Transumbilical laparoscopic-assisted appendectomy *versus* laparoscopic appendectomy in children: a single center experience

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Abstract

Laparoscopic Appendectomy (LPSA) is the first choice for appendectomy in pediatric surgery. Trans-Umbilical Laparoscopic Assisted Appendicectomy (TULAA) is another used technique. We compared both these procedures used for the treatment of acute appendicitis. The study was conducted between January 2019 to December 2020. Patients were divided into two groups: LPSA and TULAA groups. The collected data were: operative time, number of conversions, time of canalization and hospital stay. A total of 181 patients were included: 73 were kept in the LPSA and 108 in the TULAA group. Mean operative time was 70.9 minutes (range 45-130 min) for LPS and 56.4 (30-145 min) for TULAA group (p <0.0001). Complications rate showed no statistically significant difference between both the two groups. However, conversions showed a statistically significant difference (p=0.04). Both techniques showed similar results. TULAA technique takes a significantly shorter operating time. The selection between LPSA and TULAA techniques depends on the experience of the surgeon's work and the personal laparoscopic learning curve. In our experience LPSA was a useful technique to improve the laparoscopic skill of the pediatric surgery residents.

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Introduction

Appendicitis is the most common indication of abdominal surgery in children. A wide variation has been reported among different centers for surgical management of pediatric appendicitis.[1,2] Since the beginning the standard treatment for acute appendicitis was an open appendectomy. Currently, the minimally invasive surgical approaches are significantly being applied in the pediatric setting to improve the results of several procedures such as appendectomy.[3-5]

The introduction of laparoscopy for appendicitis in the pediatric population brought a dramatic change in the operative approaches. Laparoscopic appendectomy has been introduced a few decades ago and it has become a popular choice for improving cosmetics, decreasing postoperative pain, and decreasing the length of hospitalization.[6,7] Compared to open surgery, Laparoscopic Appendectomy (LPSA) has been shown to significantly reduce wound infections.[8] Furthermore, the laparoscopic operation has been found to reduce the risk of intestinal occlusion in the postoperative period.[9] Conventional LPSA uses three ports and requires one of these to be used for the introduction of optics and the other two as work access points (Figure 1).

The most important step of laparoscopic appendectomy is how to secure the base of the appendix. In everyday practice linear staplers, endoscopic loops and polymer clips are commonly used. Each technique has advantages and disadvantages.[10,11] More recently clipless and sutureless appendectomy, using harmonic scalpel, has been introduced.[12]

Another minimally invasive surgical technique to perform appendectomy is TULAA (Trans-umbilical laparoscopic assisted appendicectomy), firstly described by Pelosi and Pelosi, which is a combination of techniques of open and laparoscopic approaches. The principle of this technique is to create a single umbilical surgical access for the insertion of a camera equipped with an operative channel. Through this single access it is possible to identify and exteriorize the appendage, which will then be removed externally.

In recent years in the literature both of these techniques have found admirers and detractors, who have tried to identify evidence to support either technique.

In this work, we evaluated and compared the results of two minimally invasive approaches in the pediatric field, for the treatment of acute appendicitis: LPSA and TULAA procedures.

Materials and Methods

This retrospective study was carried out from January 2019 to December 2020 at Pediatric Surgery Department, Salesi Children's Hospital, Ancona, Italy.

During the study period, the minimally invasive approaches *i.e.*, LPSA and TULAA techniques were applied based on the surgeon's experience. The open appendectomy procedure was suggested for a limited number of patients with complicated appendicitis in which an inflammatory adherential syndrome was suspected, which generally causes hindrance in the minimally invasive intervention.

The surgeons at our center have a good learning curve regarding the open approach and the TULAA approach. Only a portion had acquired the core skills of three trocar laparoscopy. Our pediatric surgery center team consisted of 10 surgeons, and all participated in the study.

We retrospectively evaluated the data of patients diagnosed with acute abdomen from suspected appendicitis. Our inclusion criterion was to evaluate patients operated with a minimally invasive technique, using LPSA and TULAA procedures. Patients operated with the open technique were excluded from the study.

In our series the following data were evaluated: age, sex, weight, number of TULAA appendectomies, number of LPSA appendectomies, number of open conversions for each of the two techniques (conversion is defined such as the inability to continue the surgical procedure with a minimally invasive approach and the need to perform an open appendectomy with a McBurney incision), operative time, post-operative hospitalization, time to pass gas or stool, intraoperative complications (major bleeding, visceral organ injuries), post-operative complications (wound infections, ileus, intestinal occlusion by adhesions, intraabdominal abscess formation, readmissions), the cost of each procedure (Table 1).

Only data from unconverted LPSA and TULAA appendectomies were statistically analyzed.

IRB consent was not needed by our institution for this kind of study.

Outcomes of the study

The primary outcome was to evaluate if there are significant differences in favor of one of the two techniques.

Statistics

GraphPad Prism6 (GraphPad Software Inc., San Diego, CA, USA) was used for statistical analyses. Data were presented as mean ±SD, and comparisons between groups were analyzed using Student's t-test for unpaired data. A p-value <0.05 was considered significant. The normality test that was used is the Shapiro-Wilk.

Surgical techniques

Three -port Laparoscopic Appendicectomy (LPSA) technique

A 10 mm ballooned trocar is inserted in an "open" fashion through an infraumbilical incision. The pneumoperitoneum is obtained by CO2 insufflation (pressure range: 10 to 12 mmHg). A 10-mm 30° laparoscope is inserted, and under direct vision, two 5-mm operative trocars are inserted into the left flank and suprapubic level. The appendix is identified and freed from any adhesions. Resection of the appendicular mesenteric is performed with bipolar forceps or a monopolar hook. Two endoloops are inserted and tied one at the base of the appendix and one a few millimeters above. Next, the appendix is cut, between the two endoloops, with cold scissors. The appendix is exteriorized through the umbilical trocar. The abdominal cavity is carefully explored, any abscess collections are toileted, and in case of gangrenous appendicitis with abundant purulent material, a tubular drain is placed through one of the 5 mm openings.

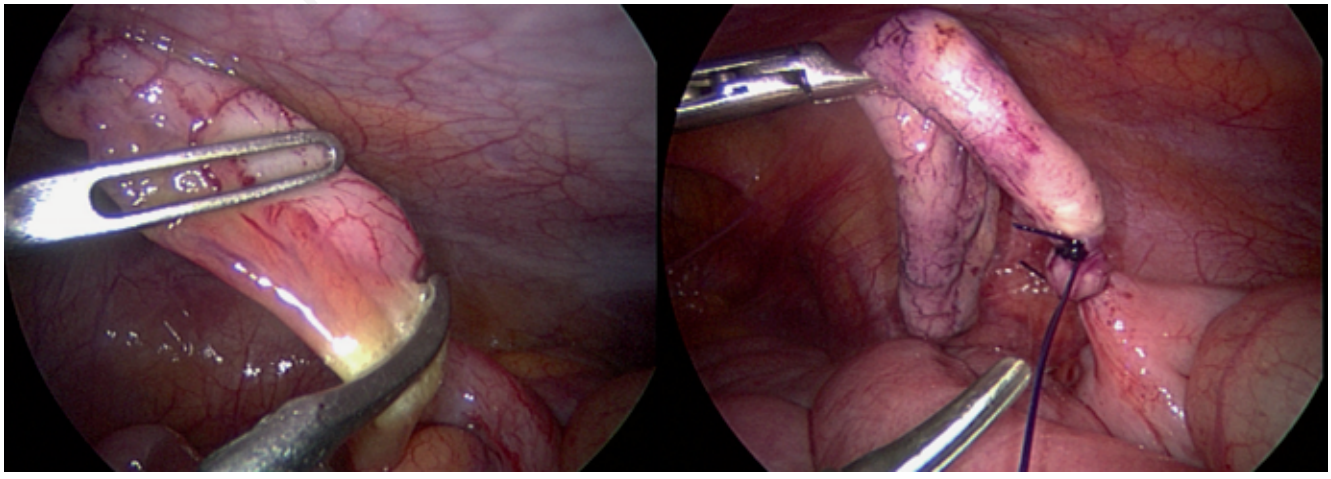

Figure 1. Three-port Laparoscopic Appendectomy (LPS): electrocoagulation of the appendicular mesenteric and ligation of the appendix.

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Trans-Umbilical Laparoscopic Assisted Appendicectomy (TULAA) technique

A 10 mm ballooned trocar is inserted in an "open" fashion through an infraumbilical incision. The pneumoperitoneum is obtained by CO2 insufflation (pressure range: 10 to 12 mmHg). Systematic exploration of the abdominal cavity is done using a 10mm operative laparoscope. The appendix is grasped with a laparoscopic atraumatic instrument and pulled through the umbilical incision with the cecum, if mobile. Adhesiolysis is performed in presence of adhesions between the appendix, cecum, and peritoneum by bipolar forceps or monopolar hook. Appendectomy is realized outside the abdominal cavity with conventional techniques (ligation of the appendiceal vessels, ligation on the basis of the appendix stump, excision of the appendix, and burial of the stump by making a tobacco pouch). The cecum is repositioned inside and a new laparoscopy is performed in order to evaluate the integrity of the cecum, bleeding, and presence of eventual content in the cavity. When the appendectomy is considered impossible to be safely completed with transumbilical laparoscopic-assisted approach because of an inadequate exposition and exteriorization through the umbilical incision (some cases of unclear anatomy, inflammatory appendiceal adhesions/mass, retrocecal/subserosal position), a conversion to open appendectomy was preferred.

Results

In total 215 surgical interventions of appendectomy were performed. The operations performed using TULAA were 108 (50%), while for laparoscopy (LPSA) were 73 (35%). In 34 (15%) cases it was necessary to convert the intervention into open, and of these 28 (20.6%) were TULAA and 6 (7.6%) LPSA (p=0.04). There were no conversions from TULAA to LPSA. The mean age was of 9.2 years in LPSA and 10.7 years in TULAA group. Of the considered cases, the intraoperative diagnosis was acute catarrhal appendicitis in 95 (44%) patients, acute phlegmonous appendicitis in 81 (37%), and gangrenous in 39 (19%) patients. Of the latter 20 (51%) presented a picture of peritonitis.

In the 136 TULAA, 71 (52.2%) were catarrhal, 55 (40.5%) phlegmonous, and 10 (7.3%) gangrenous. Among the 28 cases of conversions 18 (64.2%) were phlegmonous and 10 (35.8%) gangrenous. In the LPSA group of 79 treated appendicitis 24 (30.4%) were catarrhal, 26 (32.9%) phlegmonous, and 29 (36.7%) gangrenous. Among the 6 cases of conversions (100%) were gangrenous.

After excluding all cases of conversion, in total data of 181 were considered for the statistical analysis. There was a significant difference in the conversion rate between the two groups (p=0.04).

The statistics did not highlight a significant difference in terms of time for passing stool (p=0.11), time of hospitalization (p=0.86), and weight (p=0.06). Regarding these outcomes, the nonsignificant difference was found not only between the TULAA and LPSA groups, but also within the individual groups the outcomes did not prove to be significantly different in terms of appendicitis severity.

A statistically significant difference was found in operative time and cost of the procedure that was higher in LPSA group (p<0.0001).

Regarding operative time, there was no significant difference within the individual TULAA and LPSA groups in terms of the degree of appendicitis severity.

Among the cases analyzed we had a total of 8 postoperative complications, represented by abdominal abscesses, 2 (3%) in the LPSA group and 6 (5%) in the TULAA group (p=0.25). In the LPSA group the 2 abscesses occurred in patients who presented a gangrenous appendicitis, and in the TULAA group the 6 abscesses occurred after appendectomy for a phlegmonous appendicitis. There was no significant difference, in terms of abdominal abscess formation, based on the severity of appendicitis.

All patients started intravenous antibiotic therapy before surgery with a third-generation cephalosporin and metronidazole. This therapy was continued in the postoperative period, with the possible addition of an aminoglycoside in cases of gangrenous appendicitis.

Table 1. Data of the study.

	Three-port laparoscopic appendectomy (LPSA)	Trans-umbilical laparoscopic assisted appendicectomy (TULAA)	p value
Number of patients	73	108	NA
Mean age at intervention	9.2 years±0.4 (range 4-14 years)	10.7 years±0.6(range 5-14 years)	NA
Mean weight at intervention	32.9 Kg±1.8 (range 16-80 Kg)	36.2 Kg±1.5 (range 5-84 Kg)	0.06
Mean operative time	70.9 minutes±3.1 (range 45-105 min)	56.4 minutes±2.9 (range 40-120)	<0.0001
Mean hospitalization	5.4 days±0.4 (range 2-10 days)	5.3 days±0.3 (range 3-11 days)	0.86
Mean time for passing stool	1.7 days±0.1 (range 1-4 days)	1.6 days±0.3 (range 1-3 days)	0.11
Intraoperative complications			
Major bleeding	0	0	NA
Visceral organ injuries	0	0	NA
Postoperative complications			
Wound infections	0	0	NA
Ileus	0	0	NA
Intestinal occlusion by adhesions	0	0	NA
Intra-abdominal abscess formation	2	6	0.25
Readmissions	0	0	NA
Conversions	6 (7.6%)	28 (20.6%)	0.04
Mean cost of the procedure	271.1 euros±0.4 (range 240-302.5 euros)	86.9 euros±0.5 (range 60.3-102.4 euros)	<0.0001

There were no differences in antibiotic therapy among patients who did not present with abdominal abscesses compared with those in whom they were reported.

The mean cost of surgical materials for a laparoscopic appendectomy was €271.1 and that for a TULAA intervention was €86.9 with a statistically significant difference ($p<0.0001$).

Discussion

Appendicitis can be treated in different ways such as a conservative approach or a surgical approach. In recent decades, operative treatment has changed its direction from the beginning open approach to a minimally invasive one.[12-14] The minimally invasive surgical techniques available for specialists are LPSA, TULAA, and SILS (Single Incision Laparoscopic Surgery).[15] In our study, we presented a retrospective analysis, evaluating two surgical techniques; TULAA and laparoscopy (LPSA). The idea of comparing these two operative methods comes from the fact that before the year 2020 at our department, the TULAA was considered the first choice for the surgical treatment of appendectomy. Following the change of strategy and the choice of approaching appendicitis with the laparoscopic technique as the first choice, we felt an unmet need to examine whether there are substantial differences between the two techniques. The first thing that we highlighted was since the very first operation carried out in laparoscopy, more and more surgeons of the center have been confronted with this method, making it clear that this procedure has a "learning curve" easy to assimilate. In fact, in the second half of the evaluated period, most of the operations were performed laparoscopically until it becomes the procedure of choice for all surgeons including residents.

We found significant differences in terms of operating time between TULAA and laparoscopy procedures. In fact, the operating time was longer in laparoscopy than in TULAA. In the LPSA group operative time was influenced by the "learning curve" while we had a much lower conversion rate. This may be justified by the fact that the intervention with video-assisted technique involves a phase in which the appendix and the cecum must be externalized through the navel. In some cases, the presence of adhesions between the cecum and the abdominal wall, a retrocecal position of the appendix, or the presence of complications such as periappendicular abscesses or the perforation of the appendix, can make impossible to externalize the appendix, with the need to convert the intervention. These over-mentioned complications, on the other hand, can be managed in LPS, without the need to drastically change the surgical technique. This explains the great difference in conversion rates in favor of laparoscopy.

In accordance with the data that highlighted the greater speed of the TULAA technique compared to laparoscopy, a study carried out by Visnjic *et al.*,[16] examined the medical records of 72 children undergoing appendectomy operations at the pediatric hospital of Zagreb during the period 2003-2006. In this work, the median intervention time was 39 min (range: 24-66 min) in the laparoscopic group, and the median operative time in the TULAA group was 33 min (range: 25-55 min), which was significantly shorter ($p<0.05$). Another study, by Sekioka *et al.*[17] performed from 2007 to 2016, agreed to report shorter times in video-assisted compared to laparoscopy, moreover with no need for conversion to open for any of the patients treated.

Data regarding the number of conversions emerged, which is higher in the group of patients undergoing TULAA than in those undergoing LPSA. Our analysis highlighted a statistically significant result, confirming an idea of ours that emerged during the execution and observation of the two different procedures. In TULAA the operator works with an instrument that is on the axis with the optics. This attitude limits the degrees of freedom of movement, making it difficult to perform more complex maneuvers. In the presence of a retrocecal appendix or one that is fixed to the abdominal wall due to the presence of adhesions, it is difficult and dangerous to grasp and exteriorize it, leading to the need to convert the operation. Obviously, such situations are easily overcome in laparoscopy, working with two instruments. In accordance with what was found in this work, Karam *et al.*,[18] agreed with the brevity of the TULAA, also rendering a greater trend towards the need for conversion for the video-assisted technique. Stanfill *et al.*[19] reported that of the 48 cases of TULAA in their analysis, 9 were converted to LPS.

Another interesting but not statistically significant result showed a trend in the rate of postoperative abscesses, which were numerically relevant in TULAA compared to laparoscopy. This data supported the fact that TULAA, providing a single access point, permits a lower number of maneuvers and a less degree of abdominal exploration compared to laparoscopy. Therefore, during a TULAA, irrigation, aspiration, and placement of drains are the procedures that can be less easily performed in comparison to laparoscopy.

In our study, we performed a cost analysis related to these two procedures. We found a significantly higher cost of laparoscopy compared with TULAA. This result can be explained by the higher number of devices used in this procedure, The higher cost of three-port laparoscopy, in our case, is not compensated by a shorter hospital stay, since the hospitalization times were similar between the two groups. Hence, it should be noted that the TULAA group, as described earlier, has a significantly higher number of conversions, an element that affects costs and hospitalization. In addition, the finding, not significant in our study, of a higher number of postoperative intraabdominal abscesses in the TULAA group might be an element to consider in the cost analysis. The possible presence of abscesses is an element that, in addition to lengthening hospital stay, may result in increased use of antibiotics or the use of additional procedures such as ultrasound drainage. This assessment, which is beyond the scope of our study results, is a necessary consideration if a comparative cost analysis is to be made between TULAA and LPSA. Certainly, it is useful as a future direction to perform additional studies to have meaningful results in this aspect.

In terms of safety, LPSA, has proven to be very valid, so it can be an opportunity to increase the laparoscopic "learning curve" of healthcare workers. It is also emphasized, as in centers conducting a residency school, the possibility of having a good number of appendectomies done, gives the consultant the opportunity to acquire iron confidence with this method, and to the trainee to approach the technique, and acquire those that are the fundamental skills of the procedure and also increase the learning of the same.

Conclusions

The techniques evaluated in this study were comparable, with no significant differences, in terms of safety, hospitalization, complications. The findings of our study confirm that both techniques show similar results on the basis of the minimally invasive approach. TULAA technique takes a significantly shorter operating time. The selection between LPSA and TULAA techniques depends on the experience of the surgeon's work and the personal laparoscopic learning curve. One of the advantages of the LPSA is that allows to improve the laparoscopic "learning curve" of younger residents in pediatric surgery.

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