

What's the best minimal invasive approach to pediatric nephrectomy and heminephrectomy: conventional laparoscopy (CL), single-site (LESS) or robotics (RAS)?

Holger Till, Ali Basharkhah, Andras Hock

Department of Paediatric and Adolescent Surgery, Medical University of Graz, Graz, Austria

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Correspondence to: Holger Till, MD, PhD. Department of Paediatric and Adolescent Surgery, Medical University of Graz, Auenbruggerplatz 34, A - 8036 Graz, Austria. Email: holger.till@medunigraz.at.

Background: Conventional laparoscopy (CL) using 3–5 mm ports has become the goldstandard for pediatric nephrectomy (N), heminephrectomy (HN) and heminephrecto-ureterectomy (HNU) for many years now. Recently the spectrum of minimal invasive surgery (MIS) has been extended by variants like laparoendoscopic single-site surgery (LESS) or robot-assisted surgery (RAS). However such technical developments tend to drive surgical euphoria and feasibility studies, but may miss adequate academic research about function and proven patients' benefits. This article delivers a comprehensive analysis of present pediatric studies comparing at least two MIS approaches to N, HN and HNU.

Methods: A systematic literature-based search for studies published between 2011–2016 about CL versus LESS or RAS for pediatric N, HN, and HNU was performed using multiple electronic databases and sources. The level of evidence was determined using the Oxford Centre for Evidence-based Medicine (OCEBM) criteria. Single arm observational studies about N, HN or HNU using CL, LESS or RAS as well as publications including adult patients were excluded.

Results: A total of 11 studies met defined inclusion criteria, reporting on CL versus LESS or RAS. No studies of OCEBM Level 1 or 2 were identified. Performing CL for N and HN limited evidence indicated reduced analgesic requirements and shorter hospital stay over open surgery, but longer operating time. Preservation of renal function of the remaining moiety after CL-HN was 95%. Importantly, of patients losing their remaining moiety, median age at surgery was 9 months (range, 4–42 months), and all except 1 (6/7) had an upper pole HN. Several authors compared TNP versus RPN access for CL and confirmed a longer operating time for RPN versus TPN-NU. Moreover one study reported a longer ureteric stump in RPN versus TPN-HNU (range, 2–5 cm *vs.* 3–7 mm). Disadvantages of LESS or RAS over CL were longer operative time and higher total costs (RAS). There were no differences regarding complications, success rates, or short-term outcomes between pediatric RAS versus CL. No long-term studies about preservation of renal function or length of ureteric stump using LESS or RAS could be retrieved.

Conclusions: Several approaches to MIS-NU and HNU are available today. CL represents the method of choice for any age group. TPN or RPN can be chosen according to age of the patient. LESS and RAS offer distinct advantages, but also lack evident patients' benefits over CL at present. Hopefully, as pediatric MIS advances over the next decade, larger studies comparing CL, LESS or RAS directly for pediatric NU and HNU will be published to gain a higher level of evidence what's really best for the child.

Keywords: Paediatric; urology; nephrectomy; laparoscopy; laparoendoscopic single-site surgery (LESS)

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Introduction

Since the introduction of minimal invasive nephrectomy in 1991 by Clayman for adults and only 2 years later by Koyle for children the approach has quickly gained general acceptance among pediatric urologists. Today the “conventional laparoscopy” (CL) using several ports is considered safe and effective for a variety of pediatric procedures such as nephrectomy (N), heminephrectomy (HN) in case of duplex systems or heminephrectomy-uterectomy (HNU) for reflux nephropathy (1). Both, the transperitoneal (TPN) as well as the retroperitoneal (RPN) route have been established (2-5). In recent years single incision techniques like laparoendoscopic single-site surgery (LESS) and robotic assisted surgery (RAS) have been introduced (6-8) as well. Such technical developments tend to be driven by surgical euphoria and feasibility studies, which may require academic research focussing on the patients’ perspective at times. Consequently, this article presents a comprehensive analysis of the present literature about pediatric MIS for N, HN, HNU to answer the most important question from the families and pediatric nephrologists: what is the best procedure for the child?

Methods

A systematic literature-based search for studies published between 2011–2016 about CL versus LESS or RAS for pediatric N, HN, and HNU was performed using multiple electronic databases and sources. The level of evidence was determined using the Oxford Centre for Evidence-based Medicine (OCEBM) criteria. Single arm observational studies as well as publications including adult patients were excluded.

Results

A total of 11 studies met defined inclusion criteria, reporting on CL versus LESS or RAS. No studies of OCEBM Level 1 or 2 were identified. Performing CL for N and HN limited evidence indicated reduced analgesic requirements and shorter hospital stay over open surgery, but longer operating time. Preservation of renal function of the remaining moiety after CL-HN was 95%. Importantly, of patients losing their remaining moiety, median age at surgery was 9 months (range, 4–42 months), and all except 1 (6/7) had an upper pole HN. Several authors compared TNP versus RPN access for CL and confirmed a longer operating time

for RPN versus TPN-NU. Moreover one study reported a longer ureteric stump in RPN versus TPN-HNU (range, 2–5 cm *vs.* 3–7 mm). Disadvantages of LESS or RAS over CL were longer operative time and higher total costs (RAS). There were no differences regarding complications, success rates, or short-term outcomes between pediatric RAS versus CL. No long-term studies for LESS and RAS about preservation of renal function or length of ureteric stump are presently available.

Discussion

In recent years many novel technologies in MIS have been introduced claiming a progress in pediatric surgery. However such innovations must be assessed for their safety, efficacy and value, especially from a patient’s point of view. For her or him the most important things that matter are there the 3 f’s, being function (did the operation have the intended effect), fit (was the performance as good as possible) and form (does the cosmetic result look good)? The best academic method to make this assessment remains a systematic research of present data. The highest level of evidence according to OCEBM would be a randomized controlled trial (RCT). As performing RCTs for surgical procedures in children remains a difficult task due to small number of patients per centre and ethical approval, careful observational studies with clear clinical parameters may be the best evidence we can achieve for most questions.

Pediatric nephrectomy is mostly indicated in benign conditions having caused severe damage of renal function (<10% partial function radionuclide renal scan). The aim of surgery is to prevent urinary tract infections or limit the risk of hypertension. While resection of MCDK (multi-cystic dysplastic kidney) remains a matter of vivid discussion, because a “natural” involution can be expected, reflux nephropathy with/without megaureter must be considered for NU. In such cases it is essential to continue the resection all the way down to the vesico-ureteric junction. We will argue later that in such cases a MIS approach is absolutely superior to any open surgery, because one access reaches it all.

Pediatric heminephrectomy of non functioning moieties in duplex systems requires a more elaborate urological expertise in order to understand the blood supply of both units, anatomy of the two pelvises and type of ureters (e.g., duplex, fissus) as well as the pathology at the vesicoureteral junction (e.g., ureterocele). About 30% of duplex systems are associated with VUR (vesico-ureteral reflux), renal dysplasia, ureterocele, ureteric obstruction and ectopia. At

the time of surgery, the pediatric urologist must be capable of dealing with all of these challenges. Consequently, his urological experience and technical armamentarium must meet these tasks. We will explore this matter further when discussing the ergonomics of LESS versus CL.

Technically speaking the surgical steps for pediatric N, HN HNU follow the same principles independent of the surgical approach. Only sizes of instruments or fine technical details differ between CL, LESS or RAS.

For CL most pediatric urologist would use a 5-mm scope and two 3-mm working ports (for right side a third port may be necessary to elevate the liver). Two approaches have been established, a TPN and a RPN. Both techniques employ the same instruments and truly deserve the attribute “minimal invasive”. In smaller children (less than 12 months) the working space between the tip of the 12th rib and the iliac crest may become so small that an ureterectomy all the way down to the bladder may not be technically feasible. In such cases a TPN approach may be more efficient.

As far as performance of CL is concerned Golebiewski stated that upper pole HNU is a safe and feasible procedure, even in infants (1). In his analysis CL-HNU was associated with minimal morbidity and the operative time was acceptable and not significantly longer in comparison with the open approach. As a patient's benefit he identified reduced analgesic requirements and hospital stay over open surgery and advocated CL-HNU as the method of choice in children (1).

In a multicentre review Jayram (9) looked at the “fate” of the remnant moiety following CL-HNU and with a median follow-up of 4.5 years he found that 4.9% experienced a significant loss of function in the remaining moiety, with 3/122 patients requiring final nephrectomy. Importantly, of patients losing their remaining moiety, median age at surgery was 9 months (range, 4–42 months), and all except 1 (6/7) had an upper pole HN. The authors concluded that CL-HN for duplex kidney produced satisfactory outcomes in the pediatric population, but care must be taken in younger children requiring an upper pole HNU.

Dingemann (10) compared two age groups for CL-HNU in duplex systems being younger (G1) or older than 12 months (G2). He found an elevated operating time in G2 (mean 197 *vs.* 152 minutes) and encountered one urinoma in G1. During a follow-up of median 5.2 years he noticed febrile urinary tract infections to almost the same extend in both groups (G1: 1/12; G2: 2/10). The author concluded that “laparoscopic transperitoneal heminephrectomy for duplex kidneys is safe and feasible even in small infants. Long-term

results are excellent irrespective of the patient's age”.

The comparison between TPN versus RPN approach for CL remains ongoing. Esposito (5) published a multicentre study assessing TPN versus RPN nephrectomy and found overall complications rate was significantly higher after RPN (15/50; 30%) than after TPN (10/52; 19%). In TPN group, complications [4 urinomas, 2 symptomatic refluxing distal ureteral stumps (RDUS) and 4 urinary leakages] were conservatively managed. In RPN group, complications (6 urinomas, 8 RDUS, 1 opening of remaining calyces) required a re-operation in two patients. In both groups no conversion to open surgery was reported. Operative time (TPN: 166.2 min *vs.* RPN: 255 min; $P < 0.001$) and hospitalization (TPN: 3.5 days *vs.* RPN: 4.1 days; $P < 0.001$) were significantly shorter in TPN group. No postoperative loss of renal function was reported in both groups. He concluded that TPN seemed 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.

One key parameter of success after NU and HNU, especially in reflux nephropathy, is the length of the remaining ureteric stump, because it may be a source of recurrent urinary tract infections. Escolino (11) published an evaluation of the distal ureteral stump after NU in children comparing the TPN versus RPN approach. The authors included 21 consecutive patients (median age 3.5 years; range, 1–10 years). He found a longer operating time for RPN versus TPN (80 *vs.* 50 min). The length of the distal ureteric stump was significantly shorter after TPN (range, 3–7 mm) versus RPN (range, 2–5 cm). In conclusion the authors stated that TPN permits removal of all ureter near to the bladder dome. In children with non-functioning kidneys due to VUR it is advisable to perform a laparoscopic rather than RPN nephrectomy.

LESS means working through one access such as the umbilicus only. This technique challenges the paradigm of CL to angulate the instruments for optimal working spaces. Instead it introduces significant ergonomic difficulties such as clashing (of the ports outside), crowding (of the instruments within the single port) and most important crossing of the instruments (6,12). The latter means that all intuitive movements of CL become counterintuitive, just like crossing your hands when playing the piano. Such ergonomic phenomena must be considered when testing the surgical performance especially for more complex HN and HNU.

Despite all euphoria for LESS the surgical performance

remains a matter of vivid discussions due to the different ergonomics. Tam (13) from Hong Kong found that LESS nephrectomy took longer than CL (mean 156 vs. 99 min) and no postoperative complications occurred. The authors conclude that LESS nephrectomy and HN is safe and effective with a minimal invasive nature comparable to CL. However, they recommend further studies to investigate the implication of patient selection and the cosmetic benefits of LESS. Finally Islam (14) from the United Kingdom reported that single-incision N or HN was cheaper in terms of operating costs than CL (942 versus 1,127 British pounds).

Robot-assisted surgery (RAS) has been proven to be safe and effective for various urological procedures in children, including pyeloplasty, orchidopexy, nephrectomy, and bladder augmentation (7). The robot system enables delicate and precise movements, which are ideal for reconstructive surgeries (7). Today RAS is mostly performed using the DaVinci System. The company produces two different models with a 12-mm scope and either 8 or 5 mm instruments. Such dimensions seem worth mentioning in comparison to CL using 5 or 3 mm instruments. The advantages for the surgeon include 3-D visualisation, tremor-free movements and most important the 360° wrist movement of the tip allowing for complex manoeuvres. Disadvantages are certainly sizes of instruments, loss of tactile feedback and costs (7,8,12).

Most studies reporting about RAS compare their data with open surgery (15). However such a comparison seems inadequate, because the surgical “competitor” in terms of access, tissue trauma and cosmesis remains a different MIS approach like CL or LESS. Consequently, we searched for studies comparing RAS versus CL or even LESS urology in children.

Evidence is certainly limited (16). Malik (15) compared RAS with open and CL-HN and found that RAS-HN provided comparable outcomes in regard to complication rate and renal function of the remnant moiety.

Two Individual cohort/case-controlled studies (OCEBM level 4) were identified that compared RAS with LESS nephrectomy in children. Both investigations confirmed longer operating times for RAS, whereas they did not find any statistical differences in postoperative analgesia requirements and length of hospital stay.

Kim (12) published an evaluation between RAS, LESS and CL and found that LESS nephrectomy in children was associated with similar surgical times, lengths of hospital stay and postoperative pain medication use as the

other minimally invasive modalities. Bansal (17) compared directly pediatric RAS-NU with LESS-NU and found that LESS-NU had a significantly shorter operative time with comparable in-patient postoperative narcotics use as compared to RAS-NU.

In conclusion several approaches to MIS NU and HNU are available today. CL represents the method of choice for any age group. TPN versus RPN can be chosen according to age of the patient. LESS and RAS offer distinct advantages, but also lack evident patients’ benefits over CL at present. Hopefully, as pediatric MIS advances over the next decade, larger studies comparing directly CL, LESS or RAS for pediatric NU and HNU will be published to gain a higher level of evidence what’s really best for the child.

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Footnote

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

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