34. Laparoscopic Appendectomy

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Introduction

Acute appendicitis is the most common surgical emergency among children, and its incidence increases with age until adolescence. In the United States, approximately 70,000 children are affected each year, with peak incidence occurring at 12–18 years. Acute appendicitis can be either simple or complicated, with perforation and/or abscess formation occurring in the latter [1, 2].

In the case of simple acute appendicitis, appendectomy remains the generally accepted standard of care, although some centers now treat acute appendicitis with only medical management [3]. Timing of surgery for complicated appendicitis, on the other hand, remains controversial. Immediate operation in the face of a well-formed abscess may lead to an increased rate of postoperative complications, in particular, intra-abdominal abscess formation. In the case of complicated appendicitis, the surgeon may choose immediate surgical intervention or medical treatment with antibiotics and image-guided or surgical drainage. Medical management in the acute phase may then be followed by subsequent interval appendectomy in 2–3 months. Some surgeons may not even perform an interval appendectomy and only operate for recurrent symptoms. In a meta-analysis of 17 studies, conservative management with or without interval appendectomy was associated with better postoperative outcomes, fewer complications, fewer re-operations, and comparable hospital length of stay [4].

Surgical treatment of acute appendicitis has evolved over the past few decades. Prior to advances in minimally invasive surgery, right lower quadrant abdominal incisions were the gold standard surgical approach. In the past two decades, laparoscopic appendectomy has

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gained popularity and has been shown to improve patient outcomes. Advantages of laparoscopic appendectomy include shorter hospital stay, lower incidence of wound infection, reduced postoperative pain, and less conspicuous incision sites when compared to open appendectomy [5, 6]. In the case of complicated appendicitis, recent studies have shown no difference in the rate of abscess formation between laparoscopic and open appendectomy [7, 8]. Additionally, a laparoscopic approach confers the ability to completely visualize the abdominal cavity, enabling diagnosis and treatment of other abdominal pathologies.

The use of single-incision laparoscopic surgery may represent an improvement over conventional laparoscopic surgery. With the number of incisions reduced to one umbilical incision, the potential advantages are better cosmetic outcome, less postoperative pain due to non-penetration of the abdominal wall musculature, and avoidance of possible hemorrhagic complications from injury to the epigastric vessels. In recent years, an increasing number of articles have demonstrated the feasibility of this approach in different pathologies [9–16]. A recent randomized prospective study comparing single-incision appendectomy to the conventional laparoscopic approach found a longer operative time with the single-incision approach but, significantly, less postoperative pain and no difference between the two groups for early and late complications and length of hospital stay [17]. St. Peter et al. did a similar study in children and found that there was no clinical difference between single-port appendectomy and three-port appendectomy, except for a marginal increased operative time in the single-port group [18].

Technique

Other authors have already described several techniques for single-incision appendectomy. Below is one established technique.

Single-Incision Laparoscopic Appendectomy

Single-incision appendectomy is best suited for straightforward acute appendicitis cases and is easiest to perform when the appendix is freely mobile. This technique can essentially be divided into two

techniques: extracorporeal and intracorporeal. The extracorporeal technique involves placing a laparoscopic grasper and camera through the umbilicus, exteriorizing the appendix, and performing an open, transumbilical appendectomy. The intracorporeal technique involves placing a camera and at least two other laparoscopic instruments (with or without trocars) through the umbilicus and performing the appendectomy inside the abdomen, removing the appendix at the end of the case. While the authors originally utilized the intracorporeal technique in the past, they have switched to the extracorporeal technique, as it seems to be easier, faster, less costly, and less painful. This technique was originally described using an operative laparoscope to exteriorize the appendix through the umbilicus and perform an extracorporeal appendectomy. Recently, alternatives to exteriorize the appendix without an operative laparoscope have been reported, and this technique is described here. The extracorporeal technique may be unique to children, as the thin abdominal wall and shorter distance from the cecum to the umbilicus allows the appendix to be easily exteriorized; however it can also be applied, although with more difficulty, in larger adolescents.

Extracorporeal, Single-Incision Technique

1. Make a 15-mm infraumbilical skin incision. A Veress needle is inserted to create 15 mmHg of pneumoperitoneum, and a 5-mm AnchorPort (Surgiquest, Inc., Orange, CT) is inserted into the umbilicus. This trocar has a low-profile, small-diameter head, and the phalange of the trocar allows re-insufflation at the end of the case even though the fascial incision is 10 mm.
2. Insert one 5-mm, 30-degree laparoscope into the abdominal cavity through the umbilical trocar. Place a 3-mm grasper, such as the MiniLap® Alligator Grasper (Teleflex Inc., Wayne, PA) within the same skin incision but through the fascia 2–4 mm inferior to the 5-mm trocar (Fig. 34.1).
3. Grab the appendix using the grasper. Aiming just below the tip ensures the appendix doesn't bend during removal and also allows for identification of the distal end of the appendix during extrication from the umbilicus (Fig. 34.2). Divide the abdominal wall fascial bridge between the 3-mm instrument and the 5-mm trocar. Extend this incision in larger patients (sometimes up to 15–20 mm is necessary). Bring the appendix to the abdominal wall surface through the fascial

Fig. 34.1. Insertion of laparoscope and grasper through umbilical trocar.

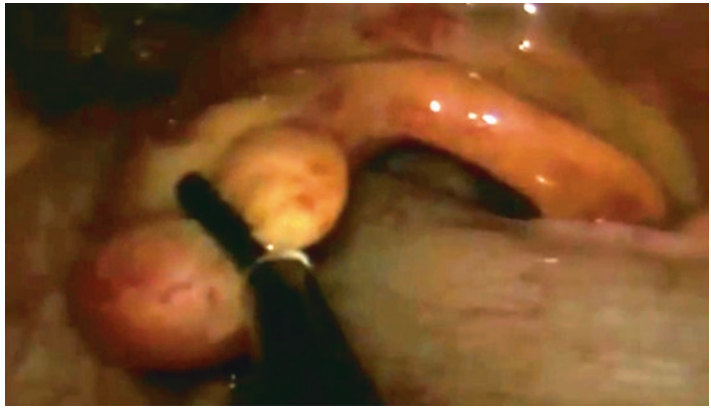

Fig. 34.2. Use grasper to grab distal end of appendix.

opening (Fig. 34.3). Divide the appendix and mesoappendix extracorporeally (Fig. 34.4). Ligate the appendix with two 3-0 Vicryl sutures and cauterize the mucosa (Figs. 34.5 and 34.6).

4. Because of the plastic anchor on the AnchorPort, the port can be reinserted into the new, larger fascial opening and still maintain insufflation. This allows for a brief insertion of the scope to assure no bleeding and ensures the presence of an adequately short appendiceal stump.

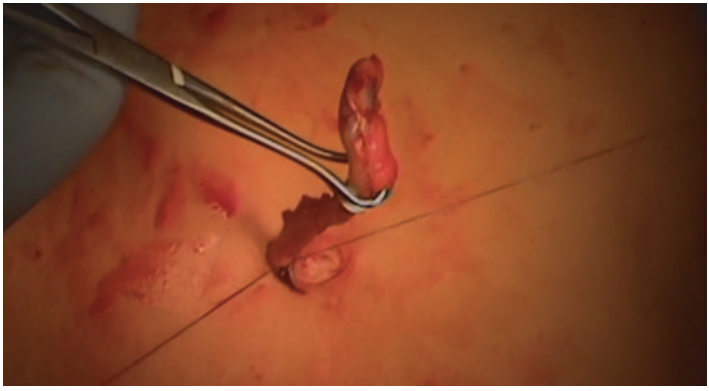

Fig. 34.3. Extracorporealization of appendix through umbilical incision.

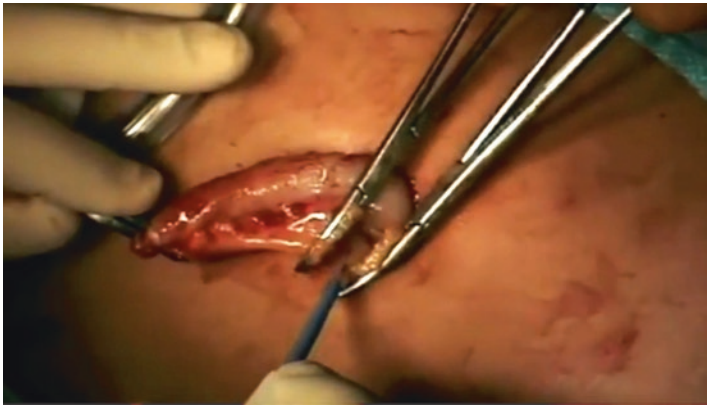

Fig. 34.4. Extracorporeal division of mesoappendix.

Intracorporeal, Single-Incision, Multiport Technique

1. Make a 2-cm infraumbilical or transumbilical incision.
2. If multiple, individual ports are utilized, insufflate with a Veress needle and then insert three AnchorPorts. Alternatively, one could insert 3-mm instruments through the fascia in the same skin incision as the trocar.

Fig. 34.5. Extracorporeal division of appendix.

Fig. 34.6. Cauterization of appendix stump after division.

3. The use of a 2-cm Hasson incision and one multi-port trocar can alternatively be inserted in the umbilicus. The technique for intracorporeal appendectomy is discussed below in the three-port laparoscopic appendectomy section.

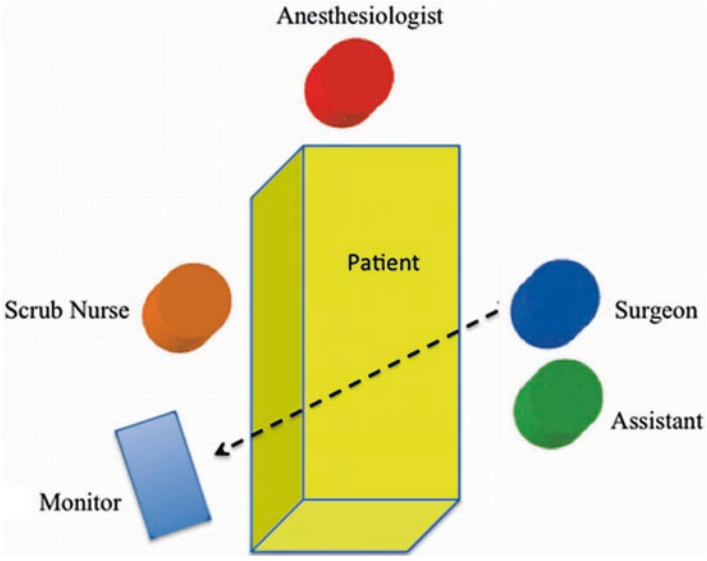

Fig. 34.7. Surgical team position. The surgeon and assistant stand on the left side. The scrub nurse is on the right side.

Traditional Three-Port Laparoscopic Appendectomy

Patient Position and Room Setup

1. Position the patient supine.
2. Although not mandatory, an orogastric tube can be placed to decompress the stomach and similarly a Foley catheter can be placed to decompress the bladder. If the patient urinates prior to surgery, a Foley catheter is rarely required. If placed, both catheters should be removed at the end of the case.
3. The surgeon and assistant stand on the patient's left side. The Mayo stand and scrub nurse are on the patient's right.
4. Place the monitor at the patient's hip on the right or directly below the feet (Fig. 34.7).

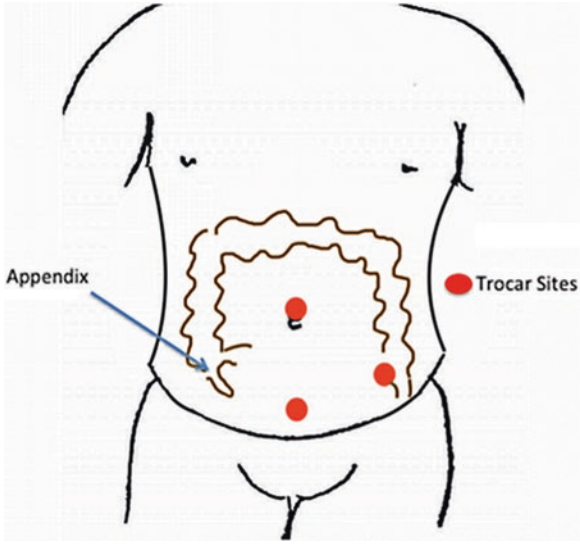

Fig. 34.8. Trocar placement.

Trocar Position and Choice of Laparoscope

1. Prep the abdominal wall from pubis to lower costal margin.
2. Place the initial 10–12 mm port at the umbilicus through open cut-down technique or Veress needle. Carbon dioxide pneumoperitoneum is established at a maximum pressure of 15 mmHg. Insert a 5-mm 30-degree telescope for visualization.
3. Place the second 3- or 5-mm port in the left lower quadrant.
4. The third 3 or 5-mm port is placed in the midline immediately over the pubis. Care is taken to avoid injury to the bladder (Fig. 34.8).

Performing the Appendectomy

1. Place the patient in Trendelenburg position and left side down to allow the intestines to slide out of the pelvis.
2. Perform a thorough exploration to confirm the diagnosis. If the appendix is normal, seek other sources for abdominal pain; run the small bowel to evaluate for a Meckel's diverticulum and in females, examine the ovary for torsion or cyst. If no other source is found, proceed with appendectomy.

3. Utilize two 5-mm atraumatic graspers through the midline suprapubic and left lower quadrant ports.
4. Follow the taenia coli down to their confluence at the base of the cecum and use the grasper through suprapubic port to grab the appendix 1 cm from the base, holding it up and toward the left upper quadrant. Prestige atraumatic graspers (Aesculap, Inc., Center Valley, PA) are an example of blunt graspers that are still sharp enough to get a strong, yet safe, hold of the appendix.
5. If the appendix is adherent to other bowel or abdominal wall, use of the suction as a dissection tool can gently break the adhesions. If the adhesions are not located close to the bowel, hook cautery can be used for dissection. Free the appendix from tip to base, progressing in the opposite direction, if necessary.
6. Intracorporeal division can be performed with the use of Endoloops (Ethicon, Somerville, NJ) or stapling devices.

Endoloop Technique

In many cases, especially when the appendix is very adherent to surrounding structure and a shortened mesoappendix makes it difficult to identify the base of the appendix, the mesoappendix is divided with electrocautery. This technique has proven safe in over 400 cases [19]. Some may prefer to divide the adhesions between the appendix and the surrounding mesentery using energy devices. Once the mesoappendix is divided, three sequential 0 Monofilament Endoloops are used to ligate the base of the appendix, and the appendix is divided sharply between the proximal two loops and the distal loop. Remove the appendix through the umbilical port using a specimen retrieval bag.

Stapling Technique

Create a window in the mesentery at the base of the appendix. A vascular stapler is used to transect the mesoappendix, and another load is used to transect the base of the appendix. Cut the appendix as close as possible to the cecum, leaving a very short stump. Examine the mesentery and base of the appendix for bleeding. Remove the appendix through the umbilical port using a specimen retrieval bag.

Technical Pearls and Pitfalls

- The extracorporeal single-site technique may be challenging in larger patients. However, this challenge can be mitigated by creating a generous infraumbilical incision of 1.5–2 cm.
- Do not waste time. If there is difficulty performing the single-incision technique, do not hesitate to convert to the three-port technique. Creating an iatrogenic perforation in a non-perforated appendix from an overly zealous attempt to extracorporealize may be harmful to the patient.
- Some have described the use of wound protectors or surgical gloves to prevent wound infection in the extracorporeal, single-port technique.
- During three-port laparoscopy with an appendix that is adherent to multiple structures and difficult to dissect, hook cautery may be used to separate the mesoappendix from the appendix.
- Use of endo-loops may be more cost-effective than stapling in the intracorporeal technique [19].
- Single-incision technique may allow for a higher tissue concentration of local anesthetic at the incision.

Postoperative Management

In patients with non-perforated appendicitis, the diet may be advanced as tolerated postoperatively. There is no need for additional antibiotics. Patients may be discharged home when they are tolerating a diet and are afebrile. In patients with perforated appendicitis, inpatient admission is required for broad spectrum intravenous antibiotics. The choice of antibiotics and duration differ based on institutional protocols. The authors prefer daily dosing of intravenous ceftriaxone (50 mg/kg) and metronidazole (30 mg/kg) as described by St. Peter et al. [20].

Complications

1. Bleeding from the epigastric vessels, ileac vessels, and appendicular artery are rare complications that may be avoided with careful port site placement and dissection.
2. Superficial wound infection for non-perforated appendicitis has been shown to be 3.3 % after single-incision appendectomy and 1.7 % after

three-port appendectomy in one series [18]. After laparoscopic appendectomy for perforated appendicitis, superficial wound infection occurred in 0–2 % of patients, but intra-abdominal abscess formation occurred in 16–20 % [20].

3. Intraperitoneal fluid collection or abscess is a common complication following perforated appendicitis. Historically, some surgeons have used irrigation and suction to minimize this risk. However, a recent prospective randomized study suggested no difference between irrigation versus suction alone during laparoscopic appendectomy for perforated appendicitis in a pediatric population [21]. In fact, in a prospective cohort analysis of 1817 adults undergoing laparoscopic appendectomy, peritoneal irrigation was identified as an independent risk factor for postoperative abscess formation [22]. The same study analyzed characteristics of antimicrobial treatment and the incidence of intra-abdominal abscess and found the length of postoperative antibiotic treatment and antimicrobial combination therapy did not affect the development of intra-abdominal abscess, and prolonged antibiotic treatment did not prevent abscess formation.
4. Wound infection from stump leak may occur from disintegration of the avascular appendix base, diathermy burn, or overly tight ligature.
5. Small bowel obstruction is a known complication of appendicitis and can be seen after laparoscopic or open appendectomy procedures, although it appears less commonly than after open appendectomy [23].

Summary

- Laparoscopic appendectomy is the preferred treatment for acute appendicitis.
- Single-incision techniques may be preferred for non-perforated appendicitis in normal-weight children.
- Given the frequency in which pediatric surgeons perform appendectomies, it is important to select surgical devices that are cost-effective.

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