catheterized during surgery and arrived in the PACU with an empty bladder.

Previous pelvic surgery may contribute to an increase in the risk of POUR, probably due to damage to the nerves of the lower urinary tract.[2]

The prolonged duration of surgery may be responsible for POUR.[30,31] In outpatients undergoing spinal anesthesia, it has been shown that the voiding time is directly proportional to the total duration of anesthesia.[31] These results could be explained by the volume of fluids administered intravenously in relation to the duration of the surgery. In patients under spinal anesthesia, bladder filling perception is abolished,[32] so excessive infusion of intravenous fluids may lead to overdistension of the bladder.[28]

Pavlin *et al*.[30] found a significant correlation between bladder volume and the duration of surgery but failed to show a relationship between the bladder volume and the total amount of fluids administered.

In patients undergoing hernioplasty and anorectal surgery, intravenous administration of more than 750 ml of fluid during the perioperative period increased the risk of POUR by 2.3 times.[2,17,26,33] Bladder overdistension inhibits detrusor function and the normal urination reflex cannot be restored even after emptying the urinary bladder with a catheter.[26,33] A bladder volume >270 ml represents a risk factor for POUR.[12]

Some medications commonly used in the perioperative period, such as anticholinergic agents and sympathomimetics, may interfere with bladder function. Anticholinergics such as atropine and glycopyrrolate block detrusor contractions and may cause bladder hypotonia, resulting in urinary retention.[2,34] Alpha-2 agonists and antagonists alter bladder function by acting on alpha-receptors in the smooth muscle cells of the upper and lower urinary tract.[34–36] In a randomized, double-blind trial, Gentili *et al*.[35] studied the effect of intrathecal clonidine, an alpha-2 agonist, on bladder function, finding that clonidine caused less POUR than morphine. Several possible mechanisms of clonidine have been proposed, including a decrease in spinal cord sympathetic outflow with the reduction in IUS tone, a supraspinal inhibitory effect on IUS tone and a diuretic effect.[35,36]

The administration of anesthetics, and in particular general anesthetics, cause bladder atony by interfering with the autonomic nervous system. Studies on rats and dogs have shown that sedative hypnotics and volatile anesthetics suppress the micturition reflex due to inhibition of the pontine micturition center and voluntary control of the cortex over the bladder. Propofol decreases detrusor contraction while isoflurane abolishes it.[37] In patients undergoing cholecystectomy and appendectomy, the incidence of POUR is directly related to the amount of systemic opioids used in the postoperative period.[32,38]

Spinal local anesthetics block the transmission of action potentials on efferent and afferent nerve fibers from and to the bladder (S2–S4).[32,39] The feeling of urgency disappears 30–60 seconds after the intrathecal injection of local anesthetic, but a feeling of tension from the bladder filling persists.

Bladder analgesia is due to the blocking of the transmission of afferent nerve fibers from the bladder to the micturition centers located in the brainstem and cortex. Detrusor contraction (detrusor block) is completely abolished 2–5 minutes after spinal anesthetic injection, and its recovery depends on the duration of the sensory block over the sacral segments S2 and S3. The time required for the sensory block to regress to S3 is 7–8 hours. Normalization of the detrusor occurs 1–3.5 hours after walking.[39]

The use of long-acting local anesthetics is related to a higher incidence of POUR compared to the use of short-acting anesthetics.[31,32]

Opioids administered intrathecally, by the action on the spinal cord[40] and on the other cerebral structures,[41] also reduce the sensation of urgency and detrusor contraction, increasing bladder capacity and residual volume and altering sphincter function.[40,42] The onset time of these effects is 1 hour after intrathecal morphine and sufentanil administration and the recovery time is approximately 24 hours.[42]

Intrathecal fentanyl prolongs the duration of the sensory block linked to spinal local anesthetic without affecting the ability to void[43] minimizing POUR and facilitating discharge.[44]

Lumbar epidural anesthetics act on sacral and lumbar nerve fibers, through a mechanism similar to that of intrathecal anesthetics, blocking the transmission of afferent and efferent nerve impulses to and from the bladder. The incidence of POUR when the epidural is performed with local anesthetics for inguinal hernioplasty is found to be lower than with spinal anesthesia.[45] In contrast, in a nationwide follow-up survey in Sweden, anesthesiologists reported a higher incidence of POUR with epidural morphine (38%) compared to intrathecal morphine (13%).[46]

Sufentanil and fentanyl are more lipophilic than morphine and have less diffusion into the central nervous system with a lower influence on urodynamics.[47] The site of opioid injection may also be related to POUR. The lumbar epidural space is associated with a higher rate of urinary retention compared to the thoracic one.[48]

Among the adjuvants used to prolong the effect of neuraxial anesthesia, opioids and epinephrine may both increase the risk of POUR.[49,50]

There are no reports of POUR associated with interscalene block,[51] while epidural anesthesia or patient-controlled analgesia (PCA) seem to increase the risk of POUR, compared to paravertebral and intercostal blocks, in patients undergoing thoracotomy and cholecystectomy.[52,53]

After herniorrhaphy, local anesthetic infiltration has been shown to decrease analgesic requirements in the post-operatory period and, consequently, the risk of POUR.[54,55]

Glycopyrrolate, an anticholinergic agent, is commonly used with neostigmine, an anticholinesterase, for the reversal of

neuromuscular blockade by nondepolarizing neuromuscular blockers (NDNMB). Acetylcholinesterase inhibitors indirectly increase detrusor contraction by increasing local levels of acetylcholine.[56]

Anticholinergics are used in general anesthesia to prevent the muscarinic effect of anticholinesterase, e.g. bradycardia and oral, tracheobronchial, and pharyngeal secretions.

In urogynecological surgery and joint arthroplasties, glycopyrrolate causes bladder hypotonia and increases the frequency of urinary retention by blocking the muscarinic receptors in the detrusor muscle.[57-59]

Especially in older patients, the use of sugammadex seems to have a good correlation with the reduction in the incidence of POUR.[17,60]

In a recent study by Valencia Morales *et al.*,[60] a correlation was demonstrated between the use of sugammadex and the lower incidence of POUR in adult patients undergoing hernioplasty under general anesthesia to whom aminosteroid neuromuscular blockers had been administered. The antagonization of residual neuromuscular block was carried out in 106 patients using neostigmine and glycopyrrolate, and in 75 patients using sugammadex. From the comparison between the two groups, 16 patients with POUR were identified in the neostigmine/glycopyrrolate (n/g) group and only two patients in the sugammadex group, regardless of common risk factors, such as the use of opioids, catheterization, and prostate disease. The onset of POUR forced nine patients, who would have been discharged, to be admitted to the ward for the night, whilst four cases required access to the emergency room. Even if these results require confirmation with larger studies, they lay solid foundations for investigating the role of reversal on the onset of POUR. These data show that most patients were over 65 years old in both groups. Only six out of 16 patients with POUR in the n/g group were under 65 years of age, while in the sugammadex group, the two patients were 69 and 71 years old, respectively.[60]

Scott *et al*.[61] analyzed risk factors for POUR in a cohort of 382 patients undergoing outpatient surgical procedures, finding an association between glycopyrrolate administration, age older than 56 years and increased risk of POUR to multivariable logistic regression. The receiver operating characteristic analysis produced a cut-off of 56 years in this group, though the precise reason why older patients are at greater risk of POUR is not entirely clear, this study, however, was limited by incomplete data, a low number of patients with both POUR and glycopyrrolate administration, and a low incidence of other risk factors. Mason *et al*.[19] also found that elderly patients (more than 60 years old) may have an increased risk of POUR. Keita *et al*.[12] have hypothesized that degradation of the spinal pathways may be responsible.

Even if the sugammadex cost is higher in the first instance, the economic analysis shows greater convenience linked to its faster neuromuscular recovery time. Sugammadex, being devoid of cholinergic activity, should not have effects on the contractility of the detrusor muscle, and this could be the reason why the incidence of POUR is lower in these patients.[62] Further studies on a larger series of cases are needed to confirm that sugammadex can reduce the real incidence of POUR, especially in patients over 65.[16,63–65]

Complications

POUR negatively impacts patients both physically and psychologically.[1]

Among the complications of POUR, the following should be mentioned: The autonomic response and the painful stimulus given by bladder overdistension can cause vomiting, bradycardia, hypotension, hypertension, cardiac dysrhythmias, or even asystole.[32] POUR increases the length of stay in patients undergoing cholecystectomy[13] and increases the time to discharge in 19% of outpatients.[65]

In fact, increased susceptibility to urinary infections may be a direct complication of persistent POUR (resulting from bladder hypotony and the inability to completely empty the bladder) or an indirect consequence of prolonged catheterization.[66] Akhtar *et al*.[67] demonstrated that 21% of women who underwent a single catheterization before a laparoscopic procedure had bacteriuria within 6 days.

Catheterization also increases the risk of bleeding due to the trauma in the urogenital tract.[68]

Bladder overdistension occurs in 44% of cases of POUR and is associated with adverse effects on urodynamics.[10]

Acute urinary retention may lead to bladder tissue damage, impairing renal glomerular, and tubular function.[69]

Based on animal models, bladder ischemia following overdistension may be causing persistent dysfunction, a serious adverse effect impacting the quality of life. Kitada *et al*.[70] showed that a rabbit bladder overdistention longer than 4 hours may lead to a reduction of muscarinic receptors, thus resulting in reduced detrusor contractility.

Table 1: Modifiable and no modifiable factors associated with POUR

Modifiable risk factors	Non-modifiable risk factors
General anesthetics (propofol, isoflurane, opioids)	Sex (men)
Intrathecally/epidural long-acting local anesthetics	Age (over 50)
Intrathecally/epidural opioids	Benign prostatic hyperplasia
Patient-controlled analgesia (PCA)	Lower urinary tract symptoms
Anticholinergic agents	Neurological pathologies (stroke, poliomyelitis, cerebral palsy, multiple sclerosis, spinal lesions, diabetic, and alcoholic neuropathies)
Sympathomimetic agents	Type and duration of surgery
Volume of fluids administered intravenously	
Bladder volume >270 ml	

Prevention

The prevention of POUR currently involves identifying patients with pre-operative risk factors, and then modifying them, where possible, by using fluid restriction strategies and adequate anesthetic techniques. Favoring local infiltration techniques, peripheral nerve blocks and alpha-agonists and avoiding neuraxial epinephrine and hydrophilic opioids (e.g., morphine), intrathecal and epidural long-acting local anesthetic, spinal high doses of local anesthetic and opioids are preferred choices.[1]

In Table 1, both modifiable and non-modifiable risk factors are summarized.

According to Sirisreetreerux *et al.*,[71] early ambulation, acupuncture, opioid antagonist agents, alpha-adrenergic antagonists, and non-steroidal anti-inflammatory drugs (NSAIDs) significantly reduce the incidence of POUR with no difference in adverse events.

Treatment

Treatment of POUR includes pharmacological therapy and catheterization, among the pharmacological strategies, the use of phenoxybenzamine is controversial, while the administration of alpha-antagonists in patients undergoing anorectal surgery with post-operative pain is being examined and appears to be effective in reducing POUR.[27] Bladder catheterization is the standard treatment of POUR, but further studies are necessary to establish patients who need a bladder catheter, bladder volume thresholds and duration of catheterization.[1]

Conclusions

In conclusion, various anesthetic and non-anesthesiologic factors contribute to the development of POUR in surgical patients. Identifying the patient at risk, adopting the appropriate anesthetic techniques and the main perioperative care principles, monitoring the bladder volume with ultrasound are fundamental tools to prevent POUR, and reduce its associated morbidity. Elderly patients are at greater risk for the development of POUR, regardless of the use of a reversal. The use of sugammadex, particularly in the geriatric population, could help to reduce the incidence of this postoperative complication.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

References

1. Baldini G, Bagry H, Aprikian A, Carli F. Postoperative urinary retention: Anesthetic and perioperative considerations. Anesthesiology 2009;110:1139–57.
2. Tammela T, Kontturi M, Lukkarinen O. Postoperative urinary retention. Incidence and predisposing factors. Scand J Urol Nephrol 1986;20:197–201.
3. Johansson RM, Malmvall BE, Andersson-Gäre B, Larsson B, Erlandsson I, Sund-Levander M, *et al.* Guidelines for preventing urinary retention and bladder damage during hospital care. J Clin Nurs 2013;22:347–55.
4. Toyonaga T, Matsushima M, Sogawa N, Jiang FS, Matsumura N, Shimojima Y, *et al.* Postoperative urinary retention after surgery for benign anorectal disease: Potential risk factors and strategy for prevention. Int J Colorectal Dis 2006;21:676–82.
5. Hall JE. Urine formation by the kidneys. In: Guyton AC, Hall JE, editors. Textbook of Medical Physiology. 11th ed. Philadelphia: Saunders Elsevier; 2006. p. 307–14.
6. Kemp D, Tabaka N. Postoperative urinary retention: Part II–A retrospective study. J Post Anesth Nurs 1990 5:397–400.
7. Brouwer TA, Eindhoven BG, Epema AH, Henning RH. Validation of an ultrasound scanner for determing urinary volumes in surgical patients and volunteers. J Clin Monit Comput 1999;15:379–85.
8. Ding YY, Sahadevan S, Pang WS, Choo PW. Clinical utility of a portable ultrasound scanner in the measurement of residual urine volume. Singapore Med J 1996;37:365–8.
9. Pavlin DJ, Pavlin EG, Fitzgibbon DR, Koerschgen ME, Plitt TM. Management of bladder function after outpatient surgery. Anesthesiology 1999;91:42-50.
10. Lamonerie L, Marret E, Deleuze A, Lembert N, Dupont M, Bonnet F. Prevalence of postoperative bladder distension and urinary retention detected by ultrasound measurement. Br J Anaesth 2004;92:544-6.
11. Ceratti RDN, Beghetto MG. Incidence of urinary retention and relations between patient's complaint, physical examination, and bladder ultrasound. Rev Gaucha Enferm 2021;42:e20200014.

12. Keita H, Diouf E, Tubach F, Brouwer T, Dahmani S, Mantz J, *et al.* Predictive factors of early postoperative urinary retention in the postanesthesia care unit. Anesth Analg 2005;101:592–6.
13. Petros JG, Rimm EB, Robillard RJ. Factors influencing urinary tract retention after elective open cholecystectomy. Surg Gynecol Obstet 1992;174:497–500.
14. Lau H, Lam B. Management of postoperative urinary retention: A randomized trial of in-out versus overnight catheterization. ANZ J Surg 2004;74:658-61.
15. Sivasankaran MV, Pham T, Divino CM. Incidence and risk factors for urinary retention following laparoscopic inguinal hernia repair. Am J Surg 2014;207:288–92.
16. Aceto P, Antonelli Incalzi R, Bettelli G, Carron M, Chiumiento F, Corcione A, *et al*. Perioperative Management of Elderly patients (PriME): Recommendations from an Italian intersociety consensus. Aging Clin Exp Res 2020;32:1647-73.
17. Luca E, Schipa C, Cambise C, Sollazzi L, Aceto P. Implication of age-related changes on anesthesia management. Saudi J Anaesth 2023;17:474-81.
18. Schipa C, Luca E, Ripa M, Sollazzi L, Aceto P. Preoperative evaluation of the elderly patient. Saudi J Anaesth 2023;17:482-90.
19. Mason SE, Scott AJ, Mayer E, Purkayastha S. Patient-related risk factors for urinary retention following ambulatory general surgery: A systematic review and meta-analysis. Am J Surg 2016;211:1126-34.
20. Madani AH, Aval HB, Mokhtari G, Nasseh H, Esmaeili S, Shakiba M, *et al*. Effectiveness of tamsulosin in prevention of post-operative urinary retention: A randomized double-blind placebo-controlled study. Int Braz J Urol 2014;40:30-6.
21. Basheer A, Alsaidi M, Schultz L, Chedid M, Abdulhak M, Seyfried D. Preventive effect of tamsulosin on postoperative urinary retention in neurosurgical patients. Surg Neurol Int 2017;8:75.
22. Poylin V, Curran T, Cataldo T, Nagle D. Perioperative use of tamsulosin significantly decreases rates of urinary retention in men undergoing pelvic surgery. Int J Colorectal Dis 2015;30:1223-8.
23. Oishi CS, Williams VJ, Hanson PB, Schneider JE, Colwell CW Jr, Walker RH. Perioperative bladder management after primary total hip arthroplasty. J Arthroplasty 1995;10:732–6.
24. Lingaraj K, Ruben M, Chan YH, De Das S. Identification of risk factors for urinary retention following total knee arthroplasty: A Singapore hospital experience. Singapore Med J 2007;48:213–6.
25. O'Riordan JA, Hopkins PM, Ravenscroft A, Stevens JD. Patient-controlled analgesia and urinary retention following lower limb joint replacement: Prospective audit and logistic regression analysis. Eur J Anaesthesiol 2000;17:431–5.
26. Zaheer S, Reilly WT, Pemberton JH, Ilstrup D. Urinary retention after operations for benign anorectal diseases. Dis Colon Rectum 1998;41:696–704.
27. Cataldo PA, Senagore AJ. Does alpha sympathetic blockade prevent urinary retention following anorectal surgery? Dis Colon Rectum 1991;34:1113–6.
28. Gerstenberg TC, Nielsen ML, Clausen S, Blaabjerg J, Lindenberg J. Bladder function after abdominoperineal resection of the rectum for anorectal cancer. Urodynamic investigation before and after operative in a consecutive series. Ann Surg 1980;191:81–6.
29. Gönüllü NN, Gönüllü M, Utkan NZ, Dülger M, Gökgöz S, Karsli B. Post-operative retention of urine in general surgical patients. Eur J Surg 1993;159:145–7.
30. Pavlin DJ, Pavlin EG, Gunn HC, Taraday JK, Koerschgen ME. Voiding in patients managed with or without ultrasound monitoring of bladder volume after outpatient surgery. Anesth Analg 1999;89:90–7.
31. Mulroy MF, Salinas FV, Larkin KL, Polissar NL. Ambulatory surgery patients may be discharged before voiding after short-acting spinal and epidural anesthesia. Anesthesiology 2002;97:315–9.
32. Kamphuis ET, Ionescu TI, Kuipers PW, de Gier J, van Venrooij GE, Boon TA. Recovery of storage and emptying functions of the urinary bladder after spinal anesthesia with lidocaine and with bupivacaine in men. Anesthesiology 1998;88:310–6.
33. Petros JG, Bradley TM. Factors influencing postoperative urinary retention in patients undergoing surgery for benign anorectal disease. Am J Surg 1990;159:374–6.
34. Durant PA, Yaksh TL. Drug effects on urinary bladder tone during spinal morphine-induced inhibition of the micturition reflex in unanesthetized rats. Anesthesiology 1988;68:325–34.
35. Gentili M, Bonnet F. Spinal clonidine produces less urinary retention than spinal morphine. Br J Anaesth 1996;76:872–3.
36. Hamaya Y, Nishikawa T, Dohi S. Diuretic effect of clonidine during isoflurane, nitrous oxide, and oxygen anesthesia. Anesthesiology 1994;81:811–9.
37. Matsuura S, Downie JW. Effect of anesthetics on reflex micturition in the chronic cannula-implanted rat. Neurourol Urodyn 2000;19:87–99.
38. Javery KB, Ussery TW, Steger HG, Colclough GW. Comparison of morphine and morphine with ketamine for postoperative analgesia. Can J Anaesth 1996;43:212–5.
39. Axelsson K, Möllefors K, Olsson JO, Lingårdh G, Widman B. Bladder function in spinal anaesthesia. Acta Anaesthesiol Scand 1985;29:315–21.
40. Kuipers PW, Kamphuis EdT, van Venrooij GE, van Roy JP, Ionescu TI, Knape JT, *et al.* Intrathecal opioids and lower urinary tract function: A urodynamic evaluation. Anesthesiology 2004;100:1497–503.
41. Dray A, Metsch R. Morphine and the centrally-mediated inhibition of urinary bladder motility in the rat. Brain Res 1984;297:191–5.
42. Herman RM, Wainberg MC, delGiudice PF, Willscher MK. The effect of a low dose of intrathecal morphine on impaired micturition reflexes in human subjects with spinal cord lesions. Anesthesiology 1988;69:313–8.
43. Ben-David B, Solomon E, Levin H, Admoni H, Goldik Z. Intrathecal fentanyl with small-dose dilute bupivacaine: Better anesthesia without prolonging recovery. Anesth Analg 1997;85:560–5.
44. Ben-David B, Maryanovsky M, Gurevitch A, Lucyk C, Solosko D, Frankel R, *et al.* A comparison of minidose lidocaine-fentanyl and conventional-dose lidocaine spinal anesthesia. Anesth Analg 2000;91:865–70.
45. Faas CL, Acosta FJ, Campbell MD, O'Hagan CE, Newton SE, Zagalaniczny K. The effects of spinal anesthesia versus epidural anesthesia on 3 potential postoperative complications: Pain, urinary retention, and mobility following inguinal herniorrhaphy. Aana J 2002;70:441–7.
46. Rawal N, Arnér S, Gustafsson LL, Allvin R. Present state of extradural and intrathecal opioid analgesia in Sweden. A nationwide follow-up survey. Br J Anaesth 1987;59:791–9.
47. Ahuja BR, Strunin L. Respiratory effects of epidural fentanyl. Changes in end-tidal CO2 and respiratory rate following single doses and continuous infusions of epidural fentanyl. Anaesthesia 1985;40:949–55.
48. Torda TA, Pybus DA. Comparison of four narcotic analgesics for extradural analgesia. Br J Anaesth 1982;54:291–5.
49. Finucane BT, Ganapathy S, Carli F, Pridham JN, Ong BY, Shukla RC, *et al*. Prolonged epidural infusions of ropivacaine (2 mg/mL) after colonic surgery: The impact of adding fentanyl. Anesth Analg 2001;92:1276–85.
50. Moore JM, Liu SS, Pollock JE, Neal JM, Knab JH. The effect of epinephrine on small-dose hyperbaric bupivacaine spinal anesthesia: Clinical implications for ambulatory surgery. Anesth Analg 1998;86:973–7.
51. Brown AR, Weiss R, Greenberg C, Flatow EL, Bigliani LU. Interscalene block for shoulder arthroscopy: Comparison with general anesthesia. Arthroscopy 1993;9:295–30.
52. Asantila R, Rosenberg PH, Scheinin B. Comparison of different methods of postoperative analgesia after thoracotomy. Acta Anaesthesiol Scand 1986;30:421–5.
53. Marret E, Bazelly B, Taylor G, Lembert N, Deleuze A, Mazoit JX, *et al*. Paravertebral block with ropivacaine 0.5% versus systemic

analgesia for pain relief after thoracotomy. Ann Thorac Surg 2005;79:2109–13.
54. Sanjay P, Woodward A. Inguinal hernia repair: Local or general anaesthesia? Ann R Coll Surg Engl 2007;89:497–503.
55. Young DV. Comparison of local, spinal, and general anesthesia for inguinal herniorrhaphy. Am J Surg 1987;153:560–3.
56. Paton F, Paulden M, Chambers D, Heirs M, Duffy S, Hunter JM, *et al*. Sugammadex compared with neostigmine/glycopyrrolate for routine reversal of neuromuscular block: A systematic review and economic evaluation. Br J Anaesth 2010;105:558-67.
57. Walter PJ, Dieter AA, Siddiqui NY, Weidner AC, Wu JM. Perioperative anticholinergic medications and risk of catheterization after urogynecologic surgery. Female Pelvic Med Reconstr Surg 2014;20:163-7.
58. Ziemba-Davis M, Nielson M, Kraus K, Duncan N, Nayyar N, Meneghini RM. Identifiable risk factors to minimize postoperative urinary retention in modern outpatient rapid recovery total joint arthroplasty. J Arthroplasty 2019;34 (7S):S343-7.
59. De Lima Laporta Miranda ML, Ochs Kinney MA, Bakkum-Gamez JN, Schroeder DR, Sprung J, Weingarten TN. Sugammadex and urinary retention after hysterectomy: A propensity-matched cohort study. Biomol Biomed 2023. doi: 10.17305/bb. 2023.9569.
60. Valencia Morales DJ, Stewart BR, Heller SF, Sprung J, Schroeder DR, Ghanem OM, *et al*. Urinary retention following inguinal herniorrhaphy: Role of neuromuscular blockade reversal. Surg Laparosc Endosc Percutan Tech 2021;31:613-7.
61. Scott AJ, Mason SE, Langdon AJ, Patel B, Mayer E, Moorthy K, *et al*. Prospective risk factor analysis for the development of post-operative urinary retention following ambulatory general surgery. World J Surg 2018;42:3874-9.
62. Low J, Escobar M, Baquero S, Goldman HS, Rosen G. Glycopyrrolate and post-operative urinary retention: A narrative review. Cureus 2020;12:e11379.
63. Deljou A, Schroeder DR, Ballinger BA, Sprung J, Weingarten TN. Effects of Sugammadex on time of first postoperative bowel movement: A retrospective analysis. Mayo Clin Proc Innov Qual Outcomes 2019;3:294-301.
64. Hunt ME, Yates JR, Vega H, Heidel RE, Buehler JM. Effects on postoperative gastrointestinal motility after neuromuscular blockade reversal with Sugammadex Versus Neostigmine/Glycopyrrolate in colorectal surgery patients. Ann Pharmacother 2020;54:1165-74.
65. Pavlin DJ, Rapp SE, Polissar NL, Malmgren JA, Koerschgen M, Keyes H. Factors affecting discharge time in adult outpatients. Anesth Analg 1998;87:816–26.
66. Martinez OV, Civetta JM, Anderson K, Roger S, Murtha M, Malinin TI. Bacteriuria in the catheterized surgical intensive care patient. Crit Care Med 1986;14:188–91.
67. Akhtar MS, Beere DM, Wright JT, MacRae KD. Is bladder catheterization really necessary before laparoscopy? Br J Obstet Gynaecol 1985;92:1176-8.
68. Igawa Y, Wyndaele JJ, Nishizawa O. Catheterization: Possible complications and their prevention and treatment. Int J Urol 2008;15:481-5.
69. Lai S, Mariotti A, Coppola B, Lai C, Aceto P, Dimko M, *et al*. Uricemia and homocysteinemia: Nontraditional risk factors in the early stages of chronic kidney disease--preliminary data. Eur Rev Med Pharmacol Sci 2014;18:1010-7.
70. Kitada S, Wein AJ, Kato K, Levin RM. Effect of acute complete obstruction on the rabbit urinary bladder. J Urol 1989;141:166–9.
71. Sirisreetreerux P, Wattanayingcharoenchai R, Rattanasiri S, Pattanaprateep O, Numthavaj P, Thakkinstian A. Medical and non-medical interventions for post-operative urinary retention prevention: Network meta-analysis and risk-benefit analysis. Ther Adv Urol 2021;13:17562872211022296.