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Laparoscopic Appendectomy in Children: A Comparative Analysis of Single Port Intra-Corporeal Technique with Standard 3-Port Approach

Umashankar K. Ballehaninna and Sathyaprasad C Burjonrappa*

Department of Pediatric Surgery, Maimonides Medical Center, Brooklyn, New York, USA

***Corresponding author:** Sathyaprasad C. Burjonrappa, Attending Pediatric Surgeon, Children's Hospital of New Jersey, 2130 Millburn Ave; suite C-1 Maplewood, New Jersey 07040, USA, Tel: 973-313-3115; Fax: 973-313-3188; E-mail: sathyabc@yahoo.com

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Abstract

Purpose: Single port appendectomy (SPA) offers a new paradigm to minimally invasive approach for appendectomy in children. This study sought to evaluate feasibility and assess its' clinical effectiveness compared to traditional 3-port approach (3PA).

Methods: After an institutional review board approval, data from children with acute appendicitis, admitted to a single surgeon, who underwent SPA were prospectively collected and compared with 3 PA (2010-2012). Outcomes analyzed include operative duration, blood loss, time to resume diet, duration of hospital stay, cumulative dose of antibiotics and analgesics as well as comparison of complication rate and types.

Results: 104 children underwent either SPA (N=52) or 3PA (N=52). Both groups were age and sex-matched and there was no statistical difference with regards to clinical presentation, leukocyte count, severity of illness, mode of diagnosis (Ultrasound or computerized tomography scan), preoperative antibiotic usage and time from admission to actual time of operation ($p>0.05$). Average operative time for SPA was 66.5 min compared to 56.6 min using 3PA ($p<0.05$). The SPA group had an increased length of hospital stay; total dose of analgesics and complications (wound infection, abscess-requiring drainage, ileus and readmission), albeit not statistically significant. There were no significant difference pertaining to intra-operative blood loss, duration of antibiotic therapy, pathologic subtypes and antibiotic prescription among either groups.

Conclusions: This study illustrates that while SPA is technically feasible in the pediatric population it may be associated with a higher incidence of surgical morbidity. Larger randomized controlled studies are needed to verify its applicability in pediatric appendicitis.

Keywords: Laproscopy; Appendectomy; Intra-Corporeal Technique

Introduction

Appendectomy is one of the most common general surgical procedures performed in the pediatric population with reported appendectomy rates of 8-10% in children. [1,2] Laparoscopic appendectomy (LA) has become the preferred approach over the traditional open technique (OA) due to decreased risk of wound infection, less analgesic requirement, decreased hospital stay, overall hospital cost, and improved cosmesis [3,4]. National database registry studies report that almost 95-98% of appendectomies are performed by laparoscopy in the pediatric population [5,6]. Traditionally LA is performed using 3 ports (3-port appendectomy-3PA). Recently single port appendectomy (SPA) has received a lot of attention as surgeons have devised techniques such as NOTES (Natural Orifice Transluminal Endoscopic Surgery) to further decrease surgical invasiveness [7]. A single port appendectomy (SPA) has an obvious advantage of increased cosmesis and patient appeal, however its' validity in the pediatric population has been only recently been evaluated [8,9]. This study was envisioned to assess our institutional experience-comparing SPA versus 3PA in the pediatric population.

Materials and Methods

After an institutional review board approval, data from consecutive children (up to 18 years) with acute appendicitis, admitted to a single surgeon, who underwent SPA were prospectively collected and compared with 3 PA (2010-2012). All operations were performed under the guidance of the senior author, a board certified general and pediatric surgeon, with advanced training in pediatric laparoscopic surgery. While patients were offered only 3-PA initially, SPA was offered to all patients as an alternative in the beginning of 2011 with the only exclusion criteria for SPA being age less than 4 years. Patient choice determined procedure chosen. A database was created using Microsoft Excel software program and following clinico-pathologic data were collected: demographic data including age (years), sex, height, weight, and body mass index. Preoperative data collected included nature and duration of symptoms, leukocyte count, nature of preoperative imaging and their results (ultrasound or computerized tomography scan), and information on preoperative antibiotics. Intravenous piperacillin/tazobactam was the standard antibiotic unless the patient was penicillin allergic wherein intravenous ciprofloxacin was used. Intraoperative characteristics assessed include type of procedure (single port or 3 port appendectomy), operative time, blood loss, use of irrigation and associated complications. Intraoperative appearance of the appendix i.e. whether acute, suppurative, perforated

or gangrenous and where indicated the reasons for conversion from SPA to open or 3 port appendectomy were collected. Postoperative data collection involved pathology, duration of hospital stay, the dose and duration of intravenous antibiotics and analgesics, and timing and pattern of resumption of normal diet. The patient was deemed to have postoperative ileus or small bowel obstruction (SBO) if there was a failure to tolerate a diet 48 hours after surgery or if there was radiological evidence of the same. Duration and nature of discharge antibiotics and complications such as wound infection (erythema or abscess formation at an incision site), intra-abdominal abscess, and the necessity of abscess drainage and readmission to hospital were also recorded. All patients had a standardized postoperative care and were followed up after 4 weeks from day of discharge.

Surgical technique

Our surgical technique for SPA has been described in detail elsewhere [10]. Briefly, all operations were performed under general anesthesia after endotracheal intubation. A 12-15 mm transverse umbilical incision was used, and access to the peritoneal cavity was achieved by a modified Hasson technique. An Olympus TriPort15^{TM} (Olympus INC, NC, USA) access system was placed. In cases of 3PA a 5 mm port at the umbilicus and 2 additional 5 mm ports (left lower quadrant and supra-pubic) were placed. After achieving adequate pneumoperitoneum, peritoneal cavity was thoroughly inspected with a 5 mm thirty degree laparoscope. The appendix was grasped and the mesoappendix was divided off the appendix using electrocautery all the way down to the appendico-cecal junction. Dissection was done using specific angulated instruments in SPA. The appendico-cecal junction was ligated using endoloops and the specimen retrieved through the plastic sheath of Triport or a laparoscopic endopouch was used for specimen retrieval in cases of 3PA. In the presence of purulence or if the appendix was perforated, the entire abdominal cavity was thoroughly irrigated and contents aspirated.

Statistical analysis

The main outcomes analyzed include operative duration, blood loss, time to resume diet, duration of hospital stay, cumulative dose of antibiotics and analgesics as well as comparison of complication rate and types. Statistical analysis of continuous variables was performed using Wilcoxon log-ranks or Student t test whereas discrete variables were analyzed by the chi-square test using the SPSS software program.

Results

A total of 104 consecutive children aged less than 18 years underwent either single port appendectomy (N=52) or 3-port appendectomy (N=52) during June 2010 to September 2012.

Preoperative data

There was no difference in age and gender distribution, weight/body mass index, and duration of symptoms, presence of fever between the 2 groups. Both the groups were also similar with regards to preoperative imaging, antibiotic usage and time from admission to actual surgery. Preoperative imaging characteristics suggestive of perforation such as the presence of free air/free fluid were also similar (Table 1).

Characteristics	Single port appendectomy	3 port appendectomy	P Value
Mean Age in years (SD)	11.1 (± 3.2)	11.2 (± 3.2)	0.55
Mean Weight in kg (Range)	43.1 (18-81)	45.5	0.61
Male Gender (%)	36 (69%)	36 (69%)	NA
Mean Body mass index in kg/m^2 (Range)	19.2 (11.5-31)	20.1 (13.5-37)	0.64
Mean Symptom duration in days (Range)	1.5 (1- 2 days)		0.14
Mean Maximum admission temperature (in Fahrenheit)	100.1	100.4	0.82
Mean Leukocyte count (Range)	14.9 (6.9-30.6)	15.6 (5.2-25)	0.32
Preoperative imaging Ultrasound USG+CT scan Computerized Tomography	18 2 32	19 2 31	0.63
Imaging characteristics of perforation Perforation Free fluid/Abscess	7 19	8 15	0.48
Preoperative antibiotic use	52	52	NS
Mean Time in hours from admission to appendectomy (Range)	6.8 (3-28 hours)	6.6 (2-30 hours)	0.54

Table 1: Comparison of preoperative characteristics of patients undergoing SPA with 3PA Abbreviations: SD: Standard Deviation; SPA: Single Port Appendectomy; 3-PA: 3 Port Appendectomy; USG: Ultrasound; CT: Computerized Tomography Scan; NS: Not Significant

Operative results

The mean operative time required to perform SPA was 66.5 min compared to 56.6 min in cases of 3-port appendectomy (P<0.01). None of the patient required conversion to open appendectomy. Mean blood loss and use of suction irrigation were similar for both the groups. The severity of appendicitis as determined by the presence of perforation or gangrenous appendix was also similar in both the groups (Table 2).

Characteristics	Single port appendectomy	3 port appendectomy	P Value
Mean Operative time in minutes (range)	66.5 (17-115)	56.6 (28-110)	0.01
Mean Blood loss in ml (range)	10 (5-20 ml)	8.7 (5-20 ml)	0.11
Use of irrigation	14	18	0.43
Intraoperative appearance of appendix Simple	35 17	34 18	0.83

Perforated/Gangrenous			
Conversion to 3-port or open technique	One conversion to 3-PA	None	NA

Table 2: Comparison of intraoperative characteristics among children undergoing SPA versus 3PA; Abbreviations: SPA: Single Port Appendectomy; 3-PA: 3 Port Appendectomy; NA: Not Available

Comparison of complications and postoperative outcomes

There was no difference between SPA and 3-PA groups with regards to a pathologic subtype of appendicitis, time to resumption of diet, duration of hospital stay and readmission related to the procedure (Table 3). We noted a slightly higher rate of wound infection (2 vs. 1) and abscess formation that required drainage (3 compared to 1) among SPA group however this difference was not statistically significant ($p>0.05$). A significantly higher number of patients had postoperative ileus among SPA group (N=10) compared to 3-PA group (N=5). The in-hospital narcotic use, antibiotic dose/duration, and type and duration of prescribed discharge antibiotics were also similar in both groups.

Characteristics	Single port appendectomy	3 port appendectomy	P Value
Pathologic subtype Simple appendicitis Complicated appendicitis (Suppurative Perforated/ Gangrenous)	41 12	42 11	0.81
Wound infection	2	1	>0.5
Abscess Drainage	4 3	1 1	0.85
Mean Time to clear diet in days (Range)	1.4 (1-5)	1.4 (1-4)	NS
Mean Time to regular diet (Range)	2.8 (1-9 days)	2.7 (2-5 days)	NS
Post-operative ileus	10	5	0.05
Mean Antibiotic duration in days (range)	4.2 (2-12)	4.5 (2-10)	0.6
Mean Narcotic usage (Range)	6.1 (0-30)	4.7 (0-32)	0.45
Mean Hospital stay (Range)	4.5 (2-12)	4.2 (2-10)	0.34
Readmission	2	1	0.15
Discharge antibiotics Number of patients Duration in days	37 4.7 (2-7)	26 5.1 (3-7)	0.04 0.56

Table 3: Comparison of complications and postoperative outcomes in children undergoing SPA with 3PA; Abbreviations: SPA: Single Port Appendectomy; 3-PA: 3 Port Appendectomy; NS: Not Significant

Discussion

Single incision laparoscopic surgery has recently become the new frontier for advanced laparoscopy and the driving force behind this change is the patient appeal of excellent cosmesis and technical feasibility coupled with equivalent results as compared to standard 3-port procedures. [7] Although in adults many single incision laparoscopic procedures such as appendectomy, cholecystectomy and colectomy have been increasingly reported, only a few studies have described its' applicability in the pediatric population. [11,12] Two recent randomized controlled trials (RCT) that compared SPA with traditional 3PA have provided useful insights into the actual utility of SPA in the pediatric population. [8,9] St. Peter and colleagues compared 360 pediatric patients undergoing SPA with 3-PA in a randomized fashion. [8] The authors found no difference in wound infection rate, time to regular diet, length of hospitalization, or time to return to full activity. Operative time, doses of narcotics, surgical difficultly and hospital charges were greater with the single site approach. Specifically, the mean operative time was 5 minutes longer in the single site group. In that trial, 10% of SPA patients required conversion to 3-PA because of difficulties in dissecting appendix. In a smaller RCT that compared 50 children who underwent SPA with 3PA with 2.2 years follow up, Perez and colleagues found no differences in complication rates, hospital stay and readmission rates. [9] However, mean operative duration for SPA was significantly longer compared to 3PA (46.8 min compared to 34.8 min, $P<0.01$). Similar to above well-conducted RCTs our results are comparable in that our study population (SPA compared to 3-PA) had no differences with regards to patient demographics, clinical presentation, preoperative evaluation, hospital stay, antibiotic and narcotic use and readmission rates. (Tables 1-3) In this study, we found that operative time for SPA was significantly longer (66.5 min) compared to 3PA (55.4 min). This finding was similarly reported in the above-mentioned RCTs as well as by multiple retrospective studies and is attributable to learning curve and less ergonomic devices. [8,9,13] Thus, this study demonstrates feasibility of SPA in the pediatric population and with an improved instrumentation SPA has the potential to replace 3PA as the preferred method of appendectomy in children.

Several case series that described SPA in pediatric population noted an increased incidence of wound infection (5-10%) and abscess formation (4-7%) with SPA [5,8,9,14]. This increased rate of wound infection was attributed to radial pressure on the surrounding tissues from instrument manipulation through a narrow working channel. However in the two randomized trials the wound infection and abscess rates were found to be low (3.4-5%) and similar to 3PA. In our study the incidence of wound infection was 3.8% in SPA group compared to 2% in 3PA group (not significant). Also, 4 patients in SPA group developed an intra-abdominal abscess (IAA) compared to 1 patient in 3-port appendectomy. Most of the reported literature on SPA in pediatric patients consists of uncomplicated appendicitis and specifically patients with complicated appendicitis such as perforated or retrocecal appendicitis were excluded. [5,8] In our study 33% (17 of 52) of SPA patients had intraoperative evidence of either perforated or gangrenous appendicitis. In a subgroup analysis we found that although the operative time was longer in this group of patient, the overall morbidity and outcomes were similar to patient with simple appendicitis undergoing SPA. Although patient selection is key and a stable hemodynamic condition of the patient is mandatory, our results suggest that SPA can be successfully utilized in pediatric appendicitis. However based on our experience we believe that the jury is still out as to whether SPA should be offered to a selected subgroup of patients

without significant peritoneal contamination as we have seen a higher incidence of IAA, ileus, and wound infection, albeit not statistically significant, by making it available to all presentations of pediatric acute appendicitis.

Some of the reported disadvantages of single port laparoscopic procedures include a compromise in the degrees of freedom, loss of triangulation and less desirable ergonomics, making the procedure inherently more difficult to learn and to perform [8,11]. We found that similar to the early experience with laparoscopic surgery, single port technique has a steeper learning curve and with increased experience, broader Triport (with more widely spaced trocar sites to minimize instrument conflict) and the use of pre-curved instruments and a flexible tip laparoscope, one can safely perform SPA. Another important disadvantage of performing SPA is the inability to use surgical stapling device [14]. In this series we used PDS (Polydioxanone) endo-loops (Ethicon Inc, NJ, USA) to ligate the appendix at the base. We successfully used endo-loops for both simple and complicated appendicitis and results are comparable to those in literature where the staples were used [15]. While our data suggest that endo-loops provide significant cost saving compared to staplers, it requires precision, increased operative time and experience to safely ligate the appendix exactly at the base to avoid a subtotal appendectomy.

To summarize, in children with acute appendicitis, single port appendectomy by intra-corporeal technique using endo-loops to ligate appendix is feasible and is a safe alternative to traditional 3-port appendectomy. Although our data suggest that it required longer operative time and has an increased rate of ileus, IAA, and wound infection, these differences were not statistically significant. Single port appendectomy in children needs validation by a large randomized trial that includes all presentations of the pathology. Improved equipment and port design, and increased instrument ergonomics will pave the way for broader application of SPA in general and specifically in the pediatric population. Our data demonstrate that SPA is technically feasible even in patients with complicated appendicitis such as those with perforation and gangrenous appendicitis.

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