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A comparative study of retroperitoneal laparoscopic adrenalectomy via intra and extra perinephric fat approaches

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Abstract

Objective To investigate the safety and effectiveness of retroperitoneal adrenalectomy via extra and intra perinephric fat approaches to provide experience and basis for resection of adrenal tumors through the retroperitoneal cavity.

Methods The clinical data of 284 patients undergoing retroperitoneal adrenalectomy in our hospital from December 2017 to March 2023 were collected. The basic characteristics of the two groups of patients and the changes in perioperative indicators were retrospectively analyzed.

Results A total of 117 patients with intra perinephric fat approach (IPFA) were included,and 167 patients with extra perinephric fat approach (EPFA) were included. The estimated blood loss in the IPFA group (123.59 ± 50.76 ml) was higher than that in the EPFA group (99.10 ± 99.51 ml) ($p = 0.015$),and the operative time in the IPFA group(105.25 ± 42.25 min) was longer than that in the EPFA group(81.75 ± 30.45 min) ($p < 0.001$).The hospitalization expenses of IPFA patients (36,306.39 ± 7544.25RMB) were higher compared with patients receiving EPFA (32,122.77 ± 7284.00RMB) ($p < 0.001$).There were no significant differences between the two groups in terms of tumor size,blood transfusion times and postoperative hospitalization time.

Conclusion Retroperitoneal laparoscopic adrenalectomy is a safe and effective procedure that can be performed via extra and intra perinephric fat approaches.IPFA is associated with higher estimated blood loss, and the operation time of EPFA is shorter than IPFA. The choice of surgical approach may depend primarily on the experience of the surgeon, the characteristics of adrenal tumor, and the nature of perirenal adipose tissue.

Keywords Adrenal tumor, Retroperitoneoscopy, Perirenal fat, Minimally invasive surgery

Introduction

Retroperitoneal adrenalectomy is considered the standard treatment for benign, smaller adrenal tumours,at present [1].A classical retroperitoneal adrenalectomy method was proposed by Professor Zhang Xu,based on 3 planes of kidney plane, renal fat sac plane and adrenal glands plane,which is extra perinephric fat approach [2]. But kidney fat can affect the field, especially in patients with small tumour volumes and obesity.For this reason, some researchers have found intra perinephric fat approache that can expose the adrenal glands very well by only separating the plane between the anterior renal fascia and the upper renal perirenal fat sac, as well as the plane between the lower adrenal gland and the upper pole of the renal perirenal fat sac, this method is similar to the traditional separation method in terms of operative time and estimated blood during surgery [3].

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As retroperitoneal adrenalectomy improves by leaps and bounds, the identification, isolation and dissection of adrenal tumours by the best surgical route has become a major concern [4, 5]. This study will describe in detail the anatomical landmarks and surgical approaches of the extra perinephric fat approach (EPFA) and the intra perinephric fat approach (IPFA), and evaluate advantages and disadvantages of EPFA versus IPFA by comparing patients who have undergone these two different surgical approaches. This study will also provide some suggestions on how to choose surgical methods for adrenal tumors based on the experience of the surgeon, providing evidence for the retroperitoneal approach in the treatment of adrenal tumors.

Materials and Methods

General materials

From December 2017 to February 2023, a total of 284 cases of retroperitoneal adrenalectomy were performed in our hospital. These surgeries were completed by two urologists from our hospital, who had reached a proficiency level (> 50 surgeries) and had extensive surgical experience before 2017 [6].One urologist performed the surgery using the EPFA method, while the other urologist performed the surgery using the IPFA method, so the patients who underwent this surgery were divided into two groups. Among them, 167 patients received retroperitoneal adrenalectomy via EPFA; 117 patients received retroperitoneal adrenalectomy via IPFA.

Our inclusion criteria were based on the following characteristics: Patients:We collected data from patients aged 20 to 80 years old with a BMI of less than 32. Tumors:We included adrenal tumors measuring 3 to 9 cm in size,as well as functional adrenal tumors with a size of less than 3 cm.In the preoperative phase, we obtained a detailed medical history of all patients, including age, sex, body mass index and major surgical complications. Routine preoperative serum electrolyte levels and endocrine tests were performed in all patients, including plasma cortisol, serum adrenocorticotropic hormone, aldosterone, renin activity and catecholamine metabolites. All patients'adrenal tumors were confirmed by CT or MRI in terms of tumor size and side. In the postoperative period, we collect surgery-related data, including operative time, estimated blood loss, and pre-and postoperative haemoglobin. At the same time, perioperative information such as intraoperative complications, postoperative complications, and postoperative hospital stay were collected for both groups of patients, and their pathological types were determined by pathological examination after surgery.

Surgical technique description

Patients were placed on the surgical bed at the side position, the affected side facing up, and the surgical bed was bent above the anterior superior iliac spine to establish a waist bridge. An incision about 1.5–2.0 cm was made in the vertebrocostal point, after cutting the skin, the waist and back fascia is separated bluntly by vascular clamp into the retroperitoneal space. A special airbag dilatator was put in, note 500–600 ml air and keep for 3 to 5 min, prepare a retroperitoneal space, a 12 mm sleeve needle (Trocar) was placed through this hole. Then the other two operating holes were taken: one is on the intersection of the anterior superior iliac spine upward 2 cm and anterior axillary line, the other is on the intersection of the twelfth rib down edge and the front line of the armpit,12 mm trocar was put in them respectively. After the incision was closed, the carbon dioxide gas was injected into to retroperitoneal space and maintain the gas pressure at 12–15.An ultrasonic sword was used to clean up the retroperitoneal fat tissue outside the Gerota fascia. After cutting Gerota fascia, the follow -up steps of the two surgical paths are different from each other [7, 8].

In EPFA, the ventral section of the adrenal gland is dissected between the perirenal fat sac and the anterior perirenal fascia, turning to the dorsal side, the relative avascular space between the perirenal fat sac and the posterior perirenal fascia is separated. Finally, by separating the gap between the upper pole of the kidney and the adrenal gland, the location of the adrenal gland or tumor can be roughly located. After the anatomical plane is exposed, the retroperitoneal space becomes large enough for subsequent adrenal dissection. dissectting the adrenal gland in the bloodless plane between the adrenal gland and the upper pole of the kidney. For partial adrenalectomy, the central adrenal vein should be preserved; For total adrenalectomy, the central adrenal vein can be clamped and transected. The branches of the adrenal artery exposed in the separation path can be directly cauterized with an ultrasonic Scalpel, and then the adrenal tumor can be removed by endoscopic scissors and hoomlock ligation clip (Fig. 1, A-D).

In IPFA, the perirenal adipose sac is longitudinally opened, and the gap space between the perirenal adipose tissue and the renal surface is dissected ventrally and dorsally. Keeping the perirenal fat attached to the peritoneum and pushing the kidneys downwards, the pressure generated by the pneumoperitoneum helps create a wider surgical space. Search for the adrenal gland above the upper pole of the kidney. In most cases, the adrenal gland is faintly visible above the upper pole of the kidney. However, for obese patients'kidneys, further cleaning of the perirenal adipose tissue around the adrenal glands is necessary to determine the location

of the adrenal glands. Then, the surgical procedure for complete or partial adrenalectomy is the same as in EPFA (Fig. 1, E–H).

Statistical analysis

All statistical analyses were calculated using SPSS 26 (2017; IBM Corp, Armonk, NY, USA).The measurement data conforming to the Normal distribution, are expressed as mean ± standard deviation (x ± s), and compared with two independent sample t-tests; The measurement data that do not conform to the Normal distribution are represented by the Quartile Md (P25, P75), and compared by the rank sum test; The counting data were represented by composition ratio and compared by Chi-squared test.A P value of < 0.05 was considered statistically significant.

Results

General materials comparison

This study analyzed 117 patients in the IPFA group and 167 patients in the EPFA group, and compared the two groups of patients in pairs. The Demographics characteristics, perioperative data and pathological results of the two groups are shown in Table 1. There were no statistically significant differences in age, tumor side, and body mass index (BMI) between the two groups of patients. There was no difference between the two groups in the preop Hb and past abdominal surgery, but the proportion of patients with IPFA combined with hypertension or diabetes was significantly less than that of patients with EPFA (72% VS 82%,13% VS 26%, < 0.05). The operative time in the IPFA group (105.25 ± 42.25 min) was significantly longer than that in the EPFA group (81.75 ± 30.45) ($p < 0.001$); The estimated blood loss in the IPFA group

Table 1 Demographic and clinical parameters in the study

Parameters		IPFA	EPFA	*P* value
Age (years)		47.26 ± 10.99	47.13 ± 11.60	0.924
Gender				**0.018**
	Male	33(28%)	70(42%)	
	Female	84	97	
BMI(kg/m^2)		24.16 ± 2.97	24.11 ± 2.65	0.880
Hypertension		84(72%)	137(82%)	**0.041**
Diabetes		15(13%)	44(26%)	**0.006**
Past abdominal surgery		31	35	0.277
Tumor side				0.528
	Right	53	82	
	Left	64	85	
Tumor size(mm)		27.99 ± 14.51	28.39 ± 14.68	0.822
Preop Hb(g/dl)		128.29 ± 14.47	127.08 ± 14.31	0.485
Hb at discharge(g/dl)		119.50 ± 11.01	119.44 ± 10.81	0.964
Operative time(min)		105.25 ± 42.25	81.75 ± 30.45	**< 0.001**
Estimated blood loss(ml)		123.59 ± 50.76	99.10 ± 99.51	**0.015**
Open conversion		1	1	1.000
Intraoperative transfusions		1	1	1.000
Postoperative transfusions		0	3	0.271
postoperative hospital stay (days)		4.16 ± 1.31	4.20 ± 1.61	0.819
Readmission		10	9	0.294
Cost(RMB)		36,306.39 ± 7544.25	32,122.77 ± 7284.00	**< 0.001**
Histology type	Adrenocortical adenoma	88(75%)	151(90%)	**0.001**
	Pheochromocytoma	7	11	0.837
	Others	22(19%)	5(3%)	**< 0.001**
Diagnosis	Cushing syndrome	27	44	0.531
	Aldosteronoma	60	98	0.217
	Pheochromocytoma	7	11	0.837
	Nonfunctioning tumor	23(20%)	14(8%)	**0.005**

EPFA extra perinephric fat approach, *IPFA* intra perinephric fat approach, *BMI* Body Mass Index

Table 2 Comparison of complications between the two groups

Group	Intraoperative complications			Postoperative complications	
	Renal cortical injury	Peritoneal injury	Inferior vena cava injury	Infection of the incision	Retroperitoneal haematoma
IPFA	11(9%)	3(3%)	1	16	3
EPFA	2(1%)	14(8%)	2	19	3
P Value	**0.002**	**0.045**	1	0.562	0.658

EPFA extra perinephric fat approach, *IPFA* intra perinephric fat approach

(123.59 ± 50.76 ml) was significantly higher than that in the EPFA group (99.10 ± 99.51 ml) ($p = 0.015$). There was no significant difference between the two groups in terms of tumor size, blood transfusion frequency and postoperative hospital stay.

Intraoperative and postoperative complications

There were no complications such as renal pedicle vascular injury or chest injury in both groups. Among the intraoperative complications, there were 2 cases of renal cortical injury, 14 cases of peritoneal injury and 2 cases of inferior vena cava injury in the EPFA group. In IPFA group, there were 11 cases of renal cortical injury, 3 cases of peritoneum injury and 1 case of inferior vena cava injury. Postoperative complications include incision infection and retroperitoneal hematoma, among them, there were 22 cases in the EPFA group and 19 cases in the IPFA group. Except for the higher incidence of peritoneal injury and lower incidence of renal cortex injury in the EPFA group($p < 0.05$), there was no statistically significant difference in intraoperative and postoperative complications between the two groups ($P > 0.05$), as shown in Table 2.

Estimated blood loss

We conducted a one-way analysis of variance on the estimated blood loss to identify the factors that affect the estimated blood loss. We selected several indicators with statistical differences in the general data of two groups of patients, such as patient gender, history of hypertension and diabetes and operative time. In the one-way ANOVA results, history of hypertension and operative time (p < 0.05) that significantly affects the estimated blood loss, the other factors did not have a significant impact on the estimated blood loss, as shown in Table 3.

In univariate analysis of variance, we identified two factors that may affect estimated blood loss. In order to investigate whether there is an interaction effect between these two factors, we further conducted a multivariate analysis of variance on estimated blood loss. The results are shown in Table 4, and there is no interaction effect between history of hypertension and operative time.

Table 3 Univariate analysis of estimated blood loss

Variable	Estimated blood loss (ml)	*P* value
Gender		0.069
Male	121.17 ± 118.85	
Female	102.38 ± 53.74	
Heypertension		**< 0.001**
Yes	99.23 ± 60.59	
No	144.13 ± 131.83	
Diabetes		0.472
Yes	102.20 ± 61.76	
No	111.02 ± 88.62	
Operative time(min)		**< 0.001**
< 65	97.19 ± 47.08	
65–85	84.42 ± 43.72	
85–110	111.18 ± 63.01	
> 110	142.16 ± 132.44	

EPFA extra perinephric fat approach,IPFA:intra perinephric fat approach

Table 4 Multivariate analysis of estimated blood loss

Variable	*P* value
Heypertension	**0.001**
Operative time	**< 0.001**
Heypertension * Operative time	0.640

Discussion

The common surgical approaches of adrenalectomy include open surgery, and Laparoscopy via intraperitoneal approach or retroperitoneal approach. Studies have shown that laparoscopic adrenalectomy is more effective and safer than open adrenalectomy [9, 10]. The transabdominal and retroperitoneal approaches are two common approaches for laparoscopic adrenalectomy. Compared to the retroperitoneal approach, the transabdominal approach is more suitable for treating larger tumors [11]. However, the location of adrenal tumors through the abdominal approach is relatively deeper and has some interference with the abdominal cavity. The history of gastrointestinal surgery and abdominal infection

will greatly increase the difficulty of abdominal surgery. The retroperitoneal approach is considered by many experts to be superior to the transperitoneal approach because it is not easy to damage abdominal organs and Great vessels, has less interference with abdominal organs, and is conducive to postoperative recovery. However, due to the limited retroperitoneal space, dealing with larger adrenal tumors can bring great difficulties to the surgery. If peritoneal perforation occurs during the surgery, it can cause the retroperitoneal space to collapse. Even if remedial measures are taken, it will affect manual surgery due to the deep anatomical position of the adrenal gland [12].

In recent years, robot platform plays a leading role in Urology surgery. However, in terms of adrenalectomy, robot assisted adrenalectomy requires a balance of various factors [13, 14].Firstly, Cost-effectiveness: In most developing countries, including China, the high cost of robotic surgery is prohibitive for many individuals, thus laparoscopic surgery remains the preferred choice for the majority of patients.Secondly, Popularity: Currently, robotic surgery is predominantly popular in developed countries. In most developing nations, including China, it is only available in regional medical centers, whereas laparoscopic surgery is accessible in a broader range of regions and hospitals. And finally, Surgical Effect: At present, robotic adrenal surgery does not demonstrate a clear superiority over laparoscopic surgery in terms of surgical outcomes. In addition to losing the tactile feedback that laparoscopic surgery provides, robotic surgery also requires increased investment in surgical infrastructure and personnel support, with more complex demands. Consequently, medical professionals may not prioritize robotic surgery when selecting surgical methods. Therefore, Laparoscopy is still the mainstream of adrenalectomy, especially in developing countries. Laparoscopy has a variety of recognized benefits, but surgeons also need to overcome some specific drawbacks, including operator fatigue, poor quality laparoscopic instruments and preoperative two-dimensional imaging views [15, 16].

This study compared the perioperative results of retroperitoneal adrenalectomy using two different surgical methods. The results indicate that both methods of retroperitoneal laparoscopic surgery are equally safe and effective.There were no significant statistical differences in variables that may affect surgical outcomes, such as age, tumor size, tumor side and BMI between our two groups of patients, and the variables were well controlled. The surgical results showed that the IPFA group had more bleeding than the EPFA group. Through reviewing the surgical video, we found that the IPFA group was very prone to bleeding during the separation of the renal capsule and the perirenal fat sac, as the perirenal fat sac contained abundant blood vessels, which were inevitably damaged during the separation process, leading to more bleeding. This is similar to the research results of Constantinides and Christakis [17, 18]. In addition, the process of separating the the perirenal fat sac from renal capsule is carried out in a very narrow environment, and even experienced urologists may inevitably damage the renal capsule or even the renal parenchyma, which is also one of the reasons for more bleeding in the IPFA group. We also confirmed this in a comparative study of intraoperative complications, and the incidence of intraoperative renal cortex injury in the IPFA group was significantly higher than that in the EPFA group. In addition, our study shows a close correlation between bleeding volume and surgical time. The longer the surgical time, the more bleeding volume there is.

In addition, there was a significant difference in the average surgical time between the two groups of patients, with the EPFA group having a shorter surgical time, which is consistent with studies in other countries [19, 20]. Compared with traditional three-layer adrenal surgery, IPFA is an improvement, which only requires the separation of a layer between the perirenal adipose sac and the anterior fascia to effectively expose the adrenal gland. However, the IPFA surgical method sometimes requires cleaning up the extrafascial fat of Gerota, and the space between the perirenal fat capsule and the renal capsule is relatively narrow, making the separation process more difficult and lacking clear anatomical markers, requiring more time to search for adrenal tumors, thereby increasing the surgical time. Moreover, previous studies have shown that the IPFA group is more prone to bleeding and requires more time to stop bleeding, which also increases the surgical time for the IPFA group. Therefore, IPFA surgery is more difficult, requires higher technical requirements, and requires more surgical experience. The anatomical level of EPFA is in the avascular zone, with less intraoperative bleeding and clear anatomical landmarks, making it more suitable for beginners to learn. However, due to the need to separate the space between the peritoneal and the perirenal fat sac during EPFA surgery, it is more prone to peritoneal injury, leading to retroperitoneal space collapse, making it difficult for surgery to proceed further.

EPFA group spends less on hospitalization, but one should be vigilant about the occurrence of peritoneal rupture, which may make it difficult to proceed with the surgery. When deciding to use IPFA, it is necessary to use the Mayo score to evaluate the degree of perirenal adipose sac adhesion [21]. If the adhesion or stiffness of the perirenal adipose sac is severe, intraoperative complications such as renal capsule rupture and

renal parenchymal injury may occur. In IPFA surgery, if patients with thick perirenal fat are encountered, the arcuate ligament can be selected as an anatomical marker to effectively determine the position of the kidney and improve the efficiency and safety of perirenal fat separation [22]. In addition, another issue to consider when using IPFA is that if the affected kidney later develops into a kidney tumor or other kidney disease that requires surgery, the next surgery will be very difficult. When doctors decide which method is more suitable for patients, the characteristics of perirenal fat are the most important considerations.

In the final clinical diagnosis of all patients, 37 patients had non-functional adrenal adenoma, 247 patients had functional adrenal adenoma. The most common pathological types of adrenal tumors in both groups are adrenal cortex adenoma, which is consistent with other national research findings [23, 24]. Most patients with adrenal tumors often have abnormal and complex endocrine manifestations. All patients in our study received preoperative endocrinological advice. Some patients with hypertension, hypokalemia and diabetes underwent bilateral adrenal venous blood sampling in the endocrine department to identify functional tumors. We believe that multidisciplinary collaboration is necessary in preoperative preparation and long-term follow-up, and strongly recommend that urologists and endocrinologists fully discuss the preoperative evaluation of patients to ensure patient safety. This study is a retrospective analysis, including only patients with adrenal disease who have attended our department in the last 5 years. The region is relatively unique and there is a lack of long-term postoperative follow-up work. Additionally, this study did not evaluate other important outcome variables such as patients'postoperative pain management, treatment satisfaction, etc. And, our study was based on the cases of two different surgeons, and individual differences between surgeons may also affect the results of the study.In future clinical research, we need to design better experimental schemes,such as prospective studies, to overcome these limitations and explore this area with more compelling data.

In summary, whether using IPFA or EPFA, retroperitoneal laparoscopic adrenalectomy is a safe and effective surgical method. IPFA causes more bleeding and takes longer than EPFA, making it more prone to kidney injury and bleeding. EPFA is more likely to damage the posterior peritoneum, making it difficult for surgery to proceed further. Based on the characteristics of adrenal tumors, the nature of perirenal fat, and the surgical experience of the chief surgeon, a relatively suitable surgical method need to be selected to better complete the operation, benefit patients.

Abbreviations

IPFA Intra perinephric fat approach
EPFA Extra perinephric fat approach

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Authors' contributions
Qi Tan:Conception and design of study,Acquisition of data,Analysis and interpretation of data,Drafting the manuscript,Revising the manuscript Fan Lin:Software,Acquisition of data,Analysis and interpretation of data Yunfeng He:Data curation,Revising the manuscript Shengjun Luo:Formal analysis,Supervision,Project administration,Revising the manuscript.

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Data availability
All experimental data can be provided by the corresponding author.

Declarations

Ethics approval and consent to participate
Our study was submitted to, and approved by, Ethics Committee of Chongqing Medical University,and informed consent to participate was obtained from all of the participants in the study.

Consent for publication
All authors agree to publish our manuscript in BMC urology.

Competing Interests
The authors declare no competing interests.

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