Original Article

Retroperitoneal and laparoscopic heminephrectomy in duplex kidney in infants and children

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Background: Two main techniques are adopted to perform partial nephrectomy in children: laparoscopy and retroperitoneoscopy. The aim of this paper is to review the larger multicentric experience recently published by our group to review indications, techniques and results of both approaches.

Methods: Data of 102 patients underwent partial nephrectomy in a 5-year period using minimally invasive surgery (MIS) procedures were analyzed. Fifty-two children underwent laparoscopic partial nephrectomy (LPN), and 50 children underwent retroperitoneoscopic partial nephrectomy (RPN). Median age at surgery was 4.2 years. Statistical analysis was performed using χ^2 test and Student's *t*-test.

Results: The overall complications rate was significantly higher after RPN (15/50, 30%) than after LPN (10/52, 19%) (χ^2 =0.05). In LPN group, complications [4 urinomas, 2 symptomatic refluxing distal ureteral stump (RDUS) and 4 urinary leakages] were conservatively managed. In RPN group, complications (6 urinomas, 8 RDUS, 1 opening of remaining calyxes) required a re-operation in 2 patients. In both groups no conversion to open surgery was reported. Operative time (LPN: 166.2 min *vs*. RPN: 255 min; P<0.001) and hospitalization (LPN: 3.5 days *vs*. RPN: 4.1 days; P<0.001) were significantly shorter in LPN group. No postoperative loss of renal function was reported in both groups.

Conclusions: MIS now represents the gold standard technique to perform partial nephrectomy in children with duplex kidney. Our results demonstrate that RPN remains a technically demanding procedure with a significantly higher complications and re-operation rate compared to LPN. In addition, length of surgery and hospitalization were significantly shorter after LPN compared to RPN. LPN seems to be a faster, safer and technically easier procedure to perform in children compared to RPN due to a larger operative space and the possibility to perform a complete ureterectomy in refluxing systems.

Keywords: Partial nephrectomy; duplex kidney; children; complications

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Introduction

Duplication of the renal system is one of the most common congenital anomalies of the urinary tract. The majority of these anomalies remain clinically silent (1). A smaller number of them become evident as a consequence of hydronephrosis, vesico-ureteral reflux (VUR) or incontinence (2). Recently, antenatal diagnosis permits to identify many urologic anomalies, including different variants of ureteral duplications, which are clinically asymptomatic. A duplex renal system often has one moiety that is either poorly or non-functioning. In these cases there is an indication to remove surgically the non-functioning moiety (3,4). The most common indications for partial nephrectomy are recurrent urinary tract infections (UTI), ectopic ureter causing incontinence and VUR to the non-functioning moiety (5,6). Nowadays, two main techniques are adopted to perform partial nephrectomy in children: laparoscopy and retroperitoneoscopy.

Jordan and Winslow firstly reported laparoscopic partial nephrectomy (LPN) in 1993 and since then it has gained wide acceptance, mainly due to the large working space (7). The first report of a pediatric retroperitoneal laparoscopic heminephrectomy was published by Miyazato *et al.* (8) in 2000. Both procedures in children are considered complex techniques with limited diffusion among pediatric surgeons and pediatric urologists (9,10). For this reason scanty reports exist in the international literature about the use of laparoscopy and retroperitoneoscopy in children to perform partial nephrectomy. In particular, very few comparative series comparing the results of LPN with RPN have been reported (11,12). In the recent years thanks to the use of new hemostatic and synthesis devices that permit a faster and safer procedure, the technique seems to be easier to perform (13-15). The aim of this study is to analyze the results of a larger European multicentric survey about laparoscopic and retroperitoneoscopic partial nephrectomy (RPN) in infants and children with duplex kidneys.

Methods

A retrospective multicentric study was carried out among pediatric laparoscopic surgeons and urologists experts in laparoscopic renal surgery. During the European Society of Pediatric Urology (ESPU) Advanced Laparoscopic Course in Urology held at Biotechnology Center of Naples in Italy on July 2013, there was a strong discussion among the present experts about the technique and the results of LPN and RPN. For this reason we decided to organize two retrospective international multicentric surveys on this topic involving the present experts and the main international experts in this field. All involved experts had a strong experience in pediatric laparoscopic urology and all of them had started laparoscopy more than 5–10 years ago and they performed more than ten laparoscopic or retroperitoneoscopic procedures every week. Six international centers were involved in this study. We selected only centers with good experience with the technique (mean 3–5 cases operated per year). Two questionnaires were created, the first one focused on LPN and the second one on RPN and then mailed to the ten centers selected for the study. The questionnaires were focused on patients' characteristics, technical details and outcome of LPN and RPN performed in these centers in the last 5 years. We have reported descriptive data about patients' demographics, details of operative techniques and follow-up evaluation of the operated patients. In addition, among the two groups of patients underwent LPN and RPN, respectively, we have statistically compared the variables of outcome such as the overall complications rate, the re-operation rate, the average of operative time, the average length of hospital stay, the average time of resuming full oral feeding and the average time of analgesic requirements. Statistical analysis was performed using χ^2 test with Yates corrections and Student's *t*-test.

Results

We analyzed the data of 102 patients underwent partial nephrectomy in a 5-year period using minimally invasive surgery (MIS) procedures. Fifty-two children underwent LPN (42 upper pole nephrectomies and 10 lower pole nephrectomies) and 50 children underwent RPN (41 upper pole nephrectomies and 9 lower pole nephrectomies). The surgical procedures were performed by a single surgeon for each participating center. Median age at surgery was 4.2 years (range, 6 months–11.7 years). The indications for surgery were recurrent UTIs in 37 patients (secondary to VUR in 23 patients and associated with an ureterocele in 14 patients), loss of kidney moiety function (<10%) in 45 patients and ectopic ureter causing urinary incontinence in 20 cases. In regard to the surgical technique, in all patients a ureteral catheter was positioned preoperatively via cystoscopy in the ureter of the normal functioning moiety, to easily identify it during the dissection. LPN was always performed with the patient

in a semi-lateral decubitus, while RPN was performed with the patient in lateral decubitus. Three or four trocars were used according to the surgeon's preference. A 30° optic was always adopted. Special hemostatic devices were always used for dissection and parenchymal section. The vessels supplying the moiety were ligated separately with endoscopic clips enabling the demarcation of the non-functioning pole. The pole was then excised using special devices. In the patients with associated VUR into the affected kidney moiety, the ureter of the removed moiety, isolated as proximally to the bladder as possible, was ligated, after its section. We assessed intraoperative and postoperative morbidity. Follow-up (median 2.5 years; range, 12 months–5 years) was based on clinical controls (POD 7, POD 30, POD 180 and every year for 5 years after surgery) and renal ultrasounds performed 1 month and 1 year after surgery. A renal scan was performed 1 year after surgery in all centers. The overall complications rate was significantly higher after RPN (15/50, 30%) than after LPN (10/52, 19%) (χ^2 =0.05). In LPN group, complications (4 urinomas, 2 symptomatic refluxing ureteral stumps with recurrent UTIs and 4 urinary leakages) were classified as II grade complications according to Clavien-Dindo grading system (16). The patients with prolonged urinary leakage were managed conservatively, leaving the bladder catheter and the drainage *in situ* until the complete resolution of the leakage (max 12 days). Only in one patient underwent upper heminephrectomy, the urinary leakage was discovered intraoperatively and a concomitant cystoscopy was performed to exclude opening of the lower part. Four children presented a postoperative urinoma, and they were followed-up with ultrasonography until spontaneous complete resolution of the collection, without the needing of a new surgical procedure. The remaining complications (two recurrent UTIs in symptomatic refluxing ureteral stumps) resolved spontaneously or after antibiotic therapy, without the needing of a new surgical procedure. In RPN group, complications (six urinomas, eight symptomatic refluxing ureteral stumps with recurrent UTIs, one opening of remaining calyxes) were classified as II grade complications according to Clavien-Dindo grading system and were managed conservatively except two cases that required a re-operation (III-b grade according to ClavienDindo grading system). The first patient developed a sepsis on the 3rd postoperative day and a hypoechogenic collection in the right flank was detected on ultrasonography. The urinoma was drained, and a residual upper pole parenchyma nephrectomy was performed on the 5th postoperative day. In the second patient with recurrent UTIs associated with cyst formation secondary to refluxing distal ureteral stump (RDUS), a 5-cm long RDUS was removed via a groin incision. We decided to stratify the complications recorded in each group of patients on the basis of patients' age, and we chose the age of 2 years as cut-off. We noted that in laparoscopic approach the incidence of urinary leakage was significantly higher in children older than 2 years of life compared to younger children but no difference was found in regard to the incidence of other complications such as urinomas and symptomatic ureteral stumps. We think that the higher incidence of leakage in children older than 2 years was probably due to the more extensive dissection required to detach the colon for an optimal exposure of the ureter and the kidney. Instead, in retroperitoneoscopic approach, we found a higher incidence of urinomas and symptomatic ureteral stumps in children younger than 2 years. Perhaps the higher incidence of these complications was related to the technical challenges encountered in the younger children due to the narrow working space available. We decided to stratify the complications occurred in each group of patients also on the basis of the time of occurrence, and we distinguished early onset (<2 weeks after surgery) and late onset (>2 weeks after surgery) complications. The most significant findings were that urinomas and/or seroma were all late onset complications except one case of the retroperitoneoscopic group that required a reintervention on the 5th postoperative day. Also symptomatic residual ureteral stumps were late onset complications, and they required a re-intervention only in one patient of the retroperitoneoscopic group. The prolonged leakage was an early onset complication in all patients underwent LPN. No conversion to open surgery was reported in both the groups. Operative time (LPN: 166.2 min *vs.* RPN: 255 min; P<0.001) and hospitalization (LPN: 3.5 days *vs.* RPN: 4.1 days; P<0.001) were significantly shorter in LPN group. No postoperative loss of renal function was reported in both the groups. No other differences between the two groups were found in regard to other parameters.

Discussion

After the first description of LPN in children by Jordan and Winslow more than 20 years ago in 1993 (7), this procedure seems to be considered the gold standard and to have replaced the open approach (17-20). This procedure can be carried out either through a retroperitoneal or

transperitoneal approach (11,21,22). Even if there is no evidence in the international literature about which technique, between laparoscopy and retroperitoneoscopy, is the best to adopt to perform partial nephrectomy, analyzing the international literature it seems that retroperitoneoscopy has a higher rate of conversion and a higher number of major complications compared to LPN (11,23,24). Leclair *et al.* (10) published in the 2009 a retrospective series of 48 patients underwent PN via a retroperitoneoscopic lateral or prone approach with a conversion rate of 21% (10/48). El-Ghoneimi reported one nephrectomy for renal artery thrombosis and one conversion in his series of 29 patients underwent RPN (25,26). Probably our series is one of the largest series published on partial nephrectomy in children using MIS (27-30). As for the complication rate, it was significantly higher after RPN (15/50, 30%) than after LPN (10/52, 19%) (χ^2 =0.05). A re-intervention was required in two patients underwent RPN. In both series no conversion to open surgery neither nephrectomy was necessary. As for the length of surgery, it was statistically significant shorter after LPN (166.2 min) compared to RPN (255 min) (P<0.05). This is justified because in RPN operative field is smaller and sometimes it is difficult to add a 4th trocar to help dissection. The length of hospital stay was significantly shorter after LPN (3.5 days) compared to RPN (4.1 days) (P<0.05). As for the follow-up, no loss of function of the residual kidney moiety was recorded in all patients. We have to recognize as limitations of our study: the retrospective nature of the surveys, the heterogeneous patients' collection and the multicenter aspect of the study that made the data hardly comparable. The tool of each survey was a questionnaire, and each center completed the questionnaire by extrapolating from its own databases the records of the patients. We reported descriptive objective data about the patients' demographics, the details of the operative techniques and the follow-up evaluation of the operated patients. In addition, among the two groups of patients underwent LPN and RPN, respectively, we have statistically compared the variables of outcome. Although the procedures were performed by different surgeons, in regard to the technical details, the groups may be considered homogeneous because the surgical procedures in each group of patients were similar. As for the technical considerations, new hemostatic devices (Starion TLS3, LigaSure or Ultracision) are fundamental tools to adopt to perform partial nephrectomy. First of all, they permit an easy and fast dissection of tissues, an easy vascular control of the non-functioning moiety and in the last step an easy and simple resection of the non-functioning moiety and of the ureter without any bleeding (15). In our study no intraoperative bleeding was reported in all cases of both groups. In addition, another key message is to position always a ureteral catheter in the ureter of the normal moiety via cystoscopy before surgery. In this way during LPN it is easier to identify the normal ureter and to dissect the megaureter of the non-functioning moiety safely without the risk to damage the normal ureter. We think that the main advantage of laparoscopy to perform partial nephrectomy is the good overall exposure of the anatomy of the kidney and its vasculature; in particular thanks to the use of a 30° optic, it is extremely easy the identification of the vascularization of the non-functioning kidney. In addition, during the dissection of the dilated ureter, it is extremely important to identify and save the gonadal vessels that cross the ureter in particular on the left side. Another advantage of laparoscopic route is the possibility to remove the entire ureter near the bladder dome. From technical point of view, retroperitoneoscopy, by avoiding bowel mobilization, seems to provide a more direct access to the kidney and the renal hilum. Postoperative urinoma or hematoma collections are confined to the retroperitoneum. Drawbacks are the spatial limitations of the narrow retroperitoneal working space, especially in smaller children (younger than 12 months) and the difficulty to remove the entire ureter near the bladder dome. In our series, we found a higher incidence of urinomas and symptomatic ureteral stumps in children younger than 2 years underwent RPN. Perhaps the higher incidence of these complications was related to the technical challenges encountered in the younger children due to the narrow working space available. Another important point is the well positioning of the patient on the operative table, it is preferable to use a lateral decubitus for RPN and a semi-lateral decubitus for LPN; in this way, the loops fall down and permit a good exposure of the kidney. In case of LPN, we believe that to perform the procedure safely without the risk to damage intestinal loops or colon, above all in infants, a preoperative bowel preparation is necessary to empty intestinal loops and to have a larger working space. As for specimen removal, the nonfunctioning moiety and the dilated ureter can be removed through the umbilicus, it is not necessary to use an endobag. We also recommend to leave a drain in the abdominal cavity for at least 24–48 h after surgery to check an eventual leakage. We think that the prolonged leakage occurred in patients of laparoscopic group was due also to an excessive peritoneal secretion due to the colon

mobilization to better expose the kidney and the ureter. Instead, in our opinion, the most of the asymptomatic collections that we reported as urinoma and that were detected with ultrasound as anechogenic masses occupying the space of the removed kidney moiety, was otherwise seroma, evolving toward a spontaneous resolution; for this reason, they could be managed conservatively only with ultrasound periodic evaluation. Since that these collections can be due also to the residual excretive structures of an incompletely resected kidney moiety or to the opening of the normal functioning kidney moiety, an useful expedient in our experience is to check the integrity of the parenchymal resection edge by injection of methylene blue dye into the ureteral catheter positioned preoperatively into the ureter of the normal functioning moiety. In this way you can check that the normal functioning kidney moiety has not been opened during the resection of the non-functioning moiety. Finally we think that another important recommendation is always to perform distal ureterectomy to the level of the bladder hiatus and to ligate the ureteral stump in patients with reflexive systems to avoid postoperative symptoms associated with recurrent UTIs. This can be achieved only via transperitoneal approach. The retroperitoneal access can be achieved either posteriorly with the patient prone or laterally with the patient in a lateral decubitus position. Borzi (31) compared the two approaches and found that the lateral approach created more inferomedial space and allows to remove the majority of the ureteral length in patients younger than 5 years. In our series, all retroperitoneoscopic procedures were performed with the patient in lateral decubitus and the ureter was sectioned as proximally to the bladder as possible and it was ligated in refluxing systems but in retroperitoneoscopy you usually are able to section the ureter until it crosses the iliac vessels, leaving in place the last 3–6 cm of the ureter. In fact, in RPN group eight cases of symptomatic refluxing ureteral stumps with recurrent UTIs were reported *vs.* two cases in LPN group. For this reason, we now recommend to adopt always the transperitoneal approach and to perform a complete ureterectomy in patients with associated VUR into the affected kidney moiety. In fact, we measured using US the residual ureteral stump after laparoscopic approach and its length ranged from 3 to 7 mm. Our results demonstrated that RPN remains a technically demanding procedure with a significantly higher complications and re-operation rate compared to LPN, also in experts' hands. On the basis of the results of our study, LPN seems to be a faster, safer and easier procedure to perform in children compared to RPN due to a larger operative chamber available, a good overall exposure of the anatomy of the kidney and its vascularization and the possibility to remove the entire ureter near the bladder dome in refluxing systems avoiding to leave a refluxing ureteral stump.

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None.

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

Ethical Statement: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee (No. 1245) and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Being our study retrospective, formal consent is not required.

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