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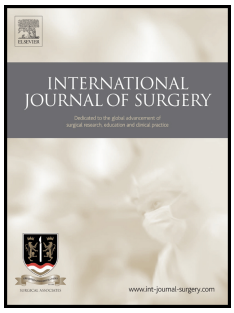

Laparoendoscopic single site surgery (Less) for major urological procedures in the pediatric population: A systematic review

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LAPAROENDOSCOPIC SINGLE SITE SURGERY (LESS) FOR MAJOR UROLOGICAL PROCEDURES IN THE PEDIATRIC POPULATION: A SYSTEMATIC REVIEW

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LAPAROENDOSCOPIC SINGLE SITE SURGERY (LESS) FOR MAJOR UROLOGICAL PROCEDURES IN THE PEDIATRIC POPULATION: A SYSTEMATIC REVIEW

Background: Improvements in laparoscopic surgery have led to the introduction of Laparoendoscopic Single Site Surgery (LESS) as an alternative to conventional laparoscopy conferring a number of possible advantages. In this review, we aim to elucidate the aspects of LESS for major urological procedures in the pediatric population.

Materials and Methods: An in-depth search of the literature was performed in the databases of PubMed and Scopus, for studies investigating the technical aspects and clinical outcomes of partial nephrectomies, nephrectomies, nephroureterectomies, varicocelectomies and pyeloplasties in children. Data on parameters such as operation time, instrumentation, perioperative complications, hospital stay and follow up period were collected and further analyzed cumulatively.

Results: Twenty nine studies met the inclusion criteria incorporating 386 patients who underwent 401 procedures. There were no major intraoperative complications, with only 19 patients (4.73%) facing postoperative complications. No perioperative deaths were reported.

Conclusions: In the hands of experienced surgeons LESS seems a feasible, efficient and less invasive alternative to standard laparoscopy in the field of pediatric urology. There is an eminent need of well-designed randomized controlled trials comparing the two techniques.

Keywords: urology; pediatrics; laparoscopy; surgery; LESS

1. Introduction

Laparoscopic surgery is currently the gold standard for the surgical management of pediatric urologic pathologies [1]. Recent improvements in laparoscopic surgical techniques have led to the introduction of laparoendoscopic single site surgery (LESS), as an alternative to conventional laparoscopy (CL) conferring a number of possible advantages: better esthetic outcome, decreased incidence of port-site complications, less postoperative pain, reduced analgesic requirements and faster recovery [2].

However, pediatric surgeons are hesitant in embracing LESS. According to a survey among members of the International Pediatric Endosurgery Group (IPEG), lack of proficiency, inadequate resources and mainly disbelief in the benefits of this technique were the most commonly cited factors for not adopting LESS [3]. A recent meta-analysis, comparing LESS and CL appendectomy in pediatric patients, concluded to the non-superiority of the former, which was associated with higher wound infection rates and longer operative time [4].

Even though urologic LESS is frequently performed in adults, the first cases in the pediatric population were described only recently [5,6]. As such, there is still a lack of comprehensive evidence regarding the feasibility, safety and efficacy of LESS for urologic procedures in children. The aim of this systematic review was to perform an in-depth literature search and present all the available evidence on this novel technique.

2. Material and Methods

This systematic review was conducted in accordance to the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) guidelines [7]; a protocol was agreed beforehand by all authors. A comprehensive electronic search of Medline and Scopus databases was performed with the following keywords: *"Single AND (trocar OR incision OR Site) AND Surgery AND (child* OR infan* OR pediatr* OR paediatr* OR adolescen*) NOT adult"*. Inclusion criteria were: 1) pediatric patient population (age <18 years) 2) single site approach initially selected by the surgeon, 3) procedure carried out completely laparoendoscopically, 4) major urological procedure performed were limited to: nephrectomy, nephroureterectomy, pyeloplasty, varicocelectomy and partial nephrectomy 5) study population of more than one patient. Studies of any design, including studies comparing CL and LESS, were eligible for inclusion. Articles in language other than English, and studies reporting on animal models and mixed adult and pediatric population were excluded. Studies reporting pyeloplasties with LESS mobilization of the ureteropelvic junction (UPJ) and open extracorporeal anastomosis were not included in this review. In addition, all references were hand-searched in order to detect any potentially missed studies. Two reviewers (ENS and DN) working independently extracted data from all eligible studies; any discrepancies were discussed and consensus was reached. When applicable the methodological quality of the study was assessed using the Newcastle-Ottawa Quality Assessment Scale (NOS) of non-randomized studies.

From each eligible study the following parameters were extracted when available: general study characteristics (author, date of publication), patient demographics (age and gender), procedure performed, indication, site of incision, details of surgical technique

(entry device employed, access route, size of incision, laparoscopic instruments used, toal operation time), intraoperative complications (including conversion to open surgery, use of additional ports and estimated blood loss (EBL)) and surgical outcome (length of hospital stay and post-operative complications). For studies commenting on pyeloplasty, the following additional parameters were collected: number of crossing vessels, outcome, method and period of follow-up.

Intraoperative complication was defined as any reported *"deviation from the ideal intraoperative course occurring between skin incision and skin closure"* [8]. A procedure was considered as converted when it was not completed using the same technique as initially planned; thus both conversion to open surgery and the use of additional(s) port(s) were taken into consideration for the calculation of the conversion rate. Postoperative complication was defined as any reported "*deviation from the ideal postoperative course that is not inherent in the procedure and does not comprise a failure to cure*" [9]. As such UPJO recurrence was not included in the calculation of postoperative complication rate. Reported postoperative complications were categorized according to the modified Clavien-Dindo classification system which has been used extensively in urologic surgery [10]. Conversion and postoperative complication rate were calculated based on the total number of procedures performed.

All extracted data were tabulated and the outcomes were presented cumulatively when applicable. In order to calculate the weighted mean of patient age, total operation time and post-operative hospital stay, median values were converted to mean as previously described [11].

3. Results

The flow diagram of the literature search is presented in Figure 1. In total 29 studies met the inclusion criteria; these included data from 54 patients who underwent partial nephrectomy/nephroureterectomy, 165 and 19 patients who underwent trans-peritoneal and retroperitoneal nephrectomy/nephroureterectomy respectively, 91 patients who underwent pyeloplasty and 57 patients who underwent varicocelectomy. Only one of the eligible studies was a prospective study; all other were retrospective.

3.1 Partial nephrectomies

For the partial nephrectomy group (**Table 1**), 55 procedures were performed in 54 patients aged from 0.42 -16.4 years (weighted mean: 1.29 years from 50 patients) [12-17]. Total operation time, ranged from 55 to 400 minutes (weighted mean: 132.05 minutes from 55 procedures). All procedures were performed trans-peritoneally and no intraoperative complications were noted. For 51 procedures (92.7%) a commercially available single-port device was employed. There was one case (1.8%) of conversion to open surgery and EBL in all cases did not exceed 120 ml. Postoperative complications were encountered in 3 (5.45%) patients; two Clavien-Dindo grade I complications; namely one case of minor urine leak managed with continuous drainage, and one case of urinoma that resolved spontaneously. One patient developed a Clavien-Dindo grade III complication; renal artery spasm which was noted in postoperative ultrasound and required diagnostic work-up with computed tomography and angiography. Postoperative hospital stay ranged from 0 to 10 days (weighted mean: 4.6 days from 43 patients).

3.2 Nephrectomies and nephroureterectomies

For the transperitoneal group of nephrectomies and nephroureterectomies (**Table 2**) 165 patients, aged 0.06 - 18 years (weighted mean: 5.05 years from 157 patients), underwent 174 procedures [12,13,15-30]. In 13 patients (7.47%) a concomitant procedure was performed. The size of incision ranged from 1 – 2.5 cm. For 153 procedures (85.5%) a commercially available single-port device was employed. There were no intraoperative complications; in two cases an additional port was required and one case was converted to open surgery (1.72 % conversion rate). Total operative time ranged from 6 to 370 minutes (weighted mean 122.13 minutes from 167 procedures). Postoperative hospital stay ranged from 0 to 12 days (weighted mean: 2.33 days from 102 patients) and postoperative complications were observed in 5 patients (2.87 %); four Clavien-Dindo grade II (two cases of port site infection, one case of umbilical infection all treated with oral antibiotics in an outpatients basis and one case of supplemental analgesia) and one Clavien-Dindo grade III complication (persistent fever, anemia requiring transfusion and radiological evidence of retroperitoneal fluid collection drained percutaneously complicated by pseudomembranous colitis).

In 19 patients (5 male and 14 female) aged 1.67 – 15.9 years, 20 nephrectomies were performed via the retroperitoneal route (**Table 3**)[31-33]. The size of incision ranged from 1.1 –to 2.5 cm. The procedures were carried out between 50 and 90 minutes without any intraoperative or postoperative complications occurring. Ten (50%) procedures were completed with the use of a commercially available single-port device. No cases required an additional port (0 % conversion rate) and the postoperative hospital stay ranged from 1 to 1.5 days.

3.3 Pyeloplasties

For the pyeloplasty group (**Table 4**,**5) 92** procedures were performed in 91 patients, aged between 0.16 and 17.9 years (weighted mean: 5.7 years from 91 patients) [18-21,34-36]. In 7 cases (7.6%) a crossing vessel was present. For 70 procedures (76.1%) a commercially available single-port device was employed. The size of incision ranged from 1.5 cm to 2.5 cm. All procedures were completed transperitoneally; one case was converted to open, and in another case an accessory port was employed (2.17% conversion rate). In one study with 21 patients, an 2-mm accessory port was routinely employed; that study was excluded from the calculation of the conversion rate. Mean operation time ranged from 145 – 240 min (weighted mean: 192.93 minutes from 92 procedures). Postoperative complications occurred in 10 (10.86%) patients; 8 grade I Clavien-Dindo (two cases of postoperative fistula disappearing naturally and 6 cases of postoperative fever, 2 of which were associated with urine extravasation detected by ultrasound) and 2 grade II Clavien-Dindo complications (one case of wound infection and one case of urinary infection, both managed conservatively). Mean hospital stay ranged from 2 to 7 days (weighted mean: 5.2 days from 91 patients). **Table 5** summarizes the postoperative follow-up and outcome of patients undergoing LESS pyeloplasty.

3.4 Varicocelectomies

For the varicocelectomy group 57 patients (weighted mean age 13.71 years from 55 patients) underwent 60 procedures **(Table 6)** [13,15,16,19,20,22,26,37-40]. All procedures were completed transperitoneally and weighted mean operation time was minutes 38.35 minutes (from 52 procedures). No cases required an additional port and only one Clavien-

Dindo grade III postoperative complication (postoperative hydrocele requiring secondary open procedure)(1.7%) was observed. Mean hospital stay ranged from 1-3 days.

4. Discussion

Laparoscopic surgery is currently the gold standard in the field of pediatric urology for the surgical management of urinary tract diseases [41]. CL traditionally requires 3 or more incisions of a size ranging from 0.5 to 2 cm [34,36]. The need for a less invasive technique, which would minimize morbidity and result in a superior cosmetic outcome, led to the development of LESS, a novel technique that has gained popularity during the last decade [42,43]. The first cases of transperitoneal LESS nephrectomy in children were reported in the year 2009 [5,6].

LESS can be performed through both retroperitoneal (RP) and transperitoneal (TP) access routes. On one hand, the RP approach provides the surgeon with a direct access to the UPJ and eliminates the risk of peritoneal contamination and irritation by CO2. On the other hand TP access is superior when there is a need to perform a concomitant procedure within the abdomen. Also, with TP LESS, the surgical scar can be easily concealed by the umbilicus resulting possibly to a superior aesthetic outcome. The limited working space of RP approach can also aggravate instrument crowding and loss of triangulation, a main obstacle encountered in LESS procedures. In their systematic review, Kim et al. analyzed the perioperative parameters of CL nephrectomy, nephroureterectomy, and partial nephrectomy in children comparing the TP (n=288) and RP (n=401) approach. The overall complication rates were found to be similar, 3.5% and 4.3%, respectively and authors concluded that the choice of approach should be guided by the surgeon's preference, patient anatomy, or the nature of the procedure to be performed [44].

In the group of partial nephrectomies, the most prominent result, was a prolonged operation time and length of postoperative hospital stay compared to TP nephrectomy [12-17]. These results seem to be comparable with those of adult patients [45]. LESS partial nephrectomy is regarded as the most demanding upper urological tract procedure associated with an increased risk of conversion [46].

Similarly, pyeloplasty with intracorporeal UPJ anastomosis requires an advanced laparoscopic skill-set. Instrument clashing and loss of triangulation encountered during LESS limit retraction and dissection and may raise exponentially the level of difficulty; as such the weighted mean of total operative time was 192.93 min. Mean duration of follow-up varied from 6 to 35.1 months. This alone, raises doubts on whether several long-term complications have not yet been revealed for the cases with short follow-up; as such longer follow-up is imperative in order to determine the efficacy and durability of LESS for the treatment of ureteropelvic junction obstruction (UPJO) in the pediatric population. It should be noted that for adults, a recent met-analysis concluded that LESS pyeloplasty offers comparable surgical and functional outcomes compared to CL [47].

A number of studies included in this review, compared retrospectively LESS and CL. Kim et al. demonstrated similar surgical times, postoperative pain medication use and length of hospital stay between LESS (n=11) and CL nephrectomy (n=11). When compared to open nephrectomy (n=39), LESS was associated with significantly shorter length of hospital stay and lower postoperative pain medication requirements but also with a slightly longer operation time [48]. Woldrich et al. compared retrospectively LESS (n=7), CL (n=11) and open (n=8) nephrectomy concluding that LESS was comparable to CL in terms of perioperative factors and cost [29]. Tam et al compared 12 consecutive

children undergoing LESS (7 nephrectomies and 4 heminephrectomies) with a matched cohort of 18 children that had CL surgery (12 nephrectomies and 6 heminephrectomies). There were no differences between the two groups regarding length of hospital stay and postoperative analgesic requirements but LESS nephrectomy required significantly longer operative time. However, in that study LESS and CL nephrectomies were performed through TP and RP approach respectively [17]. Recently Zhou et al. compared a group of 34 patients who underwent LESS heminephroureterectomy with 34 patients undergoing the CL, without observing any significant difference in total operative time, postoperative hospital stay, analgesic requirements and perioperative complications [14]. Naitoh et al compared a group of 14 TP fully laparoscopic LESS pyeloplasties with an age-matched control group of 14 CL cases; operative time did not differ between the two groups but LESS was associated with a significantly decreased pain face scale score on postoperative day 3 and 4 [49]. Similarly, Khambati et al reported no difference in operative time, hospital stay or cost between a group of 7 patients that underwent LESS pyeloplasty and a match cohort of 28 patients that underwent CL pyeloplasty [19]. It should be underlined that in literature, there is no prospective randomized study comparing outcomes of pediatric LESS and CL for a major urologic procedure apart from varicocelectomy [39].

It has been well demonstrated that conversion rate for LESS is low [50]. However, this composes a field of controversy. As “conversion” many authors define the need of conversion to open surgery, while others refer to the use additional ports or skin incisions [17,21,29]. Surgeons should not hesitate to introduce additional mini-laparoscopic instruments through mini-ports or stab wound incisions in order to control possible bleeding and complete safely a procedure. It should be noted that since LESS is technically

demanding, it is carried out by more experienced laparoscopic surgeons; as such the complication rate may be artificially low [13]. It is not surprising that EUA recommends that LESS should be performed only by experienced laparoscopic surgeons [51].

As a recent and relatively new technique LESS may have a steep learning curve [12,13,16]. This can be explained by the fact that surgeons initially face the loss of classical triangulation, limitations in available instrumentation, challenging working angles and most importantly intra- and extracorporeal instrument clashing [12,51,52]. The combination of flexible or pre-bent instruments with a flexible laparoscope can pose additional difficulties in the limited working spaces encountered in pediatric patients [15]. However, certain authors claim that LESS might in fact have a short learning curve for those surgeons who are experienced in CL [42,52]. Moreover, compared to adult patients in the pediatric population, the distance from the umbilicus to the target organ is shorter, visceral fat is minimal and target organs are smaller, factors that may facilitate the performance of LESS [15,18].

Probably the major advantage of LESS compared to CL is the superior aesthetic result, which is of even greater value in the pediatric population, given that a surgical scar is expected to enlarge along with the growth of the child [18]. Fan et al. in their recent meta-analysis, reported significantly better cosmetic satisfaction scores in the LESS nephrectomy group compared to the CL approach [2]. However, cosmesis still remains subjective with no clear consensus for what is considered aesthetically satisfactory. Future studies should include objective measures of cosmetic outcome. Currently, the European Urology Association (EUA) recommends that *"LESS should be favored in cases where cosmesis is of paramount importance"*[51].

A major strength of this study is the fact that a systematic approach was adopted for the identification of all eligible studies and the data extraction. However given that the majority of studies included in this systematic review were either case-series or retrospective cohort studies with the risk of bias, especially publication-bias, remaining unambiguous, the results should be interpreted with caution. In addition as discussed previously the most of the procedures were performed by surgeons with extensive experience in laparoscopic surgery or adult LESS, as such these results may not be reproducible by the average surgeon. Also, it should be noted that certain retroperitoneal nephrectomies were performed through one trocar, using a single intrument [32,33].

5. Conclusion

During the last decade the number of urological LESS procedures performed worldwide in the pediatric population has increased. Each surgeon based on his experience or preference employed different instruments and entry ports. In the hands of experienced surgeons LESS seems a feasible and attractive alternative to CL with comparable results. However, there is not enough evidence to support the superiority of LESS thus wide adoption cannot be recommended. There is an imperative need of well-designed prospective randomized trials, with large number of patients, in order to clarify the safety and long term efficacy of LESS for urological procedures in the pediatric population.

Disclosure Statement

The authors declare that they have no competing interests

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Table 1. Partial Nephrectomies

Author - Year	**Number of Patients/ Procedures**	**Age, years** median (range)	**Gender**	**Operation time, min** median (range)	**Procedure**	**Access**	**Conversion***	**Postoperative complications**	**Postoperative hospital stay, days** median (range)
Gor et al. 2015 [12]	5	0.42 (0.25-1)	2M/3F	90 (60-125)	heminephrectomy/partial nephrectomy	TP	0	0	1 (1-1)
Soto-Aviles et al. 2015 [13]	4	0.71 (0.42-3)	2M/2F	57.5 (55-65)	heminephrectomy	TP	0	0	< 1
Zhou et al. 2014 [14]	34	2.04 (0.42-11)	14M/20F	105 (75-210)	heminephroureterectomy	TP	0	1 (minor urine leak)	5 (2-10)
Bansal et al. 2014 [15]	4	0.52 (0.21-1.37)	n.a	126 (97-180)	partial nephrectomy	TP	0	0	1 (1-2)
Szavay et al. 2013[16]	3/4	2.3 (0.58-4.8)	2M/1F	150 (120-150)	partial nephrectomy	TP	0	2 (1 urinoma & 1 post-op renal artery spasm)	n.a
Tam et al. 2013 [17]	4	**3.8** (1.9- 7) †	3M/9F†	300 (265-400)	heminephroureterectomy	TP	1	0	**2.9** (2-6)†

† data not separate from nephrectomy, **bold**: mean, TP: transperitoneal
*(use of additional trocar) or open surgery , n.a : not available

Table 2. Transperitoneal Nephrectomies

Author	**Number of Patients/ Procedures**	**Age, years** median (range)	**Gender**	**Operation time, min** median (range)	**Procedure**	**Access**	**Conversion***	**Postoperative complications**	**Postoperative hospital stay, days** median (range)
Gor et al. 2015 [12]	41/44	nephrectomy: 4 (0.92-11) nephroureterectomy 7 (6-13) bil. nephrectomy 5 (3-11)	18M/23F	R nephrectomy 80 (6-130) L nephrectomy 60.5 (40-125), nephroureterectomy 116 (90-160), bil.nephrectomy 128 (122-132)	35 nephrectomy, 9 nephroureterectomy	TP	0	1 (supplamental analgesia)	R nephrectomy 1 (1-3), L nephrectomy 1 (1-4), nephroureterectomy 1.5 (1.5-2), bil. nephrectomy 3 (3-3)
Yamada et al. 2015 [18]	4	**5** (5-7)	n.a	**128** (90-178)	nephrectomy	TP	0	0	**4.8** (3-6)
Soto-Aviles et al. 2015 [13]	20	0.95 (0.25-17)	7M/13F	52.5 (40-120)	nephrectomy	TP	0	0	< 1

Khambati et al. 2015 [19]	2	(9-10)	n.a	153-218	nephrectomy	TP	0	0	1.5-1.8
Abdel-Karim et al. 2015 [20]	2	**10.0** (SD:0.5)	n.a	**125** (SD:5)	nephrectomy	TP	0	0	**1.2** (SD:0.21)
Bansal et al. 2014 [15]	24	nephrectomy: 1.6 (0.6-14.1) nephrouretere ctomy: 5.1 (1.4-12.1)	n.a	nephrectomy: 90 (46-136) nephrouretere ctomy: 174 (74-222)	15 nephrectomy/ 9 nephroureterectomy	TP	0	3 (2 port site infections & 1 umbilical infection)	10 pts: same day discharge / 12 pts: 1 (1-2)
Ganpule et al. 2013 [21]	7	**3.14** (SD:1.7)	3M/4F	**97.5** (SD:12.54)	nephrectomy	TP	2	0	3 (3-4)
Szavay et al. 2013 [16]	11	1(0.06-10.7)	7M/ 4F	110 (50-260)	nephrectomy	TP	0	0	n.a

Uygun et al. 2013 [22]	5	**7** (2-15)	5M	**120** (110-135)	nephroureterectomy	TP	0	0	**4** (2-6)
Tam et al. 2013 [17]	8	**3.8** (1.9- 7) †	3M/9F†	155 (100-230)	nephrectomy	TP	0	0	**2.9** (2-6)†
Ham et al. 2011 [23]	6	3.5 (0.6 -11)	2M/4F	112 (90-148)	4 nephrectomy/ 2 nephroureterectomy	TP	0	0	2(2-2)
Urbanowicz et al. 2011 [24]	7	6 (3-10)	n.a	50-90	nephrectomy/ nephroureterectomy	TP	0	0	3(3-3)
Marietti et al. 2011 [25]	4/8	17 (1.5-18)	3M/1F	345 (308-370)	nephrectomy	TP	0	0	4 (4-5)
Kocherov et al. 2011 [26]	4	6.5 (1.8-12)	n.a	75 (60-80)	3 nephrectomy/ 1 nephroureterectomy	TP	0	0	1 (1-2)

Lee et al. 2011 [27]	4	**3.2** (1.5–4.92)	3F/1M	**83.3** (55– 125)	nephrectomy	TP	0	0	1 (1-2)
Barbancho et al. 2011 [28]	6	**1** (0.67-1.33)	n.a	**100** (90-120)	nephrectomy	TP	0	0	**2** (1-4)
Woldrich et al. 2011 [29]	7	8.8 (1.9-15.3)	n.a	180.5 (171-244)	nephrectomy	TP	1	0	1.9 (1-3.2)
Vricella et al. 2010 [30]	3/5	11 (10-13)	1F/2M	214 (188-300)	nephrectomy	TP	0	1 (persistent fever, pseudomembranous diarrhea, anemia & retroperitoneal fluid collection)	3 (1-12)

† data not separate from heminephrectomies, TP: transperitoneal
*(use of additional trocar) or open surgery

Bold: mean , S.D:standard deviation , ♮ : 2 patients were excluded from the analysis due to concomitant procedures

Table 3. Retroperitoneal Nephrectomies

Author - Year	**Number of Patients/ Procedures**	**Age, years** median (range)	**Gender**	**Operation time, min** median (range)	**Procedure performed**	**Access**	**Conversion***	**Postoperative complications**	**Postoperative hospital stay** median
Featherstone et al. 2015 [31]	9/10	10.9 (2.7-15.9)	4M/5F	n.a	nephrectomy	RP	0	0	n.a
Liem et al. 2013 [32]	5	4 (2-5)	1M/4F	60 (60-70)	nephrectomy	RP	0	0	1 (1-1.5)
Liem et al. 2012 [33]	5	4 (1.67-11)	5F	60 (50-90)	nephrectomy	RP	0	0	1.5

***use of extra trocar or open surgery
n.a: not available , RP: retroperitoneal

Table 4. Pyeloplasties Intracorporeal

Author-Year	**Number of Patients/ Procedures**	**Age, years** mean (range)	**Operation time, min** mean (range)	**Ureteropelvic Anastomosis Site**	**Crossing Vessels**	**Access**	**Conversion ***	**Postoperative Complications-Recurrence**	**Postoperative hospital stay (days)** mean (range)	**Follow-up, months** mean (range)
Yamada et al. 2015 [18]	21	6.5 (1-14)	240 (178-363)	intracorporeal	n.a	TP	21	0	5.2 (3-8)	35.1 (12-78)
Khambati et al. 2015 [19]	7	12.7 (7.7-17.9)	**233** (155-250)	intracorporeal	n.a	TP	1	n.a	2.2 (1.53-2.61)	15.7
Abdel-Karim et al. 2015 [20]	3	14.2 (SD:2.6)	155.6 (SD:5.6)	intracorporeal	2	TP	0	0	2 (sd:0)	n.a

Ganpule et al. 2013 [21]	3/4	2.43 (SD:2.3)	192 (SD:47.16)	intracorporeal	n.a	TP	1	0	4.67 (4-6)	6
Zhou et al. 2012 [34]	24	1.2 (0.2-5.2)	145 (70-300)	intracorporeal	2	TP	0	2 (post-operative fistula disappearing naturally)	7 (6-10)	6 (3-12)
Tugcu et al. 2011 [35]	11	10 (2-17)	182.5 (160-300)	intracorporeal	3	TP	0	2 (1 wound infection & 1 urinary infection)	2 (1-3)	6 (4-8)
Bi Y et al. 2011 [36]	22	4.74 (0.16-11.16)	198 (150–270)	intracorporeal	0	TP	0	7 (6 post-operative fever - 2 associated with urine extravasation, one anastomosis obstruction)	6.4 (4–10)	n.a

*(use of additional trocar) or open surgery
n.a: not available
bold: median
S.D: standard deviation
TP: transperitoneal

Table 5. Pyeloplasties Intracorporeal Outcome

Author-Year	**Number of Patients/ Procedures**	**Follow-up, months** mean (range)	**Outcome (definition of sucess)**	**Follow-up method**
Yamada et al. 2015 [18]	21	35.1 (12-78)	100% (hydronephrosis improvement, renal function stable or improved)	U/S 1,6,12 months post-op and yearly
Khambati et al. 2015 [19]	7	15.7	85.7% (hydronephrosis improvement)	n.a
Abdel-Karim et al. 2015 [20]	3	n.a	100% (improved renal excretion, hydronephrosis improvement and/or patency of UPJ)	n.a
Ganpule et al. 2013 [21]	3/4	6	for 2 patients good drainage	renogram at 6 months
Zhou et al. 2012 [34]	24	6 (3-12)	100% (symptom resolution and hydronephrosis improvement and/or improved renal excretion)	renogram 6 months

Tugcu et al. 2011 [35]	11	6 (4-8)	100% (symptom resolution and hydronephrosis improvement and/or improved renal excretion)	U/S and renogram and/or IVU at 3 months
Bi Y et al. 2011 [36]	22	n.a	One patient developed symptoms of anastomosis obstruction	renogram recommended

n.a: not available
S.D: standard deviation
UPJ: ureteropelvic junction
U/S: ultrasound
IVU: intravenous urography

Table 6. Varicocelectomies

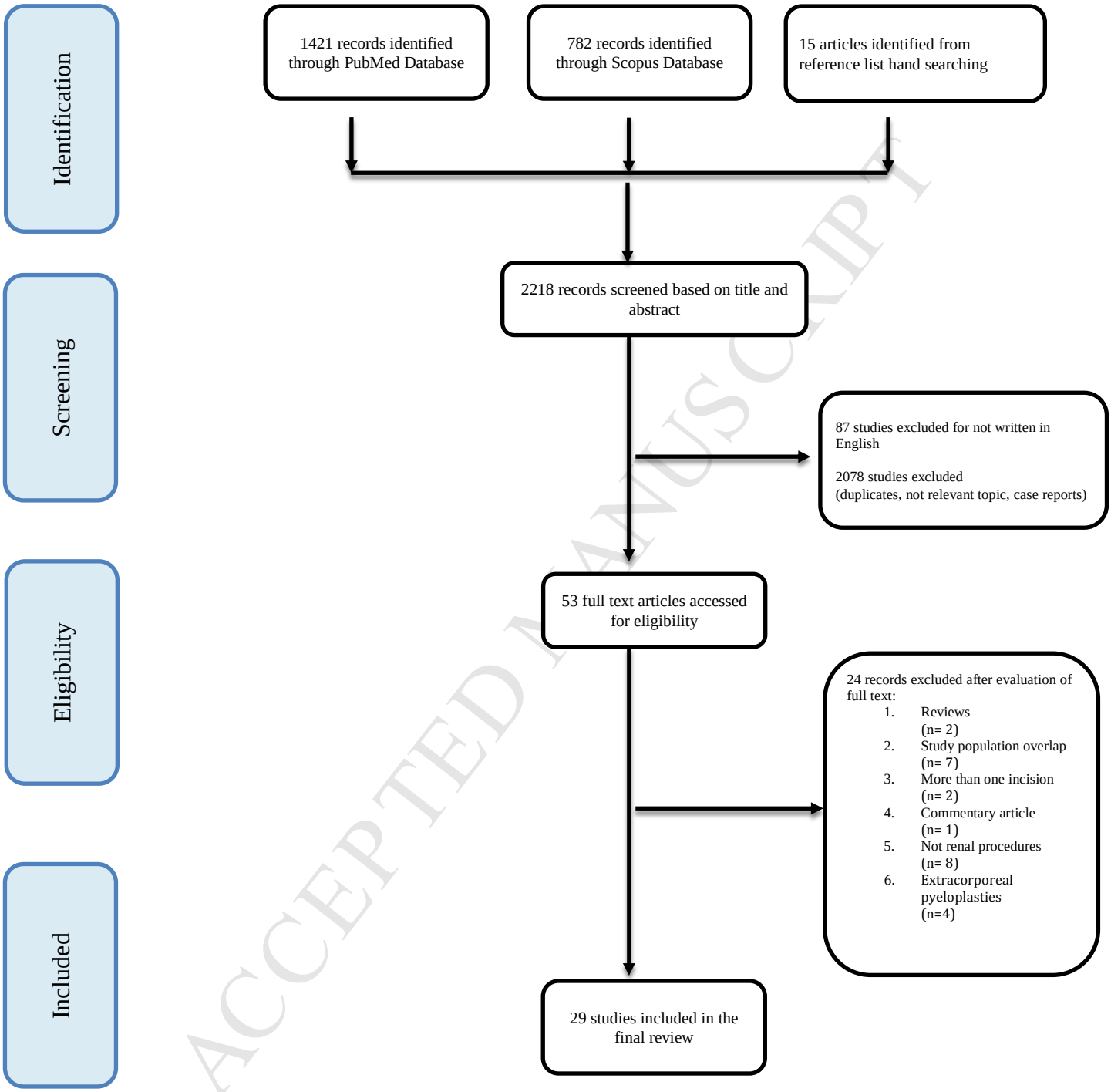
Author - Year	**Number of Patients/ Procedures**	**Age, years** median (range)	**Operation time, min** median (range)	**Access**	**Conversion***	**Postoperative complications**	**Postoperative hospital stay, days** median (range)
Soto-Aviles et al. 2015 [13]	5	n.a	n.a	TP	0	0	1 (1-1)
Khambati et al. 2015 [19]	5	15 (13-17.5)	55 (45-61)	TP	0	0	< 1
Abdel-Karim et al. 2015 [20]	4	**15.2 ± 0.5**	**41.3 ± 6.2**	TP	0	0	< 1
Madhi et al. 2015 [37]	2	8-10	**30**	TP	0	0	**1**
Chen Q et al. 2015 [38]	12/14	**13.6 ± 2.6**	**25.0 ± 5.7**	TP	0	0	**2.1 ± 0.6**
Bansal et al. 2014 [15]	11	15.3 (12.4-20)	49 (33-76)	TP	0	1 post-op. hydrocele	< 1 †

Szavay et al. 2013 [16]	2	12.6-14.1	33-76	TP	0	0	n.a
Uygun et al. 2013 [22]	2	12-14	30-60	TP	0	0	1-3
Hao et al.2012 [39]	6	**15.3 ± 2.6**	**38.5 ± 6.9**	TP	0	0	**0.33 ± 0.52**
Kocherov et al. 2011 [26]	5/6	13 (12-16)	25 (20-30)	TP	0	0	1
Kaouk et al. 2008 [40]	3	15 (13-16)	<60	TP	0	0	< 1

† one patient that underwent bilateral varicocelectomy stayed 4 days because of increased pain at the site of the abdominal incision and severe pruritus from multiple pain medications,

bold: mean, TP: transperitoneal
*(use of additional trocar) or open surgery, n.a : not available

Fig.1 .PRISMA flow diagram of Laparoendoscopic Single-Site Surgery(LESS) for major urologic procedures



Highlights

- In the hands of experienced surgeons LESS is a feasible approach for pediatric urologic procedures
- LESS can be performed for all major urologic procedures in the pediatric population
- There is not enough evidence supporting LESS widespread adoption in the field
- Prospective trials comparing LESS to conventional laparoscopy are warranted

International Journal of Surgery Author Disclosure Form

The following additional information is required for submission. Please note that failure to respond to these questions/statements will mean your submission will be returned. If you have nothing to declare in any of these categories then this should be stated.

Please state any conflicts of interest

No conflicts of interest

Please state any sources of funding for your research

No funding received

Please state whether Ethical Approval was given, by whom and the relevant Judgement's reference number

Not applicable

Research Registration Unique Identifying Number (UIN)

Please enter the name of the registry and the unique identifying number of the study. You can register your research at http://www.researchregistry.com to obtain your UIN if you have not already registered your study. This is mandatory for human studies only.

Not applicable

If you are submitting an RCT, please state the trial registry number – ISRCTN

Not applicable

Author contribution

Please specify the contribution of each author to the paper, e.g. study design, data collections, data analysis, writing. Others, who have contributed in other ways should be listed as contributors.

Evangelos Symeonidis: study design, data collection, data analysis, initial drafting and revising, final approval

Dimitrios Nasioudis: study conception, study design, data collection, data analysis, initial drafting and revising, final approval

Konstantinos P.Economopoulos: study design, data analysis, initial drafting and revising, final approval

Guarantor

The Guarantor is the one or more people who accept full responsibility for the work and/or the conduct of the study, had access to the data, and controlled the decision to publish.

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