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SURGICAL ENDOSCOPY and Other Interventional Techniques

Laparoscopic nephrectomy for autosomal dominant polycystic kidney disease

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Abstract
Background: The authors reviewed their experience with laparoscopic nephrectomy for autosomal dominant polycystic kidney disease to evaluate whether patient-related or surgery-related factors influence operative outcomes.
Methods: A retrospective review was carried out of 22 consecutive laparoscopic nephrectomies performed by one surgeon in a university setting between March 1998 and March 2003. The impact of patient factors (body mass index, preoperative hemoglobin level, preoperative blood urea nitrogen and creatinine, kidney size and side, prior abdominal surgery, dialysis) and surgical factors (surgeon experience and preoperative embolization) on short-term outcomes (estimated blood loss, transfusion requirements, operative time, conversion, intra- and postoperative complications and length of stay) was analyzed using the Student's *t*-test, Pearson correlation, and Mann–Whitney and Fisher tests.
Results: A total of 19 patients underwent 22 nephrectomies. The average patient age was 49 years (range, 36–65 years) and the average body mass index was 31.4 kg/m^2 (range, 20.4–64.5 kg/m^2). Fourteen patients (68%) were receiving dialysis. Fifteen right (68%) and 7 left (32%) nephrectomies were performed. The median kidney size was 22 cm (range, 8–50 cm). Five patients (23%) had preoperative embolization. The median operative time was 255 min (range, 95–415 min). There were no mortalities. The intraoperative complication rate was 18% (1 vena cava laceration, 1 cecal perforation, 1 dialysis fistula thrombosis, 1 intrarenal bleeding requiring conversion), and the postoperative complication rate was 32% (1 myocardial infarction, 1 urgent laparotomy for clinical peritonitis, 1 minor bile fistula, 1 AV fistula thrombosis, 2 incisional hernias, 1 urinary retention). Four procedures (18%) were converted (1 for vena cava laceration, 1 for cecal perforation, 1 for intrarenal bleeding, 1 for adhesions). The median blood loss was 400 ml (range, 100–5000 ml). Eight patients (36%) received transfusions (median, 2 units). The median length of stay was 4 days. The patients who required blood transfusions had lower preoperative hemoglobin levels. Preoperative embolization did not affect surgical outcome. However, surgeon experience significantly reduced operative time.
Conclusions: Laparoscopic nephrectomy for autosomal dominant polycystic kidney disease is a safe procedure, providing patients with a short hospital stay. Complication and conversion rates are relatively high.

Key words: Polycystic kidney diseases — Polycystic kidney — Autosomal dominant — Laparoscopy — Nephrectomy — Complications — Surgical procedures — Minimally invasive

Autosomal dominant polycystic kidney disease (ADPKD), a common hereditary disorder, is the direct cause of renal failure for 5% to 10% of patients with end-stage renal disease in America. The disease is caused by a mutation in either the ADPKD-1 or ADPKD-2 genes, altering the synthesis of polycystin-1 and polycystin-2 proteins, respectively. Loss of function of either of these proteins causes the clinical syndrome of autosomal dominant polycystic disease, characterized by the progressive compression and destruction of normal renal parenchyma by multiple enlarging cysts. Progressive renal failure develops in 45% of patients by the age 60 years [4, 8, 20].

The classical indications for surgery in these patients are pain attributable to enlarging cysts, recurrent infection, upper urinary tract obstruction, hematuria or intracystic hemorrhage, hypertension, and the need to create space for an eventual kidney transplant. Cyst decortication or aspiration and unilateral or bilateral nephrectomy are the most commonly reported interventions for this condition.

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Laparoscopic nephrectomy is now a well-established surgical approach for a variety of renal conditions [3, 5, 7, 9, 14, 17]. It has resulted in better short-term outcomes such as shorter length of stays, reduced postoperative pain, and quicker recovery [4, 12].

The goals of this study were to review our experience with 22 laparoscopic nephrectomies for ADPKD, and to determine the impact of patient-related factors (body mass index [BMI], preoperative hemoglobin level, blood urea nitrogen (BUN) and creatinine, kidney size and side, prior abdominal surgery, dialysis) and surgery-related factors (preoperative embolization, surgeon experience) as predictors of adverse short-term surgical outcome.

Materials and methods

We retrospectively reviewed the experience of one surgeon performing laparoscopic nephrectomies for ADPKD between 1998 and 2003 in a university setting.

The laparoscopic operative technique, described in detail elsewhere by the authors [17], is reported briefly. Preoperative arterial embolization is performed in selected cases the day before surgery in an attempt to achieve preoperative vascular control, diminish intraoperative and postoperative blood loss, and potentially reduce transfusion requirements. Informed consent for laparoscopic nephrectomy is obtained from each patient. Cefazolin is used routinely for antibiotic prophylaxis, and the patient is placed in a lateral decubitus position with the ipsilateral side up. Three or four 12-mm trocars are placed circumferentially about the umbilical port in a gentle arc formation, and the colon is mobilized medially.

Once the kidney is exposed, the cysts are disrupted and aspirated using a 12-mm suction aspirator of our own design (Fig. 1). The progressive volume reduction of the kidney increases the working space in the abdominal cavity, allowing for easier mobilization and eventual access to the renal hilum for vascular control. Finally the resected kidney is placed in a bag, morcelated, and extracted through one of the 12-mm port sites (Fig. 2). No additional access incision is used. Clear fluids are ordered on postoperative day 1. Opioids are used sparingly and replaced by nonsteroidal antiinflammatory drugs (NSAIDs) and acetaminophen.

Patients are discharged when they are able to tolerate a full fluid diet, and when the pain is well controlled with oral analgesics. Intraoperative transfusion need is determined by the anesthetist and the surgeon on the basis of estimated ongoing blood loss. Postoperative transfusion indications are symptomatic anemia with cardiac or respiratory symptomatology, severe anemia (hemoglobin < 70 g/L) and lethargy or anemia (hemoglobin < 80 g/L), and cardiac history.

A major surgical complication is defined as one that adversely affects the outcome by prolonging hospital stay or patient recovery. A minor complication is defined as one that does not affect hospital stay or patient recovery. Student's t-test, Pearson's correlation coefficient, and Fisher's test or the Mann–Whitney test were used for statistical analysis as appropriate, and statistical significance was defined as a p value less than 0.05.

Results

A total of 22 consecutive laparoscopic nephrectomies for ADPKD were reviewed. These operations were performed on 19 patients (10 men and 9 women). Three patients had both kidneys removed laparoscopically on different dates. No patient was denied a laparoscopic operation. The mean age of the patients was 49 years (range 36–65 years), and the mean body mass index was 31.4 kg/m^2 (range, 20.4–64.5 kg/m^2). The median kidney size was 22 cm (range, 8–50 cm). All the patients were hypertensive preoperatively, and two were diabetic. Five patients had prior kidney transplantation, and 15 (68%) had prior abdominal surgery. One of the patients who had undergone transplantation was receiving dialysis at the time of nephrectomy.

Fig. 1. Suction aspiration device.

Fig. 2. Extraction of residual renal parenchyma through a 12-mm trocar incision.

The indications for nephrectomy were discomfort ($n = 12$), the need to create space for renal transplantation ($n = 6$), bleeding ($n = 3$), and recurrent infections ($n = 2$). Some patients had more than one indication. Seven left (32%) and 15 right (68%) nephrectomies were performed, and the median operative time was 255 min (range, 95–415 min). Five patients (23%) underwent preoperative embolization.

The median hospital length of stay was 4 days (range, 1–10 days). There was no postoperative death. However, the overall complication rate was 50%, with 4 (18%) intraoperative complications and 7 (32%) postoperative complications. Six complications were major and five were minor.

In four cases (18%), the procedure was converted to open surgery. One caval injury occurred during aspiration of cysts adjacent and adherent to the inferior vena cava. This required rapid conversion for control of bleeding and primary repair of the vessel. The patient required 15 units of blood, but did well in the postoperative period, leaving the hospital 8 days postoperatively.

The second conversion was necessary because of acute intraparenchymal bleeding during cyst aspiration. The cysts became difficult to identify, and the kidney progressively enlarged, making laparoscopic continuation unsafe. A first trocar injury to the colon prompted the third conversion, and another case required conversion to open surgery because of dense adhesions between the transverse mesocolon, kidney, and spleen. There was no correlation between conversion rate and prior surgery, kidney size, body mass index.

The median blood loss was 400 ml (range, 100–5,000 ml). Eight patients (36%) required a median of two blood transfusions, with three patients receiving only intraoperative transfusions (median blood loss, 1,150 ml), four patients receiving only postoperative transfusions, and one patient receiving both intra- and postoperative transfusions. There was no difference in median blood loss (200 vs 400 ml; $p = 0.37$), median transfusion requirements (0 vs 0 units), or number of patients requiring transfusion (2/5 vs 7/17; $p = 1.0$) between preembolized and nonembolized patients. The patients who required transfusions had lower mean preoperative hemoglobin levels (107 vs 126 g/l; $p = 0.02$). Interestingly, blood loss did not correlate with patient body mass index, preoperative blood urea nitrogen level, or kidney size or side. However, when the patient with a caval injury was considered an outlier (significance level, < 0.05, Grubb's test) and excluded from analysis, there was a trend for patients receiving dialysis to have a greater mean intraoperative blood loss than patients without dialysis (504 vs 150 ml; $p = 0.0595$).

A review of the first 11 cases compared with the last 11 cases showed that there was no significant difference in median blood loss (400 vs 250 ml; $p = 0.29$), median transfusion requirements (0 vs 0 unit), or median length of stay (4 vs 4 days). There were three major complications in the early group compared with two in the later group, and three compared with two minor complications. Three cases required conversion in the early group (2 for intraoperative complication and 1 for adhesions), and one in the second group (for intraoperative complication). This difference was not statistically significant (3/11 vs 1/11; $p = 0.59$). The median operative time was significantly reduced in the later group (300 vs 220 min; $p = 0.04$).

There was one intraoperative A-V dialysis fistula thrombosis during surgery, which was recanalized by the interventional radiologist. There were three major postoperative complications (1 myocardial infarction, 1 clinical peritonitis resulting in a negative laparotomy, 1 prolonged urinary retention), and four minor postoperative complications (1 dialysis fistula thrombosis, 1 minor bile leak after a right nephrectomy, 2 incisional hernias) (Table 1).

Table 1. Complications

Complications	Patients (*n*)
Intraoperative complications	
First trocar injury to colon[a]	1
Caval injury[a]	1
Intrarenal bleeding[a]	1
Dialysis fistula thrombosis	1
Total	4
Postoperative complications	
Myocardial infarction[a]	1
Minor bile leak	1
Clinical peritonitis[a]	1
Dialysis fistula thrombosis	1
Urinary retention[a]	1
Surgical port hernia	2
Total	7

[a] Major complications

Discussion

To our knowledge, this is the largest published series of laparoscopic nephrectomy for ADPKD. It would have been useful to compare our surgical outcomes with those of historical control subjects who underwent open unilateral nephrectomies for ADPKD. However, we believe no such series has been reported. Laparoscopic cyst aspiration or unroofing has been described for pain control by some authors [11], and cyst aspiration also has been described as a useful technique for diminishing kidney bulk and allowing nephrectomy through a standard lateral incision [1]. Cyst aspiration is critical in laparoscopic surgery to create sufficient intraabdominal working space, and to access the renal vessels for ligation. The theoretical risk of septic complications from spillage of cyst contents did not materialize in our series, and no patient experienced intraabdominal sepsis or wound infection. Our technique also is unique in that it allows us to extract the kidney without the use of an access incision.

The conversion rate of 18% was not insignificant. It was higher than the 5% to 10% reported by other groups [9, 18], but these groups were treating a variety of renal pathologies and ADPKD represented only a small proportion of their patient sample. This conversion rate was not related to prior surgery, gender, or kidney size. Most of our conversions (75%) were attributable to intraoperative complications, which were appreciably less frequent as we gained experience. When the magnitude of the surgery for ADPKD is considered, which generally involves manipulation of kidneys larger than 20 cm with adhesions to the surrounding structures, our conversion rate is quite acceptable, with the overwhelming majority of patients provided a minimally invasive approach to their renal pathology. Body mass index and weight had no impact on the conversion rate. This contrasts with a growing body of evidence from the literature for other laparoscopic procedures, especially colorectal surgery [10, 13, 16].

Some of the postoperative complications reported may be attributed at least in part to the sequelae of renal failure: dialysis fistula thrombosis, ischemic cardiopathy [19], and altered wound healing [2]. We believe that none of these complications were related to the laparoscopic approach, and could have occurred after an open approach.

Our initial choice of preoperative embolization was based on the rationale that it would reduce bleeding and

transfusion requirements. It was performed early in our experience and used mostly as a safety net. Initially, the patients underwent embolization the morning of surgery, but we quickly found that it was difficult to coordinate the timing of embolization with the surgery. Also, the short interval between embolization and nephrectomy was insufficient to allow for complete thrombosis and infarction of the kidney. We therefore instituted the embolization of patients the day before surgery, which ensured complete infarction of the renal parenchyma.

Pain never seemed to be a major issue after embolization, and only a small number of patients (1 in 5) experienced moderate discomfort. This was managed easily with one or two doses of narcotic analgesia.

Although our cohort was not large, the data do not support our initial theory that embolization reduces operative blood loss. This may represent a type 2 error, but another explanation for this is that patients with ADPKD have a significantly reduced renal blood flow. We therefore no longer perform preoperative embolization for these patients because there is no clear advantage in doing so.

A trend toward significantly more intraoperative bleeding was observed in patients receiving dialysis. This may reflect a coagulopathy associated with chronic renal failure. It is reasonable to assume that the combined effects of poor bone marrow function, minor coagulopathy associated with renal failure [19], and the creation of a large surface area of dissection augment the likelihood of increased bleeding both intraoperatively and postoperatively. It is possible that these patients may do better with preoperative embolization, although it currently is too early to tell. It also was noted that the patients who required blood transfusions had lower preoperative hemoglobin levels, which seems logical.

A comparative analysis between the first and the last 11 nephrectomies showed that there was a significant reduction in operative time between the early and late groups. The improved operative time was probably attributable to the increasing familiarity of the surgeon with the procedure, as has been reported with other laparoscopic procedures [6, 10, 15]. The fact that other short-term outcome measures were not appreciably different seems to indicate that in experienced hands, much of the morbidity associated with this surgery is related to the underlying kidney disease, and not to the inherent technical difficulties of the laparoscopic approach itself.

Conclusion

Laparoscopic nephrectomy for ADPKD is safe and technically feasible, but remains a major intervention. Body habitus, kidney size, renal function, and prior abdominal surgery, including prior renal transplantation, are not contraindications to laparoscopic nephrectomy and do not adversely affect outcomes. Preliminary results indicate that embolization does not reduce intraoperative and postoperative blood loss, but further validation is necessary. Laparoscopic nephrectomy for ADPKD provides a relatively short hospital stay, and as with other laparoscopic procedures, the operative time decreases with experience.

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