Ther Adv Urol
2021, Vol. 13: 1–9
DOI: 10.1177/1756287220984046

Comparison of laparoscopic and hand-assisted laparoscopic nephrectomy for inflammatory renal disease: which is the preferred approach?

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Abstract

Aims: Management of inflammatory renal disease (IRD) can still be technically challenging for laparoscopic procedures. The aim of the present study was to compare the safety and feasibility of laparoscopic and hand-assisted laparoscopic nephrectomy in patients with IRD.

Patients and methods: We retrospectively analyzed the data of 107 patients who underwent laparoscopic nephrectomy (LN) and hand-assisted laparoscopic nephrectomy (HALN) for IRD from January 2008 to March 2020, including pyonephrosis, renal tuberculosis, hydronephrosis, and xanthogranulomatous pyelonephritis. Patient demographics, operative outcomes, and postoperative recovery and complications were compared between the LN and HALN groups. Multivariable logistic regression analysis was conducted to identify the independent predictors of adverse outcomes.

Results: Fifty-five subjects in the LN group and 52 subjects in the HALN group were enrolled in this study. In the LN group, laparoscopic nephrectomy was successfully performed in 50 patients (90.9%), while four (7.3%) patients were converted to HALN and one (1.8%) case was converted to open procedure. In HALN group, operations were completed in 51 (98.1%) patients and conversion to open surgery was necessary in one patient (1.9%). The LN group had a shorter median incision length (5 cm *versus* 7 cm, $p < 0.01$) but a longer median operative duration (140 min *versus* 105 min, $p < 0.01$) than the HALN group. There was no significant difference in blood loss, intraoperative complication rate, postoperative complication rate, recovery of bowel function, and hospital stay between the two groups. Multivariable logistic regression revealed that severe perinephric adhesions was an independent predictor of adverse outcomes.

Conclusion: Both LN and HALN appear to be safe and feasible for IRD. As a still minimally invasive approach, HALN provided an alternative to IRD or when conversion was needed in LN.

Keywords: hand-assisted, inflammatory renal disease, laparoscopic, nephrectomy

Received: 8 July 2020; revised manuscript accepted: 5 December 2020.

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Introduction

Laparoscopic nephrectomy has become the gold-standard procedure in both benign and malignant renal conditions requiring surgical removal since it was first introduced by Clayman *et al.* in 1991.[1] With the increasing experience of laparoscopic techniques, the indications of laparoscopic nephrectomy (LN) have been gradually extended to inflammatory renal disease (IRD), such as xanthogranulomatous pyelonephritis (XGPN), tuberculosis, hydronephrosis, pyelonephritis, and pyonephrosis. These certain conditions are often associated with marked chronic inflammation, dense adhesion, and anatomical disorganization, leading to higher complication rates and conversion rates in laparoscopic procedures.[2]

Also as a minimally invasive approach, hand-assisted laparoscopic nephrectomy (HALN) was first introduced in 1997 as a transition from open surgery to standard laparoscopic surgery.[3] Hand-assisted laparoscopic surgery might offer more convenience and possibilities in those challenging situations, as it can provide surgeons with the assistance of tactile feedback, effective dissection, and facilitated control of the renal hilar vessels.[4] Compared with standard laparoscopy, HALN has been reported to be associated with shorter operative time and higher safety, and has been considered a preferred alternative for IRD.[5] However, laparoscopic surgeons argued against HALN because it might lead to longer incision, more blood loss, delayed postoperative patient recovery, or higher perioperative complication.

Thus, when it comes to IRD, controversy still exists about the optimal surgical procedure. This present study is the first direct comparison of LN and HALN for IRD. The objective is to compare the perioperative safety and postoperative outcomes between the two approaches.

Patients and methods

Data were retrospectively reviewed from patients who underwent LN and HALN for inflammatory and infectious renal disease from January 2008 to March 2020. The demographic information [age, gender, body mass index (BMI), clinical symptoms, and type of infection], perioperative parameters (operative time, blood loss, incision length, intraoperative and postoperative complication rate, conversion rate, recovery time of bowel function, and duration of hospital stay) were collected and compared between LN and HALN groups. The two groups were roughly matched for gender, age, and disease components. The Clavien–Dindo classification system was used to evaluate the degree of postoperative complication.[6] Written informed consent was obtained from all participants and this study was approved by the local ethical committee of Shandong provincial hospital (SWYX: 2020-239).

All patients underwent routine physical and auxiliary examination before surgery. Abdominal ultrasonography and computed tomography urography was conducted to evaluate the anatomical details of the urinary tract. Differential renal function was assessed by 99mTc-DTPA (diethyltriamine pentaacetic acid) renal scan. In general, diseased kidney with differential function $<10\%$ or glomerular filtration rate <15 ml/min were taken as the indication criteria for nephrectomy. In addition, patients' signs and symptoms were taken into account for the indication of nephrectomy, such as recurrent urinary tract infection, severe flank pain, and repeated gross hematuria. Patients with acute infection due to urinary tract obstruction underwent percutaneous nephrostomy tube drainage with B-ultrasonic guidance until the inflammation was controlled (the procedure usually took 8–12 weeks). Patients with renal tuberculosis received an adequate anti-tuberculosis treatment in Shandong Provincial Tuberculosis Hospital before operation.

Operations were performed by two surgeons with extensive experience, LN by Shaobo Jiang and HALN by Xunbo Jin, respectively. All operations were performed *via* transperitoneal approach. We made a modification to the position of the hand port to facilitate the operation. The patient was placed in a lateral decubitus position with sufficient padding for the brachial plexus, knees, and ankles. The operating bed was flexed with an angle of 60° to achieve optimal exposure. For the right HALN, a 7-cm paraomphalic vertical incision was employed to place the hand-assist port (Figure 1). For the left HALN, an oblique hand port incision was made one finger breadth inferior to the costal margin (patients in the LN group underwent standard transperitoneal laparoscopic nephrectomy using 3–4 trocars as has been previously described[7]). We usually preferred to mobilize the kidney outside Gerota's fascia, which was similar to radical nephrectomy, in both LN and HALN procedures. However, in some cases with extensive adhesion between Gerota's fascia and adjacent viscera, subcapsular dissection was employed to avoid peripheral organ injury. The renal hilum was routinely divided en bloc using an endovascular stapler (45 mm staple line, Ethicon Endo-Surgery, USA). After the ureter was identified interior the lower pole of the kidney, the ureter was further dissected toward the renal pelvis, and then the kidney was lifted up from the underlying psoas muscle to expose the area posterior and inferior to the renal hilum. Subsequently, Gerota's fascia above the hilum was incised, dissecting the plane between adrenal gland and upper pole of the kidney, to ensure sufficient space around the pedicle and complete clamping under direct vision by the stapler. Sometimes, the inflammatory tissue or enlarged lymph node adhered densely around the renal hilum, preventing the renal pedicle from being

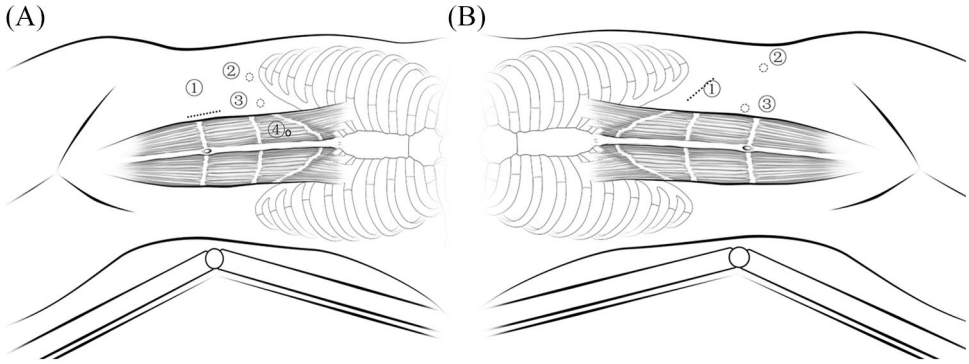

Figure 1. Hand port placement and trocar sites for hand-assisted laparoscopic radical nephrectomy (right-handed surgeon). (A) Right laparoscopic radical nephrectomy: ① hand port incision, ② 12 mm working port inferior to the costal margin at the midclavicular line, ③ 12 mm camera port interior to the first trocar beside the rectus abdominis, ④ 5-mm trocar just under the xiphoid for the liver retractor. (B) Left hand-assisted laparoscopic radical nephrectomy: ① hand port incision, ② 12 mm working port at the anterior axillary line at the level of the umbilicus, ③ 12 mm camera port at the lateral border of rectus muscle at the level of the umbilicus.

freed slim enough for stapler. In these situations, the renal pedicle was divided into two bundles using a blunt-ended stripping bar and then managed by endovascular stapler or Hem-o-lok (Teleflex Medical, Raleigh, NC, USA). In the end, the specimen was completely retrieved within a laparoscopic specimen bag *via* the hand port incision or through an extended subcostal port site in the LN group.

During the laparoscopic procedure, intraoperative findings, such as hemorrhage, visceral injury, presence of perinephric adhesions, were recorded. The degree of adhesion was identified as follows: no or mild adhesion, no marked adhesion or mild adhesion that could be readily separated using blunt dissection; severe adhesion, dense adhesion that should be separated using blunt or sharp dissection. Finally, factors including surgical method, age, renal size, laterality, BMI, and degree of adhesion were assessed for their correlation with adverse outcomes. All patients were followed up in the outpatient clinic at 1 month and 6 months postoperatively.

Statistical analyses were performed using SPSS software (version 21.0, SPSS, Chicago, IL, USA). We compared continuous variables between groups with the unpaired *t*-test (normal data) or Mann–Whitney test (non-normal data). Categorical variables were analyzed using the chi-squared test or Fisher's exact test. Multivariate logistic regression was used to determine factors for adverse outcomes. $p < 0.05$ was considered statistically significant.

Results

Between January 2008 and March 2020, 55 patients underwent LN and 52 patients underwent HALN for benign IRD. Patients' demographics and disease characteristics are displayed in Table 1. Most of the patients had recurrent clinical symptoms and proved to have severely damaged renal function. Pyonephrosis and hydronephrosis accounted for most indications in the LN (34.5% and 45.5%, respectively) and HALN (38.4% and 42.3%, respectively) groups. Patients presenting with pyonephrosis due to urinary tract obstruction were adequately treated with percutaneous nephrostomy drainage (15 cases in LN group and 17 cases in HALN group). There was no statistical difference between the two groups with respect to age, gender, laterality, and BMI. Composition and proportion of disease subtypes were comparable in the two groups.

In the LN group, laparoscopic nephrectomy was successfully completed in 50 patients, while four patients (one pyonephrosis, two renal tuberculosis, and one xanthogranulomatous pyelonephritis) were converted to hand-assisted laparoscopic procedures due to failure to progress and one patient (renal tuberculosis) were converted to open surgery due to injury of the vena cava. In the HALN group, conversion to open surgery was

Table 1. Patient demographics and disease characteristics.

Variable	LN *n* = 55	HALN *n* = 52	*p* value
Patient characteristics			
Gender, *n* (%)			
Male	21 (38.2)	20 (38.5)	0.97
Female	34 (61.8)	32 (61.5)	
Age, years			
Median (range)	53 (25–76)	48.5 (24–74)	0.69*
BMI, kg/m^2			
Median (range)	24.48 (18.01–29.34)	24.47 (18.34–32.15)	0.48†
Laterality, *n* (%)			
Right	27 (49.1)	29 (55.8)	0.81
Left	28 (50.9)	23 (44.2)	
Signs and symptoms, *n* (%)	45 (81.8)	43 (82.7)	
Fever	35 (63.6)	28 (53.8)	
Pain	22 (40)	12 (23.1)	
Urinary tract infection	19 (34.5)	8 (15.4)	
Nausea	11 (20)	3 (5.8)	
Hematuria	4 (7.3)	1 (1.9)	
Indications/pathology, *n* (%)			
Pyonephrosis	19 (34.5)	20 (38.4)	0.95
XGPN	3 (5.5)	2 (3.8)	
Renal tuberculosis	8 (14.5)	8 (15.4)	
Hydronephrosis	25 (45.5)	22 (42.3)	
Perinephric adhesions, *n* (%)			
Mild	24 (43.6)	21 (38.5)	0.73
Severe	31 (56.4)	31 (61.5)	

*Unpaired *t*-test.
†Mann–Whitney test.
BMI, body mass index; HALN, hand-assisted laparoscopic nephrectomy; LN, laparoscopic nephrectomy; XGPN, xanthogranulomatous pyelonephritis.

required in one patient of xanthogranulomatous pyelonephritis due to duodenal injury. Intraoperative data and postoperative outcomes are summarized in Table 2. Median operative time was significantly longer in the LN group compared with the HALN group (140 min *versus* 105 min, $p < 0.01$). The median length of incision for specimen retrieval was significantly shorter in the LN group (5 cm *versus* 7 cm, $p < 0.01$). The two groups were equivalent in terms of blood

Table 2. Operative and postoperative outcomes.

Variable	LN *n* = 55	HALN *n* = 42	*p* value
Operative characteristic			
Conversions, *n* (%)	5 (9.1)	1 (1.9)	0.21*
Estimated blood loss, mL)]			
Median (range)	55 (20–1800)‡	80 (20–1200)§	0.76†
Operation duration, min			
Median (range)	140 (95–245)‡	105 (75–185)§	<0.01†
Incision length, cm			
Median (range)	5 (3–9)‡	7 (6–9.5)§	<0.01†
Blood transfusion, *n* (%)	5 (9.1)‡	3 (5.8)§	0.72*
Postoperative characteristics			
Postoperative complications, *n* (%)			
No complications	38 (69.1)	32 (61.5)	0.86
Clavien grade I	14 (25.5)	16 (30.8)	
Clavien grade II	2 (3.6)	3 (5.8)	
Clavien grade IIIa	1 (1.8)	1 (1.9)	
Clavien grade IIIb	0	0	
Clavien grade IV–V	0	0	
Recovery to bowel function, days	1 (0.5–5)‡	1 (0.5–8)§	0.76†
Length of postoperative stay, days			
Median (range)	7 (5–15)‡	7 (5–36)§	0.65†

*Fisher's exact test.
†Mann–Whitney test.
‡Only in patients in whom LN was complete (*n* = 58).
§Only in patients in whom HALN was complete (*n* = 48).
HALN, hand-assisted laparoscopic nephrectomy; LN, laparoscopic nephrectomy.

loss, intraoperative complication rate, postoperative complication rate, time to recovery of bowel function, and duration of hospital stay.

During the operation, complications occurred in four patients (7.3%) in the LN group and three patients (5.8%) in the HALN group. In the LN group, one patient with inferior vena cava injury was converted to open surgery, one case of colon injury was managed by primary repair laparoscopically, and two cases of intraoperative diaphragm injury were managed by laparoscopic diaphragm patching with a closed thoracic drainage. Intraoperative complications were observed in three patients in the HALN group: one patient required conversion to open surgery for severe duodenal injury, one gonadal vein injury and one diaphragmatic injury were managed laparoscopically. The case involving conversion due to duodenal injury showed a longer hospital stay, of 36 days, while other patients with conversions had no significantly prolonged hospital stay.

Table 3. Multivariate logistic regression analysis for predictors of postoperative adverse outcomes.

Variable	OR (95% CI)	*p* value
BMI >25	0.925 (0.632–1.317)	0.541
Diabetes mellitus	1.065 (0.851–1.726)	0.345
Severe perinephric adhesion	6.271 (1.347–29.183)	0.019

BMI, body mass index; CI, confidence interval; OR, odds ratio.

Postoperative complications occurred in 17 patients (30.1%) in the LN group and 20 patients (38.5%) in the HALN group. All were minor complications including pain, fever, paralytic ileus, pneumonia, transient renal dysfunction, and thrombosis of lower extremity veins. All the complications were effectively managed and recovered smoothly.

When the final histopathologic specimens and surgery process were reviewed, most of the kidneys were involved in the inflammatory process, with a variable degree from mild to severe (Table 1). Overall, inflammatory reaction and adhesion were more severe in pyonephrosis (89.7%), renal tuberculosis (81.25%), and XGPN (100%) than those in hydronephrosis (19.1%). Subcapsular dissection was required (eight cases in LN group and five cases in HALN group, respectively) due to extensive adhesions between Gerota's fascia and adjacent viscera. Interestingly, patients with renal tuberculosis and XGPN represented mainly by perihilar adhesions, while dense adhesions were found predominantly on the surface of the renal parenchyma in patients with pyonephrosis. When surgery types, BMI, age, gender, diabetes mellitus, and severe perinephric adhesions were included in the multivariate analysis, only severe perinephric adhesions was identified as an independent risk factor for adverse outcomes including visceral injury, blood transfusion, and major complications (odds ratio: 6.271, 95% confidence interval: 1.347–29.183) (Table 3).

Discussion

IRD is a group of chronic inflammatory disorders involving the renal parenchyma and adjacent structures. The most common causes include hydronephrosis, pyelonephritis, pyonephrosis, XGPN, and tuberculosis.[8] IRD evolving into non-functioning kidney requires nephrectomy to remove the source of infection and relieve related symptoms. Chronic inflammation and infection may result in severe perinephric and perihilar fibrosis, making LN a difficult task with high risk of complications and high conversion rate to open surgery, as well as increased risk of injury to adjacent organs. Although the laparoscopic approach offered many advantages of shorter hospital stay, shorter time to ambulation, and quicker recovery to daily life activities,[9] LN has been considered a relative contraindication in its early era.[10] However, with accumulated laparoscopic experience and modified skills, numerous recent reports have shown encouraging surgical results of reduced complication rates and conversion rates.[7,11,12]

HALN has been demonstrated to be a safe and feasible alternative treatment for IRD. While retaining the advantages of minimally invasive surgery, the hand-assisted approach also offers tactile feedback and facilitates dissection and retraction.[13] In cases with dense perinephric adhesions, surgeons could use their fingers for tactile sensation, blunt dissection, and retracting surrounding structures, so as to avoid the damage to adjacent organs and reduce the conversion rate to open surgery. During hilar dissection with severe perihilar adhesions or lymph node enlargement, this approach may enable direct palpation of renal artery and early control of the renal pedicle. Additionally, when the laparoscopic procedure fails to progress because of extensive adhesions or uncontrollable complications, HALN is a better option worth considering instead of open surgery.

It is still controversial which of the two approaches is the better choice for IRD. Proponents of LN argued that HALN was associated with more blood loss, longer incision length, and delayed postoperative recovery, while supporters of HALN believed that this procedure had shorter operative duration and comparable postoperative parameters, and, most importantly, could avoid unnecessary conversion to open surgery.[14] In this present study, the two groups did not have a statistically significant difference in terms of blood loss, time to recovery of bowel function, and duration of hospital stay. Compared with the HALN group, the incision length in the LN group was shorter, but the operative time was significantly longer.

The main advantages of HALN were shorter operative time and facilitating progress in complicated conditions compared with LN, which has been reported by previous studies.[14] In this present study, the HALN group had a median operative time of 118 min, which was significantly shorter than that of the LN group (140 min). Possible reasons may be related to the superiority of HALN in lysis of adhesions and management of the renal hilum.

However, HALN showed a longer length of incision compared with LN, which might lead to more abdominal pain and delayed postoperative recovery. The median incision length was 7 cm in the HALN group and 5 cm in the LN group in the present study. Although the involved kidney often had a large volume, the atrophic renal parenchyma usually could be compressed in the specimen bag and retrieved through a slightly prolonged trocar incision. Nevertheless, there were no significant differences with respect to the time to recovery of bowel function and duration of hospital stay between the two groups. Similar results have been reported previously.[15]

The overall conversion rate was higher in the LN group than that in the HALN group (9.1% *versus* 1.9%, $p = 0.21$); however, the difference was not statistically significant. The hand-assisted procedure has been shown to minimize the need for open conversion while preserving minimally invasive features.[16] On the other hand, HALN provided an alternative when conversion was required in LN due to failure to continue or uncontrolled complication. In this present study, four patients in the LN group were converted to HALN: three cases for dense adhesions between kidney and adjacent structures and one case for bulky renal pedicle. With the help of intra-abdominal hand, these aforesaid conditions could be resolved without conversion to open surgery. More recently, Ma *et al.*[7] reported 33 patients who underwent LN for IRD with an overall conversion rate of 12.1%. Among them, three cases were converted to hand-assisted laparoscopy and one case was converted to open procedure. However, Arvind *et al.* did not use this technique when conversion was needed in LN because of the expensive hand port equipment.[11] Nevertheless, the domestic hand port device (Beijing Kadi Technology Company, China) we used costs only US$112 per person and showed a high cost-effectiveness. Thus, we tended to consider HALN as the first option of conversion when severe inflammation precluded progression.

The incidence of intraoperative and postoperative complication was comparable between the two groups in our study. In the LN group, intraoperative complications occurred in four patients (7.3%), including one inferior vena cava injury, one colon injury, and two diaphragm injuries. In the HALN group, three cases (5.8%) of intraoperative complications were seen: one severe duodenal injury, one gonadal vein injury, and one diaphragmatic injury. Most of the intraoperative complications were associated with structure laceration and vessel injury due to tenacious adhesions during adhesiolysis. It should be noted that blunt dissection of intra-abdominal hand could allow the procedure to continue most of the time in laparoscopic surgeries with failure to progress; however, sometimes it also may lead to severe tissue laceration that is hard to repair. Thus, the dissection should follow the anatomical plane and be as gentle as possible to avoid rough traction.

A number of technique modifications for LN and HALN in inflammatory conditions have been reported to make the procedures safer and easier. We made a modification to the position of the hand port device and trocar sites to facilitate the operation. Compared with conventional HALN, the overall position of hand port incision was nearer to the upper abdomen, which allows the intra-abdominal hand to be closer to the renal hilum, better control of the renal pedicle, and effective dissection of the upper and dorsal part of the kidney. Generally, we tend to choose a subcostal incision for the hand port device, which is considered to be associated with lower probability of incisional hernia compared with midline incision or Gibson incision. Furthermore, the secluded upper abdominal incision provides a better cosmetic effect, especially for young women.

When it comes to the selection of anatomic plane in IRD, both subcapsular and extracapsular approaches have been described. Kapoor *et al.* preferred to use subcapsular dissection in a series of XGPN, and reported a success rate of 80%.[17] On the other hand, Arvind *et al.*[11] recommended mobilizing the kidney outside Gerota's fascia to keep the anatomical plane. In the present study, we routinely mobilized the kidney outside Gerota's fascia in both LN and HALN procedures, to avoid dissecting the

perinephric adhesion. Most of the dissections could be completed outside Gerota's fascia apart from a few patients with dense adhesion. In these situations, dissection should be attempted below the Gerota's fascia using blunt or sharp dissection. However, in order to reserve the adrenal gland, we applied the subcapsular approach in the upper pole of the kidney, also minimizing the possibility of injury to splenic the vessel and diaphragm.

The dissection of the renal hilum is a key step for both LN and HALN. However, management of the renal hilum in IRD sometimes can be more challenging due to serious perihilar fibrosis and inflammation. *En bloc* stapling of the renal hilum allows a less sophisticated dissection of the hilar structures and may lead to decreased operative duration and reduced vascular injury. Several series so far have demonstrated *en bloc* stapling of the renal hilum as an efficient, effective, and safe method without risk of postoperative arteriovenous fistula (AVF) formation.[18,19] In the present series, *en bloc* stapling was employed to divide the renal pedicle for both LN and HALN approaches. The renal pedicle, of course, should be freed slim enough to ensure complete clamping by the stapler. Sometimes, especially in patients of XGPN or tuberculosis, the inflammatory tissue or enlarged lymph node adhered densely around the renal hilum. In these situations, we usually divided the renal hilum into two bundles using a blunt-ended stripping bar and then ligated them with endovascular stapler or Hem-o-lok respectively. No conversion to open surgery was needed due to uncontrolled renal vessels. Postoperative follow-up revealed no clinical or radiographic evidence of AVF.

The best approach for IRD remains controversial. Owing to the complexity and diversity of IRD, we should adopt personalized operative strategies according to the characteristic of kidney, surgeon's experience, and intraoperative situation: LN or HALN, transperitoneal or retroperitoneal approach, dissection outside or below Gerota's fascia, *en bloc* stapling or separated ligation of the renal hilum. We tend to recommend LN as the first choice in routine inflammatory conditions. However, when extensive perinephric infiltration or complex perihilar conditions are suggested by preoperative computed tomography, HALN may be a safe and feasible option. When laparoscopic procedure is unable to progress due to dense adhesions or uncontrolled complications, HALN can be considered as an alternative instead of open surgery.

We acknowledge that this study had several limitations. The major limitation was that this study was a non-randomized and retrospective study. Additionally, the selection criteria of surgical procedure were not predetermined but mainly depended on the surgeon's own preference as a result of his expertise and training. Finally, postoperative pain score and time to return to normal activities were not evaluated because of the retrospective nature of this study; we used recovery of bowel function and duration of hospital stay to assess the postoperative recovery of patients between the two groups.

Conclusion

For laparoscopic surgeons with extensive experience, both LN and HALN appear to be safe and feasible in patients with IRD. Personalized operative strategies should be adopted owing to the complexity and diversity of IRD. As a still minimally invasive approach, HALN provides an alternative for complicated IRD or when conversion is needed in LN.

Author Contributions

Xudong Guo and Hanbo Wang were involved in the study design, data collection and analysis, follow up, and prepared the draft and the final manuscript. Yuzhu Xiang was involved in the data collection and analysis. Xunbo Jin and Shaobo Jiang played critical roles in the study design, data analysis, and manuscript preparation. All the authors have read and approved the final manuscript.

Conflict of interest statement

The authors declare that there is no conflict of interest.

Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

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