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A cost and outcome analysis of pediatric single-incision appendectomy

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ABSTRACT

Background: For appendicitis, single-incision laparoscopic appendectomy (SIA) has been proposed as an alternative to 3-port appendectomy (3PA). However, there remains controversy regarding outcomes and cost of SIA. We sought to review our experience with these two techniques to identify differences in these factors.

Materials and methods: The charts of children (0-17 y) who underwent appendectomy at a tertiary pediatric hospital from 2011-2014 were retrospectively reviewed. Appendectomy was either performed through traditional 3PA or SIA (laparoscopically assisted via externalization through an umbilical incision). Demographic data including age, body mass index, comorbidities, and gender were examined. Information on perforation, operative time and cost, length of stay, and infectious complications for both SIA and 3PA was identified. Data were analyzed using student *t* tests and chi square analysis.

Results: A total of 337 patients underwent appendectomy (141 SIA and 197 3PA), 35.6% of whom (40 SIA, 80 3PA) had perforated appendicitis. For nonperforated appendicitis, SIA had significantly shorter operative times, decreased operative costs, and length of stay. However, these differences were not found for perforated appendicitis. Regardless of appendicitis severity, there was no difference in rates of wound infection, abscess, or readmission between the two techniques.

Conclusions: Our study suggests that SIA is a faster, more cost effective alternative than 3PA for acute appendicitis. SIA did not result in increased infection rates for acute or perforated appendicitis and can be considered an equivalent alternative to 3PA in the surgical management of appendicitis.

Introduction

Appendectomies remain one of the most common surgical procedures performed by pediatric surgeons.[1] In adults, several studies have found no significant difference between conventional three-port laparoscopic appendectomy (3PA) and single-incision appendectomy (SIA) in overall morbidity, postoperative complications (including ileus, abscess, and abdominal wall infection), postoperative length of stay, or rate of conversion to open procedure.[2-6] Data on postoperative pain scores, cosmesis, and operative time are mixed. Overall, although a significant benefit has not been consistently demonstrated, SIA in adults appears to be at least a feasible alternative to 3PA.

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Data on pediatric outcomes are more limited. Single-incision and single-port laparoscopic appendectomies (SIAs) have been performed in children with acceptable safety and efficacy.[7-11] Comparisons of conventional 3PA to SIA using multiple ports/instruments through one incision have demonstrated longer operative times for SIA but no difference in length of stay or postoperative complications.[12-14] Another method of SIA is the single trocar, transumbilical, laparoscopically assisted appendectomy (TULAA) described by Pelosi and Pelosi in 1992.[15] This method has been safely performed in children since 1998.[16] The only study comparing it to 3PA in children found TULAA less expensive with no difference in operative time, length of stay, or postoperative complications.[17] Given the increasing implementation of SIA in the pediatric population and the push for more cost effective medical care, more data comparing outcomes and costs between SIA and 3PA are needed.

The purpose of this study was to compare SIA (performed using the TULAA technique) to 3PA with respect to clinical outcomes, efficacy, and cost.

Methods

We performed a single center, retrospective review with the approval of the Oregon Health and Science University Institutional Review Board (IRB00010916). All patients who underwent an appendectomy between January 2011 and February 2014 at Doernbecher Children's Hospital, a tertiary pediatric referral center, were identified based on CPT code search for appendectomy. Incidental appendectomies were excluded. Patients with nonoperatively managed appendicitis were not evaluated in this study.

Medical charts were reviewed for demographics (age, gender, body mass index (BMI), other comorbidities), diagnosis (nonperforated, gangrenous, or perforated appendicitis), type of laparoscopic appendectomy performed, operative time and cost, length of stay, and postoperative infectious complications. The diagnosis of nonperforated, perforated, or gangrenous appendicitis was based on operative findings. Gangrenous and perforated appendicitis were grouped together as the postoperative management is the same based on institutional protocol. In the case of interval appendectomies, only the admission during which the appendectomy occurred was evaluated. Complications occurring within 90 d were examined, including postoperative intra-abdominal abscess, wound infection, and need for readmission.

Surgeon preference determined whether the patient underwent a SIA or 3PA. The patient's age, BMI, and likelihood of perforation were not absolute determinants of surgical method. Operations were performed by a pediatric surgery fellow or general surgery resident under the supervision of one of six attending pediatric surgeons. Three attending surgeons performed both 3PA and SIA, and three performed only 3PA. During the study period, the three surgeons who performed both SIA and 3PA were comfortable with the SIA technique, and SIA operations were performed across the entire study period.

Three-port appendectomies were performed in the standard fashion with a 12-mm umbilical port and two additional 5-mm ports (typically in the left lower quadrant and lower midline positions). In all 3PA cases, the surgical stapler with a reload was used to divide the appendix and the appendiceal mesentery, and an endocatch bag was used for extraction of the appendix. Single-incision laparoscopic appendectomies were performed using the TULAA technique,[17] with a 10-mm Frazee operative laparoscope (Karl Storz, Tuttlingen, Germany; Figure), which is designed with a side-entering camera and a port for an extra-long (bariatric) atraumatic instrument, placed through a 12-mm trans-umbilical port. In these cases, the appendix was freed bluntly from adhesions to surrounding structures and externalized through the umbilicus. The mesoappendix was divided using standard bovie electrocautery. The appendix was doubly ligated with either absorbable surgical ties or 0-PDS Endoloops, divided sharply, and the mucosa was cauterized. The abdomen was suctioned or irrigated as indicated through the use of a bariatric tip for the laparoscopic suction irrigator. For both the SIA and 3PA, extra ports were added as necessary, to aid with mobilization or visualization. Conversion from SIA was examined in data analysis in an intention to treat fashion.

Operative costs were determined by combining the costs of equipment and operative time. For cases in which more ports were added, the cost of additional equipment was added to the equipment cost. To determine the difference in supply costs, the average cost of available ports and available ligatures was used. Average operative time for all 3PA and SIA was used to determine the cost variance due to differences in procedure time between the groups.

Perioperative management was based on diagnosis and was not affected by whether the patient underwent a 3PA or SIA. Broad spectrum antibiotics were started at the time of diagnosis. For patients without perforated appendicitis, no further antibiotics were given after appendectomy. For patients with perforated or gangrenous appendicitis, intravenous antibiotics were continued until the patient was afebrile for at least 48 h, eating a regular diet, had only incisional pain, and had a normal white blood cell count and neutrophil count. Diet was advanced as tolerated. No patients were discharged on antibiotics.

All comparative data were analyzed with student independent *t* tests and two-tailed Fisher exact test, with a *P* value < 0.05 considered significant. Statistical analyses were performed with GraphPad (GraphPad Software, LaJolla, CA).

Results

Over 3 y, 337 appendectomies were performed: 196 were 3PA and 141 were SIA. There was no significant difference in age,

Figure – Operating laparoscope is a 10-mm instrument with a 0° lens and 5-mm working port. (Color version of figure is available online.)