

Laparoscopic Single-Site Surgery in Pediatric Urology: Where Do We Stand Today?

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Abstract Since the first description of the laparoendoscopic single-site surgery (LESS) in the pediatric urology population, various authors have shared their experiences and results. We aim to provide a review of current studies of LESS and share our experience with this modality. The current literature describes the use of LESS for most surgeries performed in the pediatric urology population with similar results to open and standard laparoscopic surgery. The authors have described their experiences with transabdominal and retroperitoneal nephrectomy, nephroureterectomy, pyeloplasty, orchidopexy, varicocelectomy, and renal cyst decortication. In our experience, LESS has taken a role for extirpative surgery since we use other modalities for upper tract reconstruction. The data available has validated LESS as safe and has demonstrated similar results to standard laparoscopic surgery and open surgery with better cosmetic results.

Keywords Laparoendoscopic single-site surgery · Single-incision surgery · Pediatric urology

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Introduction

The introduction of laparoscopic nephrectomy in 1991 by Clayman and his colleagues marked the beginning of the ever-expanding field of minimal invasive urology. Experience with laparoscopic surgery and advances in technology have allowed surgeons to proceed from multiple-site surgery to single-site surgery, now referred as laparoendoscopic single-site surgery (LESS) or single-incision laparoscopic surgery (SILS).

Although with some limitations, the expansion of minimally invasive urology to pediatric urology has not fallen short, and most procedures done in the adult population are performed today in our pediatric patients. In 2008, Kaouk and Palmer reported for the first time the use of single multifunctional port for varicocelectomy in three patients [1]. A year later, Park et al. described the first pediatric case of LESS nephrectomy and opened the door for various institutions to explore this new technology [2].

In this article, we aim to review the current literature, analyze the current trends of LESS, share our clinical experience, and provide some expert opinion with regard to the future of minimally invasive surgery in pediatric urology.

Access Ports and Instrumentation

Currently, there are a variety of commercially available products worldwide to perform single-site surgery. In our institution, we used the GelPOINT Advanced Access Platform (Applied Medical, Rancho Santa Margarita, California), which provides the opportunity to use standard laparoscopic instruments and an increase in range of motion when compared to other products. The GelPOINT Advanced Access Platform also offers the opportunity to use instruments up to 12 mm

in diameter when needed. Other commercially available products are Tri-Port or R-Port (Olympus, New York, NY and Advance Surgical Concept, Wicklow, Ireland), SILS port (Covidien, Chicopee, MA), and the Uni-X system (Pnavel systems Inc, Morganville, NJ).

Variations in the instrumentation use in combination with the single-site ports have been reported. Various authors have reported the use of curve instruments as well as reticulating instruments to performed LESS and have reported decreased instrument collision with these instruments. Most authors used a 5 mm either 0 or 30° telescope, whereas other surgeons have favored the advantages provided by a reticulating telescope. Also, some preferred the use of a longer length laparoscope to decrease the amount of collision between the laparoscope operator and the surgeon. As previously mentioned, we used standard laparoscopic instruments and standard telescopes in all of our single-port cases. Some of the access ports require curve instruments and with the combination of a reticulating laparoscope in our opinion makes the learning curve for single-site surgery steeper. Kawauchi et al. published a great review article, which gave detail with regards to the instrumentations and access ports used around the world [3••].

Clinical Experience (2011–Early 2015)

Since the first description of LESS in the pediatric urologic populations, various institutions have published their results to demonstrate that this technology is feasible, safe, and with similar results to open and standard laparoscopic surgery. Initial reports had a small cohort of patients, but as time passed experience grew as well as follow-up time.

In 2011, Kocherov et al. published their initial experience with single-site surgery. Their experience consisted of 11 patients who underwent 14 procedures. Procedure performed included nephrectomy due to nonfunctioning kidney, bilateral gonadectomy, and unilateral or bilateral varicocelectomy. All procedures were done with the SILS port system (Covidien), 0° telescope for nephrectomies, and 30° telescope with a right angle light for pelvic surgery or varicocelectomy. They successfully treated all patients without complications and no extended hospital stay related to surgery [4].

Of interest, Lee et al. reported their experience with children who underwent laparoendoscopic single-site (LESS) nephrectomy for single-system ectopic ureters with dysplastic kidney using a homemade single-port device in all patients. The mean age for this cohort was 3.2 years (1.7–4.9 years), the mean operation time was 83.3 min (range 55–125 min), and the mean postoperative hospital stay was 1.3 days (range 1–2 days). LESS nephrectomy was completed successfully in all four patients without complications using a homemade single-port device [5].

Few years later, Abdel-Karim et al. published their single-center single-surgeon experience with laparoendoscopic single-site surgery for the treatment of different urologic pathologies in pediatrics. Twenty-two children underwent a total of 39 LESS procedures. The procedures done included diagnostic laparoscopy for undescended testis with first-stage Fowlers–Stephen when possible or staged orchidopexy versus orchiectomy if the testis was atrophied, nephrectomies, pyeloplasties, and varicocelectomies. All patients in this series were successfully treated with no use of narcotics for postoperative pain control and short hospital stay (0.5 ± 0.3 days) [6].

Bansal et al. published their retrospective data, which consisted of 61 patients who underwent a LESS procedure. In their cohort of patients, they were able to do nine different types of LESS procedures including orchidopexies, nephrectomies, varicocelectomies, nephroureterectomies, partial nephrectomies, and ureterectomies. Their mean operative time was 72 min (33–314 min). This is one of the first articles that provide data with regards to complications associated with laparoscopic surgery and LESS. Overall, they had six patients who developed some sort of complication in the postoperative period. Five patients developed grade II complications which most of them consisted of postoperative wound infections treated with oral antibiotics. One patient had a grade IIIb complication after he developed febrile urinary tract infection and prolonged ileus secondary to an infected obstructed system after a previous partial nephrectomy for an upper urinary tract duplication anomaly. In their series, LESS surgery was successfully completed in 59 out of 61 (97 %) patients without the need for ancillary ports or additional instrument insertion sites [7••].

Luithe et al. published their series of single-incision laparoscopic nephroureterectomy to assess the feasibility of this procedure with regards to different approaches according to patient weigh. They were concern that smaller patients will have less space for instruments mobilization and surgeon's range of motion. In their 11-patient series, the authors concluded that SILS/LEES nephroureterectomy could be done safely and efficiently, irrespective of age and weight. They acknowledge that the instrumentation used was varied according to patient's age and weight [8].

In 2015, Khambati et al. from the Hospital for Sick Children published their series of 15 LESS procedures (7 pyeloplasties, 4 unilateral and 1 bilateral varicocelectomies, 2 simple nephrectomies, and 1 renal cyst decortication). In their article, they used a variety of instruments and different access ports as part of the process to determine what access port/instrumentation will be better for them. In their age-matched cohort analysis, they found that there was no difference with regards to operative time and length of stay with LESS pyeloplasty when compared to traditional laparoscopic pyeloplasty. It is important to mention that as part of their discussion, the authors stated that the results obtained might

be related to expertise of the surgeon since LESS surgery requires advanced laparoscopic skills especially for intracorporeal suturing [9].

In a matched-pair analysis, Naitoh et al. compared the outcomes of single-site laparoendoscopic pyeloplasty versus conventional laparoscopic pyeloplasty in both adults and pediatric population. There were 14 pediatric patients in their study with a mean age of 7.1 years (1–14 years) with an operative time of 243 ± 49 min. When compared to the conventional laparoscopic pyeloplasty, there was no significant difference in the operative time, and no intraoperative or postoperative complications were observed in the LESS group [10].

Initial series and reports of LESS renal surgery have been described using the transperitoneal approach; some reports have reported on the retroperitoneal approach to avoid entry to the peritoneum therefore reducing the morbidity of peritoneal entry during surgery. Cherian and De Win reported a retroperitoneal approach in two pediatric patients. The first patient was a 13-year-old female with nephrotic syndrome requiring bilateral nephrectomies and the second patient was an 8-year-old girl with a poorly functioning duplex kidney and dilated non-refluxing ureter that underwent nephroureterectomy. Both patients recovered well from surgery without perioperative complications. Their techniques consist of placing the patient prone with the hips and chest elevated. A single transverse 2.5 cm is made at the midpoint on a line along the lateral border of the erector spinae bound by lower border of the 12th rib and the iliac crest. After the incision, the posterior lumbar muscles splitted and the lumbodorsal fascia opened. Once in the retroperitoneum, the GelPOINT Mini was placed, and surgery continued as traditional retroperitoneal surgery [11•].

Our Institutional Experience

Our current series consists of 31 pediatric patients (ages 3 months to 17 years of age) that underwent LESS procedure at one of our sponsoring institutions since 2011. The procedures performed included 20 nephrectomies, 4 heminephrectomies, 2 renal cyst ablations, and 5 varicocelectomies. All patients underwent procedures by the same surgeon (MPB), and the instrumentations and device used were the GelPOINT Advanced Access Platform (Applied Medical Rancho Santa Margarita, California), standard 5 mm laparoscopic instruments including Ligasure, and a 5 mm 0° laparoscope (see Fig. 1).

For renal extirpative surgery, the patient is placed in a 45° lateral position and is well secured in an operating table with rotational capabilities. A 1.5 cm skin incision is made around the umbilicus with an approximately 2.5 cm fascia incision. After positioning of the single-site port, direct visualization of the inner ring is made to ensure no bowel entrapment. Great

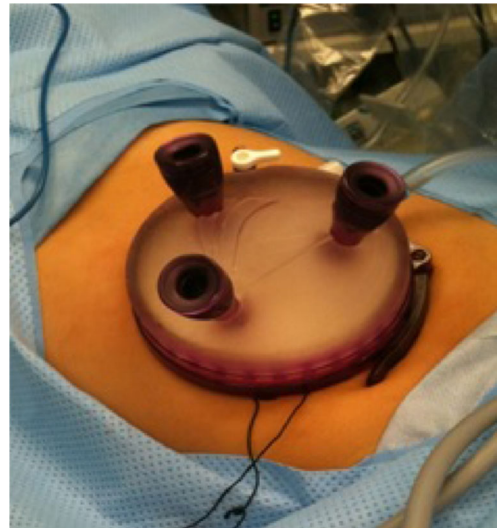


Fig. 1 GelPOINT in place with three 5 mm trocars

care is needed with instrument insertion to avoid inadvertent bowel injury. Abdominal insufflation pressures are kept between 8 and 12 mm depending on the patient size. We always place the four trocar included with GelPOINT as they are frequently used for retraction of bowel or liver. Occasionally, a 2–0 PDS is used as retraction after introducing it through the abdominal wall and securing it to the target organ. All specimens are removed using the abdominal site without laparoscopic retrieval bags.

All procedures were completed without the need of placing additional ports or converting to open surgery. All five varicocelectomy patients were performed as same day surgery with resolution of their varicoceles and no complications. Patients who underwent renal extirpative procedures had a mean age of 6.1 years with nine patients being 2 years old or younger. All patients were discharge on postop day number 1. No intraoperative complications and no clavien III b or above complications on follow up were seen. Only one patient had a febrile UTI early in the postop period without further sequelae (see Table 1).

Discussion

More than 5 years have passed after the first description of LESS in the pediatric population. The data available has validated this modality as safe and has demonstrated similar results to standard laparoscopic surgery and open surgery with better cosmetic results. Most laparoscopic procedures done in pediatric urology has been performed using the LESS/SILS approach.

Single-site surgery is ideal for the pediatric patients. Most patients are thin without previous intra-abdominal surgery. Because of the shorter skin to target organ distance, most procedures can be performed with minimal instrument

Table 1 Our clinical experience with renal extirpative LESS

| Age | Sex | Procedure | OR time (min) | Complications |
|---------------|--------|----------------------------|---------------|---------------|
| 3 months old | Female | Left nephrectomy | 55 | None |
| 3 years old | Female | Left nephrectomy | 120 | None |
| 14 years old | Female | Right nephrectomy | 60 | None |
| 17 years old | Male | Left nephrectomy | 50 | None |
| 12 years old | Male | Left nephrectomy | 50 | None |
| 3 years old | Male | Right nephrectomy | 40 | None |
| 10 years old | Female | Right nephrectomy | 75 | None |
| 6 months old | Male | Left nephrectomy | 50 | None |
| 2 years old | Male | Right nephrectomy | 50 | None |
| 1 year old | Female | Left nephrectomy | 75 | None |
| 2 years old | Male | Left nephrectomy | 45 | None |
| 11 years old | Female | Right nephrectomy | 55 | None |
| 11 months old | Female | Right nephrectomy | 45 | None |
| 4 years old | Female | Right nephrectomy | 45 | None |
| 9 years old | Female | Right nephrectomy | 60 | None |
| 5 years old | Male | Right nephrectomy | 55 | None |
| 7 months old | Female | Left nephrectomy | 45 | None |
| 1 year old | Female | Left nephrectomy | 50 | None |
| 9 months old | Female | Left nephrectomy | 60 | None |
| 9 years old | Female | Left nephrectomy | 65 | None |
| 3 years old | Male | Left lower heminephrectomy | 55 | None |
| 5 months old | Male | Left lower heminephrectomy | 65 | None |
| 1 year old | Female | Left upper heminephrectomy | 55 | None |
| 5 months old | Female | Left upper heminephrectomy | 60 | None |
| 14 years old | Female | Cyst ablation | 20 | None |
| 8 years old | Female | Cyst ablation | 25 | Febrile UTI |

All patients had EBL <10 ml and a mean LOS of less than 24 h

crossing. There is a steep learning curve with LESS approach that it is significantly less with surgeons' proficient with retroperitoneal laparoscopic approach. Similarities between the two approaches included the feeling of instrument crowding and decrease triangulation and laparoscope vision angle. Single-port surgery can be performed in the infant with our younger patient being 3 months of age at the time of surgery. We have noted that most umbilicus can accommodate the 1.5 cm umbilical incision without difficulties and with great postoperative cosmetic results.

In our institution, LESS has taken a significant role for extirpative surgery, such as nephrectomy for nonfunctioning kidney and heminephrectomies for duplex nonfunctioning moiety. The advantage provided by LESS for extirpative surgery entails the creation of only one incision in or around the umbilicus which creates excellent cosmesis but also decrease the risk of intra-abdominal injury secondary to additional port placements. Also, the specimen can be removed through the initial incision without the need of extending previous incisions or creating a new incision for specimen removal. This obviates the

need to use a specimen retrieval bag and also facilitates the ease of removing the specimen and decrease operative time. In addition, the GelPOINT system allows for the placement of 3 5 mm ports and a 10 mm port. The extra port as compared to traditional laparoscopic three-port approach gives the surgeon flexibility to use instruments for retraction of bowel or liver without adding an additional port for this purpose. The 10 mm port can be useful in cases where the renal vein is significant in size and would require a staple devise.

Single-port surgery/LESS involves some technical difficulties that require advanced laparoscopic techniques as well as a novel approach of laparoscopic surgery in order to obtain good results. During LESS procedures, instruments must be in line and move all together in unison to avoid clashing. The classical triangulation seen in standard laparoscopic surgery is limited since all instruments are within centimeters of each other. Other limitations are crossing of instruments for wider retraction and laparoscopic view in line with the instruments. This could create difficulties with angles used in clipping, cutting, or suturing.

As previously mentioned, the field of minimally invasive is an ever-expanding field and with this evolution, new technology arrives. Even though several institutions have reported on their experience with pyeloplasties, we feel that upper tract and lower tract reconstruction is technically easier with the use of robotic surgery. At our institution, we use the Da Vinci Xi system for all upper tract and lower tract reconstructive procedures instead of the LESS approach.

Conclusion

As seen on this review of literature, current experience with LESS has expanded to a vast majority of procedures with minimal complications and no significant patient morbidity. Transperitoneal LESS and retroperitoneal LESS approaches have been described with great success. All throughout the literature, the authors have used different access ports and instrumentations making instrument selection a surgeon's choice that will be greatly influence by his/her expertise.

Since the first reported cases, LESS has been proven to be safe and effective for pediatric urologic patients. Clinical results have demonstrated similar efficacy to standard laparoscopy with improved cosmesis and decreased morbidity as compared to the use multiple port sites. LESS approach is ideal for the pediatric patient undergoing renal extirpative surgery.

Compliance with Ethics Guidelines

Conflict of Interest Omar E. Soto-Aviles, Karina Escudero-Chu, and Marcos R. Perez-Brayfield each declare no potential conflicts of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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