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Review Article

An Update on the Surgical Management of Acute Appendicitis: Review Article

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Abstract: The management of acute appendicitis involves performing an appendectomy, which can be done as an open or laparoscopic method. Since its introduction, laparoscopic appendectomy has been performed for both uncomplicated and complicated appendicitis. Laparoscopic appendectomy is minimally invasive and associated with reduced postoperative complications, early ambulation, and faster recovery. Single incision laparoscopic appendectomy and natural orifice transluminal appendectomy are newer variants of minimally invasive surgery that are being performed for acute appendicitis. In this review, we will investigate the role of laparoscopic appendectomy, single incision laparoscopic appendectomy, and natural orifice transluminal appendectomy in the management of acute appendicitis.

Keywords: Acute Appendicitis, Complicated Appendicitis, Uncomplicated Appendicitis, Laparoscopic Appendectomy, NOTES, and Single Incision Laparoscopic Appendectomy.

INTRODUCTION

Acute appendicitis is one of the most common general surgical emergencies that presents to the emergency department, and it has an incidence of 90-100 cases per 100,000 population in most developed countries. It is commonly seen in the second and third decades of life, and it has a slight male predominance. The etiology of this condition is unknown, and acute appendicitis can be divided into uncomplicated and complicated appendicitis (Bhangu *et al*., 2015). The diagnosis of acute appendicitis involves clinical examination and blood investigations, which may reveal leukocytosis and elevated C-reactive protein (CRP). Imaging modalities like ultrasound and computerized tomography are reserved for cases where the diagnosis is equivocal or if complications like perforation or mass formation are suspected(Teng *et al*., 2021). The management of acute appendicitis is by performing an appendectomy, which can be performed by either an open or laparoscopic method. Non-operative management has now become an alternative option for the management of acute, uncomplicated appendicitis. For complicated appendicitis, laparoscopic appendectomy is the preferred method, although non-operative management is used for certain appendicular masses and abscesses(Becker *et al*., 2018; Wray *et al*., 2013).

The World Society of Emergency Surgeons (WSES) in their 2020 guidelines for the management of acute appendicitis, has recommended laparoscopic appendectomy for the management of acute appendicitis, and non-operative treatment is performed in selected patients with the absence of appendicolith, advising of the possibility of recurrence and the risk of complications like perforation and abscess formation(Di Saverio *et al*., 2020). The European Association of Emergency Surgeons (EAES), in their consensus on the management of acute appendicitis, has recommended appendectomy for the management of acute appendicitis, with non-operative treatment being selected for specific patients(Gorter *et al*., 2016). The Society of American Gastrointestinal Surgeons(SAGES), in their guidelines for the diagnosis and management of acute appendicitis, has recommended that appendectomy is the recommended treatment of choice for both acute uncomplicated and complicated appendicitis, and both adult and pediatric patients will benefit from this method of management(Kumar *et al*., 2024.).The Swedish national guidelines for the management of acute appendicitis in adults and children have recommended laparoscopic appendectomy for the management of acute uncomplicated appendicitis, and do not recommend non-operative treatment(Salö *et al*., 2025).

In this review, we will look at the role of laparoscopic appendectomy, single incision laparoscopic appendectomy, and natural orifice transluminal appendectomy in the management of acute appendicitis. We conducted a literature review using PUBMED, the Cochrane database of systematic reviews, Google Scholar, and Semantic Scholar, looking for randomized controlled trials, non-randomized trials, observational and cohort studies, clinical reviews, systematic reviews, and meta-analyses from 1980 to 2025. The following keywords were used: "Acute appendicitis", "Uncomplicated appendicitis", "Complicated appendicitis", "NOTES", "laparoscopic appendectomy", and "single incision laparoscopic appendectomy". All articles were in English, and all articles were assessed by manual cross-referencing of the literature. Commentaries, case reports, and editorials were excluded from this review. Only Adult and pediatric patients with acute appendicitis were included in this study.

DISCUSSION

Laparoscopic Appendectomy for Acute Appendicitis

Since its introduction in the 1990s, laparoscopic appendectomy has now become the preferred method of performing an appendectomy. The 3-port method includes the placement of a 10mm sub-umbilical port, followed by a suprapubic and a left lateral 5mm port. The advantage of laparoscopic appendectomy is the visualization of the peritoneal cavity and pelvic organs, and it is associated with reduced postoperative pain, early ambulation, and better wound healing(Korndorffer *et al*., 2010). Laparoscopic appendectomy was, however, associated with a higher incidence of intra-abdominal abscess formation and a longer operative time when compared with open appendectomy(Sohn *et al.,* 2017).

Laparoscopic appendectomy was compared to open appendectomy in a prospective study by Shaikh *et al*., A total of 60 patients were included in this study, with 30 undergoing laparoscopic appendectomy and 30 undergoing an open appendectomy. The operative was slightly longer in the laparoscopic appendectomy group, but the postoperative wound infection rate was 6.6% in the laparoscopic appendectomy group and 13.3% in the open appendectomy group(Shaikh *et al*., 2022). Bulut *et al*., retrospectively assessed 627 patients with acute appendicitis, of whom 298 underwent laparoscopic appendectomy, and 329 underwent open appendectomy. The length of hospital stays and postoperative infection rates were lower in the laparoscopic appendectomy group(Bulut & Ucar, 2025).A nationwide cohort study by Klief *et al*., looked at the trend of both open and laparoscopic appendectomy in the management of acute appendicitis over the past 20 years, and the rate of laparoscopic appendectomy has increased from 7.4% to 93%, and the 30-day mortality rate has remained at 0.93%(Kleif *et al*., 2021).

A meta-analysis of randomized controlled trials comparing laparoscopic versus open appendectomy in acute appendicitis was conducted by Dai *et al*., A total of 33 studies with 3642 patients were included in this study, of which 1810 underwent laparoscopic appendectomy, and 1832 underwent open appendectomy. Laparoscopic appendectomy was associated with reduced postoperative morbidity and faster return to work. The intra-abdominal abscess rate was similar between the groups(Dai & Shuai, 2017). Another meta-analysis comparing laparoscopic versus open appendectomy for acute appendicitis was conducted by Temple *et al*., A total of 8 studies with 1383 patients were included in this study, of which 730 underwent laparoscopic appendectomy, and 653 underwent open appendectomy. Laparoscopic appendectomy was associated with reduced wound infection and faster return to work. There were no differences in the intra-abdominal abscess rate, but the operative time was longer in the laparoscopic appendectomy group(Temple *et al*., 1999).

A systematic review of meta-analyses of randomized controlled trials comparing laparoscopic versus open appendectomy was conducted by Jaschinski *et al*., A total of 9 systematic reviews were included in this study, and laparoscopic appendectomy was associated with a longer operative time, but the postoperative wound infection and the length of hospital stay were shorter. The intra-abdominal abscess rate was, however, higher in the laparoscopic appendectomy group(Jaschinski *et al*., 2015).A meta-analysis comparing laparoscopic versus open appendectomy for acute appendicitis was conducted by Bennet *et al*., A total of 34 studies with 4414 patients were included, of which 2064 underwent laparoscopic appendectomy and 2350 underwent open appendectomy. Laparoscopic appendectomy was associated with reduced postoperative morbidity, but the operative time was longer, and so was the intra-abdominal abscess rate(Bennett *et al*., 2007).

Laparoscopic appendectomy was found to be effective for the surgical management of complicated appendicitis with its better access to the peritoneal cavity, and the ability to perform aspiration of purulent material and peritoneal toilet. Several retrospective studies have shown that laparoscopic appendectomy is just as effective in the management of complicated appendicitis (Fukami *et al*., 2007; Khiria *et al*., 2011; Kiriakopoulos *et al*., 2006; Stöltzing Thon & Hartmut Stöltzing, 2000). A systematic review and meta-analysis comparing laparoscopic versus open appendectomy for complicated appendicitis was conducted by Athanasiou *et al*., A total of 26 studies with 4439 patients, of which 2188 underwent laparoscopic appendectomy, and 2251 underwent open appendectomy. Laparoscopic appendectomy was associated with reduced postoperative morbidity and length of hospital stay, but the operative time was longer. The intra-abdominal

abscess rate was similar between the groups(Athanasiou *et al*., 2017).

Neogi *et al*., conducted a systematic review and meta-analysis on laparoscopic versus open appendectomy for complicated appendicitis in children. A total of 40 studies with 2846 patients underwent laparoscopic appendectomy, and 3397 underwent open appendectomy. The postoperative complication rates were reduced in the laparoscopic appendectomy group, and the intra-abdominal abscess rate was similar between both groups. The procedure duration was longer in the laparoscopic appendectomy group(Neogi *et al*., 2022). A randomized controlled trial comparing the safety of laparoscopic versus open appendectomy in complicated appendicitis was conducted by Thomson *et al*., A total of 112 patients were randomized to 60 who underwent laparoscopic appendectomy and 52 who underwent open appendectomy. There were no differences in the postoperative morbidity, length of hospital stays, and intra-abdominal abscess rate between the two procedures(Thomson *et al*., 2015).

The Risk Factors for Conversion from Laparoscopic to Open Appendectomy

Ceylan *et al*., conducted a retrospective study to look at the risk factors for conversion from laparoscopic appendectomy to open appendectomy. A total of 445 patients were included in this study, and some of the factors that were associated with conversion from laparoscopic to open appendectomy include a high American Society of Anesthesiologists (ASA) score, elevated C-reactive protein (CRP), and complicated appendicitis(Ceylan *et al*., 2025)Cherif *et al*., also examined risk factors for conversion from laparoscopic to open appendectomy. A retrospective study was conducted on 725 patients, of whom 121 were converted from laparoscopy to open appendectomy. The presence of co-morbidities like diabetes mellitus and the presence of perforation and abscess formation were associated with a higher risk of conversion to open appendectomy(Cherif *et al*., 2023)Pusphanathan *et al*., conducted a retrospective study of risk factors for conversion from laparoscopic to open appendectomy for acute appendicitis. A total of 120 patients were included in this study, and 33 patients underwent conversion. Perforated appendicitis was the most common cause for conversion, with a rate of 81.1%(Pushpanathan *et al*., 2022).

Lezama *et al*., conducted a 15-year analysis of 2193 patients who underwent laparoscopic appendectomy, and 52 underwent conversion to open appendectomy. The presence of obesity, the presence of complicated appendicitis, and previous abdominal surgery were all risk factors for conversion to open appendectomy(Monrabal Lezama *et al*., 2022). Aragone *et al*., also looked at the factors that are associated with conversion from laparoscopic to open appendectomy in their analysis of 3,411 patients who had undergone laparoscopic appendectomy. Some of the factors that were associated with conversion include increasing age, a high American Society of Anesthesiology (ASA) score, the presence of perforation of the appendix, and the presence of peritonitis and adhesions(Aragone *et al*., 2024).Some of the other risk factors for conversion include a high total white cell count and C-reactive protein(CRP), and these can be detected pre-operatively to help the surgeon when performing a laparoscopic appendectomy(Bancke Laverde *et al*., 2023).

Table I

Study	Study type	Year	N=numbers	Intra-abdominal abscess rate of laparoscopic appendectomy (%)	Intra-abdominal abscess rate open appendectomy (%)
Markar *et al*.,	Review article	2012	34,474	3.69	2.59
Dai *et al*.,	Meta-analysis	2016	3642	3.17	3.77
Basukala *et al*.,	Retrospective study	2023	450	1.3	1.3

Table shows the rate of intra-abdominal abscess between laparoscopic and open appendectomy for acute appendicitis.

Single Incision Laparoscopic Appendectomy

This minimally invasive method, which was introduced in the 1990s, involves making a 2-3cm incision in the sub-umbilical region and inserting a 10mm and multiple 5mm ports through the incision, to facilitate the passage of the laparoscope and surgical instruments. This method requires training as there may be a collision of the instruments and difficulty in maintaining triangulation. Its main advantage is the better cosmetic outcome and a better surgical scar(Bhatia *et al*., 2011; Switzer *et al*., 2012). Liang *et al*., conducted a retrospective study comparing single-incision laparoscopic appendectomy versus conventional laparoscopic appendectomy. A total of 688 patients were divided into 618 who underwent conventional laparoscopic appendectomy and 70 who underwent single incision laparoscopic appendectomy. Single incision laparoscopic appendectomy was associated with reduced postoperative morbidity and early ambulation, but the length of hospital stay was longer than conventional laparoscopic appendectomy(Liang *et al*., 2014).

A systematic review and meta-analysis of single-incision laparoscopic appendectomy versus conventional laparoscopic appendectomy was conducted by Markar *et al*., A total of 7 studies with 1108 patients were included in this study, of which 555 underwent

single-incision laparoscopic appendectomy and 553 underwent conventional laparoscopic appendectomy. There were no differences in postoperative morbidity, intra-abdominal abscess formation, and length of hospital stay between the procedures, but single incision laparoscopic appendectomy was associated with a longer operative time(Markar *et al*., 2013). Another systematic review and meta-analysis comparing single incision laparoscopic appendectomy and conventional laparoscopic appendectomy was conducted by Cai *et al.*, A total of 6 studies with 1068 patients were included in this study, with 535 undergoing single incision laparoscopic appendectomy and 533 undergoing conventional laparoscopic appendectomy. There were no differences in the postoperative morbidity, but single incision laparoscopic appendectomy was associated with a longer operative time and a higher conversion rate(Cai *et al*., 2013).

A systematic review and meta-analysis of randomized controlled trials comparing single incision laparoscopic appendectomy versus laparoscopic appendectomy in adults was conducted by Kossenas *et al*., A total of 4 studies with 404 patients were included, of which 202 underwent single incision laparoscopic appendectomy, and 206 underwent conventional laparoscopic appendectomy. There were no differences in the postoperative morbidity, intra-abdominal abscess formation, length of hospital stays, and duration of the operation between the procedures(Kossenas *et al*., 2025)A similar systematic review and meta-analyses comparing single incision laparoscopic appendectomy versus conventional laparoscopic appendectomy, which was conducted by Xu *et al*., and Zhou *et al*., also concluded the same(Xu *et al*., 2015; Zhou *et al*., 2014). A meta-analysis of randomized controlled trials comparing single incision laparoscopic appendectomy versus conventional laparoscopic appendectomy was conducted by Antoniou *et al*., A total of 5 studies with 746 patients were included in this study, and the postoperative morbidity and intra-abdominal abscess formation were similar between the groups, but single incision laparoscopic appendectomy was associated with a longer operative time(Antoniou *et al*., 2014).

A systematic review and meta-analysis comparing single-incision laparoscopic appendectomy versus conventional laparoscopic appendectomy in children was conducted by Zhang *et al*., A total of 14 studies with 2249 patients, of which 744 underwent single-incision laparoscopic appendectomy and 1505 under conventional laparoscopic appendectomy. There were no differences in the postoperative complications, intra-abdominal abscess rate, but single incision laparoscopic appendectomy was associated with longer operative time and higher wound infection rate(Zhang *et al*., 2015).Another systematic review and meta-analysis comparing single-incision laparoscopic appendectomy versus laparoscopic appendectomy in children was conducted by Zhao *et al*., and they concluded that both procedures did not show any differences in complications and duration of operation, and single-incision laparoscopic appendectomy did not show any advantage over conventional laparoscopic appendectomy(Zhao *et al*., 2015).

Natural Orifice Transluminal Endoscopic Appendectomy

Natural orifice transluminal endoscopic appendectomy is performed via a trans gastric or a transvaginal route, and it has the advantage of not making a skin incision and gaining access to the peritoneal cavity via these routes and then performing the appendectomy. The advantages of this procedure include reduced postoperative pain and wound infection, but the procedure takes longer than a conventional laparoscopic appendectomy, as the orientation and triangulation of instruments make it difficult for the surgeon(Huang *et al*., 2011; Moreira-Pinto *et al*., 2011). Some surgeons have combined natural orifice transvaginal surgery with laparoscopic surgery, and this is called a hybrid or Natural orifice-assisted laparoscopic appendectomy, where, after introduction of the endoscope into the peritoneal cavity, a 5mm laparoscope is introduced to assist in performing the appendectomy(Nezhat *et al*., 2009).

A systematic review was conducted by Slouha et al on Transvaginal laparoscopic appendectomy, where 20 studies were included. Transvaginal laparoscopic appendectomy was associated with reduced postoperative complications, postoperative pain, and minimal scarring. The recovery period was 2 to 3 weeks(Slouha *et al*., 2024).Yagci *et al*., conducted a systematic review on Transvaginal appendectomy and included 112 cases in this study. The complication rate was 8.2% and the conversion rate was 3.6%. This study concluded that transvaginal appendectomy should only be performed for uncomplicated acute appendicitis in non-obese patients(Yagci & Kayaalp, 2014).

CONCLUSION

Laparoscopic appendectomy is now considered the gold standard for the management of acute appendicitis, due to its reduced postoperative nausea and vomiting, early ambulation, and faster return to work. As more surgeons get trained in performing laparoscopic appendectomy, open appendectomy will probably be reserved for complications like a perforated appendix or when the base is compromised. Complicated appendicitis is considered a risk factor for conversion from a laparoscopic to an open appendectomy. Single-incision laparoscopic appendectomy is an attractive alternative to laparoscopic appendectomy, but it requires special equipment and training, which limits its use. Natural orifice transluminal appendectomy is still in its early stages, and it is not popular for the surgical management of acute appendicitis.

Conflict of Interest: There is no conflict of interest.

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