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Original Research

Transumbilical laparoscopically assisted extracorporeal appendectomy in children and young adults: A retrospective cohort study

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HIGHLIGHTS

- Comparing transumbilical laparoscopically assisted extracorporeal appendectomy in pediatric patients and young adults.
- Operative time, length of stay, and cost did not differ significantly between pediatric and young adult patients.
- No difference of infection rate or conversion to conventional appendectomy was noted between children and young adults.

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ABSTRACT

Background: To compare surgical outcomes of pediatric patients aged 0–15 with acute appendicitis treated with single-port, transumbilical, extracorporeal laparoscopically assisted appendectomy (SP) with young adult patients aged 16–21.

Materials and methods: Single center retrospective chart review in patients 21 years and younger with a pre-operative diagnosis of appendicitis who underwent SP between January 2010 and December 2015. Patients were divided into two groups based on age. Operative time (OT), length of stay (LOS), cost, rates of conversion to standard three-port laparoscopic appendectomy (TP), and rates of infection were compared between the groups.

Results: SP was performed in a total of 263 patients: 211 in pediatric patients aged 0–15 and 52 in patients aged 16–21. Age groups did not differ significantly on cost, LOS, operative time, rates of conversion to TP, or rates of infection.

Conclusions: SP has comparable surgical outcomes in adolescent, adult, and pediatric patients.

1. Introduction

Laparoscopic appendectomy was introduced by Semm in 1983 [1] and first performed for acute appendicitis by Schreiber in 1987 [2]. It has since replaced open appendectomy as the gold standard for the surgical treatment of appendicitis [1,3,4]. Within laparoscopic techniques, different single-incision approaches for appendectomies have been described for the adult population [5–10]. Single port, transumbilical, extracorporeal laparoscopically assisted appendectomy (SP) is a single incision, single port technique, combining the advantages of laparoscopic and open appendectomy. The procedure was first performed in adults by Pelosi [11] and subsequently described in children by Begin [12]. SP is well-established in the pediatric population as an alternative surgical technique to conventional three-port laparoscopic appendectomy (TP) with intracorporeal appendiceal amputation. In pediatric patients, SP has demonstrated lower costs, shorter operative times, with improved cosmetic results compared to the conventional TP [13,14]. SP has been described as a viable treatment

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option in the adult population; however, it is still not commonly performed in North America [15–17].

There is significant heterogeneity in single-incision laparoscopic techniques, with few comparative studies describing a single port extracorporeal laparoscopically assisted appendectomy in adults. Furthermore, there have been a limited number of studies assessing the cost savings of SP in adults. The aim of this study is to determine whether SP in fully grown patients can achieve similarly improved operative times (OT), hospital lengths of stay (LOS), and cost savings already demonstrated in the pediatric population.

2. Materials & methods

Following approval by our institutional review board, a single center retrospective chart review was performed to identify patients undergoing TP or SP appendectomy between January 2010 and December 2015. All patients 21 years and younger with a preoperative diagnosis of appendicitis were candidates. All procedures were performed by four pediatric surgeons at a tertiary referral center. Patients with a post-operative, histological diagnosis of acute, perforated, or gangrenous appendicitis, available BMI data, operative time (OT), length of stay (LOS), and available cost data were analyzed. Cases in which an appendectomy was not the sole procedure were excluded. A total of 625 appendectomies were performed in the study period of 2010-2015.

Patients undergoing SP were divided into two groups based on age: patients 0–15 years of age were defined as “pediatric” and patients 16–21 years old as fully grown or “adult”. Patients were not randomized to either SP or TP technique. Surgical technique was decided based on surgeon preference. Outcomes analyzed for each group included: OT in minutes (time of incision to time of dressing application), LOS in hours (post-anesthesia care unit discharge time to hospital discharge time), total cost of hospitalization in US dollars, surgical site infections with post-operative need for antibiotics (SSI), post-operative ileus (defined as no return of bowel function within two days), conversion from SP to conventional TP, and intra-operative complications such as vascular, urethral, or bowel injury.

This work has been reported in line with the STROBE criteria [18].

2.1. Operative technique for SP

All patients received preoperative antibiotics within an hour prior to incision. For the SP approach, the umbilicus is everted and a vertical intra-umbilical incision is made. Using the Hasson technique, an 11-mm Covidien STEP™ trocar (Covidien, Minneapolis, MN) is placed into the abdominal cavity. Capnoperitoneum to a pressure of 12–15 mmHg of CO_2 is established. The 10 mm, offset Storz operating laparoscope (Karl Storz Endoscopy-America, Inc., El Segundo, CA) is introduced and, if necessary, the cecum is mobilized using a blunt 5 mm grasper. The tip of the appendix is grasped, the capnoperitoneum released, and the appendix exteriorized through the umbilical incision. In cases of a severely inflamed or thickened appendix, the fascial defect is enlarged prior to exteriorization. The mesoappendix is clamped, ligated, and divided. The base of the appendix is doubly ligated with a long lasting polydioxanone suture and amputated extracorporeally. The mucosal stump is allowed to retract into the peritoneal cavity. Completion laparoscopy confirms correct position of the cecum, hemostasis, and proper seal of the appendiceal stump. The umbilical ring is closed using a figure-of-eight polyglactin suture and the umbilical skin approximated with simple interrupted absorbable monofilament. Bupivacaine is subcutaneously injected and a simple vacuum dressing is applied using gauze and a bio-occlusive film [19]. SP operative technique was standard for all patients in the study regardless of age.

2.2. Statistical methods

BMI, age- and gender-adjusted BMI z-scores, percentiles, and percentage of 95th percentile of the age- and gender-adjusted BMI were computed for patients under the age of 20 years from the 2000 CDC growth charts using a program provided by the Centers for Disease Control and Prevention [20].

Data were described using medians and ranges for continuous variables, and counts and percentages for categorical variables. Age groups were compared on the continuous outcomes cost, length of stay (LOS) and operative time using Chi-square, Fisher's exact, and Wilcoxon rank sum tests as appropriate. Sample sizes for individual variables reflect missing data. All analyses were performed on a complete-case basis. All tests were two-tailed and performed at a significance level of 0.05. SAS 9.4 software (SAS Institute, Cary, NC) was used for all analyses.

3. Results

A total of 625 appendectomies were performed in the study period of 2010–2015. 362 were TP and 263 SP. Among the 362 TP appendectomies, 291 were patients aged 0–15 and 71 in patients aged 16–21. 263 SP appendectomies were performed among which 211 were in patients aged 0–15 and 52 in patients aged 16–21 (Table 1). Patients aged 16–21 were more likely to be female than patients 0–15 (58% vs 41%; $p = 0.028$). The older age group had a lower BMI-for-age percentile (median percentile 53 vs 67; $p = 0.032$). There were no significant differences in BMI or type of appendicitis between the two age groups.

Outcomes of OT, LOS, and cost did not differ significantly between the two SP groups. There were a total of 17 (8%) conversions from SP to TP in patients age 0–15 and 1 (2%) in the age 16–21 group, but did not reach statistical significance ($p = 0.12$). Among the 17 conversions in patients age 0–15, 12 were in cases of perforated or gangrenous appendicitis and 6 were in overweight or obese children. The single conversion in the age 16–21 group was for acute appendicitis in a normal weight patient. There were 13 (6%) surgical site infections in patients aged 0–15 and 4 (8%) in patients aged 16–21, also statistically insignificant ($p = 0.69$). All infections were superficial wound infections which resolved with a course of oral antibiotics and did not require IV antibiotics or surgical drainage.

No intraoperative complications, post-operative complications aside from the mentioned SSI, or post-operative ileus were encountered for any patients in the study. There were no conversions from SP to open technique. In addition, all patients were seen at four weeks for a routine post-operative visit and no incisional hernias were found.

4. Discussion

While the SP technique has been well-established in the pediatric population for the treatment of appendicitis, there have been a limited number of studies evaluating its use in an adult population. Possible concerns over increased technical difficulty of SP in adults, including larger peritoneal space with longer distance from appendix to umbilicus, larger abdominal wall, and increased intra-abdominal adhesions, may explain its limited application. Our single center experience using SP in patients aged 16–21 revealed no significant differences in OT, LOS, cost, SSI, or intraoperative complications compared to younger patients. Our subset of 16-21-year-old patients was selected to show comparable outcomes in

Table 1
Comparison of age groups in single port appendectomy cohort.

Factor	Total (N = 263)	Age 0–15 (N = 211)	Age 16–21 (N = 52)	p-value
Sex, no. (%)				**0.028**[c]
• Male	147(56)	125(59)	22(42)	
• Female	116(44)	86(41)	30(58)	
Age (years), median (Min, Max)	12(2,21)	11(2,15)	17(16,21)	**<0.001**[b]
Type of appendicitis, no. (%)				0.11[c]
• Acute	217(83)	169(80)	48(92)	
• Gangrenous	17(6)	16(8)	1(2)	
• Perforated	29(11)	26(12)	3(6)	
BMI category (4 levels), no. (%)				0.12[c]
• Underweight	11(4)	7(3)	4(8)	
• Normal weight	187(71)	146(69)	41(79)	
• Overweight	37(14)	33(16)	4(8)	
• Obese	28(11)	25(12)	3(6)	
BMI-for-age percentile*, median (min, max)	63(0,100)	67(0,100)	53(0,98)	**0.032**[b]
Cost, median (min, max)	6266(3122,32311)	6373(3240,32311)	5939(3122,19531)	0.34[b]
LOS (hours), Median (Min, Max)	20(1244)	20(1244)	19(1134)	0.083[b]
OT (minutes), median (min, max)	40(16,227)	40(19,160)	40(16,227)	0.81[b]
Converted (0 = no, 1 = yes), no. (%)	18(7)	17(8)	1(2)	0.12[c]
SSI (0 = no, 1 = yes), no. (%)	17(6)	13(6)	4(8)	0.69[c]

Length of stay (LOS); Surgical site infections (SSI); Operative time (OT).
p-values: a = ANOVA, b = Kruskal-Wallis test, c = Pearson's chi-square test, d = Fisher's Exact test.
* Data not available for all subjects. Missing values: BMI-for-age percentile = 1.

adult-sized patients and prompt further consideration of SP in an adult population. The subset of 16-21-year-old patients does not represent the entire adult population range, and we caution generalization of our findings to all ages. Older adults carry a higher risk for peritoneal adhesions from previous abdominal surgeries and frequently have increased intra-abdominal fat, which both can challenge feasibility of the SP technique.

The growth curve for stature-for-age percentiles for boys and girls ages 2–20 begins to plateau around age 16 [21]. Weight at that age is arguably more variable and likely lower in average and does not necessarily represent adult weight. However, in a previous study done at our institution assessing outcomes in overweight and obese children compared to normal weight children undergoing SP, the outcomes, with the exception of conversion rate, did not differ based on body habitus. The study found a higher conversion rate in obese children, but conversion was defined as transition to TP; there were no conversions to open appendectomy [22].

TP is safe and associated with lower overall complications compared to open appendectomy, even in cases of advanced appendicitis [23,24]. The question arises why to advocate for the SP technique. SP has been shown to be more cost effective in children than TP [13,25], and those savings may be applied to an adult population. In our study, SP performed in the two age groups resulted in no significant differences in cost.

The 18 conversions from SP to TP were mostly in cases of perforated or gangrenous appendicitis (67%). This reflects that SP may not be optimal for all patients, particularly cases of advanced appendicitis. We do not consider this conversion rate as a reason to avoid initiating the appendectomy with SP technique as SP technique requires identical umbilical access as TP and laparoscopy is not abandoned.

Our study was limited by its retrospective nature and the selection bias that resulted from having surgeries performed by four different surgeons, each of whom may have preferentially selected for SP or TP based on a patient's body habitus or surgeon preference. Among the 362 patients operated by TP, 240 (66%) were acute appendicitis, 22 (6%) gangrenous, and 100 (28%) perforated. The higher percentage of perforated cases operated by TP (28%) vs SP (11%) is likely due to surgeon preference.

Furthermore, a significant limitation of this study is the small number of patients in the age 16–21 group (n = 52). As consideration of the SP technique in adults expands, future studies with larger cohorts will be needed to re-assess surgical outcomes differences.

5. Conclusion

The SP technique for appendicitis was found to have similar OT, LOS, and cost in young adults and pediatric patients. There were no significant differences in rates of infection or conversion to TP between the two groups. SP should be considered as an alternative surgical technique for the treatment of acute appendicitis in adult patients.

Ethical approval

IRB approved at Cleveland Clinic Foundation.
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Author contribution

Arathi Mohan: study design, data collections, data analysis, writing, and manuscript submission.
Paul Karam: study design, data collections, data analysis, and writing.
Martin Buta: study design and writing.
Sarah Worley: data analysis.
Federico Seifarth: study design, data collections, data analysis, manuscript editing.

Discolure of interest

The authors declare that they have no competing interest.

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N/A.

Guarantor

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