Hernia (2018) 22:871–879
https://doi.org/10.1007/s10029-018-1792-2

ORIGINAL ARTICLE

Paravertebral blocks reduce the risk of postoperative urinary retention in inguinal hernia repair

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Received: 17 April 2018 / Accepted: 9 June 2018 / Published online: 16 June 2018

Abstract
Purpose Inguinal hernia repair and general anesthesia (GA) are known risk factors for urinary retention. Paravertebral blocks (PVBs) have been utilized to facilitate enhanced recovery after surgery. We evaluate the benefit of incorporating PVBs into our anesthetic technique in a large cohort of ambulatory patients undergoing inguinal hernia repair.
Methods Records of 619 adults scheduled for ambulatory inguinal hernia repair between 2010 and 2015 were reviewed and categorized based on anesthetic and surgical approach [GA and open (GAO), GA and laparoscopic (GAL), PVB and open (PVBO), and GA/PVB and open (GA/PVBO)]. Patients were excluded for missing data, self-catheterization, chronic opioid tolerance, and additional surgical procedures coinciding with hernia repair. Risk factors associated with the primary outcome of urinary retention were examined using logistic regression.
Results PVBO ($n = 136$) had significantly lower odds than GAO of experiencing urinary retention (odds ratio 0.16; 95% CI 0.05–0.51); overall ($P < .01$), with 4.4% ($n = 6$) of the patients in the PVBO group having urinary retention versus 22.6% ($n = 7$) with GAO. Expressed as intravenous morphine equivalences, the PVBO group had the lowest median opioid use (5 mg), followed by GA, PVB, and open (7.5 mg); GAO 25 mg; and GAL 25 mg. Also, 30% ($n = 41$) of the PVBO group required no opioid analgesia in the postanesthesia care unit.
Conclusions PVBs as the primary anesthetic or an adjunct to GA is the preferred anesthetic technique for open inguinal hernia repair as it facilitates enhanced recovery after surgery by decreasing risk of urinary retention, opioid requirements, and length of stay.

Keywords Decreased length of stay · Inguinal hernia repair · Paravertebral blocks · Postoperative urinary retention · Regional anesthesia

Introduction

General anesthesia (GA) and inguinal hernia repair (IHR) are known risk factors for postoperative urinary retention and prolonged hospital stay [1]. Different anesthetic techniques, including local infiltration, peripheral nerve block, neuroaxial anesthesia, and GA, have been used, but optimal

Presented at the International Anesthesia Research Society (IARS) 2016 in San Francisco, California, and the Florida Society of Anesthesia (FSA) 2017 in West Palm Beach, Florida.

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anesthetic management of patients undergoing IHR remains controversial [1, 2]. To facilitate enhanced recovery after surgery, regional anesthetic techniques, such as paravertebral block (PVB), can be essential tools in reducing perioperative opioid use and opioid-related adverse events, like urinary retention [3, 4]. Furthermore, as this surgical population is at risk of urinary retention postsurgery, avoiding a neuroaxial anesthetic technique, while minimizing opioid use intraoperatively, would be ideal. We hypothesized the use of PVBs as an alternative or adjunct to GA during IHR would reduce opioid requirements and risk of urinary retention.

Methods

After the Mayo Clinic Institutional Review Board accepted the proposal on 24 November 2015, the study was conducted as an historical cohort study by reviewing the charts of all adults undergoing elective IHRs between 1 January 2010, and 1 June 2015. A total of 619 patient charts were identified and reviewed; 26 patients were excluded due to missing data (7), chronic urinary retention requiring self-catheterization (2), chronic opioid tolerance (8), and additional surgical procedures coinciding with the hernia repair (9).

Data collected included patient age, sex, history of benign prostatic hyperplasia (BPH), redo inguinal hernia, placement of an intraoperative urinary catheter, unilateral versus bilateral hernia repair, laparoscopic versus open surgical approach, operation time, intraoperative intravenous (IV) fluids (ml), type of anesthesia (GA, PVB with IV sedation, and combined GA and PVB), time to urinate postoperatively (mins), urinary retention, length of hospital stay in hours, and opioid use.

All PVBs were performed in the preoperative holding area using standard American Society of Anesthesiologists monitoring. Using anatomic landmark technique [5], levels T11, T12, and L1 were individually blocked using 5 ml of 0.5% ropivacaine per level. All blocks were checked for surgical anesthesia in the appropriate dermatomes and repeated if necessary prior to the surgery.

Standard GA consisted of propofol induction, rocuronium or succinylcholine for intubation, and rocuronium or vecuronium for abdominal relaxation. Maintenance anesthesia consisted of isoflurane, sevoflurane, or propofol. All neuromuscular blockers were reversed using neostigmine and glycopyrrolate. For patients undergoing open IHR with PVB as the primary anesthetic, monitored anesthesia care was provided with propofol. The predominant technique for open IHR was Lichtenstein approach for tension-free hernia repair with polypropylene mesh, using Cooper ligament fixation selectively [6]. The predominant technique for laparoscopic IHR was total extraperitoneal repair with polypropylene or polyester mesh and tack fixation of mesh.

For the purpose of this study, urinary retention was defined as the patient's inability to void with a bladder scan of greater than 600 ml, thus requiring an in and out catheterization. All patients had to spontaneously void prior to discharge. Opioid requirements were converted to equianalgesic parenteral morphine based on the Mayo Clinic Florida Narcotic Equianalgesic Dosage Charts (Appendix).

Statistical analysis

Data were descriptively summarized using frequencies and percentages for categorical variables and medians and quartile ranges for continuous variables. We compared distributions across four combinations of anesthetic and surgical approach [GA and open (GAO), GA and laparoscopic (GAL), PVB and open (PVBO), and GA/PVB and open (GA/PVBO)] using Chi-square and Fisher's exact tests (where appropriate) for categorical variables and Kruskal–Wallis test for continuous variables. Risk factor associations with the primary outcome of urinary retention were examined using logistic regression. A univariate model was fit for each variable listed previously. All variables statistically significant in univariate models were included in one final multivariable model. Variables distributed differently by the four categories of anesthetic and surgical approach were also included in the multivariable modeling. Risk factors associated with minutes to first void and hours to discharge were analyzed using linear regression with similar methods. All analyses were performed using SAS version 9.4 (SAS Institute Inc., Cary, NC), and all tests were two-sided. $P < .05$ was determined to be significant.

Results

Of the 593 patients meeting inclusion criteria, 31 (5.2%) received GAO, 386 (65.1%) GAL, 136 (22.9%) PVBO, and 40 (6.7%) GA/PVBO. Patients receiving GAO, PVBO, or GA/PVBO tended to be older (median age 72–73.5 years) than patients with GAL (median age 64; $P < .01$; Table 1). Similarly, 64 (47.1%) PVBO patients and 19 (47.5%) GA/PVBO patients were of advanced age (age > 75 years) versus 8 (25.8%) GAO and 61 (15.8%) GAL patients ($P < .01$). Additionally, the PVBO group was less likely to have intraoperative urinary catheter placement with 4 out of 82 (2.9%) cases, compared to ~15% for the other groups ($P < .01$). Bilateral hernia repairs were significantly more common in GAL (29.8%) than the other three groups (<3%; $P < .01$). There was no significant difference between the four groups in sex, history of BPH, and redo IHR.

Significant differences in preoperative courses were noted, with PVBO having the lowest median of intraoperative IV fluids and opioid requirements (Table 1). To evaluate

Table 1 Demographic and perioperative outcomes by anesthetic and surgical approach

Characteristic[a]	GA, open $n=31$	GA, laparoscopic $n=386$	PVB and IV sedation, open $n=136$	PVB and GA, open $n=40$	P value
Demographic characteristics					
Age at surgery, year (Q1, Q3)	72 (61, 76)	64 (54, 72)	73.5 (64.5, 82.0)	73.5 (68.5, 77.0)	<.01[b]
Age at surgery					<.01[c]
<55	5 (16.1)	105 (27.2)	14 (10.3)	4 (10.0)	
55–64	6 (19.4)	98 (25.4)	20 (14.7)	2 (5.0)	
65–74	12 (38.7)	122 (31.6)	38 (27.9)	15 (37.5)	
75+	8 (25.8)	61 (15.8)	64 (47.1)	19 (47.5)	
Male	29 (93.5)	354 (91.7)	122 (89.7)	36 (90.0)	.84[d]
BPH	4 (12.9)	36 (9.3)	19 (14.0)	4 (10.0)	.43[d]
Bilateral hernia	0 (0.0)	115 (29.8)	3 (2.2)	0 (0.0)	<.01[d]
Intraoperative urinary catheter	5 (16.1)	67 (17.4)	4 (2.9)	6 (15.0)	<.01[d]
Redo inguinal hernia	4 (12.9)	42 (10.9)	10 (7.4)	6 (15.0)	.41[d]
Perioperative characteristics					
Operation time, min (Q1, Q3)	68 (46, 92)	61 (43, 79)	67 (58, 80)	68.5 (54.5, 81.0)	<.01[b]
Intraoperative IV fluid, cc (Q1, Q3)	1000 (750, 1400)	1050 (875, 1300)	800.0 (600.0, 1002.5)	1000 (600, 1250)	<.01[b]
Morphine equivalent opioid use, mg (Q1, Q3)	25.0 (19.2, 30.0)	25.0 (20.0, 31.7)	5 (0, 10)	10.0 (2.9, 18.8)	<.01[b]
Morphine equivalent opioid use					<.01[c]
None	0 (0.0)	1 (0.3)	41 (30.1)	8 (20.0)	
<10 mg	0 (0.0)	9 (2.3)	53 (39.0)	10 (25.0)	
10–20 mg	8 (25.8)	67 (17.4)	34 (25.0)	13 (32.5)	
20–30 mg	14 (45.2)	190 (49.2)	6 (4.4)	6 (15.0)	
>30 mg	9 (29.0)	119 (30.8)	2 (1.5)	3 (7.5)	

BPH benign prostatic hyperplasia, *GA* general anesthesia, *IV* intravenous, *PVB* paravertebral block, *Q1* first quartile, *Q3* third quartile

[a]Numbers represent no. (%) unless otherwise noted

[b]Kruskal–Wallis

[c]Chi-square

[d]Fisher's exact

opioid requirements in this surgical population, a subgroup analysis for opioid use in the operating room versus recovery room was performed. Expressed as IV morphine equivalences, PVBO had the lowest median opioid use (5 mg), followed by GA/PVBO (10 mg), GAO (25 mg), and GAL (25 mg) ($P<.01$; Fig. 1). Additionally, 30.1% of the PVBO group required no opioid analgesia in the post anesthesia care unit, compared to 20.0% GA/PVBO and <1% for GAO and GAL ($P<.01$; Table 1). However, via multivariable analysis, opioid requirements were not significantly associated with urinary retention, time to first void, or hospital stay.

In univariate comparisons, PVBO patients had significantly lower odds of experiencing urinary retention compared to patients receiving GAO [odds ratio (OR), 0.16; 95% CI 0.05–0.51; overall $P<.01$], with 4.4% of the patients in the PVBO group having urinary retention versus 22.6% with GAO (Table 2). The association remained significant after multivariable adjustment (OR, 0.11; 95% CI, 0.03–0.42; overall $P=.02$). Other risk factors significantly associated after multivariable adjustment included bilateral hernias (ref = unilateral; OR 2.35; 95% CI 1.28–4.32; $P<.01$) and redo inguinal hernias (ref = no; OR 2.91; 95% CI 1.53–5.56; $P<.01$). Opioid use, operation time, and intraoperative IV fluid were significant in univariate comparisons ($P=.04$, $P<.01$, and $P=.03$, respectively), but not after multivariable adjustment. Urinary retention developed in 17 out of the 82 (20.7%) patients with intraoperative urinary catheter placement and 66 out of 511 (12.9%) without a catheter, but this difference was not significant in univariate analysis ($P=.06$) or multivariable analysis ($P=.59$).

Box plots of minutes to first void and hours to discharge are presented in Figs. 2 and 3. When compared to GAO patients, the mean time to first void was significantly shorter in multivariable comparisons among GAL, PVBO, and GA/PVBO by a reduction in time of 79.9, 153.5, and 131.9 min, respectively (overall $P<.01$; Table 3). Longer operation time and larger intraoperative IV fluid volume were significantly

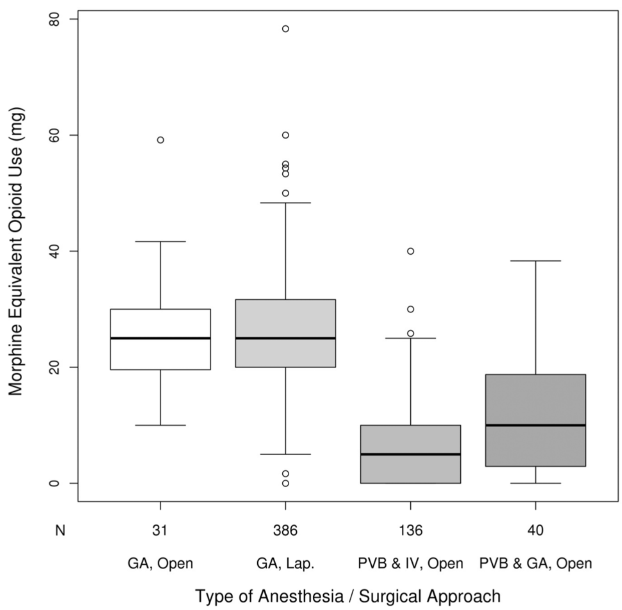

Fig. 1 Boxplot of morphine equivalent opioid use by anesthetic and surgical approach. *GA* general anesthesia, *IV* intravenous, *Lap*. laparoscopic, *PVB* paravertebral block

associated with longer minutes to first void. In multivariable comparison to GAO patients, mean hours to discharge was significantly shortened among GAL, PVBO, and GA/PVBO by 4.4, 4.8, and 1.6 h, respectively (overall $P<.01$; Table 4). Variables significantly associated with increased hours to discharge after multivariable adjustment included longer operation time, intraoperative urinary catheter, age > 75 years (ref < 55; $P<.01$), and increased intraoperative IV fluid. To determine if outliers had any impact, sensitivity analyses of minutes to first void and hours to discharge were repeated on log-transformed variables of the outcome. The associations between anesthetic/surgical approach, minutes to first void and hours to discharge remained significant in univariate ($P<.01$), and multivariable comparisons ($P<.01$) (data not shown).

Discussion

Postoperative urinary retention is a common complication after IHR, delaying discharge and frequently requiring bladder catheterization, which increases the risk for urinary tract infections. The incidence of urinary retention is dependent on the patient population, comorbidities, and choice of anesthetic and surgical approach. In patients undergoing hernia repair, the incidence has been estimated to range from 6 to 38%, and this wide range likely reflects the multitude of variables predisposing a patient to development of urinary retention [7].

In a systematic review and meta-analysis by Law et al. [1] included 14 prospective randomized clinical trials, which include the advantages of performing PVBs for IHR by reducing postoperative pain and opioid analgesic requirements. PVBs have also been associated with a decreased incidence of urinary retention when compared to spinal anesthesia and a superior analgesic profile when compared to other peripheral regional techniques, such as the transverse abdominis plane block and ilioinguinal and iliohypogastric nerve block [8–10]. As described by Hadzic et al. [4], PVBs have also been used to facilitate enhanced recovery after surgery for IHR by facilitating *time-to-home readiness*, decreased postoperative nausea and emesis, and early discharge time.

In our surgical population, urinary retention ranged from 4.4 to 22.6% among the four anesthetic and surgical techniques, with PVBO having the least and GAO having the most. We found the same to be true when looking at time to first void and discharge time. Although to a lesser extent, preoperative PVB in combination with GA was still beneficial in terms of reducing urinary retention, time to first void, and discharge time. Our initial interpretation was a decrease in urinary retention and early recovery in patients receiving PVBs were primarily due to improved analgesia and reduced opioid use. Whether opioids are administered systemically or via a neuraxial approach, they result in a dose-dependent decrease in the sensation of urgency, inhibit urethral sphincter relaxation, and decrease contraction of the detrusor muscles [11, 12]. Based on our data, IHR under GA for both open and laparoscopic approaches had a 2–3 times higher opioid requirement when compared to the combined PVB and GA technique and 5 times higher when compared to PVB with sedation. Furthermore, approximately 30% of patients undergoing IHR under PVBO required no opioid analgesics in the intra- and postoperative periods. Yet, opioid use was not found to be an independent factor affecting the risk of urinary retention.

With the routine use of non-opioid multimodal analgesic, one potential interpretation would be the total dose of opioids required is insufficient to cause urinary retention directly related to opioid use, regardless of the anesthetic and surgical approach. Additionally, opioid doses were converted to equianalgesic morphine doses for the purpose of statistical analysis. Different opioids vary in their urodynamic characteristics [11] and this difference may be lost when converted to equianalgesic morphine doses. Furthermore, exposure to GA may increase the effects of opioid administration, since it poses a risk for urinary retention by interfering with autonomic nervous system function and decreased detrusor contraction [13].

Although not utilized in our study, other strategies to avoid exposure to GA for IHR include spinal or local anesthesia [2]. However, spinal anesthesia is also associated with

Table 2 Univariate and multivariable associations with urinary retention using logistic regression

Characteristic	No event N (row %)	Urinary retention N (row %)	Univariate		Multivariate	
			Odds ratio (95% CI)	*P* value	Odds ratio (95% CI)	*P* value[a]
Anesthetic/surgical approach, no. (%)				< .01		.02
GA, open	24 (77.4)	7 (22.6)	1.00 (ref)		1.00 (ref)	
GA, laparoscopic	321 (83.2)	65 (16.8)	0.69 (0.29, 1.68)		0.56 (0.22, 1.44)	
PVB and IV sedation, open	130 (95.6)	6 (4.4)	0.16 (0.05, 0.51)		0.11 (0.03, 0.43)	
PVB and GA, open	35 (87.5)	5 (12.5)	0.49 (0.14, 1.73)		0.35 (0.09, 1.37)	
Morphine equivalent opioid use, mg	Mean (SD)	Mean (SD)		.04		.20
Ordinal effect (per 1 unit)[b,c]	20.2 (12.7)	23.0 (9.8)	1.25 (1.02, 1.54)		0.82 (0.61, 1.11)	
Operation time, min	Mean (SD)	Mean (SD)		.01		.20
Ordinal effect (per 15 min)[b]	65.3 (26.1)	75.5 (29.9)	1.21 (1.07, 1.36)		1.10 (0.95, 1.28)	
Bilateral hernia, no. (%)				< .01		< .01
No	424 (89.3)	51 (10.7)	1.00 (ref)		1.00 (ref)	
Yes	86 (72.9)	32 (27.1)	3.09 (1.88, 5.10)		2.35 (1.28, 4.32)	
Intraoperative urinary catheter, no. (%)				.06		.59
No	445 (87.1)	66 (12.9)	1.00 (ref)		1.00 (ref)	
Yes	65 (79.3)	17 (20.7)	1.76 (0.97, 3.19)		1.21 (0.60, 2.45)	
Age at surgery, no. (%)				.40		.41
< 55	114 (89.1)	14 (10.9)	1.00 (ref)		1.00 (ref)	
55–64	106 (84.1)	20 (15.9)	1.54 (0.74, 3.19)		1.42 (0.66, 3.06)	
65–74	156 (83.4)	31 (16.6)	1.62 (0.82, 3.18)		1.74 (0.86, 3.52)	
75+	134 (88.2)	18 (11.8)	1.09 (0.52, 2.30)		1.52 (0.69, 3.36)	
Intraoperative IV fluid, cc	Mean (SD)	Mean (SD)		.03		.82
Ordinal effect (per 100 cc)[b]	1023 (418)	1136 (462)	1.06 (1.01, 1.11)		1.01 (0.95, 1.07)	
Redo inguinal hernia, no. (%)				< .01		.01
No	467 (87.9)	64 (12.1)	1.00 (ref)		1.00 (ref)	
Yes	43 (69.4)	19 (30.6)	3.22 (1.77, 5.87)		2.91 (1.53, 5.56)	
BPH, no. (%)				.11		
No	460 (86.8)	70 (13.2)	1.00 (ref)			
Yes	50 (79.4)	13 (20.6)	1.71 (0.88, 3.31)			
Sex, no. (%)				.18		
Female	48 (92.3)	4 (7.7)	1.00 (ref)			
Male	462 (85.4)	79 (14.6)	2.05 (0.72, 5.85)			

Numbers indicate N (row %) for categorical variables and mean (SD) for continuous variables

BPH benign prostatic hyperplasia, *GA* general anesthesia, *IV* intravenous, *PVB* paravertebral block, *ref* reference

[a]Only covariates significant in univariate comparisons or Table 1 were included in the multivariate model

[b]Odds ratios in the rows labeled Ordinal Effect can be interpreted as the change in odds per specified unit increase. Specifically, the univariate odds ratio of 1.21 would be if you compared two patients with a 15-min difference (e.g., 60 vs. 45 min), and the 1.06 univariate odds ratio for intraoperative fluid is if you were to compare two patients with a 100 cc difference (e.g., 1100 cc vs. 1000 cc)

[c]Morphine was modeled ordinally using the categories from Table 1. The univariate odds ratio of 1.25 is if you were to compare two patients different separated by only one of the following categories (e.g., <10 mg vs. none): none, < 10, 10–20, 20–30, and > 30 mg

postoperative urinary retention, where the sensation of a distended bladder can be blocked for several hours depending on the local anesthetics used [14, 15]. Furthermore, return of normal strength to the detrusor muscles occurs as the effects of spinal anesthesia regress to the sacral nerve roots (S2-S4), and full strength of the detrusor muscles might be delayed up to 3.5 h after a patient ambulates [15]. These effects are further potentiated if intrathecal opioids are used via the mechanism described above. Local anesthetic infiltration technique has been successfully described for same-day IHR. This approach has several advantages as it decreases anesthetic exposure, analgesic requirements, opioid-related adverse events, and urinary retention [2, 16]. However, an inguinal procedure under local anesthetic infiltration has certain limitations. The degree of anesthesia can be insufficient or highly variable, increasing patient discomfort and

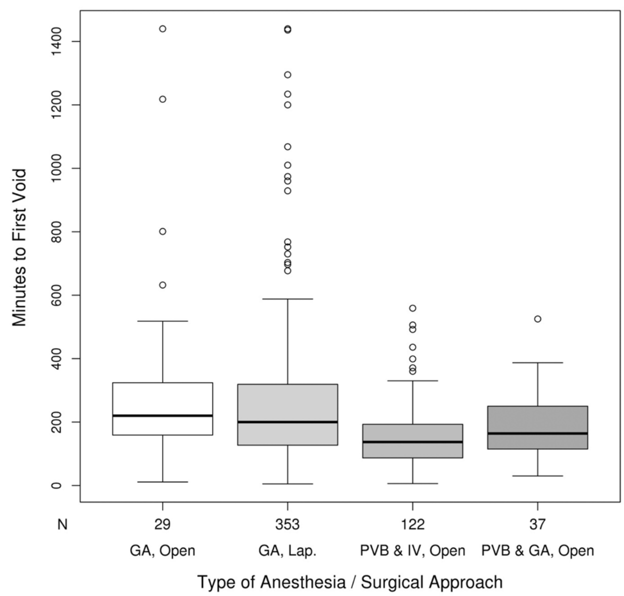

Fig. 2 Boxplot of minutes to first void by anesthetic and surgical approach. *GA* general anesthesia, *IV* intravenous, *Lap*. laparoscopic, *PVB* paravertebral block

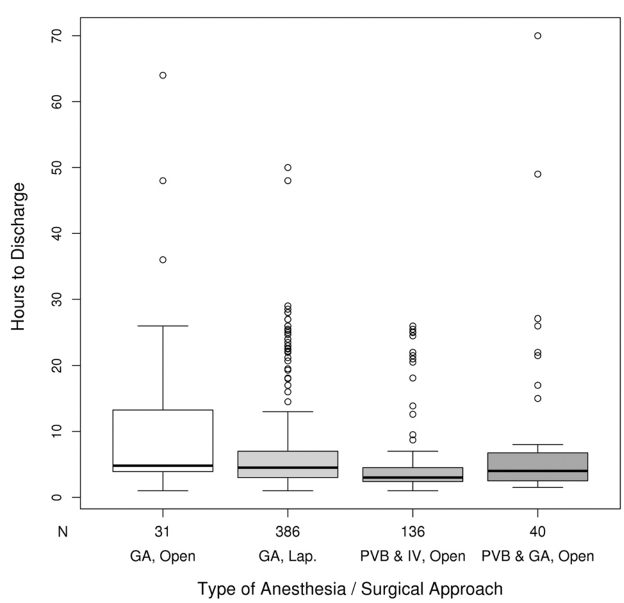

Fig. 3 Boxplot of hours to discharge by anesthetic and surgical approach. *GA* general anesthesia, *IV* intravenous, *Lap*. laparoscopic, *PVB* paravertebral block

dissatisfaction [17]. There is a risk of local anesthetic toxicity, if large doses of local anesthetic are used (i.e., obese patient). For these reasons, local anesthesia for IHR is primarily described in relatively healthy patients with normal body habitus [2] and is currently utilized sparingly by surgeons [16].

It is important to consider surgical approach, since it directly correlates with anesthetic required and physiologic stress response. The purpose of this paper is not to discuss the difference between laparoscopic and open IHR; however, there are certain anesthetic considerations. Laparoscopic approach requires GA for peritoneal insulation. In our study, we found patients undergoing a laparoscopic IHR under GA had a lower risk of urinary retention and time to void, but with equivocal opioid requirements when compared to the open technique. Conversely, open repair under PVB and sedation was superior to the laparoscopic approach in terms of postoperative analgesia, risk of urinary retention, and time to discharge. Our data are restricted to the immediate postoperative phase and long-term outcomes may differ with the laparoscopic approach as it may allow patients to more quickly return to normal activity with less persistent pain [18]. Future studies could evaluate the effect on postoperative urinary retention using combined PVB and GA techniques for laparoscopic hernia repair.

Other factors beyond anesthetic and surgical approach were considered as potential confounders in analyzing our data. Historically, the patient's age and sex have been associated with an increased risk of urinary retention, likely due to age-related dysfunction of the nervous system in relation to micturition and sex-specific comorbidities, such as BPH [19, 20]. Our results were surprising as neither age, sex, nor history of BPH were found to be associated with an increased risk of urinary retention or prolonged time to void. A possible explanation would be the definition of BPH used in the review, which included patients with a documented history of medically managed BPH. Whether symptoms of BPH were well controlled by the patients' current therapy was not evaluated. Notably, an age greater than 75 years demonstrated an independent variable predictive of a longer hospital length of stay. This is most likely due to other age-related commodities as our data did not show an increased risk of urinary retention with age. Since this is a historical review, unaccounted confounders may still be present, including, but not limited to a history of diabetes mellitus, history of a cerebral vascular accident, and multiple sclerosis, which are all associated with urinary retention [19].

Duration of surgery and IV fluids has also been described as predictors of urinary retention [19]. Our data demonstrated that operation time was a risk for urinary retention (nonindependent variable), and redo and bilateral hernia repair were each independently associated with an increased risk of urinary retention and prolonged time to void. Extrapolation supports the likelihood that increased surgical complexity contributes to urinary retention in addition to procedure duration, since the length of an intervention alone does not necessarily lead to urinary retention [21]. Similarly, larger volumes of IV fluids may potentially distend the bladder and result in detrusor muscle dysfunction [22].

Table 3 Univariate and multivariable associations with minutes to first void using linear regression

Characteristic	Total $N=541$	Minutes to first void mean (SD)	Univariate		Multivariate	
			Mean (95% CI)	*P* value	Mean (95% CI)	*P* value[a]
Anesthetic/surgical approach, no. (%)				< .01		< .01
GA, open	29	327.8 (326.2)	0.00 (ref)		0.00 (ref)	
GA, laparoscopic	353	250.2 (210.3)	− 77.6 (− 150.9, − 4.3)		− 79.9 (− 153.0, − 6.9)	
PVB and IV sedation, open	122	156.9 (103.2)	− 170.9 (− 249.4, − 92.5)		− 153.5 (− 238.5, − 68.4)	
PVB and GA, open	37	184.2 (112.3)	− 143.6 (− 237.7, − 49.5)		− 131.9 (− 226.9, − 36.9)	
Morphine equivalent opioid use, mg				< .01		.83
Ordinal effect (per 1 unit)[b,c]	541	228.8 (199.3)	28.8 (15.0, 42.7)		− 2.1 (− 21.3, 17.1)	
Operation time, min				< .01		< .01
Ordinal effect (per 15 min)[b]	541	228.8 (199.3)	21.1 (12.2, 30.1)		14.6 (4.3, 24.9)	
Bilateral hernia, no. (%)				< .01		.16
No	433	211.8 (177.6)	0.00 (ref)		0.00 (ref)	
Yes	108	296.8 (259.4)	85.0 (43.6, 126.3)		33.0 (− 12.8, 78.9)	
Intraoperative urinary catheter, no. (%)				< .01		.20
No	462	216.4 (177.0)	0.00 (ref)		0.00 (ref)	
Yes	79	301.4 (288.9)	85.0 (38.0, 132.0)		32.0 (− 17.2, 81.3)	
Age at surgery, no. (%)				.18		.76
< 55	116	225.2 (145.3)	0.00 (ref)		0.00 (ref)	
55–64	118	254.6 (230.2)	29.4 (− 21.4, 80.2)		24.6 (− 23.4, 72.7)	
65–74	171	235.6 (218.0)	10.3 (− 36.4, 57.1)		16.0 (− 28.5, 60.5)	
75+	136	200.9 (183.3)	− 24.4 (− 73.4, 24.7)		7.5 (− 41.7, 56.7)	
Intraoperative IV fluid, cc				< .01		.01
Ordinal effect (per 100 cc)[b]	541	228.8 (199.3)	10.6 (6.7, 14.4)		5.4 (1.2, 9.5)	
Redo inguinal hernia, no. (%)				.46		
No	484	226.6 (194.3)	0.00 (ref)			
Yes	57	247.3 (238.4)	20.7 (− 33.9, 75.3)			
BPH, no. (%)				.23		
No	486	232.2 (206.5)	0.00 (ref)			
Yes	55	198.2 (114.7)	− 34.1 (− 89.5, 21.4)			
Sex, no. (%)				.97		
Female	48	229.7 (248.4)	0.00 (ref)			
Male	493	228.7 (194.1)	− 1.0 (− 60.0, 57.9)			

BPH benign prostatic hyperplasia, *GA* general anesthesia, *IV* intravenous, *PVB* paravertebral block, *ref* reference

[a]Only covariates significant in univariate comparisons or Table 1 were included in the multivariable model

[b]The mean estimate in the rows labeled Ordinal Effect can be interpreted as the change in mean per specified unit increase. Specifically, the univariate mean estimate of 21.1 for operation time is per 15 min comparison (e.g., 60 min compared to 45 min), and the 10.6 univariate mean estimate for intraoperative fluid is if you were to compare two patients different by 100 cc (e.g., 1100 vs. 1000 cc).

[c]Morphine was modeled ordinally using the categories from Table 1. The univariate mean estimate of 28.8 is if you were to compare two patients different separated by only one of the following categories (e.g., <10 mg vs. none)

Large volumes of IV fluids were an independent variable in prolonging time to void and discharge from our hospital.

In summary, our historical review supports the use of PVBs, where feasible, to reduce incidence of postoperative urinary retention in patients having IHR. This beneficial effect adds to the literature supporting use of PVBs to decrease other morbidities, such as pain, nausea, and vomiting [4, 23]. Additional studies are necessary to determine whether use of PVB with GA may impact incidence of postoperative urinary retention in patients having laparoscopic hernia repair.

Author contributions EB: research design, data collection, analysis and interpretation of data, drafting of the manuscript, and corresponding author. JZL: research design, data collection, analysis and interpretation of data, and drafting of the manuscript. SB: research design, analysis and interpretation of data, and editing of the manuscript.

Table 4 Univariate and multivariable associations with hours to discharge using linear regression

Characteristic	Total *N* = 593	Hours to discharge mean (SD)	Univariate		Multivariable	
			Mean (95% CI)	*P* value	Mean (95% CI)	*P* value[a]
Anesthetic/surgical approach, no. (%)				< .01		.01
GA, open	31	11.7 (14.7)	0.00 (ref)		0.00 (ref)	
GA, laparoscopic	386	6.9 (7.0)	−4.8 (−7.7, −1.9)		−4.4 (−7.1, −1.7)	
PVB and IV sedation, open	136	5.1 (5.8)	−6.6 (−9.7, −3.5)		−4.8 (−7.9, −1.6)	
PVB and GA, open	40	9.2 (13.7)	−2.5 (−6.2, 1.2)		−1.6 (−5.2, 1.9)	
Morphine equivalent opioid use, mg				< .01		.08
Ordinal effect (per 1 unit)[b,c]	593	6.9 (8.1)	0.9 (0.4, 1.4)		0.6 (−0.1, 1.3)	
Operation time, min				< .01		< .01
Ordinal effect (per 15 min)[b]	593	6.9 (8.1)	1.5 (1.1, 1.8)		1.0 (0.6, 1.4)	
Bilateral hernia, no. (%)				< .01		.19
No	475	6.4 (7.7)	0.00 (ref)		0.00 (ref)	
Yes	118	9.1 (9.2)	2.7 (1.1, 4.3)		1.1 (−0.6, 2.8)	
Intraoperative urinary catheter, no. (%)				< .01		< .01
No	511	6.1 (6.7)	0.00 (ref)		0.00 (ref)	
Yes	82	11.8 (12.9)	5.7 (3.9, 7.5)		2.6 (0.8, 4.5)	
Age at surgery, no. (%)				.02		.01
< 55	128	5.7 (4.7)	0.00 (ref)		0.00 (ref)	
55–64	126	7.2 (7.8)	1.5 (−0.5, 3.5)		1.3 (−0.5, 3.0)	
65–74	187	6.3 (6.8)	0.6 (−1.2, 2.4)		0.5 (−1.1, 2.1)	
75+	152	8.5 (11.2)	2.7 (0.9, 4.6)		3.3 (1.5, 5.1)	
Intraoperative IV fluid, cc				< .01		< .01
Ordinal effect (per 100 cc)[b]	593	6.9 (8.1)	0.5 (0.3, 0.6)		0.2 (0.1, 0.4)	
Redo inguinal hernia, no. (%)				< .01		.07
No	531	6.6 (7.8)	0.00 (ref)		0.00 (ref)	
Yes	62	9.6 (9.4)	3.0 (0.9, 5.1)		1.8 (−0.1, 3.7)	
BPH, no. (%)				.78		
No	530	6.9 (8.1)	0.00 (ref)			
Yes	63	7.2 (8.2)	0.3 (−1.8, 2.4)			
Sex, no. (%)				.16		
Female	52	5.4 (5.8)	0.00 (ref)			
Male	541	7.1 (8.2)	1.6 (−0.6, 3.9)			

BPH benign prostatic hyperplasia, *GA* general anesthesia, *IV* intravenous, *PVB* paravertebral block, *ref* reference

[a]Only covariates significant in univariate comparisons or Table 1 were included in the multivariable model

[b]The mean estimate in the rows labeled Ordinal Effect can be interpreted as the change in mean per specified unit increase. Specifically, the univariate mean estimate of 1.5 for operation time is per 15 min comparison (e.g., 60 min compared to 45 min), and the 0.5 univariate mean estimate for intraoperative fluid is if you were to compare two patients different by 100 cc (e.g., 1100 vs. 1000 cc)

[c]Morphine was modeled ordinally using the categories from Table 1. The univariate mean estimate of 0.9 is if you were to compare two patients different separated by only one of the following categories (e.g., <10 mg vs. none)

RDF: statistical analysis, interpretation of data, generation of figures and tables, and editing of the manuscript. SP: data collection, analysis and interpretation of data, and editing of the manuscript. AR: research design, data collection, and editing of the manuscript. SP: data collection, and editing of the manuscript. RAG: research design, drafting and editing of the manuscript.

Funding Mayo Clinic Comprehensive Research Team.

Compliance with ethical standards

Conflict of interest EB declares no conflict of interest. JL declares no conflict of interest. SB declares no conflict of interest. RDF declares no conflict of interest. SHP declares no conflict of interest. AR declares no conflict of interest. SP declares no conflict of interest. RAG declares no conflict of interest.

Ethical approval Ethical approval was obtained from institutional review board (no. 15-008258).

Human and animal rights This article does not contain any studies with human participants and animals performed by any of the authors.

Informed consent For this retrospective review, formal consent is not required.

Appendix

Mayo Clinic Florida

Narcotic Equianalgesic dosage charts

The following is provided only as a guide

Equianalgesic dosage (mg)		
Medication	Parental (mg)	Oral (mg)
Morphine	10	30
Hydromorphone	1.5	7.5
Oxycodone	NA	20
Fentanyl	0.1	NA
Codeine	100–120	200
Hydrocodone	NA	30
Tramadol	NA	120
Meperidine[a]	75–100	300 (not recommended)
Oxymorphone[b]	1	10

Conversion based off morphine 10 mg IV and 30 mg PO, 0% cross tolerance assumed in these calculation

[a]Meperidine (demerol) is non-formulary, restricted (please review policy for details)

[b]Oxymorphone (opana) oral tablets are non-formulary

http://intranet.mayo.edu/charlie/nursing-neurosciences-fla/files/2016/08/Narcotic-Analgesic-Comparison-Chart.pdf.

References

1. Law LS, Tan M, Bai Y, Miller TE, Li YJ, Gan TJ (2015) Paravertebral block for inguinal herniorrhaphy: a systematic review and meta-analysis of randomized controlled trials. Anesth Analg 121:556–569
2. Ozgun H, Kurt MN, Kurt I, Cevikel MH (2002) Comparison of local, spinal, and general anaesthesia for inguinal herniorrhaphy. Eur J Surg 168:455–459
3. Tan M, Law LS, Gan TJ (2015) Optimizing pain management to facilitate Enhanced Recovery After Surgery pathways. Can J Anaesth 62:203–218
4. Hadzic A, Kerimoglu B, Loreio D, Karaca PE, Claudio RE, Yufa M, Wedderburn R, Santos AC, Thys DM (2006) Paravertebral blocks provide superior same-day recovery over general anesthesia for patients undergoing inguinal hernia repair. Anesth Analg 102:1076–1081
5. Eason MJ, Wyatt R (1979) Paravertebral thoracic block-a reappraisal. Anaesthesia 34:638–642
6. Amid PK, Shulman AG, Lichtenstein IL (1994) A critical comparison of laparoscopic hernia repair with Lichtenstein tension-free hernioplasty. Med J Aust 161:239–241
7. Baldini G, Bagry H, Aprikian A, Carli F (2009) Postoperative urinary retention: anesthetic and perioperative considerations. Anesthesiology 110:1139–1157
8. Naja ZM, Raf M, El-Rajab M, Daoud N, Ziade FM, Al-Tannir MA, Lonnqvist PA (2006) A comparison of nerve stimulator guided paravertebral block and ilio-inguinal nerve block for analgesia after inguinal herniorrhaphy in children. Anaesthesia 61:1064–1068
9. Klein SM, Pietrobon R, Nielsen KC, Steele SM, Warner DS, Moylan JA, Eubanks WS, Greengrass RA (2002) Paravertebral somatic nerve block compared with peripheral nerve blocks for outpatient inguinal herniorrhaphy. Reg Anesth Pain Med 27:476–480
10. Kaya C, Koksal E, Ustun YB, Yilmar MZ, Torun AC, Ozkan F (2014) Comparative effects of transversus Abdominis plane and paravertebral block on postoperative pain in inguinal hernia surgery. Acta Medica Mediterr 30:341–346
11. Kuipers PW, Kamphuis ET, van Venrooij GE, van Roy JP, Ionescu TI, Knape JT, Kalkman CJ (2004) Intrathecal opioids and lower urinary tract function: a urodynamic evaluation. Anesthesiology 100:1497–1503
12. Dray A, Metsch R (1984) Opioids and central inhibition of urinary bladder motility. Eur J Pharmacol 98:155–156
13. Matsuura S, Downie JW (2000) Effect of anesthetics on reflex micturition in the chronic cannula-implanted rat. Neurourol Urodyn 19:87–99
14. Kamphuis ET, Ionescu TI, Kuipers PW, de Gier J, van Venrooij GE, Boon TA (1998) Recovery of storage and emptying functions of the urinary bladder after spinal anesthesia with lidocaine and with bupivacaine in men. Anesthesiology 88:310–316
15. Axelsson K, Mollefors K, Olsson JO, Lingardh G, Widman B (1985) Bladder function in spinal anaesthesia. Acta Anaesthesiol Scand 29:315–321
16. Sanjay P, Woodward A (2007) Inguinal hernia repair: local or general anaesthesia? Ann R Coll Surg Engl 89:497–503
17. Callesen T, Bech K, Nielsen R, Andersen J, Hesselfeldt P, Roikjaer O, Kehlet H (1998) Pain after groin hernia repair. Br J Surg 85:1412–1414
18. McCormack K, Scott NW, Go PM, Ross S, Grant AM, EU Hernia Trialists Collaboration (2003) Laparoscopic techniques versus open techniques for inguinal hernia repair. Cochrane Database Syst Rev (1):CD001785
19. Tammela T, Kontturi M, Lukkarinen O (1986) Postoperative urinary retention. I. Incidence and predisposing factors. Scand J Urol Nephrol 20:197–201
20. Keita H, Diouf E, Tubach F, Brouwer T, Dahmani S, Mantz J, Desmonts JM (2005) Predictive factors of early postoperative urinary retention in the postanesthesia care unit. Anesth Analg 101:592–596 **(table of contents)**
21. Petersen MS, Collins DN, Selakovich WG, Finkbeiner AE (1991) Postoperative urinary retention associated with total hip and total knee arthroplasties. Clin Orthop Relat Res 269:102–108
22. Gerstenberg TC, Nielsen ML, Clausen S, Blaabjerg J, Lindenberg J (1980) Bladder function after abdominoperineal resection of the rectum for anorectal cancer. Urodynamic investigation before and after operative in a consecutive series. Ann Surg 191:81–86
23. Weltz CR, Mein SM, Arbo JE, Greengrass RA (2003) Paravertebral block anesthesia for inguinal hernia repair. World J Surg 27:425–429