Comparison between Retroperitoneal Laparoscopic Nephrectomy and Traditional Open Nephrectomy to Treat Polycystic Kidney Disease before Kidney Transplantation

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Purpose: To compare the efficiency and safety between retroperitoneal laparoscopic nephrectomy and traditional open nephrectomy to treat autosomal-dominant polycystic kidney disease before kidney transplantation.

Materials and Methods: A total of 57 patients diagnosed with huge autosomal-dominant polycystic kidney disease between 2000 and 2020 at our center were included in this study. Patients were divided into a retroperitoneal laparoscopic (RL; n=23) group and traditional open (TO; n = 34) group. We retrospectively analyzed and compared preoperative and perioperative variables between the two groups.

Results: Patients in the RL group showed a longer operation time (201.09±83.76min) compared to patients in the TO group (113.38 ± 51.84min, $p < 0.001$). The RL group also showed significantly less intraoperative blood loss ($p = 0.025$) and less intraoperative blood transfusion volume ($p = 0.016$) compared to the TO group. Meanwhile, time of gastrointestinal function recovery, bed leave, catheter indwelling and postoperative hospitalization in the RL group were 2.13 ± 0.63, 1.30 ± 1.0, 5.22 ± 2.09, 7.35±2.48 days, respectively, which were significantly shorter than the TO group ($p < 0.05$). Pain degree of patients during the first 48 hours after operation was similar between the RL and TO groups, but the opioid use percentage in the RL group was 8.70% (2/23) and was lower than the 26.47% (9/34) in the TO group ($p = 0.022$). Meanwhile, 5 and 23 patients exhibited postoperative complications in the RL and TO groups, respectively ($p < 0.001$).

Conclusion: Both retroperitoneal laparoscopic nephrectomy and traditional open surgery are feasible to treat huge polycystic nephrectomy. However, patients who undergo retroperitoneal laparoscopic nephrectomy experience higher levels of safety and recover more rapidly.

Keywords: nephrectomy; laparoscopy; polycystic kidney; urology; kidney transplantation.

INTRODUCTION

Autosomal-dominant polycystic kidney disease (ADPKD) is caused by mutations in either the PKD1 or PKD2 genes. ADPKD is the most common hereditary renal disease worldwide, where nearly 70% of patients diagnosed with this disease progress to end-stage renal disease.[1,2] Nephrectomy is the most common treatment used to treat ADPKD, specifically for patients experiencing infection, or bleeding after an impact. Also, nephrectomy is used to treat ADPKD patients who do not exhibit symptoms but to prepare for transplantation. Previous work revealed that both retroperitoneal and transperitoneal laparoscopic methods as well as traditional open surgery are feasible to perform a nephrectomy. However, the retroperitoneal approach (RPA) was shown to be superior to the transperitoneal approach (TPA), where patients showed lower pain intensity and experienced a shorter time and hospitalization after retroperitoneal organ operation.[3,4] Therefore, patients would have a better condition before transplantation that might cause fewer complications after transplantation. Compared to TPA, RPA accesses the kidney directly and rapidly without influencing intraperitoneal organs.[5-7]) Since the retroperitoneal approach efficiently reduces injury of abdominal organs, most centers in China choose RPA as the preferred surgical treatment for ADPKD.[8] To our knowledge, this is the first study comparing the efficiency and safety between RPA and open surgery for the management of polycystic kidneys.

Here, we expanded to postoperative variables not included in other studies and aimed to evaluate and compare the efficiency and safety of clinical protocols for giant polycystic kidneys treated with RPA and open nephrectomy.

MATERIALS AND METHODS

Clinical data was retrospectively analyzed for 57 patients who underwent nephrectomy for huge polycystic kidneys from 2000 to 2020. Due to different surgery approaches, all patients were divided into a RL group (n = 23) or a TO group (n = 34). In the RP group, patients received retroperitoneal laparoscopic nephrectomy. In the TO group, open surgery was performed. All clinical data were collected from medical records, including patient age, sex, BMI, hypertension, diabetes mellitus, total kidney volume preoperatively measured by ultra-

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Table 1. Preoperative patient characteristics

Variables	RL Group (N=23)	TO Group (N=34)	*P* Value
Age, year; mean ± SD	51.78 ± 9.45	47.53 ± 6.92	0.060
Gender, male; N	14 (60.9%)	22 (64.7%)	0.768
BMI, kg/m2; mean ± SD	23.80 ± 2.89	24.64 ± 3.03	0.357
Hypertension, N	21 (91.3%)	29 (85.3%)	0.689
Diabetes, N	2 (8.7%)	1 (2.9%)	0.559
Maximum diameter of kidney, cm; median (IQR)	19.00 (17.00-20.00)	19.00 (15.75-22.00)	0.549
Dialysis, N	22 (95.7%)	29 (85.3%) 0.385	
Serum creatinine level, mg/dL; mean ± SD	694.47 ± 287.84	582.82 ± 318.75	0.186
Hemoglobin, g/L; mean ± SD	96.30 ± 17.52	106.85 ± 22.14	0.062
ASA grade; N (%)			0.175
II	3 (13.0%)	5 (14.7%)	
III	20 (87.0%)	22 (64.7)	
IV	0 (0.0%)	7 (20.6%)	
Reason for nephrectomy; N (%)		0.290	
Transplantation preparation	20 (87.0%)	23 (67.6%)	
Cyst infection	2 (8.7%)	9 (26.5%)	
Cyst rupture	2 (8.7%)	3 (8.2%)	

BMI: body mass index; ASA: American Society of Anesthesiologists

sound, serum creatinine levels and hemoglobin (HB) 2 days before the operation and reason for nephrectomy. We also collected and compared perioperative variables between two groups, including ASA grade, operation time, blood loss during surgery, percentage of re-operation, intraoperative and postoperative drainage volume, type of dialysis after the operation, patient HB levels during the first 24 hours after the operation, postoperative pain degree in the first 48 hours measured by visual analog scale scores, use of Opioids, complications related to the operation (assessed by the Clavien-Dindo scoring system), time of gastrointestinal recovery, catheter indwelling, bed resting and postoperative hospitalization.

In our study, ADPKD patients with urologic carcinoma or calculi were excluded and those with a history of previous abdominal surgeries or trauma were also not included in this study. Patients with simultaneous bilateral nephrectomy were also excluded in this study. In the RL group, patients were placed in a folding knife position and received general anesthesia. The placement of four trocars is shown in Figure 1, where a 10 mm trocar was placed at A trocar site three centimeters above the iliac crest on midaxillary line. A 12 mm trocar was placed at B site at the intersection of the costal margin and posterior axillary line. Two trocars both 5 mm in diameter were placed at C and D sites at the intersection between the subcostal margin or a point three centimeters above the iliac crest and anterior axillary line. During the operation, carbon dioxide pneumoperitoneum pressure remained at 12 mmHg. First, we use an ultrasonic scalpel to separate the kidney from the surrounding tissue and puncture the cysts on the back of the kidney to enlarge the operative field. If renal hilum vessels were still difficult to observe, ventral cysts were also punctured by ultrasonic scalpel to reduce operation complications. After locating and dissociating the renal artery and vein, both were sutured using Hem-o-lock. Furthermore, the ureter was clipped and cut when visualized. When the kidney was completely removed, it was inserted into an entrapment bag and enlarged at the C trocar site to 10 cm or longer, which was sufficient for the specimen to pass (**Figure 2**). Lastly, the retroperitoneal space was flushed, and 1 or 2 drains were remained.

In the TO group, all patients received general anesthesia and were positioned in the lateral position. The upper body was positioned horizontally and the lower body was folded at a 30°angle before disinfection. A 20 cm incision under the 12th rib was made without modification during surgery. After exposing the kidney by pushing abdominal organs, large cysts were punctured to expand the operative field. Open nephrectomy was performed using a standard procedure and the main vessels were clipped using Hem-o-lock. After carefully flushing, 1 or 2 drainage tubes were placed based on the intraoperative exudation and bleeding.

Table 2. Surgical outcomes for patients in RL and TO groups

	RL Group (n = 23)	TO Group (n=34)	*P* Value
Operation time, minute; median (IQR)	210.00 (130.00-250.00)	92.50 (83.75-130.00)	< 0.001
Intraoperative blood loss, ml; median (IQR)	100.00 (100.00-200.00)	400.00 (400.00-600.00)	0.025
Intraoperative transfusion, ml; mean ± SD	175.65 ± 392.24	489.41±513.51	0.016
Postoperative transfusion; N	2 (8.7%)	1 (2.9%)	> 0.999
Postoperative hemoglobin, g/L; mean ± SD	87.83 ± 13.52	95.39±18.89	0.109
Postoperative hospitalization time, day; median (IQR)	7.00 (6.00-8.00)	13.50 (9.00-20.50)	< 0.001
Gastrointestinal function recovery time, day; median (IQR)	2.00 (2.00-3.00)	3.00 (3.00-3.25)	< 0.001
Bed resting time, day; median (IQR)	1.00 (1.00-1.00)	2.00 (2.00-2.00)	0.003
Drainage indwelling time, day; median (IQR)	5.00 (4.00-6.00)	6.00 (5.00-8.00)	0.028
Pain degree; mean ± SD	2.80 ± 1.10	3.11±1.02	0.559
Use of Opioids; N	2 (8.7%)	12 (35.3%)	0.022
Clavien-Dindo scoring system; N	5 (21.7%)	23 (67.6%)	< 0.001
I	3 (13.0%)	7 (20.6%)	
II	1 (4.3%)	15 (44.1%)	
III	1 (4.3%)	1 (2.9%)	
IV	-	- -	
V	-	- -	
Converted to open surgery; N	2	-	-

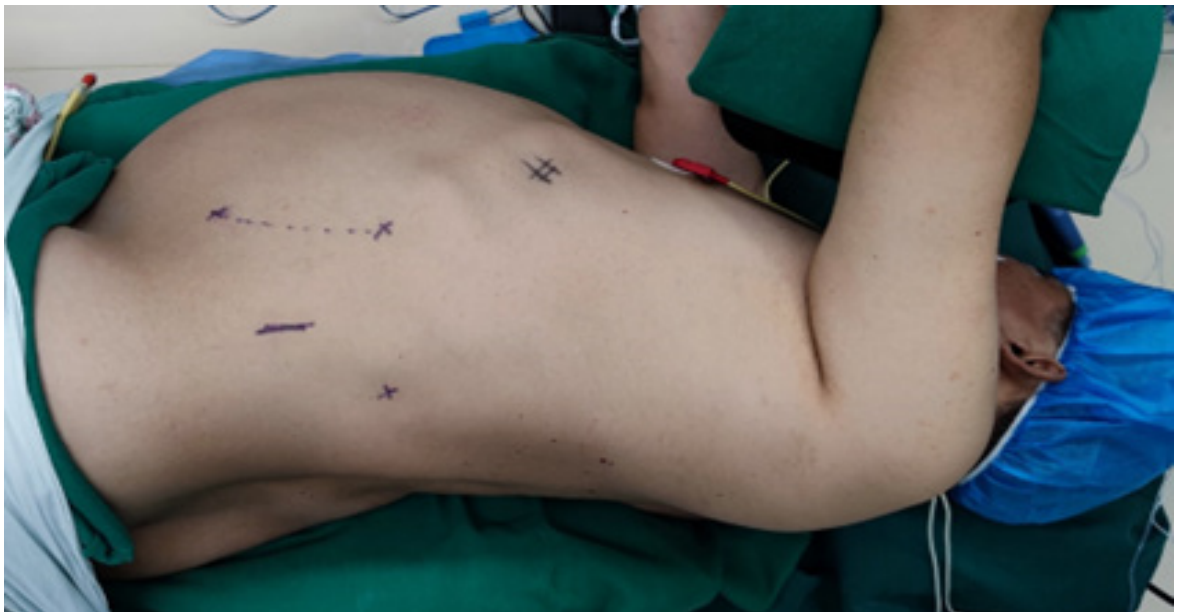

Figure 1. The placement of four trocars for every patients in RL group.

Categorical variables were compared using the Fisher's exact test or chi-square test and are presented as numbers and percentages. Continuous variables with normal distributions were compared with the t-test and are presented as the mean±standard deviation, while continuous variables with non-normal distributions are presented as the median and interquartile range. The Kolmogorov-Smirnov test was used to assess the normality of the distribution of continuous variables. $P \leq 0.05$ was considered as statistically significant.

RESULTS

The difference in the time distribution of patients between the two groups is shown in Figure 3. The mean age in the RL and TO groups was 51.78 ± 9.45 and 47.53 ± 6.92 years (P = .055), respectively. The maximum diameter of the kidney was 18.83 ± 2.49cm in the RL group and 19.47 ± 5.05cm in the TO group (P = .549). Meanwhile, all other preoperative data showed no statistically significant differences. The highest ASA score for patients in both cohorts was 3 and the most common reason for nephrectomy was for transplantation. There were 4 (17.4%) patients in the RL group and 12 (35.3%) patients in the TO group(p = 0.129) that had an indication for nephrectomy due to a hemorrhage or cyst infection (**Table 1**).

The mean operation time for the RL group was 201.09 ± 83.76 min, which was much longer than the 113.38 ± 51.84 min(P < .001) for the TO group. During surgery, the volume of blood loss and transfusion in the RL group were 316.52 ± 508.16 ml and 175.65 ± 392.24 ml, lower than the 594.12 ± 399.96ml (P = .025) and 489.41 ± 513.51 ml (P = .016) for the TO group, respectively. However, two patients in the RL group had a blood transfusion after the operation, which was more than one patient in the TO group, but this was not sta-

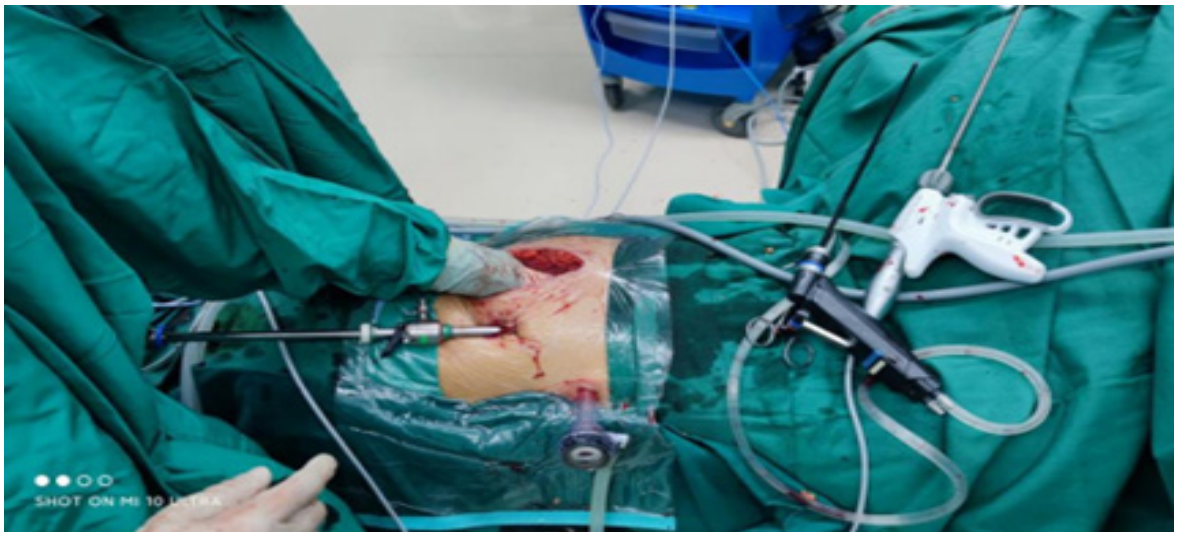

Figure 2. Enlarged C site to 10cm so that surgeon could reach his hand to take the specimen out.

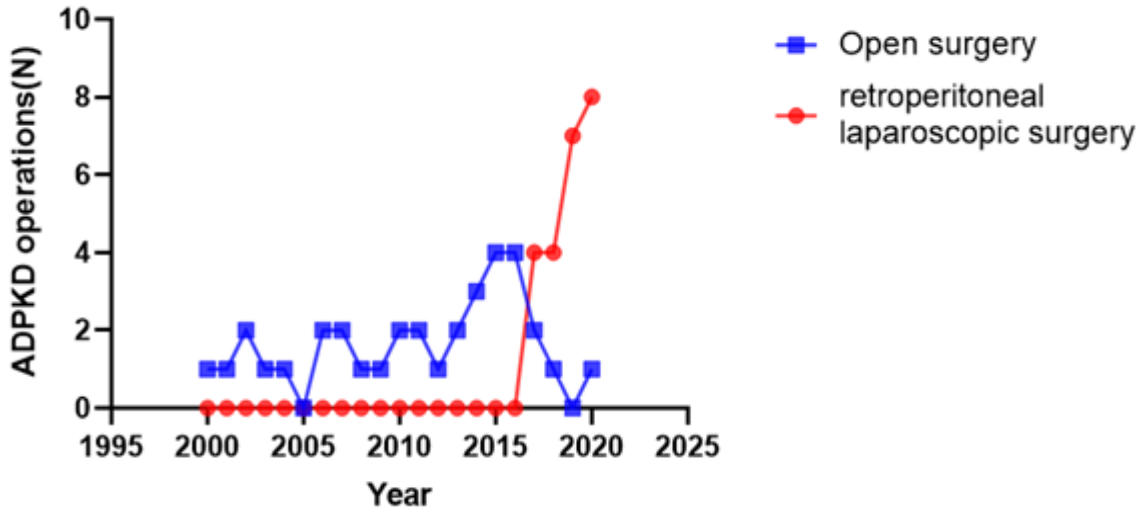

Figure 3. The difference in the time distribution of patients between the two groups

tistically significant (P = .148). Meanwhile, all cases in both groups were successful, while two patients in the RL group received open surgery due to extreme adhesion to the perirenal fascia and surrounding adipose tissues.

Patients in the RL group expressed a similar level of pain to patients in the TO group based on the visual analog scale scores during the first 24 hours after nephrectomy. The percent of patietns who use opioids during hospitalization in the RL group was 8.70% (2/23), which was significantly lower than the 26.47% (9/34) in the TO group (P = .022). HB was tested in each patient after the first 24 hours of the surgery and no statistically significant differences were observed between the two groups(p = 0.109). Compared with the TO group, patients in the RL group showed lower gastrointestinal function recovery time (P < .001), bed resting time (P = .008), catheter indwelling time (p = 0.014) and time of postoperative hospitalization (P < .001). Operation-related complications measured by the Clavien-Dindo scoring system indicated that 5 patients in the RL group and 23 in the TO group (P < .001) had an infection, pain or diarrhea, all of which were lower than grade 3. Surgical outcomes of both groups are shown in **Table 2**.

DISCUSSION

ADPKD is a common cause of end-stage kidney disease and patients usually accept nephrectomy to prepare for transplantation or due to unbearable symptoms.[8] Symptoms of low back pain caused by localized cyst compression; bleeding from renal cysts, recurrent infections; preparing the place for kidney transplantation is the indication for removal of polycystic kidney in our center, and it was similar as the other centers. We do not perform surgery when we believe the patient can be treated conservatively to avoid greater injury. In past decades, traditional open nephrectomy was seen as a preferred strategy for patients who did not respond to conservative therapies.[9] Compared with open surgery, the laparoscopic procedure evolved nephrectomy by contributing to fewer complications and invasiveness.[10,11] Thus, laparoscopic nephrectomy is used in most centers to manage ADPKD. Laparoscopic procedures can be performed using transperitoneal or retroperitoneal approaches and both have advantages and disadvantages. In transperitoneal approaches, the operative space is larger and surgeons are more familiar with preperitoneal anatomy.[3] To reach the kidney, most intestines should be removed which may cause irritation and additional injury.[8,11] Even though retroperitoneal nephrectomy allows for a smaller operative field, abdominal adhesion and other complications are less likely due to the fact that this approach does not influence intraperitoneal contents compared with the transperitoneal process.[12] Meanwhile, the retroperitoneal approach also provides an easy and direct way to the renal hilum.[13] Thus, most clinical centers in China choose the retroperitoneal approach and already showed it is an effective way to manage most kidney disease patients.[5,12,13] However, to our knowledge, most previous studies focused on the management of transperitoneal approaches and did not mention retroperitoneal nephrectomy for ADPKD treatment.[14] In addition, cyst decortication of polycystic kidneys for the purpose of preparing space for kidney transplantation has also been suggested in recent studies.[15] In this study, we compared the effectiveness and safety between the retroperitoneal laparoscopic approach and traditional open nephrectomy to manage patients with polycystic kidneys. As shown in our study, the operation time for the RL group was significantly longer than the TO group. Similarly, previous studies also reported a similar result for different kidney diseases including: ADPKD, carcinoma and donor nephrectomy.[10,16,17] One explanation may be the preoperative placement of the laparoscope and incision extension to remove the kidney. But time spent on these procedures was not obviously improved. Thibaut et al[17] reported that longer operation time in the retroperitoneal group may be related to the experience of the surgeon, patient anatomic variation and in-

dividual details. Meanwhile, other studies[13,18] showed the presence of a learning curve for retroperitoneal laparoscopic surgeries. These studies showed that surgeons who performed over 10 procedures performed shorter operation times. However, in our retrospective study, every surgeon had a great deal of experience in both retroperitoneal laparoscopic and open nephrectomy procedures for the treatment of ADPKD. Thus, in this study, the operation time for the RL group was similar between patients and there was no significant difference in the learning curve. Another reason for longer operation times observed for the RL group may be the small retroperitoneal working space where surgeons deal with frequent adhesions between perirenal tissues and cysts. The main reason for this was surgeons had to spend more time piercing cysts and aspirating fluid to expand the operative field. With the improvement of laparoscopic skills and familiarity with retroperitoneal anatomy, the operation time can be reduced.

In this study, intraoperative blood loss and transfusion volume for the RL group were both statistically lower than what was observed for the TO group. Wei et al.[18] mentioned a similar result for retroperitoneoscopic adrenalectomy in pheochromocytoma cases. This may be explained by less movement of the intestine and fewer invasion of capillaries in the RL group. However, more patients in the TO group had cyst ruptures or infections before the operation. In patients who suffered from repeated infections or broken cysts, urologists chose open nephrectomy. Even though there was no statistically significant difference, intraoperative blood loss and transfusion volume in these patients were much higher than in patients who underwent nephrectomy due to transplantation preparation in both groups. Thus, surgeons should prepare fresh plasma before either approach, while paying attention to intraoperative adhesion and separation of renal hilum vessels. In contrast to other studies[10], patients in the RL group had similar HB levels compared with patients in the TO group within 24 hours after operation. This variable may be influenced by individual HB levels before surgery as well as intraoperative transfusion. In our opinion, timely and sufficient hemostasis, proper intraoperative transfusions, and hemorrhage checks before suturing are significant measures to reduce postoperative transfusions despite the protocol chosen. Consistent with previous work investigating urologic surgeries[19-21], we found that pain degree during the first 24 hours after the operation was similar for both groups, but the percent of Opioid use was lower in the RL group. Meanwhile, postoperative bedrest, gastrointestinal recovery and drainage indwelling were all significantly shorter in the RL group. This demonstrates that polycystic kidney patients who undergo RPA relieve long-term pain after nephrectomy and show a quicker postoperative recovery compared with patients receiving traditional open nephrectomy. Previous studies demonstrated that less pain after operation supported more rapid gastrointestinal recovery.[22] Meanwhile, another reason for this may be due to the low use of Opioids, which prevents medical inhibition of gastrointestinal peristalsis.[23] In addition, the patients in our study who underwent open nephrectomy were mostly gathered before 2012 and bed resting time and eating time after surgery were both improved after 2012. This may also be a contributing factor to the longer operation time observed for the TO groups.

Previous studies also showed that, during open nephrectomy, abdominal organs had to be dragged to the opposite side to expose the kidney, which may lead to compression of intestinal vessels, ischemia-reperfusion injury and delayed function recovery after operation.[19,21] TO group has a significantly longer postoperative hospitalization time. The TO group was about twice as long as the RL group. The bed rest time and drain retention time and gastrointestinal function recovery time were longer in the TO group as one of the reasons. In addition, we believe that the greater trauma of surgery and slower postoperative wound recovery in the RO group also contributed.

For postoperative complications, 23 patients in the TO group and 5 patients in the RL group experienced complications graded from one to three according to the Clavien-Dindo scoring system. The most frequent complication was infection followed by diarrhea and all these symptoms were treated. A study by Rikki et al.[20] included 850 patients who received pyelolithotomy and revealed that patients in the open group were five times more likely to experience postoperative complications compared with the laparoscopic group. These observations suggest that retroperitoneal laparoscopic nephrectomy improves the safety and reduces complications for polycystic kidney patients compared with traditional open approaches.

Despite these findings, there were still several limitations to this study. First, we retrospectively analyzed clinical data obtained during a 20-year period. Over such a long-time span, surgeons and techniques evolved, which may lead to result bias. However, through statistical analysis of preoperative epidemiological data and general status and other conditions of patients in the two groups, we found that there was no statistical difference between the TO group and the RL group, which also tried our best to reduce the selection bias. Second, operative strategy options were not randomized, and urologists tended to choose retroperitoneal laparoscopic nephrectomy instead of the open approach for patients with smaller kidney volumes and better general conditions. This may also influence the interpretation of the results.

CONCLUSIONS

Here, we demonstrated that both retroperitoneal laparoscopic and traditional open nephrectomy have the ability to effectively remove cysts from kidneys. Compared with open surgery, the retroperitoneal approach results in fewer intraoperative injuries with and less postoperative complications, despite its longer operation time. We suggest retroperitoneoscopic nephrectomy as a feasible option to manage of polycystic kidneys.

AVAILABILITY OF DATA AND MATERIALS

All data generated or analysed during this study are included in this published article

CONFLICT OF INTEREST

The authors declare that they have no competing interests.

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