



Association between postoperative shoulder pain and left-side laparoscopic urologic surgery: a single-center retrospective cohort study

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Abstract

Purpose Postoperative shoulder pain is a common problem after laparoscopic surgery. This study aimed to investigate the association between operative side and postoperative shoulder pain following urologic laparoscopic surgery performed in the lateral recumbent position.

Methods This was a retrospective cohort study conducted at a single tertiary care center. A total of 506 patients who underwent urologic laparoscopic surgery (including adrenalectomy, radical nephrectomy, partial nephrectomy, and pyeloplasty) between January 2010 and December 2019 were included. Patients who underwent total nephroureterectomy or resection of other organs were excluded. The primary outcome was the incidence of postoperative shoulder pain. A multivariable logistic regression analysis investigated the association between the operative side and postoperative shoulder pain.

Results Among the 506 included patients, there were an equal number of surgeries on the left and right sides. Eighty-eight patients had postoperative shoulder pain. The incidence of postoperative shoulder pain in the left-side group was significantly higher than that in the right-side group (21.3% [54/253] versus 13.4% [34/253], crude odds ratio = 1.75, 95% confidence interval [CI] 1.07–2.89). After adjustment for potential confounders (age, sex, body mass index, operation duration, operative technique, epidural block, peripheral nerve block, American Society of Anesthesiologists physical status classification, and intraoperative rocuronium dose), the left operative side was found to be associated with postoperative shoulder pain (adjusted odds ratio = 1.89, 95% CI 1.15–3.09).

Conclusion The left operative side is associated with an increased incidence of postoperative shoulder pain after urologic laparoscopic surgery performed in the lateral recumbent position.

Keywords Postoperative shoulder pain · Laparoscopic surgery · Urological laparoscopic surgery

Introduction

Shoulder pain is a well-known postoperative complication of laparoscopic surgery [1]. Its incidence is reported to be 35–80% [2, 3]. If not properly managed, it leads to increased use of analgesics, delayed recovery, and increased length of hospital stay [4].

Shoulder pain after laparoscopic surgery is considered to be the referred pain resulting from the stimulation of

the phrenic nerve that innervates the diaphragm [5]. Some possible causes of diaphragmatic stimulation may include residual carbon dioxide used for pneumoperitoneum [6, 7] and tissue trauma from surgical maneuvers [8].

Thus, we hypothesized that the incidence of postoperative shoulder pain may differ depending on the side of the operation in those procedures performed in the lateral recumbent position, such as urological surgery. Carbon dioxide may stay longer on the right side between the diaphragm and the liver, while stimulation by the surgical maneuvers may be more prominent on the left side because on the right side, the liver may protect the diaphragm.

We undertook this study to investigate the association between the operative side and postoperative shoulder pain following urologic laparoscopic surgeries performed in the lateral recumbent position.

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Methods

Design and setting

This single-center, retrospective cohort study was conducted at Yokohama City University Hospital, a 674-bed tertiary care center in Japan. We collected data from the operating room databases ORSYS® (Philips Electronics Japan, Tokyo, Japan) and Prime Gaia® (Nihon Kohden, Tokyo, Japan), and the electronic medical record MegaOak® (NEC, Tokyo, Japan).

Participants

Patients who underwent laparoscopic adrenalectomy, laparoscopic radical nephrectomy, laparoscopic partial nephrectomy, or laparoscopic pyeloplasty performed in the lateral recumbent position between January 1, 2010, and December 31, 2019, at Yokohama City University Hospital were included. We also included robot-assisted laparoscopic surgeries. This study did not include laparoscopic total nephroureterectomy since it requires a longer operative duration and an intraoperative positioning change to the supine position. We excluded patients who underwent resection of other organs at the same time because we considered that the operative duration and the intensity of postoperative pain would be different.

All surgeries were performed under general anesthesia, generally combined with epidural block or peripheral nerve block at the discretion of the anesthesiologist in charge. The surgical techniques were standardized for each operation. The intraoperative pneumoperitoneal pressure was 10 mmHg. At the end of the surgery, intraperitoneal drains were inserted in all cases.

Exposure

The operative side for the surgical operation was identified from the operating room database, and patients who underwent surgery on the right side were classified into the right side group, while patients who underwent surgery on the left side were classified into the left side group.

Outcome

The primary outcome was the incidence of postoperative shoulder pain before hospital discharge. We searched the electronic medical record for keywords such as “shoulder” and “shoulder pain,” and we classified patients as having postoperative shoulder pain if the nurses or physicians noted

shoulder pain in their reports. The right or left localization of the postoperative shoulder pain and the intensity of the pain were not examined.

Covariates

We listed age [9, 10], sex [11], body mass index (BMI) [10, 12], American Society of Anesthesiologists (ASA) physical status classification, operative duration [9], use of epidural block [13], use of intravenous patient-controlled analgesia (IV-PCA) [13], use of peripheral nerve block, total amount of neuromuscular blockade used [14], and operative technique (laparoscopic adrenalectomy or not) as potential confounding factors.

The total amount of neuromuscular blockade used was defined as the total amount of rocuronium bromide used. This study’s patients were administered rocuronium bromide or vecuronium bromide as a neuromuscular blockade. Since the relative potency of rocuronium bromide is approximately 1/6 that of vecuronium bromide [15, 16], six times the amount of vecuronium bromide administered was converted and analyzed as the amount of rocuronium bromide used. In addition, since only 14 of 506 patients were administered vecuronium bromide, a multivariate sensitivity analysis was performed in which patients who were administered vecuronium bromide were excluded from the analysis of the total amount of neuromuscular blockade used.

Ethical approval

This study was approved by the ethics committee of Yokohama City University Hospital (approval number: F211100031). The ethics committee waived the requirement of informed consent. Information about research objectives, data collection types, personal information protection, and conflicts of interest are available on the Yokohama City University Hospital website. The opportunity to withdraw consent is also provided on the web. All data were fully anonymized; the data range was from January 2010 to December 2019. All procedures were carried out in accordance with the tenets of the Declaration of Helsinki.

Statistical analysis

Statistical analysis was performed using STATA Statistical Software Release 17 (Stata Corp, College Station, TX, USA). The results were expressed as median (interquartile range [IQR]) or count (%). Univariate analysis was performed using Fisher’s exact probability test for categorical variables and Wilcoxon’s signed rank sum test for continuous variables. Multivariable logistic regression analysis was used to estimate adjusted odds ratios (ORs) and 95% confidence intervals (CIs). The multivariable analysis was

adjusted for potential confounding factors (age, BMI, ASA classification, operation duration, epidural block use, IV-PCA use, peripheral nerve block, total amount of neuromuscular blockade used, and operative technique). Statistical significance was set at $p < 0.05$.

Results

During the study period, 510 patients who underwent eligible surgery were included. Four patients who underwent other organ resections concurrently (open total hysterectomy, simple mastectomy, occipital tumor resection, and small bowel resection) were excluded. Finally, 506 patients were included in the analysis (Fig. 1).

Table 1 shows the baseline characteristics of the study population. The median age of the patients was 60 years (interquartile range, 45–69 years). Three hundred ten patients (61.3%) were male, and 196 (38.7%) were female. The median BMI was 23.6 kg/m² (21.2–26.5 kg/m²). The median operation duration was 205 min (167–247 min). Among the patients, 87, 101, 220, and 98 underwent laparoscopic pyeloplasty, adrenalectomy, partial nephrectomy, and radical nephrectomy, respectively. Among the 506 patients, there were an equal number of surgeries on the left and right sides. No statistically significant differences in baseline characteristics between the two groups were found.

The incidence of postoperative shoulder pain is presented in Table 2. The incidence of postoperative shoulder pain was 21.3% in the left side group, significantly higher than that (13.4%) in the right side group (crude OR 1.75, 95% CI 1.07–2.89, $p = 0.025$). After adjustment for potential confounders, the left operative side was significantly associated with the higher incidence of postoperative shoulder pain (adjusted OR 1.89, 95% CI 1.15–3.09, $p = 0.012$, Table 3). Age was also associated with postoperative shoulder pain (adjusted OR 0.96, 95% CI 0.94–0.98, $p < 0.001$, Table 3).

As a sensitivity analysis, we conducted a multivariate analysis excluding cases of vecuronium bromide use from the analysis of the total amount of neuromuscular blockade used. We found that the left operative side was significantly associated with the incidence of postoperative shoulder pain (adjusted OR 1.93, 95% CI 1.17–3.20, $p = 0.010$, Online Resource 1), similar to the results of the main analysis.

Discussion

In this retrospective study, we investigated the association between the operative side and the incidence of postoperative shoulder pain after urological laparoscopic surgeries performed in the lateral recumbent position. We found that the left operative side was associated with a significantly increased incidence of postoperative shoulder pain. To the best of our knowledge, this is the first study to demonstrate an association between the operative side and the incidence of postoperative shoulder pain.

Although this study was not designed to elucidate the mechanism underlying the observed difference between the operative sides with regard to postoperative shoulder pain, some speculation may warrant discussion. In the right-sided operations, residual carbon dioxide would remain longer between the liver and the diaphragm, causing shoulder pain. In the left-sided operations, tissue damage and resulting inflammation of the diaphragm may be more severe than in the right-sided operation because the liver may protect the diaphragm on the right side. The results of this study suggest that the latter mechanism may be more important. Left-sided surgeries require an incision of the splenorenal ligament and phrenicosplenic ligament to ensure a better view around the kidney, resulting in tissue damage around the diaphragm. Further studies on the mechanism of postoperative shoulder pain are needed.

Fig. 1 Study flow chart

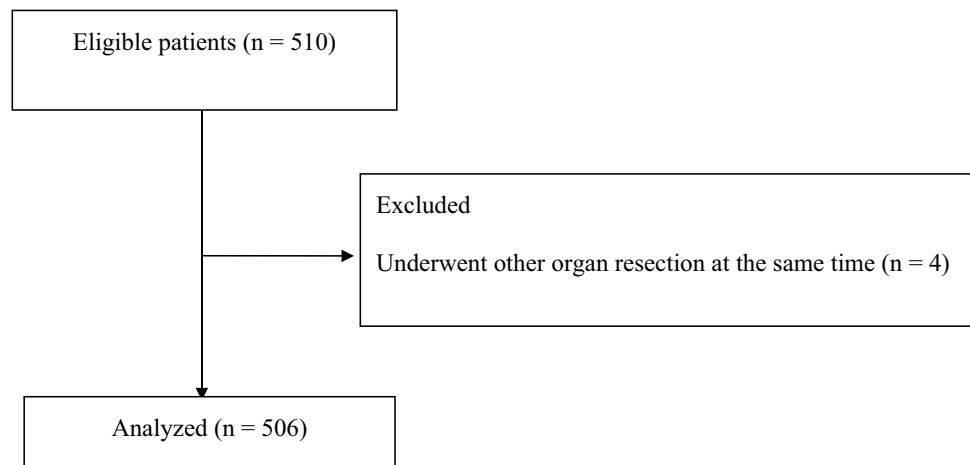


Table 1 Baseline characteristics of the study population

	Right side <i>n</i> = 253	Left side <i>n</i> = 253	<i>p</i> value
Age (years)	60 (47–68)	60 (45–71)	0.426
Sex			
Male	158 (62.5%)	152 (60.1%)	0.648
Female	95 (37.5%)	101 (39.9%)	
Height (cm)	165.0 (156.3–170.0)	163.0 (155.9–171.2)	0.777
Weight (kg)	63.7 (54.9–72.8)	64.0 (54.3–72.8)	0.679
BMI (kg/m ²)	23.6 (20.9–26.7)	23.6 (21.3–26.3)	0.981
ASA classification			
1, 2	56 (22.1%)	55 (21.7%)	1
3	197 (77.9%)	198 (78.3%)	
Operation duration (min)	200 (167–242)	211 (168–252)	0.147
Anesthesia duration (min)	272 (241–318)	283 (244–327)	0.249
Surgical procedure			
Laparoscopic pyeloplasty	35 (13.8%)	52 (20.6%)	
Laparoscopic adrenalectomy	53 (21.0%)	48 (19.0%)	
Laparoscopic partial nephrectomy	115 (45.5%)	105 (41.5%)	
Laparoscopic radical nephrectomy	50 (19.8%)	48 (19.0%)	
Intraoperative fentanyl dose (μg)	400 (300–500)	400 (300–500)	0.633
Intraoperative remifentanyl dose (mg)	1.4 (0.7–2.2)	1.5 (0.8–2.3)	0.256
Intraoperative rocuronium dose (mg)	90 (80–10)	90 (78–115)	0.695
Postoperative analgesia			
Epidural anesthesia	159 (62.9%)	160 (63.2%)	
IV-PCA	54 (21.3%)	51 (20.2%)	
TPVB	2 (0.8%)	1 (0.4%)	
Others	38 (15.0%)	41 (16.2%)	
Type of anesthetics			
Inhaled anesthetics	205 (81.0%)	205 (81.0%)	1
Intravenous anesthetics	48 (19.0%)	48 (19.0%)	
Type of anesthesia			
General anesthesia	59 (23.3%)	60 (23.7%)	
General anesthesia + Epidural anesthesia	159 (62.9%)	160 (63.2%)	
General anesthesia + PNB	35 (13.8%)	33 (13.0%)	

Values are median [IQR] or number (%)

BMI body mass index, *ASA* American society of anesthesiologists, *IV-PCA*, intravenous patient-controlled analgesia, *TPVB* thoracic paravertebral block, *PNB* peripheral nerve block, *IQR* interquartile range

Table 2 Primary outcomes; incidence of postoperative shoulder pain

Group	Incidence of postoperative shoulder pain	Crude odds ratio (95% CI)	<i>p</i> value
Right side	34/253 (13.4%)	Ref	–
Left side	54/253 (21.3%)	1.75 (1.07–2.89)	0.025

CI confidence interval, *ref* reference

In this study, the incidence of postoperative shoulder pain was 17.4%, which is lower than that previously reported (35–80% [2, 3]). This may be because of the use of low pneumoperitoneal pressure in this study (10 mmHg) and

an information drain in all patients, because both have been reported to reduce the incidence of postoperative shoulder pain [8, 17]. In addition to these maneuvers, many interventions have been reported to be effective in reducing the incidence of postoperative shoulder pain. They include the pulmonary recruitment maneuver [4], intraperitoneal local anesthetic or saline instillation [4, 7], and the reduction of residual gas in the abdominal cavity [6, 7]. As we have now demonstrated that the operative side is a risk factor for postoperative shoulder pain in urological procedures, it may be interesting to separately reevaluate the effectiveness of these preventive interventions in right- and left-sided surgeries.

This study had some limitations. First, we used the diagnosis of postoperative shoulder pain stored on the

Table 3 Univariable and multivariable logistic regression analyses

Parameter	Unadjusted odds ratio (95% CI)	<i>p</i> value	Adjusted odds ratio (95% CI)	<i>p</i> value
Operative left side	1.75 (1.09–2.80)	0.020	1.89 (1.15–3.09)	0.012
Age	0.97 (0.95–0.98)	<0.001	0.96 (0.94–0.98)	<0.001
Sex	1.27 (0.79–2.06)	0.326	1.37 (0.80–2.34)	0.252
BMI	1.00 (0.94–1.06)	0.906	1.04 (0.97–1.11)	0.277
Operation duration	1.00 (0.997–1.004)	0.927	1.00 (1.00–1.01)	0.174
Epidural anesthesia	1.96 (1.16–3.29)	0.012	1.99 (0.77–5.11)	0.155
Peripheral nerve block	0.34 (0.13–0.87)	0.024	0.63 (0.20–1.96)	0.421
IV-PCA	0.68 (0.37–1.26)	0.220	1.15 (0.42–3.18)	0.781
Intraoperative rocuronium dose	1.00 (0.99–1.01)	0.857	0.99 (0.98–1.00)	0.080
ASA classification	1.76 (1.05–2.94)	0.031	1.05 (0.53–2.09)	0.888
Laparoscopic adrenalectomy	1.32 (0.77–2.29)	0.315	1.44 (0.74–2.80)	0.286

CI confidence interval, BMI body mass index, IV-PCA intravenous patient-controlled anesthesia, ASA American society of anesthesiologists

electronic medical record; therefore, we cannot exclude the possibility that some cases of shoulder pain might have been missed. Second, detailed information on the pain intensity measured using a pain numerical rating scale, the pain duration, or whether the pain was left- or right-sided was in many cases unavailable. Therefore, we were unable to analyze such factors. Third, a selection bias may exist because the study was performed at a single tertiary care center. Hence, future multicenter prospective studies are needed.

In conclusion, this retrospective study showed that the left operative side was associated with an increased incidence of postoperative shoulder pain following urologic laparoscopic surgery performed in the lateral recumbent position. Further studies are needed to understand the mechanisms of the different types of postoperative shoulder pain, depending on the side of the operation.

Supplementary Information The online version contains supplementary material available at <https://doi.org/10.1007/s00540-024-03341-5>.

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Data availability The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Conflict of interest The authors declare that they have no competing interests.

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