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# Looped suture versus stapler device in pediatric laparoscopic appendectomy: a comparative outcomes and intraoperative cost analysis☆,☆☆

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ABSTRACT

*Background:* Appendiceal ligation during pediatric laparoscopic appendectomy (LA) may be performed using looped suture versus stapler. Controversy regarding the utility of either method exists. Clinical outcomes and cost analysis of LA with both methods were compared.
*Methods:* All pediatric LA were performed from fiscal years 2013 and 2014 by two pediatric surgeons. While one surgeon used looped suture, the other used stapler exclusively. chi-Square tests were performed to analyze associations.
*Results:* Two hundred thirty-eight cases were analyzed where looped suture versus stapler LA was performed in 46% and 54% of patients, respectively. Operating room costs were $317.10 and $707.12/person for looped suture and stapler LA, respectively ($P<0.0001$). Difference in cost of $390.02/person was attributed solely to ligation type. On bivariate analysis, rate of in-hospital complications, length of stay, return-to-ER and readmission within 30 days did not significantly differ between groups.
*Conclusion:* A comparative analysis of looped suture versus stapler device during LA for pediatric appendicitis revealed that postoperative complications, length of stay, ER visits and readmissions were not significantly different. Looped suture LA was significantly more cost efficient than stapler LA. In pediatric appendicitis, appendiceal ligation during LA may be performed safely and cost effectively with looped suture versus stapler.
*Type of study:* Cost effectiveness
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Acute appendicitis is one of the most common indications for emergent intra-abdominal surgery in children. Laparoscopic appendectomy (LA) has been progressively accepted as the treatment of choice for acute appendicitis [1]. Numerous studies have shown the advantage of LA over open appendectomy including faster recovery, less postoperative pain, reduced wound infections, shorter hospital stay and better visualization of other abdominal pathology that can mimic an acute appendicitis [1–3]. While the technique of LA was first described over 20 years ago, there are several technical variations that can potentially affect the outcome of LA including the technique used for closure of the appendiceal stump [2,3].

The base of the appendix is most frequently closed using looped suture or stapler device [3–8]. Currently, some authors recommend the routine use of looped suture as an economic, feasible and safe alternative to staplers [3–8]. However, others recommend stapler use for time efficiency given its associated ease of tissue handling in addition to possible reduction in the incidence of appendiceal stump leakage in advanced appendicitis owing to closure with a double row of staples [9]. While both techniques are safe and routinely used, they each harbor potential drawbacks. Loops are associated with more manipulation of the stump and can potentially slip, causing intra-abdominal abscess formation [10]. Loops are also unsafe for closure of the cecum when the base of the appendix is perforated, or if the inflammation of the appendix involves the cecum [10]. Conversely, linear staplers are more

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expensive than loops, require a 12-mm port for their introduction and leave metal staples on the stump that can cause adhesion-related small bowel obstruction [10].

To date, data demonstrating a systematic comparison of the efficacy of the two ligation methods for treatment of the appendiceal stump in the pediatric population affected by appendicitis remain sparse. The purpose of this study was to compare clinical outcomes in addition to intraoperative cost after application of looped suture versus stapler for stump closure in pediatric patients undergoing LA for appendicitis. The authors hypothesize that looped suture appendectomy is more cost effective with equivalent perioperative outcomes when compared to stapler device.

## 1. Methods

Clinical and pathologic data of 238 consecutive patients who underwent LA by two experienced pediatric surgeons at a children's hospital from fiscal years 2013 and 2014 were prospectively collected. For the two-year duration, a single pediatric surgeon performed either looped suture or stapler LA, exclusively. Within the two cohorts, 46% of patients (n = 110) underwent looped suture of the appendiceal base whereas 54% of patients (n = 128) underwent stapler ligation.

Indications for LA included either the presence of uncomplicated or simple appendicitis versus complicated appendicitis. Simple appendicitis was defined by the presence of peri-appendiceal inflammation, early in the time course of the disease. Complicated appendicitis was defined as the presence of significant peri-appendiceal inflammation including phlegmon or abscess formation, gangrenous involvement or perforation of the appendix. Patients identified preoperatively with several day history of symptoms, phlegmon or perforation on diagnostic imaging were excluded and treated based on interval appendectomy protocol. A previously published simple versus complicated appendectomy protocol by the authors has been briefly delineated below [11].

An appendix ultrasound (US) was ordered for children with suspected appendicitis and an Alvarado score of ≥4. A positive US was defined as a visualized appendix of 7 mm with associated hyperemia, and the presence of appendicolith, right lower quadrant fat stranding, loculated fluid, or abscess. Pediatric surgery service assumed patient care after US had been performed. If the appendix was not visualized, other diagnoses would be considered or an abdominal computed tomography (CT) with contrast was performed at the discretion of the pediatric surgery service. Patients with positive imaging tests but no signs of abscess were given intravenous fluids and intravenous cefoxitin and subsequently taken to the operating room. If imaging indicated perforation, intravenous gentamycin and zosyn were initiated preoperatively and continued postoperatively with intravenous fluids until patient was afebrile and tolerating diet, at which point the patient was switched to Augmentin by mouth to complete a 7-day course of antibiotics. Patients with a well-formed abscess were treated similarly to those noted to be perforated but had a subsequent interval appendectomy was planned 8–12 weeks later. If the US was negative with a visualized appendix of <7 mm but a strong suspicion of appendicitis was still present, the patient was admitted for observation under direction of the pediatric surgery service. If US was negative with low index of suspicion for appendicitis, the child was discharged with instructions to return if symptoms worsened [11].

For looped suture versus stapler LA, the appendix was divided between a distal grasper and two Endoloop ligatures (PDS II polydioxanone, Ethicon) placed at base of the appendix or with an Endopath ETS stapler/cutter (Ethicon). The mesoappendix in this group of patients was divided with the use of cautery. For patients who underwent LA with the use of stapler device, two loads were applied; white load for the mesoappendix and blue load for the appendix. All clinical and radiographic diagnoses were confirmed by final pathology postoperatively to be positive for acute appendicitis.

Clinical characteristics compared between both groups of patients included age, gender, BMI and ethnicity. Preoperative work-up included clinical acumen for appendicitis and/or radiographic imaging including ultrasonography and/or CT scan. Postoperative outcomes included length of stay, in hospital complications, whether patients were discharged on oral antibiotics, 30-day return to the ER and 30-day readmission. Most importantly, cost analysis was performed comparing the average total operative supply cost incurred per patient in addition to operative times for looped suture versus stapler device for acute and complicated appendicitis.

Statistical analysis was performed with SPSS Statistics, version 21 (IBM, Armonk, NY). Categorical data were analyzed using chi-square test and normally distributed continuous data were compared using Student's paired t test, as appropriate. Significance was defined as $P < 0.05$. All patient charts and information were reviewed in accordance with IRB guidelines at Baptist Health South Florida Hospital. The authors report no proprietary or commercial interest in any product mentioned or concept discussed in this article.

## 2. Results

Among the entire cohort of 238 patients who underwent LA for appendicitis, 75% were classified as simple while 25% of appendices were classified as complicated. Based on final pathology there was a 100% true positive rate for acute appendicitis and thereby no negative LA. When stratified by type of appendiceal ligation, 46% of patients (n = 110) underwent looped suture of the appendiceal base whereas 54% of patients (n = 128) underwent stapler ligation. Simple appendicitis was seen in 67% (n = 74) of looped suture appendices versus 81% (n = 104) of stapler appendices (P = 0.37). Complicated appendicitis was seen in more patients who underwent looped suture LA at 33% (n = 36) as compared to 19% (n = 24) of endostapler appendices (P = 0.06). The mean age for each group was approximately 12 ± 3.7 years. Majority of patients in each group were male (52% vs. 63%, respectively; P = 0.45) and of Hispanic ethnicity (72% vs. 81%, respectively; P = 0.55). In each group, the average BMI was within normal range at 21 ± 4.8 (Table 1).

On comparative cost analysis, total operating room supply costs incurred by the patient was $317.10 and $707.12/person for looped suture and stapler LA groups, respectively (P < 0.0001). In terms of cost breakdown, for looped suture LA, the endoloop PDS II was $40.77/unit. Given that two endoloops were used per patient, a total of $81.54 was charged to the patient for looped suture, whereas the remaining supplies cost $235.56. For the stapler device LA group, the breakdown was $254.58 for the stapler device, $108 for white load staples and $108 for blue load staples, whereas the remaining supplies cost $235.56. Given that all other operative costs between groups remained the same, the significant difference in cost of $390.02 per person was attributed solely to ligation type.

**Table 1**
Comparison of clinical and histopathologic characteristics for looped suture vs. stapler ligation in LA.

| | Looped Suture 46% (n = 110) | Stapler 54% (n = 128) | P-value |
|---|---|---|---|
| Age (mean ± SD) | 12.1 ± 3.7 | 12.0 ± 3.7 | 0.15 |
| Male | 52% (n = 57) | 63% (n = 80) | 0.45 |
| BMI (mean ± SD) | 21.2 ± 4.8 | 20.9 ± 4.8 | 0.64 |
| Ethnicity | | | |
| Hispanic | 72% (n = 79) | 81% (n = 104) | 0.55 |
| Non-Hispanic | 25% (n = 28) | 15% (n = 19) | 0.11 |
| Unknown | 3% (n = 3) | 4% (n = 5) | 0.73 |
| Appendicitis | | | |
| Simple | 67% (n = 74) | 81%.2 (n = 104) | 0.37 |
| Complicated | 33% (n = 36) | 19% (n = 24) | 0.06 |

LA = laparoscopic appendectomy.

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