
Meta-analysis of the Complications of Laparoscopic Renal Surgery: Comparison of Procedures and Techniques

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Purpose: We performed a meta-analysis of the literature to define the current expectations of complications during laparoscopic renal surgery.

Materials and Methods: References were searched in the MEDLINE database from 1995 to 2004 using the terms complications and laparoscopic nephrectomy. Inclusion criteria were any series with greater than 20 cases, patient age older than 16 years and any complications listed for certain procedures, including laparoscopic radical nephrectomy, HA laparoscopic radical nephrectomy, LPN, HALPN, laparoscopic donor nephrectomy, HA laparoscopic donor nephrectomy, laparoscopic simple nephrectomy, laparoscopic nephroureterectomy and retroperitoneal laparoscopic nephrectomy. A data extraction form was created to categorize major or minor complications. A 5 member panel adhered to the strict criteria and extracted data from articles that met inclusion criteria. Data were entered into a spreadsheet and a meta-analysis was performed.

Results: Initial review identified 73 of 405 references that were acceptable for retrieval and data extraction, of which 56 met inclusion criteria. The overall major and minor complication rates of laparoscopic renal surgery were 9.5% and 1.9%, respectively. There was a significant difference between the major complication rates of LPN and HALPN (21.0% vs 3.3%, $p < 0.05$).

Conclusions: Our results show that patients who undergo laparoscopic renal surgery may have an overall major complication rate of 9.5%. The highest major complication rate is associated with technically challenging LPN (21%). There appears to be a significantly higher wound complication rate associated with HA surgery in comparison to that of standard laparoscopy (1.9% vs 0.2%, $p < 0.05$).

Key Words: kidney, intraoperative complications, laparoscopy, nephrectomy, meta-analysis

Since the introduction of the laparoscopic nephrectomy in 1991 by Clayman et al,¹ laparoscopy has become the standard approach for most extirpative renal surgery. Contributing significantly to its acceptance has been the advancement in surgical instrumentation and technology as well as the use of hand assistance during surgery.² The role of laparoscopic renal surgery has continued to evolve in the last decade with applications toward more reconstructive-type procedures, such as partial nephrectomy and pyeloplasty. Ultimately aside from efficacy the durability of a surgical procedure is based on its safety, as defined by reported complications. Recently several laparoscopic series reports have been published defining results and complication rates. To amalgamate the surfeit of information from the various series we performed a meta-analysis of the literature to better define the most current expectations for complications during extirpative laparoscopic renal surgery. We defined specific complication rates associated with the

various laparoscopic renal procedures to provide accurate information with which to counsel patients before laparoscopic surgery.

MATERIALS AND METHODS

References were searched in the MEDLINE database from 1995 to 2004 using the terms complications and laparoscopic nephrectomy. Inclusion criteria were any series with greater than 20 patients, patient age older than 16 years and any complications listed for certain procedures, including LRN, HALRN, LPN, HALPN, LDN, HALDN, LSN, LNU and RLN.

A DES was created that included a cover page and a data extraction form. The institution name and location were recorded on the cover sheet. Additionally, the cover page categorized articles as randomized and controlled, prospective or retrospective trials. The approach (retroperitoneal or transperitoneal) to renal surgery was recorded. Page 2 of the DES included group characteristics, including the type of renal procedure, number of patients, sex, age, body mass index and reported followup. In addition, major and minor complication lists were tabulated by the data extraction team. The Appendix lists the major and minor complications associated with laparoscopic renal surgery.

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To eliminate interobserver variability the validity of the DES was tested by the 5 member panel. Data were extracted from 2 randomly assigned articles from the urological literature pertaining to complications in laparoscopy. The review panel met on 3 occasions to review the data revealed in the test articles. After strict extraction criteria were assigned the 56 articles included in the study were randomly designated to panel members with approximately 11 articles assigned to each reviewer. The articles were reviewed and returned to the principal investigator (GP) within 1 month of assignment.

Major complications calculated to be greater than 0.5% were considered significant and were statistically compared to each other if indicated. Specifically complications between LRN and HALRN, LDN and HALDN, and LPN and HALPN were directly compared when they were reported to be greater than 0.5%.

Data from the DES were entered into a spreadsheet (Microsoft® Excel) that was designed after consultation with a biostatistician. Estimates of the complication rates were obtained for each procedure by summing the number of complications per study observed in subjects undergoing that procedure and dividing by the summation of the number of subjects per study treated with that procedure. The complication rates were then compared between procedure types using the 2-tailed Fisher exact test with significance at 0.05. All analyses were performed using SAS statistical software (SAS Institute, Cary, North Carolina).

RESULTS

An initial review identified 405 references that were retrieved from a MEDLINE search (1995 to 2004) of the terms laparoscopic nephrectomy and complications, of which 56 met inclusion criteria. There were no randomized, controlled trials with all of the studies showing retrospective data. Ten of the 56 studies were multi-institutional and 46 were single institutional. Ten studies were from 1995 to 1999 and 46 were from 2000 to 2004. Demographics, such as the male-to-female ratio, body mass index and patient age, were not well reported with respect to complications and, therefore, no analysis of these data could be performed. In addition, only 25 of the 56 series mentioned minor complications. Mean followup was 9 months (range 3 to 20).

The overall major and minor complication rates for laparoscopic renal surgery were 9.5% and 1.9%, respectively. The highest major complication rates were associated with LPN (21%) and LNU (18.8%). The highest minor complication rates were associated with LSN (5.7%) and HALRN (3.4%).

The major complication rate for LRN was 10.7%, which was not significantly different from the 9.3% major complication rate associated with HALRN (p = 0.63). The major complication rate associated with LDN was 10.6%, which was not significantly different from the 7.7% major complication rate of HALDN (p = 0.16). The major complication rate associated with LPN was 21%, which was significantly higher than the 3.3% major complication rate associated with HALPN (p = 0.02).

TABLE 1. Types of complications in standard laparoscopic series

Type	No. Complications	% Complication Type
LRN:³⁻²²	1,746	
Venous bleeding		1.8
Arterial bleeding		1.0
Splenic injury		0.5
Small intestinal injury		0.6
Colonic injury		1.5
Conversion to open		2.5
Transfusion		0.7
Ileus		1.0
LPN:²³⁻²⁶	591	
Cardiac dysrhythmia		1.5
Renal failure		1.0
Deep vein thrombosis		0.5
Device failure		0.5
Venous injury		0.8
Arterial injury		1.7
Conversion to open		1.9
Transfusion		4.4
Wound infection		0.7
Retroperitoneal hematoma		0.8
Urinoma		3.9
Ureteral injury		0.5
Reoperation		1.4
LDN:²⁷⁻³²	1,386	
Device failure		1.2
Vascular injury		0.9
Venous bleeding		1.7
Arterial bleeding		1.2
Splenic injury		1.3
Conversion to open		1.5
Transfusion		0.6
LNU:³³⁻³⁶	133	
Deep vein thrombosis		1.5
Visceral injury		0.8
Neural injury		0.8
Arterial bleeding		1.5
Small intestinal injury		2.3
Incisional hernia		0.8
Conversion to open		2.3
LSN:^{8,18,37-41}	300	
Cardiac dysrhythmia		0.7
Renal failure		1.0
Deep vein thrombosis		0.5
Venous injury		1.7
Arterial injury		0.7
Incisional hernia		0.8
Conversion to open		3.7
Retroperitoneal hematoma		0.7
Ileus		2.0
Urinary tract infection		1.7
RLN:^{8,18,37-41}	195	
Device failure		1.0
Venous bleeding		1.5
Arterial bleeding		1.0
Colonic injury		1.5
Conversion to open		1.5
Transfusion		0.5
Wound infection		1.0
Retroperitoneal hematoma		1.0

Complications with an incidence of greater than 0.5%.

HALRN and LRN

The most common major complications associated with LRN were venous and arterial bleeding (1.8% and 1.0%, respectively, table 1).³⁻⁴¹ The most common major complications associated with HALRN were wound infection and arterial bleeding (1.5% and 1%, respectively). There was a significant difference in the wound infection rate between HALRN and LRN (1.5% vs 0.2%, p = 0.02).

There was no significant difference between the minor complication rates of HALRN and LRN (3.4% and 3.3%, respectively, p = 0.33). Tables 1 and 2 list the specific types of minor complications associated with each procedure type.³⁻⁵⁰

TABLE 2. *Types of complications in HA nephrectomy series*

Type	No. Complications	% Complication Type
HALDN: ^{28,31,42,43}	274	
Wound infection		2.2
Arterial		1.8
Ileus		1.1
Conversion to open		0.7
Incisional hernia		0.7
Deep vein thrombosis		0.7
HALPN (urinoma) ⁴⁴	30	3.3
HALRN: ^{22,31,45-50}	204	
Venous bleeding		0.5
Arterial bleeding		1.0
Small intestinal injury		0.5
Incisional hernia		0.5
Conversion to open		2.9
Transfusion		2.0
Wound infection		1.5
Orchialgia		0.5
Ileus		2.5
Urinary tract infection		0.5

Complications with an incidence of greater than 0.5%.

HALDN and LDN

The most common major complications associated with LDN were venous bleeding (1.7%), splenic injury (1.3%) and arterial bleeding (1.2%). The most common major complications associated with HALDN were wound infection (2.2%), arterial bleeding (1.8%) and incisional hernia (table 2).^{22,28,31,42-50} Although there was no significant difference between the overall complication rates of LDN and HALDN, a significant difference was observed with respect to wound infections, which were reported to be significantly higher for HALDN ($p = 0.03$). There was also a significant difference in splenic injury, which was observed to be significantly higher for LDN ($p = 0.02$, tables 1 and 2).³⁻⁵⁰ The minor complication rates were 2.6% and 0.5% for HALDN and LDN, respectively ($p = 0.02$, tables 1 and 2).³⁻⁵⁰

HALPN and LPN

The most common major complications associated with LPN were blood transfusion (4.4%), urinoma (3.9%) and arterial bleeding (1.7%) (table 1).³⁻⁴¹ The most common major complication associated with HALPN was urinoma (3.3%) (tables 1 and 2).³⁻⁵⁰ The minor complication rates for HALPN and LPN were 0% and 1.9%, respectively ($p = 0.03$).

The incisional hernia rates were highest for LNU (0.8%), followed by LSN (0.7%), HALDN (0.7%) and HALRN (0.5%). Blood transfusion rates were highest for LPN (4.4%), followed by LRN (0.7%) and LDN (0.6%). Ileus was observed to be greatest for HALRN (2.5%), followed by LSN (2.0%), LNU (1.5%) and HALDN (1.1%). Neural injuries from positioning were highest for LNU (0.8%). Postoperative complications were highest for LNU (5.3%), followed by LRN (0.9%) and LPN (0.8%).

DISCUSSION

Global complication rates for laparoscopic renal surgery are not well defined in the urological literature and yet in the last decade the procedure has evolved to become commonplace at many centers. Initially there was concern among urologists when considering the laparoscopic ap-

proach because of the potential for complications due to unfamiliar anatomy, lack of tactile and 3-dimensional information, and limited experience. As experience has been gained in the last decade, these limitations have been overcome. In addition, the introduction of HA laparoscopic renal surgery has shortened the laparoscopic learning curve for most urologists, especially those with limited laparoscopic training during residency.

We defined complication rates for the various types of laparoscopic renal procedures performed in the last decade to better counsel patients during treatment management. When doing so, it became evident that there is a lack of standardization for defining and categorizing complications in the urological literature. The 56 series analyzed in this report defined major complication rates but only 25 defined minor complication rates. Certain studies generalized complications, while others specified each complication. Demographic data were documented poorly with the subgroup of patients with complications often not described. The difficulty in assimilating this nonstandardized data was challenging, although inclusion criteria were used to collect the data available in series with at least 20 cases. A possible explanation for these difficulties may be incomplete reporting of data. Of the various series 44 of 56 described complications as part of the overall laparoscopic experience and laparoscopic nephrectomy articles dedicated specifically to complications were limited.^{4,9,10,16,17,23,26,37-41}

Initial review identified 73 of 405 references that were acceptable for retrieval and data extraction, of which 56 met inclusion criteria. Data from LRN and LDN series was the greatest (3,122 cases), while HALPN reported the least number of cases (30). The overall major and minor complication rates for laparoscopic renal surgery were 9.5% and 1.9%, respectively. Since laparoscopic renal surgery represents 9 types of laparoscopic renal surgeries, we defined complication rates for each type of procedure. Additionally, we statistically compared standard laparoscopic and HA techniques since the urological community has embraced the latter technique as a useful adjunct to laparoscopy. There were no significant differences observed between LRN and HALRN or LDN and HALDN. Table 3 lists the specific complication rates for each type.

The 56 series in this report categorized complications as physiological, access related, intraoperative and postoperative. Physiological complications occurred during prolonged pneumoperitoneum and had an effect on the cardiovascular, pulmonary and renal systems (tables 1

TABLE 3. *Complications rate by procedure type*

Procedure	No. Pts	% Complications	
		Major	Minor
LRN	1,746	10.7	3.3
HALRN	204	9.3	3.4
LPN	591	21.0	2.0
HALPN	30	3.3	0
LDN	1,386	10.6	0.5
HALDN	274	7.7	2.6
LNU	133	18.8	2.3
LSN	300	13.7	5.7
RLN	195	11.3	0.5

and 2).³⁻⁵⁰ Access related complications were rare with reported rates of less than 0.5%. Intraoperative complications were represented in order of frequency by hemorrhage (1.4%), bowel injury (less than 0.5%), solid organ injury (less than 0.5%), diaphragmatic injury (less than 0.5%) and neuromuscular injury (less than 0.5%). The most commonly reported postoperative complications were ileus (1.5%), bowel obstruction (less than 0.5%) herniation (less than 0.5%), deep vein thrombosis (0.7%) and urinary retention (less than 0.5%).

As expected, hemorrhage was the most common intraoperative complication. Interestingly no air emboli were noted in the literature review. There was a higher complication rate associated with LPN (21%), which is possibly attributable to the steep learning curve on the procedure at the time of our study. The significance of the difference in major and minor complication rates observed between LPN and HALPN is difficult to ascertain because lesion selection may have influenced the complication rate in the single available HALPN report. Furthermore, the paucity of reported minor complications in the literature limits data interpretation. As data from other HALPN series emerges, complication rates may change as more surgeons perform the approach and selection criteria change.

Although the overall complication rates for LRN and HALRN were not statistically different (10.7% and 9.3%), there was a significant difference in the wound infection rate between HALRN and LRN (1.5% and 0.2%, respectively, $p = 0.02$). As observed for radical nephrectomy data, the wound infection rate was significantly higher in HALDN vs LDN series (2.2% vs less than 0.5%). Certainly the incision during HA laparoscopic surgery can undergo varying levels of stress depending on the surgeon performing the procedure. Nonetheless, this is a reasonable expectation to relate to the patient.

Limitations of our analysis include the retrospective nature of the data collection and the inherent subjectivity among the various series on the reporting of complications. As more articles on the topic are published, specific guidelines for defining complications may help yield more standardized and objective results. In the meantime the data presented in this report represent the current complication rates associated with laparoscopic renal surgery and these data will hopefully serve as a tool for counseling patients at the time of disease management.

CONCLUSIONS

Whether standard or HA laparoscopy is used for extirpative renal surgery, the complication rate approaches 10%. The highest major complication rate is associated with technically challenging LPN, which is significantly higher than the HALPN rate (21% vs 3.3%). Wound infection rates associated with HA surgery appear higher than for standard laparoscopy (1.9% vs 0.5%). The data compiled in this study may help counsel all patients considering the laparoscopic approach to renal pathology.

APPENDIX

Laparoscopic Urological Complications Article Data Extraction			
Group Characteristics:			
Number of patients in group _____			
Age (years): Min _____ Max _____ Median _____ Mean _____			
Patient Characteristics: _____			
Followup (months) _____			
Complications	%	x	y
MAJOR			
Intraoperative venous bleeding			
Intraoperative arterial bleeding			
Cardiac dysrhythmias			
Renal failure			
Venous thrombosis			
Urinoma			
Venous gas embolism			
Intra-abdominal explosion			
Wound infection			
Hollow viscous injury			
Vascular injury			
Neural injury			
Intraoperative arterial bleeding			
Liver injury			
Spleen injury			
Small bowel injury			
Colon			
Stomach			
Pancreas			
Trocar site bleeding			
Incisional hernias			
Plexus injury			
Rhabdomyolysis			
Conversion to open			
Intraoperative death			
Perioperative death (within 30 days)			
MINOR			
Diaphragm irritation			
Urinary retention			
Failed entrapment			
Apnea			
Subcutaneous emphysema			
Atelectasis			
Ileus			
Hypercapnia			
Superficial cellulitis			

Abbreviations and Acronyms	
DES	= data extraction system
HA	= hand assisted
LDN	= laparoscopic donor nephrectomy
LNU	= laparoscopic nephroureterectomy
LPN	= laparoscopic partial nephrectomy
LRN	= laparoscopic radical nephrectomy
LSN	= laparoscopic simple nephrectomy
RLN	= retroperitoneal laparoscopic nephrectomy

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