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A Review of The Current Management of Acute Appendicitis: Review Article

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Abstract

The management of acute appendicitis typically involves performing an appendectomy, which can be executed using either an open or laparoscopic approach. Since its inception, laparoscopic appendectomy has been utilized for both uncomplicated and complicated cases of appendicitis. This minimally invasive technique is associated with reduced postoperative complications, earlier ambulation, and a more rapid recovery. Recent advancements in minimally invasive surgery include single-incision laparoscopic appendectomy and natural orifice transluminal appendectomy, both of which are employed in the treatment of acute appendicitis. In this review, we will examine the roles of laparoscopic appendectomy, single-incision laparoscopic appendectomy, and natural orifice transluminal appendectomy in the management of acute appendicitis. Although non-operative management has been recently introduced for selected patients, it is not recommended as a treatment for acute appendicitis.

Keywords: Acute Appendicitis; Complicated Appendicitis; Uncomplicated Appendicitis; Laparoscopic Appendectomy; Notes, non-operative treatment; Single incision laparoscopic appendectomy

Introduction

Acute appendicitis represents one of the most prevalent surgical emergencies encountered in the emergency department, with an incidence rate of 90-100 cases per 100,000 individuals in most developed nations. This condition is predominantly observed in individuals in their second and third decades of life and exhibits a slight male predominance. The etiology of acute appendicitis remains unidentified, and it is classified into uncomplicated and complicated forms [1]. Diagnosis is primarily based on clinical examination and blood tests, which may indicate leukocytosis and elevated C-reactive protein (CRP) levels. Imaging techniques such as ultrasound and computed tomography are employed when the diagnosis is uncertain or when complications like perforation or mass formation are suspected [2]. The standard treatment for acute appendicitis is appendectomy, which can be performed via open or laparoscopic methods. Non-operative management has emerged as an alternative for acute, uncomplicated appendicitis. In cases of complicated appendicitis, laparoscopic appendectomy is generally preferred, although non-operative management is applied for specific appendicular masses and abscesses [3,4]. The World Society of Emergency Surgeons (WSES), in their 2020 guidelines for the management of acute appendicitis, recommends laparoscopic appendectomy as the preferred treatment for acute appendicitis. Non-operative treatment is advised for selected patients without appendicolith, with caution regarding the potential for recurrence and risks of complications such as perforation and abscess formation [5]. Similarly, the European Association of Emergency Surgeons (EAES) endorses appendectomy for acute appendicitis, with non-operative management reserved for specific cases [6]. The Society of American Gastrointestinal Surgeons (SAGES) also advocates appendectomy as the treatment of choice for both uncomplicated and complicated acute appendicitis, applicable to both adult and pediatric patients [7]. The Swedish national guidelines for managing acute appendicitis in adults and children recommend laparoscopic appendectomy for uncomplicated cases and do not support non-operative treatment [8]. In this review, we examine the roles of laparoscopic

appendectomy, single-incision laparoscopic appendectomy, and natural orifice transluminal appendectomy in the management of acute appendicitis. A comprehensive literature review was conducted utilizing PUBMED, the Cochrane Database of Systematic Reviews, Google Scholar, and Semantic Scholar. The search focused on randomized controlled trials, non-randomized trials, observational and cohort studies, clinical reviews, systematic reviews, and meta-analyses published from 1980 to 2025. The keywords employed in the search included: "Acute appendicitis," "Uncomplicated appendicitis," "Complicated appendicitis," "conservative treatment," "NOTES," "laparoscopic appendectomy," "non-operative treatment," and "single incision laparoscopic appendectomy." All articles were in English and were assessed through manual cross-referencing of the literature. Commentaries, case reports, and editorials were excluded from this review. The study included only adult and pediatric patients with acute appendicitis.

Discussion

Laparoscopic appendectomy for acute appendicitis

Since its development in the 1990s, laparoscopic appendectomy has become the preferred method for performing an appendectomy. The 3-port technique involves the insertion of a 10mm sub-umbilical port, followed by a suprapubic and a left lateral 5mm port. The benefits of laparoscopic appendectomy include improved visualization of the peritoneal cavity and pelvic organs, as well as reduced postoperative pain, earlier ambulation, and enhanced wound healing [9]. However, laparoscopic appendectomy is associated with a higher incidence of intra-abdominal abscess formation and a longer operative duration compared to open appendectomy [10]. In a prospective study conducted by Shaikh et al., laparoscopic appendectomy was compared to open appendectomy. The study included a total of 60 patients, with 30 undergoing laparoscopic appendectomy and 30 undergoing open appendectomies. The operative duration was slightly longer in the laparoscopic appendectomy group; however, the postoperative wound infection rate was 6.6% in the laparoscopic group compared to 13.3% in the open appendectomy group [11]. Bulut et al. conducted a retrospective assessment of 627 patients with acute appendicitis, of whom 298 underwent laparoscopic appendectomy, and 329 underwent open appendectomy. The findings indicated that the length of hospital stay and postoperative infection rates were lower in the laparoscopic appendectomy group [12]. A nationwide cohort study by examined the trend of both open and laparoscopic appendectomy in the management of acute appendicitis over the past 20 years. The rate of laparoscopic appendectomy increased from 7.4% to 93%, while the 30-day mortality rate remained at 0.93% [13,14] conducted a meta-analysis of randomized controlled trials comparing laparoscopic and open appendectomy in cases of acute appendicitis. This study incorporated 33 studies encompassing 3,642 patients, with 1,810 undergoing laparoscopic appendectomy and 1,832 undergoing open appendectomy. The findings indicated that laparoscopic appendectomy was associated with reduced postoperative morbidity and a quicker return to work, while the intra-abdominal abscess rate remained comparable between the two groups. Similarly, Temple et al. conducted another meta-analysis comparing laparoscopic and open appendectomy for acute appendicitis. This analysis included 8 studies with a total of 1,383 patients, of whom 730 underwent laparoscopic appendectomy, and 653 underwent open appendectomy. The results demonstrated that laparoscopic appendectomy was linked to a decreased incidence of wound infection and a faster return to work. Although there were no differences in the intra-abdominal abscess rate, the operative time was longer for the laparoscopic appendectomy group [15]. A systematic review of meta-analyses of randomized controlled trials comparing laparoscopic versus open appendectomy was conducted by [16]. This study incorporated a total of nine systematic reviews, revealing that laparoscopic appendectomy was associated with a longer operative time. However, it resulted in shorter postoperative wound infection rates and reduced length of hospital stay. Conversely, the intra-abdominal abscess rate was higher in the laparoscopic appendectomy group. A meta-analysis conducted by [17]. compared laparoscopic versus open appendectomy for acute appendicitis. This analysis included 34 studies with a total of 4414 patients, of whom 2064 underwent laparoscopic appendectomy and 2350 underwent open appendectomy. The findings indicated that laparoscopic appendectomy was associated with reduced postoperative morbidity, although it was characterized by a longer operative time and a higher intra-abdominal abscess rate. Laparoscopic appendectomy has been demonstrated to be effective in the surgical management of complicated appendicitis, offering enhanced access to the peritoneal cavity and facilitating the aspiration of purulent material and peritoneal lavage. Several retrospective studies have indicated that laparoscopic appendectomy is equally effective in managing complicated appendicitis [18-22]. Conducted a systematic review and meta-analysis comparing laparoscopic and open appendectomy for complicated appendicitis, encompassing 26 studies with a total of 4439 patients, of whom 2188 underwent laparoscopic appendectomy, and 2251 underwent open appendectomy. The findings revealed that laparoscopic appendectomy was associated with reduced postoperative morbidity and shorter hospital stays, although the operative time was longer. The rate of intra-abdominal abscess formation was comparable between the two groups. conducted a systematic review and meta-analysis comparing laparoscopic and open appendectomy for complicated appendicitis in pediatric patients. The analysis included 40 studies, with 2,846 patients undergoing laparoscopic appendectomy and 3,397

undergoing open appendectomy. The findings indicated a reduction in postoperative complication rates in the laparoscopic appendectomy group, while the intra-abdominal abscess rate was comparable between the two groups. However, the duration of the procedure was longer for the laparoscopic approach [23]. Additionally, [24] conducted a randomized controlled trial to assess the safety of laparoscopic versus open appendectomy in cases of complicated appendicitis. In this trial, 112 patients were randomized, with 60 undergoing laparoscopic appendectomies and 52 undergoing open appendectomies. The results demonstrated no significant differences in postoperative morbidity, length of hospital stay, or intra-abdominal abscess rate between the two surgical methods.

Table 1: *The table shows the rate of intra-abdominal abscess between laparoscopic and open appendectomy for acute appendicitis.*

Study	Study type	Year	N=numbers	Intra-abdominal abscess rate of laparoscopic appendectomy (%)	Intra-abdominal abscess rate open appendectomy (%)
Quah et al	Systematic review	2019	6428	4.7	12.8
Dai et al	Meta-analysis	2016	3642	3.17	3.77
Basukala et al	Retrospective study	2023	450	1.3	1.3
Neogi et al	Systematic review & meta-analysis	2021	6243	7.9	8.3

The risk factors for conversion from laparoscopic to open appendectomy

Ceylan C [25] conducted a retrospective study to investigate the risk factors associated with the conversion from laparoscopic appendectomy to open appendectomy [25]. The study included a total of 445 patients and identified factors such as a high American Society of Anesthesiologists (ASA) score, elevated C-reactive protein (CRP) levels, and complicated appendicitis as being associated with conversion. Similarly, Cherif et al. examined the risk factors for conversion from laparoscopic to open appendectomy in a retrospective study involving 725 patients, of whom 121 underwent conversion. The study found that the presence of comorbidities, such as diabetes mellitus, as well as perforation and abscess formation, was linked to an increased risk of conversion [26]. Pushpanathan NR [27] also conducted a retrospective study on the risk factors for conversion from laparoscopic to open appendectomy in cases of acute appendicitis. This study included 120 patients, with 33 undergoing conversions. Perforated appendicitis was identified as the most prevalent cause for conversion, with a rate of 81.1%. Monrabal Lezama M [28] conducted a comprehensive 15-year study involving 2,193 patients who underwent laparoscopic appendectomy, of which 52 required conversions to open appendectomy. The study identified obesity, complicated appendicitis, and prior abdominal surgery as significant risk factors for conversion. Similarly, Aragone L [29] examined factors associated with conversion from laparoscopic to open appendectomy in their analysis of 3,411 patients. Their findings indicated that increasing age, a high American Society of Anesthesiology (ASA) score, appendix perforation, peritonitis, and adhesions were associated with conversion. Additional risk factors identified include elevated total white cell count and C-reactive protein (CRP) levels, which can be detected pre-operatively to assist surgeons during laparoscopic appendectomy [30].

Single Incision Laparoscopic Appendectomy

This minimally invasive technique, introduced in the 1990s, entails creating a 2-3 cm incision in the sub-umbilical region to insert a 10 mm port along with multiple 5 mm ports, thereby facilitating the insertion of the laparoscope and surgical instruments. This procedure necessitates specialized training due to potential instrument collisions and challenges in maintaining triangulation. The primary advantage of this method is its superior cosmetic outcome and improved surgical scar [31,32]. Liang HH [33] conducted a retrospective study comparing single-incision laparoscopic appendectomy with conventional laparoscopic appendectomy. The study involved 688 patients, with 618 undergoing conventional laparoscopic appendectomy and 70 undergoing single-incision laparoscopic appendectomy. The single-incision laparoscopic appendectomy was associated with reduced postoperative morbidity and earlier ambulation; however, the length of hospital stay was longer compared to the conventional laparoscopic appendectomy. Markar SR [34] conducted a systematic review and meta-analysis comparing single-incision laparoscopic appendectomy with conventional laparoscopic appendectomy. This study incorporated data from seven studies, encompassing a total of 1,108 patients, with 555 undergoing single-incision laparoscopic appendectomy and 553 undergoing

the conventional procedure. The findings indicated no significant differences in postoperative morbidity, intra-abdominal abscess formation, or length of hospital stay between the two procedures. However, the single-incision approach was associated with a longer operative time. Similarly, Cai YL [35] performed a systematic review and meta-analysis on the same comparison, including six studies with a total of 1,068 patients, of whom 535 underwent single-incision laparoscopic appendectomy and 533 underwent the conventional method. Their analysis also revealed no differences in postoperative morbidity, but the single-incision technique was linked to both a longer operative time and a higher conversion rate.

Kossenas K [36] conducted a systematic review and meta-analysis of randomized controlled trials comparing single-incision laparoscopic appendectomy with conventional laparoscopic appendectomy in adults. The analysis included four studies comprising 404 patients, with 202 undergoing single-incision laparoscopic appendectomy and 206 undergoing conventional laparoscopic appendectomy. The findings indicated no significant differences in postoperative morbidity, intra-abdominal abscess formation, length of hospital stay, or duration of the operation between the two procedures. Similarly, systematic reviews and meta-analyses by [37,38] reached the same conclusion. [39] also conducted a meta-analysis of randomized controlled trials comparing these two surgical techniques, incorporating five studies with a total of 746 patients. Their results showed comparable postoperative morbidity and intra-abdominal abscess formation between the groups; however, single-incision laparoscopic appendectomy was associated with a longer operative time. Zhang Z [40] conducted a systematic review and meta-analysis to compare single-incision laparoscopic appendectomy with conventional laparoscopic appendectomy in pediatric patients. The analysis included 14 studies encompassing a total of 2,249 patients, with 744 undergoing single-incision laparoscopic appendectomy and 1,505 undergoing conventional laparoscopic appendectomy. The findings indicated no significant differences in postoperative complications or intra-abdominal abscess rates between the two procedures. However, single-incision laparoscopic appendectomy was associated with a longer operative time and a higher rate of wound infection. Similarly, [41] performed a systematic review and meta-analysis comparing these two surgical techniques in children. Their conclusions mirrored those of finding no differences in complications or operative duration, and no advantage of single-incision laparoscopic appendectomy over the conventional approach.

Natural Orifice Transluminal Endoscopic Appendectomy

Natural orifice transluminal endoscopic appendectomy is conducted via either a trans gastric or transvaginal approach, offering the advantage of avoiding a skin incision by accessing the peritoneal cavity through these routes to perform the appendectomy. This procedure is associated with benefits such as reduced postoperative pain and a lower risk of wound infection. However, it requires more time than a conventional laparoscopic appendectomy due to the challenges in instrument orientation and triangulation faced by the surgeon [42,43]. Some practitioners have integrated natural orifice transvaginal surgery with laparoscopic techniques, resulting in a hybrid or natural orifice-assisted laparoscopic appendectomy. In this approach, after the endoscope is introduced into the peritoneal cavity, a 5mm laparoscope is employed to assist in the appendectomy [44]. Slouha E [45] conducted a systematic review on transvaginal laparoscopic appendectomy, incorporating 20 studies. The findings indicated that transvaginal laparoscopic appendectomy was associated with a reduction in postoperative complications, postoperative pain, and minimal scarring, with a recovery period of 2 to 3 weeks. In a separate systematic review by Yagci MA [46] 112 cases of transvaginal appendectomy were examined. The study reported a complication rate of 8.2% and a conversion rate of 3.6%. It was concluded that transvaginal appendectomy should be reserved for cases of uncomplicated acute appendicitis in non-obese patients.

Non-Operative management of acute appendicitis

Over the past two decades, there has been a notable increase in the number of studies examining patients who have received conservative treatment for acute appendicitis. The outcomes associated with conservative treatment have shown improvement, and recurrence rates have decreased [47,48]. A systematic review conducted by Talan DA [49] investigated the methods of conservative treatment for acute, uncomplicated appendicitis, incorporating 34 studies with a total of 2,944 patients. The treatment protocol involved a one-week course of antibiotics, beginning with three days of intravenous administration followed by oral preparations. Patients were subjected to fluid restrictions for up to 48 hours, resulting in improvement in up to 90% of cases after 48 hours of therapy. This study underscores the importance of optimizing conservative treatment for effective management of acute appendicitis. Another systematic review by Poon et al. examined the current management strategies for acute uncomplicated appendicitis, revealing that patients who underwent an appendectomy exhibited a higher efficacy rate compared to those receiving conservative treatment, although morbidity rates were similar between the two groups [50]. Ansaloni L [51] conducted a systematic review and meta-analysis of randomized controlled trials comparing surgical intervention with conservative antibiotic treatment for acute appendicitis. This study included four trials with a total of 741 patients, revealing that surgical intervention demonstrated higher efficacy compared to conservative treatment. However, the incidence of complications

was greater in the surgical group than in those receiving conservative treatment. Similarly, Yang et al. performed a meta-analysis comparing conservative antibiotic treatment with appendectomy in adults with acute appendicitis. This analysis encompassed eleven studies with a cumulative total of 2751 patients, of whom 1463 received conservative treatment and 1288 underwent appendectomy. The findings indicated that conservative treatment was associated with fewer complications and a reduced length of hospital stay, albeit with lower efficacy compared to appendectomy [52]. Furthermore, conducted another meta-analysis of randomized controlled trials comparing antibiotic therapy with appendectomy for acute appendicitis. This study included five trials with 980 patients, demonstrating that while antibiotic therapy resulted in fewer complications and improved pain relief, the treatment failure rate was 40.2%, compared to 8.5% in patients who underwent appendectomy [53]. An umbrella review of systematic reviews and meta-analyses conducted by Emile et al. examined the efficacy and safety of conservative treatment compared to appendectomy in cases of uncomplicated acute appendicitis. This study incorporated eighteen systematic reviews, revealing that conservative treatment was associated with a treatment failure rate of 25% relative to appendectomy. Additionally, the complication rate and length of hospital stay were marginally lower in the conservative treatment group compared to the appendectomy group [54]. The Appendicitis Acuta (APPAC) randomized clinical trial, conducted by Salminen et al., compared antibiotic therapy with appendectomy for the treatment of uncomplicated appendicitis. This study included 540 patients, of whom 273 underwent appendectomy and 257 received antibiotic therapy. The success rate for appendectomy was 99.6%, whereas the success rate for antibiotic therapy was 76%. The failure rate for antibiotic therapy was 27.3%; however, the study was unable to establish the non-inferiority of antibiotic treatment for acute appendicitis [55]. Another randomized trial, the Comparison of Outcomes of Antibiotic Drugs and Appendectomy (CODA), was conducted by CODA Collaborative [56]. In this trial, 1552 patients were randomized, with 776 receiving antibiotic therapy and 776 undergoing appendectomies. Although complication rates were higher in the antibiotic group compared to the appendectomy group, the results indicated that antibiotic therapy was non-inferior to appendectomy in managing acute appendicitis.

Conclusion

Laparoscopic appendectomy is currently regarded as the gold standard for managing acute appendicitis, primarily due to its association with reduced postoperative nausea and vomiting, earlier ambulation, and expedited return to work. As more surgeons receive training in laparoscopic appendectomy, open appendectomy is likely to be reserved for cases involving complications such as a perforated appendix or compromised base. Complicated appendicitis is recognized as a risk factor for conversion from laparoscopic to open appendectomy. Single-incision laparoscopic appendectomy presents an appealing alternative to traditional laparoscopic appendectomy; however, its application is limited by the requirement for specialized equipment and training. Natural orifice transluminal appendectomy remains in its nascent stages and is not widely adopted for the surgical management of acute appendicitis. Non-operative treatment may be considered for young patients, although they should be informed of the potential for treatment failure and recurrence.

Conflict of Interest

The authors declare that they have no conflict of interest.

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