Updates in Surgery (2023) 75:1259–1266
https://doi.org/10.1007/s13304-023-01475-x

ORIGINAL ARTICLE

Comparison of lateral transperitoneal versus retroperitoneal laparoscopic adrenalectomy for pheochromocytoma: a single-centre retrospective study

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Received: 27 September 2022 / Accepted: 20 February 2023 / Published online: 26 February 2023

Abstract

Laparoscopic adrenalectomy (LA) has became the standardized treatment for pheochromocytoma. The aim of this study was to evaluate outcomes of lateral transperitoneal and retroperitoneal LA for pheochromocytoma. Between January 2011 and December 2021, 142 patients with pheochromocytoma underwent LA via lateral transperitoneal (123 patients) or retroperitoneal (19 patients) approaches. Data of these patients were assessed to investigate the differences in perioperative outcomes and intraoperative haemodynamic parameters between the two procedures. Clinical parameters at presentation were comparable between the two groups, except for tumour size, which was larger in the transperitoneal group (50 [10–115] mm vs 35 [7–110] mm, $P=0.012$). There were no significant differences between the two groups in terms of operation time, estimated blood loss, intraoperative transfusion rate, incidence of complications, conversion to open surgery, postoperative analgesic requirement, time to first oral intake, or mean hospital stay. Intraoperative haemodynamic parameters of the two groups were similar. After adjusting for tumour size using propensity score matching, both perioperative outcomes and haemodynamic parameters were still comparable. Lateral transperitoneal and retroperitoneal laparoscopic adrenalectomies provide similar perioperative and haemodynamic outcomes for surgical resection of pheochromocytoma.

Keywords Transperitoneal · Retroperitoneal · Laparoscopic · Adrenalectomy · Pheochromocytoma

Abbreviations

CT	Computed tomography
LA	Laparoscopic adrenalectomy
MRI	Magnetic resonance imaging

Introduction

Pheochromocytoma is a catecholamine-secreting tumour which originates from medullary cells of the adrenal gland. Because of intraoperative catecholamine secretion, larger tumour size, and marked neovascularisation, surgical resection of pheochromocytoma is more challenging than that of other adrenal pathologies. Since the first report of laparoscopic adrenalectomy (LA) in the 1990s, multiple studies have proved the superiority of LA in lower estimated blood loss, shorter hospital stay, and fewer episodes of intraoperative haemodynamic instability compared with open adrenalectomy for the management of pheochromocytoma [1–3]. Among the various approaches to LA, lateral transperitoneal and retroperitoneal approaches are frequently performed. Intraoperative haemodynamic instability owing to catecholamine secretion is a major challenge during adrenalectomy for pheochromocytomas. To date, only limited studies have compared transperitoneal and retroperitoneal LA for the resection of pheochromocytoma, especially with respect to the intraoperative haemodynamic status, and the results have been conflicting. Vorselaars et al. showed that retroperitoneal adrenalectomy is associated with a greater risk of intraoperative hypotension (mean arterial pressure < 60 mmHg) than transperitoneal adrenalectomy [4]. In contrast, Ban et al. demonstrated that the transperitoneal approach was associated with greater blood pressure fluctuations and higher blood pressures than the retroperitoneal approach [5]. The other two studies conducted by Gockel

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et al. [6] and Li et al. [7] did not reveal significant difference between the two approaches in terms of intraoperative haemodynamic status. The contrasting results could be attributed to small sample sizes, heterogeneity of surgical techniques (e.g. patient position, port placements, and dissection sequence), and surgeons' level of experience. This study aimed to evaluate the outcomes of patients with pheochromocytoma surgically treated via lateral transperitoneal and retroperitoneal approaches based on our own experience, specifically focusing on intraoperative haemodynamic changes.

Methods

Patient data

This retrospective and non-randomised study was approved by the institutional review board for data analysis. A total of 151 consecutive patients underwent LA for pheochromocytoma between January 2011 and December 2021 in our center. Six patients with bilateral adrenalectomies and three patients with prior abdominal surgery on the side of tumour were excluded, and finally, 142 patients were enrolled in our study. The medical records of 142 patients were retrospectively reviewed. The lateral transperitoneal approach is preferred in our institution and was used to treat 123 patients. The lateral retroperitoneal approach was used in 19 patients. The flowchart of the inclusion and exclusion criteria of the patients was shown in Fig. 1. The surgeons performing the procedure were experienced in laparoscopic adrenal surgery (> 50 surgeries performed per surgeon). In our center, four surgeons specialized in the transperitoneal approach, whereas one surgeon specialized in the retroperitoneal approach. Information on demographic data, operative time, blood loss, incidence of transfusion, intraoperative and postoperative complications, conversion to open surgery, days to oral intake, postoperative analgesic use, and intraoperative haemodynamic parameters of both the patient groups was compared. Operative time was recorded as the skin-to-skin surgical time. Nonsteroidal anti-inflammatory drugs were administered postoperatively if necessary, based on pain requirements of patients. Intraoperative haemodynamic parameters were collected from anaesthesia records. Preliminary diagnosis of pheochromocytoma was made based on preoperative computed tomography (CT) or/and magnetic resonance imaging (MRI). Similar to the methods reported by Ban et al. [5], all patients suspected of pheochromocytoma were prepared for surgery by administering alpha-blocker (phenoxybenzamine) for at least 2 weeks to control the blood pressure (BP) to less than 130/80 mmHg and block intraoperative catecholamine surges. Additionally, beta-blockers were added for patients exhibiting tachycardia for a target heart rate (HR) of 80 beats per minute (bpm). To reduce the incidence of postoperative hypotension, adequate preoperative hydration was administered to all patients (intravenous normal saline 1000 cc for 3 days before surgery). Intraoperative hemodynamic changes were managed by the same anesthesia team. The diagnosis of pheochromocytoma was confirmed based on postoperative pathological examination findings. Parametric data (presented as mean ± standard deviation) were compared using students' *t* test. Non-parametric data (presented as median and min–max range) were compared using Mann–Whitney *U* test. Categorical data were compared using the χ^2 test or Fisher's exact test. Propensity score matching (PSM) was used to adjust for differences between the two groups. Statistical significance was set at *P* values < 0.05, and all reported *P*-values were two tailed. Data analyses were performed using SPSS 25.0 (SPSS Inc., Chicago, IL, USA).

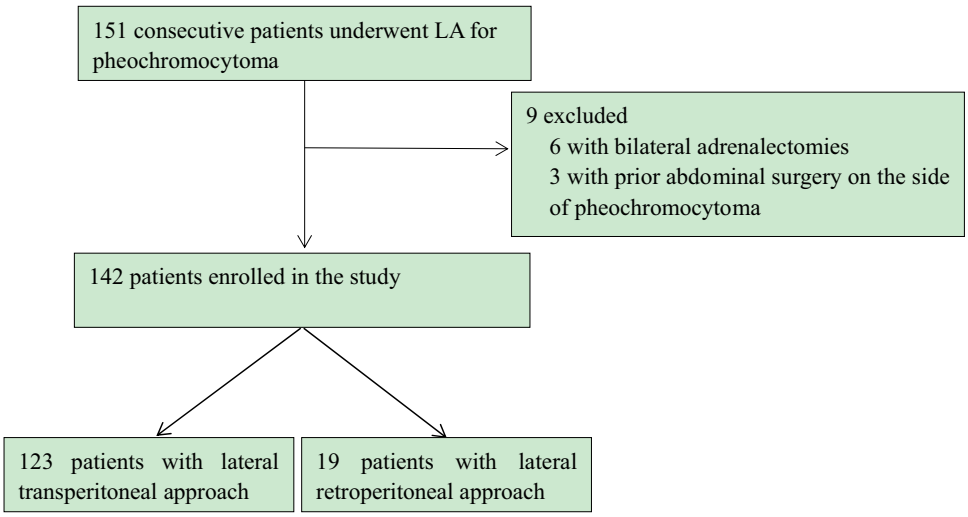

Fig. 1 Flowchart of the inclusion and exclusion criteria of the patients

Operation methods

Lateral transperitoneal LA (LTLA)

As described by our previous study [8], patients were placed in semi-lateral decubitus position. The side of the lesion was elevated at 70°. Three trocars were used for left-sided procedure and four trocars were used for right side. A Veress needle was introduced through a 10-mm supraumbilical incision to establish pneumoperitoneum using CO_2. The pressure was set at 12 mmHg. A 10-mm trocar was then inserted via the same incision to serve as the camera port. Under direct visualisation, two subcostal ports (10 and 5 mm) were placed in the midclavicular line and the anterior axillary line, respectively. For right-sided LA, an additional 5-mm trocar was placed just below the xiphoid process to retract the liver. After the liver was retracted, the upper pole of the right kidney, duodenum and vena cava were identified. An incision on the posterior parietal peritoneum above the duodenum was made longitudinally along the right margin of the vena cava and then extended outward along the reflection of the posterior peritoneum and liver. The adhesion between the adrenal gland and bare area of liver was divided. The vena cava was carefully separated from the adrenal gland to expose the medial border of the gland. An aspirator was gently inserted through the border to retract the gland laterally. The arterioles along the medial border were subsequently cut using ultrasonic device until the central vein was identified and divided. The remaining attachments along the upper border of the gland were then divided. Finally, the gland was separated from the upper pole of the kidney and resected. For left-sided LA, an incision of the splenorenal and splenodiaphragmatic ligaments was made deep enough to visualise the fundus of the stomach and the left crus of the diaphragm. The splenopancreatic bloc was mobilized medially until the adrenal region was exposed. The left renal vein was identified and isolated from the perirenal fat. An aspirator was inserted between the lower border of the adrenal gland and left renal vein to retract the gland upward. Attachments along the lower border of the gland were divided using ultrasonic device until the central vein was identified and divided. Arterioles along the medial border were subsequently divided. Finally, the adrenal gland was separated from the upper pole of the left kidney and resected.

Lateral retroperitoneal LA (LRLA)

In accordance with our previous study [8], patients were placed in the lateral decubitus position. The operating table was flexed to expand the space between the iliac crest and 12th rib. A 15-mm skin incision was made in the midaxillary line, 10 mm above the iliac crest. The index finger of the surgeon was inserted through the incision to dissect the retroperitoneal space bluntly. A balloon dissector was then introduced and inflated with 700 ml of air to further expand the space. A 10-mm trocar was placed through the incision to serve as camera port. Under direct visualisation, two operating trocars (12- and 5-mm) were introduced below the costal margin in the anterior and posterior axillary lines, respectively. The extraperitional fat was cleared to expose the Gerota's fascia. The space between the perirenal fat and anterior renal fascia was initially dissected to expose the anterior surface of the gland. Dissection was then performed along the psoas muscle until the posterior surface of the gland was exposed. Subsequently, the gland was separated from the upper pole of the kidney until the central vein was identified and transected. Finally, the remaining attachment along the upper and medial borders of the gland were divided and the tumour was resected.

Results

Table 1 summarised the basic clinical characteristics of the patients. There were no significant differences in terms of age, sex, body mass index (BMI), tumour side, preoperative BP, and comorbidities between the two groups. However, the tumour size of LTLA group was significantly larger than LRLA group (50 [10–115] mm vs 35 [7–110] mm, $P = 0.012$).

The surgical outcomes for patients of the two groups are shown in Table 2. There were no significant differences in operation time, estimated blood loss, incidence of intraoperative transfusion, intraoperative complications, conversion to open surgery, postoperative analgesic use, time to first oral intake, postoperative complications, or hospital stay between the two groups. There were two intraoperative complications in the LTLA group. Intraoperative hypotension following adrenal vein ligation occurred in one patient with a 48-mm right-sided tumour, which led to postoperative hypotention. Short hepatic vein injury occurred in another patient with a 115-mm right-sided tumour, which led to massive intraoperative bleeding and conversion to open surgery. No intraoperative complications occurred in the LRLA group. In the LTLA group, conversion to open surgery was required in three cases for extensive bleeding and in one case for difficulty to expose the right adrenal region due to interference of intestine in an obese patient. In the LRLA group, one patient underwent conversion to open surgery for extensive bleeding and another for difficulty in dissecting adhesion between the tumour and vena cava. In the LTLA group, postoperative hypotension occurred in two patients, requiring sustained vasopressor support. No postoperative complications occurred in the LRLA group.

Table 1 Characteristics of patients

	LTLA($n=123$)	LRLA($n=19$)	*P* value
Age	49(16–77)	40(20–68)	0.282
Sex			0.883
Male	54	8	
Female	69	11	
BMI(kg/m^2)	22.04(16.98–30.85)	21.22(15.02–26.78)	0.579
Tumor size(mm)	50(10–115)	35(7–110)	0.012
Tumor side(*n*)			0.961
Right	64	10	
Left	59	9	
Preoperative SBP(mmHg)	133.73 ± 22.15	127.32 ± 16.60	0.228
Preoperative DBP(mmHg)	81.53 ± 15.28	77.11 ± 9.59	0.224
Comorbidities(*n*)			
Hypertension	37	4	0.419
Diabetes	30	3	0.564
Coronary heart disease	18	2	1.000*
Stroke	10	1	1.000*

LTLA Lateral Transperitoneal Laparoscopic Adrenalectomy, *LRLA* Lateral Retroperitoneal Laparoscopic Adrenalectomy,*BMI* Body mass index, *SBP* Systolic blood pressure, *DBP* Diastolic blood pressure, *Fisher's Exact Test

Table 2 Peri-operative data of patients

	LTLA($n=123$)	LRLA($n=19$)	*P* value
Operation time(min)	105(40–335)	130(35–200)	0.292
Estimated blood loss(ml)	70(10–2800)	90(20–1500)	0.400
Intraoperative transfusion(*n*)	6	1	1.000*
Intraoperative complications(*n*)	2	0	1.000*
Conversion to open surgery(*n*)	4	2	0.183*
Postoperative analgesic use(*n*)	3	0	1.000*
First oral intake(days)	2(1–7)	2(1–5)	1.000*
Postoperative complications(*n*)	2	0	1.000*
Hospital stay(days)	14(4–38)	14(8–21)	0.515

LTLA Lateral Transperitoneal Laparoscopic Adrenalectomy, *LRLA* Lateral Retroperitoneal Laparoscopic Adrenalectomy, *Fisher's Exact Test

Table 3 presents intraoperative haemodynamic parameters of the two groups. There were no significant differences between the groups in the highest and lowest intraoperative blood pressure, incidence of extreme hypertensive episodes (systolic BP ≥ 200 mmHg), extreme hypotensive episodes (systolic BP < 80 mmHg), highest heart rate (HR), incidence of highest HR (≥ 110 bpm), and incidence of lowest HR (< 50 bpm). The difference of lowest HR was marginally significant (LTLA: 58.88 ± 11.29 bpm vs LRLA: 64.68 ± 13.91 bpm, $P=0.045$). The differences between the highest and lowest systolic and diastolic BP, which reflected intraoperative BP fluctuations, were comparable between the two groups. There was no significant difference in the intraoperative administration of vasoactive drugs between the 2 groups.

To make the results as accurate as possible, we used PSM to adjust for the differences in tumour size between the 2 groups. The propensity score for each patient was determined using multivariate logistic regression based on tumour size and laterality. The calliper width for PSM was set at 0.05. After PSM, the unbalanced differences between the 2 groups were removed, and 142 patients were matched into 18 pairs (Table 4). Surgical outcomes and intraoperative haemodynamic parameters were comparable between the two groups after PSM (Tables 5 and 6).

Discussion

Compared with other adrenal pathologies, pheochromocytomas have a larger tumour size and marked neovascularisation. Furthermore, intraoperative catecholamine secretion can lead to haemodynamic instability, making surgical resection of pheochromocytomas more challenging. Since the first report of LA in 1990s, multiple studies have proved the feasibility of LA for patients with pheochromocytoma [9–12]. Among the several surgical approaches for LA, lateral transperitoneal and retroperitoneal approaches are frequently used. For pheochromocytoma, most surgeons prefer

Table 3 Intraoperative hemodynamic parameters of LTLA vs LRLA

	LTLA($n=123$)	LRLA($n=19$)	*P* value
Highest intraoperative SBP(mmHg)	168.12 ± 21.61	169.05 ± 19.73	0.860
Lowest intraoperative SBP(mmHg)	101.07 ± 14.62	98.79 ± 19.48	0.548
Highest intraoperative DBP(mmHg)	101.26 ± 14.50	101.26 ± 10.20	0.999
Lowest intraoperative DBP(mmHg)	61.45 ± 11.22	61.21 ± 8.76	0.930
Incidence of SBP ≥ 200 mmHg(n)	9	1	1.000*
Incidence of SBP < 80 mmHg(n)	9	1	1.000*
Highest heart rate(beat/min)	98.80 ± 15.34	104.74 ± 18.88	0.131
Lowest heart rate(beat/min)	58.88 ± 11.29	64.68 ± 13.91	0.045
Incidence of highest HR ≥ 110 bpm(*n*)	34	7	0.410
Incidence of lowest HR < 50 bpm(*n*)	19	2	0.739*
Highest SBP-lowest SBP(mmHg)	67.10 ± 23.18	70.26 ± 27.64	0.590
Highest DBP-lowest DBP(mmHg)	39.81 ± 13.57	40.05 ± 13.07	0.943
Patients requiring intraoperative vasodilator drugs(*n*)	60	9	0.909
Patients requiring intraoperative vasoconstrictive drugs(*n*)	17	1	0.467*

LTLA Lateral Transperitoneal Laparoscopic Adrenalectomy, *LRLA* Lateral Retroperitoneal Laparoscopic Adrenalectomy, *SBP* Systolic blood pressure, *DBP* Diastolic blood pressure, *HR* Heart rate, *Fisher's Exact Test

Table 4 Characteristics of patients after PSM

	LTLA($n=18$)	LRLA($n=18$)	*P* value
Age	51(25–66)	43.5(20–68)	0.229
Sex			1.000*
Male	7	7	
Female	11	11	
BMI(kg/m^2)	21.90(18.92–29.75)	21.17(15.02–26.78)	0.669
Tumor size(mm)	41.5(10–95)	37.5(15–110)	0.374
Tumor side(*n*)			0.176*
Right	5	10	
Left	13	8	
Preoperative SBP(mmHg)	135.61 ± 23.16	126.89 ± 16.98	0.206
Preoperative DBP(mmHg)	85.89 ± 18.97	76.44 ± 9.41	0.070
Comorbidities(*n*)			
Hypertension	5	4	1.000*
Diabetes	5	3	0.691*
Coronary heart disease	2	2	1.000*
Stroke	1	1	1.000*

Footnotes: *LTLA* Lateral Transperitoneal Laparoscopic Adrenalectomy, *LRLA* Lateral Retroperitoneal Laparoscopic Adrenalectomy,*BMI* Body mass index, *SBP* Systolic blood pressure, *DBP* Diastolic blood pressure, *Fisher's Exact Test

transperitoneal approach due to large working space and familiar anatomic landmarks. By comparison, retroperitoneal approach avoids mobilization of intra-abdominal organs and is generally believed to accelerate recovery of bowel function and shorten hospitalization period. In the beginning, it is generally indicated for small to medium-sized tumours because the working space is limited [13]. Since Zhang et al. [14] standardized the procedure of retroperitoneal adrenalectomy using lateral decubitus position, LRLA has been progressively accepted in China. As the operating techniques mature, its indication has been expanded to large tumours and pheochromocytoma [15, 16]. To our knowledge, only a few published articles have compared the two approaches for pheochromocytoma, with conflicting results. Gockel et al. reported that the lateral transperitoneal approach was associated with shorter operating time and less frequent intraoperative BP peaks than the retroperitoneal approach [6]. However, Li et al. demonstrated

Table 5 Peri-operative data of patients after PSM

	LTLA($n=18$)	LRLA($n=18$)	*P* value
Operation time(min)	110(45–195)	130(75–200)	0.254
Estimated blood loss(ml)	80(10–150)	90(20–1500)	0.325
Intraoperative transfusion(n)	0	1	1.000*
Intraoperative complications(n)	0	0	
Conversion to open surgery(n)	0	2	0.486*
Postoperative analgesic use(n)	0	0	
First oral intake(days)	2(1–7)	2(1–5)	0.154
Postoperative complications(n)	0	0	
Hospital stay(days)	14.5(7–28)	13.5(8–21)	0.374

LTLA Lateral Transperitoneal Laparoscopic Adrenalectomy, *LRLA* Lateral Retroperitoneal Laparoscopic Adrenalectomy, *Fisher's Exact Test

that the retroperitoneal approach was safer and quicker than the transperitoneal approach in patients with unilateral pheochromocytoma < 6 cm in diameter [7]. Jiang et al. conducted a meta-analysis to compare perioperative outcomes of retroperitoneal and transperitoneal LA for pheochromocytoma [17]. Their results demonstrated that the retroperitoneal approach was superior to the transperitoneal approach with respect to operative time, blood loss, and hospital stay. Nevertheless, they only included four studies in this meta-analysis, which could have increased the bias. In addition, they ignored the effect of BMI and tumour size.

A random study by Rubinstein et al. compared 25 and 32 patients who underwent LA via the transperitoneal and retroperitoneal approaches, respectively, and demonstrated comparable operative time, blood loss, analgesic use, hospital stay, and rate of complication [18]. Another randomised study including 21 patients compared transperitoneal or retroperitoneal LA for Cushing's syndrome and revealed no differences in operative time, analgesic use, and hospital stay [19]. In our previous study, we compared the lateral transperitoneal and retroperitoneal approaches for ipsolateral LA and demonstrated that perioperative outcomes of the two approaches were comparable for adrenal tumours ≥ 50 mm in size [8]. Pheochromocytomas tend to be larger than other adrenal tumours. In the present study, the median tumour sizes in the transperitoneal and retroperitoneal groups were 50 (10–115) mm and 35 (7–110) mm, respectively. No significant difference in perioperative data was found between the two groups before and after PSM. Some authors demonstrate that the retroperitoneal approach offers direct access to the adrenal gland, which may contribute to a shorter operative time [20]. However, in our experience, it is easy to localize the adrenal gland when performing LTLA, using the vena cava, upper pole of the kidney, tail of pancreas, and renal vein as anatomic landmarks. Even for left LTLA, in the semi-lateral decubitus position it is generally easy and fast to mobilize the spleen and tail of the pancreas en bloc with the traction of gravity. For LRLA, however, the adrenal gland is buried in perirenal fat. Identification of the tumour is sometimes difficult especially for obese patients. Some authors have expressed concerns that bowel handling during LTLA could delay the time to oral intake and increase the incidence of injuring intra-abdominal organs [21, 22].

Table 6 Intraoperative hemodynamic parameters of LTLA vs LRLA after PSM

	LTLA($n=18$)	LRLA($n=18$)	*P* value
Highest intraoperative SBP(mmHg)	177.06 ± 21.98	169.44 ± 20.23	0.287
Lowest intraoperative SBP(mmHg)	102.61 ± 13.60	97.06 ± 18.47	0.311
Highest intraoperative DBP(mmHg)	105.50 ± 13.15	101.28 ± 10.49	0.295
Lowest intraoperative DBP(mmHg)	61.28 ± 10.53	60.67 ± 8.68	0.850
Incidence of SBP ≥ 200 mmHg(n)	3	1	0.603*
Incidence of SBP < 80 mmHg(n)	1	1	1.000*
Highest heart rate(beat/min)	102.50 ± 9.12	104.44 ± 19.38	0.703
Lowest heart rate(beat/min)	58.28 ± 7.55	63.83 ± 13.80	0.143
Incidence of highest HR ≥ 110 bpm(n)	5	6	1.000*
Incidence of lowest HR < 50 bpm(n)	1	2	1.000*
Highest SBP-lowest SBP(mmHg)	74.44 ± 16.03	72.39 ± 26.79	0.782
Highest DBP-lowest DBP(mmHg)	44.22 ± 9.86	40.61 ± 13.21	0.359
Patients requiring intraoperative vasodilator drugs(n)	8	9	1.000*
Patients requiring intraoperative vasoconstrictive drugs(n)	3	1	0.603*

L*TLA* Lateral Transperitoneal Laparoscopic Adrenalectomy, *LRLA* Lateral Retroperitoneal Laparoscopic Adrenalectomy, *SBP* Systolic blood pressure, *DBP* Diastolic blood pressure, *HR* Heart rate,*Fisher's Exact Test

However, in our experience, LRLA was not shown to be superior to LTLA in terms of days to oral intake for large adrenal tumours and pheochromocytoma, suggesting that extensive dissection in the retroperitoneal space for resection of large tumours during LRLA may affect the recovery of bowel function. In the present study, no intra-abdominal viscera injury or postoperative ileus was observed in the LTLA group. In our opinion, the transperitoneal approach provided direct visualisation of intra-abdominal viscera during surgery, which could minimize the incidence of injury in experienced hands. Conversely, it is relatively difficult to identify intra-abdominal viscera during LRLA, and thus injuries cannot be fully avoided, especially when the local anatomy is distorted by large tumours [19]. Analgesic use, which indicates the degree of postoperative pain, was generally low in both groups, indicating that both approaches caused minimal postoperative pain. Days of hospital stay were similar between the two groups. Compared with other reports [21, 22], duration of hospital stay is longer in our cohorts. That's because the patients were admitted to hospital for preoperative preparation in the early years. After 2017, it was no longer encouraged and the hospital stay has been shortened dramatically.

Intraoperative haemodynamic instability is still a major concern for surgeons and anaesthesiologists since it has been proven to be associated with morbidity [23]. Vorselaars et al. conducted a multi-institutional retrospective study to review haemodynamic instability during resection of pheochromocytoma using transperitoneal vs. retroperitoneal approaches [4]. Their results demonstrated that retroperitoneal approach increased the incidence of significant intraoperative hypotension (mean arterial pressure < 60 mm Hg). However, as a multi-institutional study, the authors found that the medical centre was also an independent influencing factor for intraoperative haemodynamic instability. To eliminate confounding factors including anesthesia management, operating techniques and perioperative patient management, Ban et al. conducted a single-institutional study [5]. Based on their results, the retroperitoneal approach for pheochromocytoma provides favourable intraoperative haemodynamic stability compared with the transperitoneal approach. In the authors' opinion, the anatomical benefits of the retroperitoneal approach enable minimal tumour manipulation and early control of the adrenal vein, which reduces excessive catecholamine secretion. However, when performing LRLA, we found that it was difficult to access the adrenal vein underneath larger adrenal tumours. Moreover, for right-side procedure, the kidney often blocks the path to control the adrenal vein, making early ligation more difficult. In the present study, no significant differences were found between the two approaches in terms of intraoperative haemodynamic parameters. When performing LTLA, we used the vena cava and left adrenal vein as landmarks for right and left LA, respectively. As the first step for tumour resection, we inserted an aspirator between the adrenal gland and vena cava or left renal vein to retract the tumour. In this way, attachments along the border of the glands and near the adrenal vein could be clearly exposed and easily divided. This technique allows the adrenal vein to be isolated and controlled at the early stage of LTLA. Therefore, we believe that the operating techniques and degree of intraoperative tumour manipulation, rather than surgical approaches, affect intraoperative haemodynamic parameters. Consistent with our results, in a recent case-matched study by Yeo et al., no significant difference in intraoperative hemodynamics was found between laparoscopic transperitoneal and retroperitoneal approaches for pheochromocytoma [24].

Our study had several limitations. First, though our study included a considerable amount of patients, the sample size of LRLA group was relatively small because only one surgeon specializes in LRLA in our center and thus the results could have been compromised, which could be regarded as a main drawback. Second, we did not include preoperative catecholamine levels because we did not routinely test them before 2020. Plasma or urinary level of catecholamine has been identified as a risk factor for intraoperative hemodynamic instability [25]. Third, the present study did not include long-term oncological outcomes, though we successfully performed laparoscopic resection for large pheochromocytoma (≥ 10 cm in diameter) via both approaches. The feasibility of laparoscopic adrenalectomy for large pheochromocytoma still needs to be investigated. Finally, as a retrospective, non-randomized study, the selection of the operative approach depended completely on operator preference, which could lead to a patient selection bias. As a result, mean tumour size in LTLA group was significantly larger. Tumour size is considered to be related to intraoperative hemodynamic instability [26]. However, PSM was used to reduce the effects of tumour size, and the well-matched baseline characteristics between both groups lent strength to the study results. Nonetheless, further prospective and randomised studies enrolling more patients are required to obtain more objective findings.

Conclusions

Overall, LTLA and LRLA presented comparable perioperative and intraoperative haemodynamic parameters when applied to pheochromocytoma. After adequate preparation, endoscopic adrenalectomy can be performed for patients with pheochromocytoma via both the transperitoneal and retroperitoneal approaches.

Author contributions Conception and design: QBZ and YSH; Perform research: QBZ, LY and ZL; Data analysis and technical support: YSH, ZHX and GLG; Manuscript writing: QBZ.

Funding This study was supported by grants from Natural Science Foundation of Shandong Province (ZR2021MH049).

Data availability The datasets used and 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 relevant financial interests.

Ethical approval The protocol of this research has been approved by the Ethics Committee of Qilu Hospital, Shandong University. All methods were performed in accordance with the Declaration of Helsinki.

Consent for publication None.

Informed consent All patients have signed written informed consent.

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