Volume 10, Issue 05, May 2024,
Publish Date: 21-05-2024
Doi https://doi.org/10.55640/ijmsdh-10-05-08

International Journal of Medical Science and Dental Health (Open Access)

EFFICACY AND SAFETY OF MINIMALLY INVASIVE SURGERY TECHNIQUES IN THE TREATMENT OF ACUTE APPENDICITIS: A LITERATURE REVIEW

ALEXANDER GERARDO SEGOVIA TAPIA[1], GABRIELA JOSEFINA RACINES COBA[2], JEAN PIERRE VILLAFUERTE DEMERA[3], LAURA DANIELA SOSA FIERRO[4], DOMÉNICA VILLACÍS VÁSQUEZ[5], CINTHYA CECILIA ULLOA ABAD[6], ROMÁN ROLANDO LIMA CAJAS[7]

[1]Medicine Department, Universidad Regional Autónoma de Los Andes, Ecuador
[2]Department of Hospital Management, Hospital de la Policía, Ecuador
[3]Medicine Department, Pichincha Humana, Ecuador
[4]Independent Investigator, Ecuador
[5]Medicine Department, Ministerio de Salud Pública
[6]Medicine Department, Ministerio de Salud Pública, Ecuador
[7]Medicine Department, Ministerio de Salud Pública, Ecuador

ABSTRACT

An appendectomy is often used to treat acute appendicitis, which is characterized by inflammation of the vermiform appendix. Techniques in minimally invasive surgery (MIS), such as endoscopic retrograde appendicitis therapy (ERAT), single-incision laparoscopic surgery (SILS), and laparoscopic appendectomy, have become popular substitutes for open surgery. The purpose of this review is to assess the safety and effectiveness of MIS methods for treating acute appendicitis. A comprehensive analysis of English-language literature from 2019 to 2024 was carried out to evaluate the safety and efficacy of MIS procedures for acute appendicitis. Research that satisfied the inclusion requirements was examined for pertinent information on SILS, ERAT, and laparoscopic appendectomy. Compared to open surgery, laparoscopic appendectomy showed shorter hospital stays, less pain after surgery, and quicker recovery rates. Comparable to traditional laparoscopic methods in terms of effectiveness, SILS and TULS provide potential advantages in terms of cosmesis and patient satisfaction. With faster recovery durations and fewer complications, ERAT showed encouraging results; nonetheless, questions about long-term effectiveness and recurrence rates were raised. In order to treat acute appendicitis, MIS procedures provide viable options that may shorten hospital stays, ease postoperative pain, and increase patient satisfaction. More investigation is necessary to improve patient selection criteria and operative approaches in order to maximize the efficacy of MIS in the therapy of appendicitis.

INTRODUCTION

An inflammation of the vermiform appendix is called appendicitis. The appendix is a hollow organ that is often found in the lower right quadrant of the abdomen, near the tip of the cecum. However, depending on if there were any aberrant developmental abnormalities, such as midgut malrotation, or if there are any other particular situations, such pregnancy or previous abdominal operations, it may be found in practically any location of the abdomen. The fifth week is when the appendix develops embryonically [1]. The midgut rotates in relation to the external umbilical cord, eventually rotating the cecum and returning to the abdomen. This leads to the appendix's typical retrocecal position. Although it often manifests as an acute illness, generally within 24 hours, it may also take the form of a more persistent ai lment [2]. In the event of a confined abscess by perforation, the first symptoms may be more gradual.

With a mean age of 28, appendicitis most often strikes people between the ages of 5 and 45. The frequency is around 233 per 100,000 individuals. Acute appendicitis is somewhat more common in men than in women; the lifetime incidences are 8.6% and 6.7% for men and women, respectively. About 300,000 hospital admissions for appendicitis-related problems occur in the US each year [3].

Appendicitis commonly results from lumen obstruction. An appendicolith, or appendix stone, or mechanical factors may cause this. Appendicitis and obstruction may be caused by carcinoid tumours, adenocarcinoma, intestinal parasites, and hypertrophied lymphatic tissue. The aetiology of acute appendicitis is often unknown. Clogged appendiceal lumens cause acute inflammation, perforation, and abscesses from bacteria. The death of Harry Houdini is a common rumour. He reportedly receives an abdominal punch that ruptures his appendix, causing infection and death immediately [4]. Houdini died of sepsis and peritonitis from an appendix rupture, not from being struck in the abdomen. Common peritonitis and a lack of effective treatments were to blame. The appendix contains aerobic and anaerobic Bacteroides species and Escherichia coli [4]. Next-generation sequencing shows that complicated perforated appendicitis patients contain more bacterial phyla.

The best therapy for acute appendicitis is appendectomy. Open appendectomy is less preferable than laparoscopic. Most simple appendectomies are laparoscopic. Laparoscopic and open appendectomy results have been compared in many studies. Results show the former group had fewer wound infections, postoperative analgesic needs, and shorter hospital stays. The lengthier operation duration is laparoscopic appendectomy's biggest drawback [5].

An open approach may be required for abscesses or advanced infections. Laparoscopic surgery allows tiny incisions to explore much of the belly and reduces discomfort and recuperation time. Percutaneous drainage by an interventional radiologist may be needed for perforated appendix abscesses. This stabilises the patient and reduces inflammation, making laparoscopic appendectomy easier later. Doctors start patients on broad-spectrum antibiotics. There is controversy about preoperative antibiotics for simple appendicitis. Some surgeons believe regular antibiotics are unnecessary, while others do. Several studies recommend treating simple appendicitis with antibiotics and avoiding surgery [6].

Some surgeons treat appendiceal abscesses with antibiotics for weeks before performing an elective appendectomy. When the appendix ruptures, laparoscopic surgery may be done, but considerable abdominal and pelvic irrigation is needed. Additionally, trocar sites may need to be kept open. Many

individuals with acute appendicitis may be treated laparoscopically without complications. Many variables indicate the need to switch to openness. Comorbidities are the sole preoperative predictor predicting laparoscopic appendectomy conversion [7]. Peri-appendicular abscess and widespread peritonitis are independent predictors of increased conversion rates and surgical morbidity.

Laparoscopic appendectomy is the preferred surgical treatment for acute appendicitis in many centres, but open appendectomy may be more practical in cases of complicated appendicitis with phlegmon and in patients who are converted from laparoscopic to open due to poor visibility. Recent surgical alternatives include Natural Orifice Transluminal Endoscopic Surgery (NOTES) and Single-incision Laparoscopic Surgery (SILS). In 10 Indian patients, trans-gastric appendectomy was successful. NOTES appendectomy may reduce postoperative pain and scarring [3]. This method requires hybridization with the laparoscopic approach to give enough retraction and assure entrance site closure, which is its main limitation. SILS for appendectomy uses an umbilicus incision or abdominal scar. SILS may reduce postoperative pain, wound problems, and sick leave [8]. Up to 40% of patients are converted to standard laparoscopy during the operation. Long-term incisional hernia complications are the main drawback of SILS for appendectomy.

Even though MIS appendectomy outcomes—including perioperative complications, postoperative recovery, and long-term outcomes—have been the subject of several research, the data is still very mixed, with inconsistent findings appearing in published works.

The purpose of this narrative review is to assess the available data about the effectiveness and safety of laparoscopic appendectomy and surgical internal self-ligation (SILS) procedures in the management of acute appendicitis. To give doctors a thorough grasp of the benefits, drawbacks, and factors related to MIS appendectomy, this review summarizes data from published trials and discusses important results.

METHODOLOGY

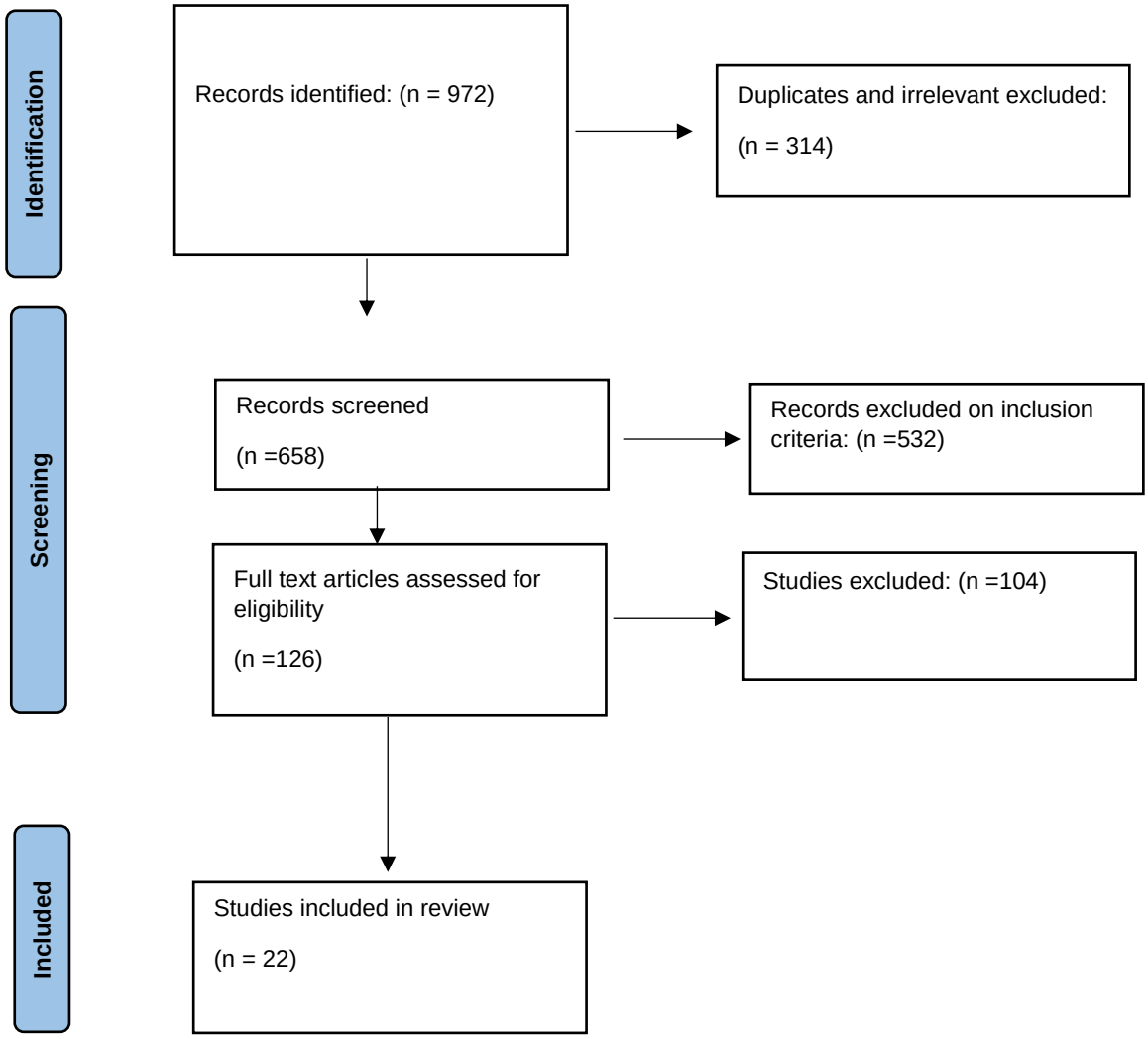
An integrated strategy was used in this narrative review to systematically gather and assess pertinent material from reliable academic sources, such as PubMed, Scopus, and Google Scholar. We adapted established methodologies from previous review studies to ensure a thorough examination of the topic, considering the complexity of treatment modalities in acute appendicitis.

Inclusion and exclusion criteria:

English-language publications over the five years (2019–2024) that addressed the effectiveness and security of minimally invasive surgery (MIS) methods for acute appendicitis were taken into consideration for inclusion. Included were studies with human participants and those that shed light on MIS protocols for acute appendicitis. On the other hand, papers with inadequate methodology or little bearing on the subject matter were not included. Every article that was found during the first screening process using abstracts and titles was carefully assessed to see whether it should be included in the review.

Categorization and Analysis:

To arrange and examine the data on MIS strategies for acute appendicitis, a methodical categorization procedure was used. Clarifying the function of MIS methods in treating acute appendicitis and highlighting recent developments and difficulties in the area were the main goals of the study. To investigate the effects of minimally invasive surgery (MIS) techniques, including laparoscopic appendectomy, single-incision laparoscopic surgery (SILS), and endoscopic retrograde appendicitis therapy (ERAT), on patient outcomes and treatment effectiveness, analytical categories were created. Examining these innovative approaches' underlying processes, clinical efficacy, and possible synergies was the goal of the review. Readers were given a thorough overview of the changing environment of acute appendicitis care by structuring the study around these key themes.



RESULTS

Laparoscopic appendectomy:

Laparoscopic surgery has been widely used to treat appendicitis in recent decades. A shorter hospital stays after surgery, less discomfort following surgery, and an earlier rate of recovery are some benefits

of laparoscopic surgery [9]. It also reduces total post-operative morbidity and surgical site infection. In the case of UA, laparoscopic appendectomy has shown to be a safe substitute for open appendectomy. The viability of laparoscopic surgery for CA hasn't gone away, however. A meta-analysis led some studies to conclude that laparoscopic surgery for CA results in lower rates of surgical site infections than open surgery, although the rates of intra-abdominal abscess complications remain unchanged [10]. It was estimated that 10% of laparoscopic appendices were converted to open appendices overall [11].

In individuals with excellent overall health who have had their CA for a few days after it first started, IA may be a reasonable option instead of emergency surgery. A recent multicenter research found that patients with CA who had their operation delayed in the hospital had a greater chance of experiencing a postoperative complication [12]. Surgeons should take note of patients with CA and choose, as we recommended, to operate on them as soon as possible.

Appendectomy techniques in laparoscopic surgery have been covered in a number of studies. Because endloop surgery is less expensive and has fewer problems than open surgery, Zorzetti N et al. recommended using it routinely for surgery, especially in cases of severe appendicitis [13] [14]. Purse-string sutures have been shown by Bao W et al. to be an effective way to lower the incidence of postoperative problems after a laparoscopic appendectomy for CA [15]. In situations of necrotic appendicitis, we often employ endstapler instead of endloop.

Shiihara et al. conducted a retrospective research to examine the treatment strategy for acute appendicitis, with a specific emphasis on the function of laparoscopic surgery. Through a retrospective analysis of data from their institution spanning over ten years, they were able to classify patients based on initial computed tomography (CT) results into two groups: uncomplicated appendicitis (UA) and complex appendicitis (CA) [16]. Laparoscopic surgery was attempted in 153 instances out of the 305 participants, with a completion percentage of 94.8%. Notably, severe appendicitis necessitated emergency surgery in every instance that progressed to an open laparotomy. In spite of this, there was no discernible difference in the rate of postoperative complications between open laparotomies and successful emergency laparoscopic procedures. But according to their research, in instances with difficult appendicitis, a longer time from start to surgery—six days or more—was independently linked to a higher chance of conversion to open laparotomy.

Single-port laparoscopic appendectomy:

The benefits of single-port laparoscopic appendectomy (SPLA), which include a tiny incision, little postoperative discomfort, a brief hospital stay, and a satisfactory aesthetic result, have made it a viable alternative to standard surgical therapy for acute appendicitis.

Andr et al, investigated the cost-effectiveness and dependability of standard multi-port laparoscopy (MPL) against single-port laparoscopic appendectomy with surgical-glove port (SGP-SILA) in treating difficult acute appendicitis in their retrospective case-control research [17]. The goal of the research was to address the issues related to the reproducibility and cost of laparoscopic procedures in environments with low resources. SGP-SILA and MPL showed similar effectiveness with 116 patients in the research; the median surgery time was 60 minutes for SGP-SILA and 39 minutes for MPL. Compared to MPL, SGP-SILA demonstrated a notably decreased incidence of surgical site infections, suggesting possible advantages in terms of postoperative results. Moreover, the investigation revealed a relationship between the duration of surgery in the MPL group and Grade III surgical site infection, underscoring the need of effective surgical methods. Significantly, SGP-SILA was linked to lower direct and indirect operational expenses than MPL, which made it a more economical choice. The aforementioned discovery highlights the possibility of SGP-SILA as a repeatable method in low- and middle-income nations, where availability of specialised laparoscopic instruments can be restricted.

Cirocchi et al. contrasted traditional three-access laparoscopic appendectomy (CLA) with laparoscopic appendectomy with single-port access (SILA) in their systematic review and meta-analysis [18]. The purpose of the research was to evaluate SILA's effectiveness and safety as a substitute for the traditional method. The study included twenty-one randomised controlled studies with a total of 2646 patients. Regardless of whether the patients were adults or children, the findings showed that SILA was linked to a significantly longer operating duration than CLA. SILA had a lower rate of postoperative wound infections, although total postoperative morbidity was greater (albeit not statistically significant) in the SILA group. SILA was also linked to lower rates of wound infections, shorter hospital stays, and a greater conversion rate, however these associations were not statistically significant. Due to differences in evaluation scales across studies, a meta-analysis on cosmetic results and postoperative discomfort was not conducted by the study. The results imply that although SILA has benefits like fewer wound infections, it also has disadvantages like longer recovery periods and possible postoperative problems.

In order to assess the safety and effectiveness of single-incision laparoscopic appendectomy (SILA) vs traditional three-port laparoscopic appendectomy (CTLA) for acute appendicitis, Han et al. performed a meta-analysis [19]. In all, the study included 26 randomised controlled trials (RCTs). Comparing SILA

to CTLA, the findings showed that the former was linked to a longer operating duration and a greater conversion rate to open surgery. On the other hand, SILA demonstrated benefits such quicker return to regular activities, increased satisfaction ratings, and improved aesthetic results. Regarding the frequency of wound infection, the overall rate of complications, or the pain ratings 24 hours postoperatively, there were no discernible variations between the two groups. According to the results, SILA is a safe and successful surgical technique, especially for patients who have a strong desire for improved cosmetic results.

Liu et al. conducted a retrospective analysis to compare the clinical outcomes of patients with acute appendicitis after new single-port laparoscopic appendectomy (NSLA) against traditional three-port laparoscopic appendectomy (CTLA) [20]. Data from 296 individuals who had surgery at a single clinical centre between September 2021 and June 2023 and were diagnosed with acute appendicitis were gathered. According to the data, patients in the NSLA group stayed in the hospital after surgery for a shorter period of time than those in the CTLA group. On the other hand, no statistically significant variations were seen between the two groups for intraoperative blood loss, duration of the procedure, appendix type, or total problems. Age, neutrophil percentage, and fever were shown to be independent predictors of overall problems in both univariate and multivariate logistic regression analyses. However, the surgical method (NSLA vs. CTLA) did not predict overall complications. According to the study's findings, NSLA and CTLA were shown to be safe, practical alternatives with similar rates of postoperative complications.

Tsushimi et al. used the 10-mm laparoscope and glove port technique—which are already in use—to assess the safety and effectiveness of single-incision laparoscopic appendectomy (SILA). Between June 2012 and September 2015, 16 patients (8 males and 8 females) had SILA procedures [21]. A 20-mm incision was made in the umbilicus, a wound retractor was positioned, and two 5-mm and a 10-mm trocar for the laparoscope were fastened to latex gloves that were fastened to the wound retractor. From the right lower abdomen, second thin forceps were introduced. Preoperative laboratory results revealed mild to moderate inflammation in patients, with an average age of 32.6 years. On the preoperative CT scan, none of the patients developed an abscess, and the average size of the appendix was 9.6 mm. With very little intraoperative bleeding, the procedure took an average of 66.4 minutes. There were no issues noted, and the average hospital stay was 5.3 days. According to the study's findings, SILA for mild to moderate appendicitis, using the 10-mm laparoscope and glove port method, seems to be a practical and safe treatment option.

In order to assess the effectiveness and safety of single-incision laparoscopic appendectomy (SILA) to conventional laparoscopic appendectomy (CLA) for acute appendicitis, Li et al. carried out a systematic review and meta-analysis [22]. Among the 2068 individuals in 17 randomised controlled trials, 1039 underwent SILA and 1029 underwent CLA. According to the meta-analysis, SILA produced better cosmetic outcomes than CLA, although it required more time to perform the procedure. Regarding patient BMI, postoperative pain ratings, or incidence of complications such abdominal abscess, conversion to open surgery, ileus, and surgical site infection, there were no significant variations between SILA and CLA. According to the study's findings, SILA is a safer treatment option for acute appendicitis than CLA, with better aesthetic results.

Transumbilical Laparoendoscopic Single-Site Surgery:

With TULS, a single umbilicus incision is used to enter the peritoneal cavity, and a single-port access device and specialised equipment are used. Compared to conventional laparoscopic procedures, TULS seeks to minimise surgical stress, lessen postoperative discomfort, and enhance cosmetic results by combining laparoscopy with endoscopy. Potential benefits of the surgery include less scarring, better cosmesis, and increased patient satisfaction.

The effectiveness and safety of TULS in appendectomy for acute appendicitis have been examined in several trials. Overall, in terms of operating time, intraoperative blood loss, duration of hospital stay, and complication rates, trans operative laparoscopic appendectomy (TULS) has shown equivalent results to conventional laparoscopic appendectomy (CLA). Additionally, because of the hidden incision made within the umbilicus, TULS has shown positive cosmetic outcomes and patient satisfaction.

In a retrospective research, Nishida et al. compared the surgical results of traditional three-port laparoscopic appendectomy (CTPLA), which is done by paediatric surgeons in training (PSITs) for children with appendicitis, with transumbilical laparoscopy-assisted appendectomy (TULAA) [23]. There were no open conversion cases among the 225 laparoscopic appendectomies that were examined, of which 94 were carried done by CTPLA and 131 by TULAA. In comparison to CTPLA, TULAA showed a shorter pneumoperitoneum time (PT) and operational time (OT). Although not statistically significant, the TULAA group had a slightly higher surgical site infection rate. When compared to CTPLA, TULAA demonstrated substantial differences in OT and PT and a reduced risk of surgical site infection in instances with uncomplicated appendicitis. Significant variations in PT and duration of hospital stay were seen in complex patients, with TULAA being preferred. For both simple and complex patients,

TULAA demonstrated comparable safety and feasibility to CTPLA, with the benefit of quicker surgical and pneumoperitoneum times.

In an investigation on adult patients with acute appendicitis, Isetani et al. assessed the clinical results of transumbilical single-incision laparoscopic appendectomy (SILA) with extracorporeal hand-sewn stump closure [24]. From July 2012 to December 2017, the surgery was performed on 131 consecutive people. In 113 patients (86.3%), the treatment was finished, and in 117 patients (89.3%), single-site surgery was accomplished. A median of 10 millilitres of blood were lost intraoperatively throughout the 79-minute surgery. A median of six days was spent in the hospital after surgery, and 17 patients (14.0%) had postoperative problems. The use of a stapler for intra-abdominal stump closure or the switch to multiport laparoscopic or open surgery were the primary causes of incomplete surgeries. Three independent risk variables for conversion were found by multivariate analysis: age ≥60 years, preoperative abscess, and peri-appendiceal fat density ≥-40.51 Hounsfield units. The research found that age, preoperative abscess, and peri-appendiceal fat density were the three risk variables for conversion and that SILA with extracorporeal hand-sewn stump closure is a safe surgery for adult patients with acute appendicitis.

Endoscopic retrograde appendicitis treatment:

A unique and potentially minimally invasive approach for treating acute appendicitis, particularly acute uncomplicated appendicitis (AUA), is endoscopic retrograde appendicitis therapy (ERAT), which was initially presented by Chinese Professor Liu et al. in 2012 [25]. The ERAT technique involves colonoscopy and endoscopic retrograde cholangiography for the purpose of appendiceal intubation. Subsequently, a stent is inserted into the appendiceal lumen after contrast injection, appendiceal stone extraction, and irrigation. ERAT is used by medical professionals to remove faecal stones via the natural lumen, which resolves the negative appendectomy conundrum and quickly lowers pressure in the appendiceal cavity, relieves pain, stops inflammation, and preserves the appendix [26].

Zhigang Xu's review included the findings from 26 trials evaluating the efficacy of ERAT [27]. Compared to OA and LA, ERAT for AA had a shorter operational duration and less intraoperative bleeding, according to the pooled data. In the meanwhile, our evaluation demonstrated that the ERAT group had a considerably reduced incidence of problems than the control group, including intestinal obstruction and infection. Furthermore, in comparison to other standard treatments (appendectomy and antibiotic therapy), this study indicated that the ERAT technique decreased patients' bed rest and length of

hospital stay. This could lessen patients' financial and physical burden while also improving the use of medical resources.

The technical failure of ERAT (4/29 and 3/55, respectively) was observed in just two investigations, indicating possible clinical availability (28). It was noteworthy that the Shen et al. research showed that mucosal oedema, not appendiceal blockage, was the cause of failure [5].

Notably, this research revealed disparities in the recurrence rate in the EART group between the overall analysis and subgroup analyses, which should not be disregarded. Shen et al.'s research [5] showed that AA recurrence constituted a significant adverse event for the ERAT group.According to the research by Liu et al, appendiceal irrigation was used as a treatment for the eight patients who had recurrent appendicitis without the need for stent implantation for drainage [28]. Furthermore, when the stent was implanted, half of these individuals choose ERAT once again and saw no recurrence, indicating that sufficient drainage would be useful in lowering recurrence.As a result, the question of recurrence after ERAT is still open, but future research must focus on identifying and differentiating individuals who are at a greater risk of recurrence. But according to a number of studies, implanting a stent may lower the recurrence rate after an ERAT [5] [29].

Nowadays, surgery is regarded as the best course of therapy for AA, although more cautious approaches such antibiotics and ERAT will be the focus of future research (30). Many AA patients in clinical practice show a great desire for therapy that leaves no scars. The main benefit of conservative care from a medical perspective is the preservation of the appendix, which is believed to have immunological and secretory activities. Research on patients who had their appendix removed has shown that women are more likely to acquire lupus erythematosus, and those who had their appendix removed had an accelerated course of diabetes and chronic renal disease [31] [32].

Surgery has a higher success rate and more effectiveness than antibiotic therapy, even if it may be a viable therapeutic choice for AA [32]. In a later follow-up, there were also additional consecutive failures. Furthermore, the presence of appendicoliths dramatically raises the rate at which antibiotic treatments fail. On the other hand, the findings of previous research indicate that ERAT might be a viable and less invasive substitute strategy for managing AUA, characterised by less trauma, quick postoperative complications, appendix preservation, quick recuperation, and lower expense [5]. Notably, ERAT with internal incision and drainage may be carried out promptly and safely, particularly in patients who have AUA together with faecal stones, appendix stenosis, or intraappendiceal abscess [28].

DISCUSSION

In order to manage acute appendicitis, the literature review offers a thorough summary of the effectiveness and safety of minimally invasive surgery (MIS) procedures, such as laparoscopic appendectomy, single-incision laparoscopic surgery (SILS), and endoscopic retrograde appendicitis treatment (ERAT). The discourse delves into several facets of these methodologies, accentuating their merits, limitations, and contemporary progressions.

With its many benefits over open surgery, such as quicker recovery times, less pain after surgery, and shorter hospital stays, laparoscopic appendectomy has become a popular method for treating appendicitis. Research continuously show that laparoscopic surgery is effective in treating both simple and complex appendicitis, and that it has a lower risk of surgical site infections than open surgery [10]. Nonetheless, issues including the need for immediate surgical intervention in complex cases and the conversion to open surgery in instances of acute appendicitis continue to be causes for worry [16].

Due to its minimally invasive nature and positive patient outcomes, such as smaller incisions, less discomfort after surgery, and shorter hospital stays, single-port laparoscopic appendectomy (SPLA) has grown in popularity [17]. Although SPLA has shown similar efficacy to conventional multi-port laparoscopy (MPL), research has indicated that SPLA entails longer operating periods and a greater likelihood of conversion to open surgery [19]. Notwithstanding these drawbacks, SPLA is a feasible option for certain patients because to its possible cost-saving advantages and enhanced esthetic outcomes.

Another minimally invasive method for appendectomy is transumbilical laparoendoscopic single-site surgery (TULS), which aims to reduce surgical trauma and improve esthetic results [23]. Research has shown that TULS and traditional laparoscopic methods are equally effective, and that using TULS also improves patient satisfaction and cosmesis [24]. Surgeons adopting TULS still have to consider technological difficulties and the possibility of switching to open surgery or multi-port laparoscopy for technical reasons.

Particularly for cases of simple appendicitis, endoscopic retrograde appendicitis therapy (ERAT) offers a special and less invasive option to standard appendectomy [27]. In order to intubate the appendiceal lumen for ERAT, colonoscopy and endoscopic retrograde cholangiography are performed. Stent implantation is then performed for drainage and stone extraction. Although compared to traditional surgery, ERAT has shown encouraging outcomes in terms of faster operational durations, less

intraoperative bleeding, and lower rates of complications, questions about long-term effectiveness and recurrence rates still exist [28]. To determine patient selection criteria and enhance procedural approaches for ERAT, further study is required.

CONCLUSION

The narrative literature review concludes by offering a thorough analysis of the safety and effectiveness of minimally invasive surgery (MIS) methods for the treatment of acute appendicitis, such as laparoscopic appendectomy, endoscopic retrograde appendicitis treatment (ERAT), transumbilical laparoendoscopic single-site surgery (TULS), and single-port laparoscopic appendectomy (SPLA). The majority of the time, laparoscopic appendectomy is still the best choice, however SILS and TULS are viable substitutes that may have advantages including less surgical site infections and better cosmetics. ERAT offers a new way to treat acute, simple appendicitis, although further research is necessary due to concerns about recurrence risk. Overall, the study emphasizes the significance of choosing the best MIS method depending on surgical competence and patient characteristics. It also emphasizes the need of continuous research to improve treatment approaches and results for acute appendicitis.

Notwithstanding the insightful information offered by the narrative literature review, a few drawbacks must be noted. First off, by focusing only on studies that have been published in the last five years, the study may have missed pertinent earlier studies or recently released data. Furthermore, the English-language publications were the primary focus of the inclusion criteria, which might create language bias and exclude relevant research published in other languages. Furthermore, since the review is narrative in nature, it might be biased when choosing and interpreting studies, which emphasizes the necessity for systematic reviews and meta-analyses to provide a more thorough synthesis of the data. Moreover, differences in research designs, patient demographics, and outcome metrics across the included studies can restrict how broadly and comparably the results can be applied. Lastly, even though the review covers MIS procedures in great detail, it could not include all recent developments or other strategies for treating acute appendicitis.

Looking forward, the results of the narrative review point to a number of directions for further study and clinical use. First and foremost, carefully planned prospective studies and randomized controlled trials are required to evaluate the safety and effectiveness of various MIS procedures, such as laparoscopic appendectomy, TULS, SILS, and ERAT, on a range of patient demographics. In order to improve treatment choices and patient care, further study on the long-term effects and recurrence rates linked to MIS techniques, namely ERAT, is necessary. To further inform healthcare policy and resource

allocation, research examining the resource usage and cost-effectiveness implications of MIS methods in comparison to open surgery is necessary. Additionally, the creation of uniform procedures and recommendations for the choice and use of MIS methods in the treatment of acute appendicitis may improve care quality and uniformity. In conclusion, continuous developments in surgical technology and methods, such natural orifice transluminal endoscopic surgery (NOTES) and robotic-assisted surgery, provide stimulating prospects for more innovation and improvement in the area of minimally invasive appendectomy.

REFERENCES

1. Vaos G, Dimopoulou A, Gkioka E, Zavras N. Immediate surgery or conservative treatment for complicated acute appendicitis in children? A meta-analysis. J Pediatr Surg [Internet]. 2019 Jul 1 [cited 2024 May 10];54(7):1365–71. Available from: https://pubmed.ncbi.nlm.nih.gov/30115448/
2. Gignoux B, Blanchet MC, Lanz T, Vulliez A, Saffarini M, Bothorel H, et al. Should ambulatory appendectomy become the standard treatment for acute appendicitis? World J Emerg Surg [Internet]. 2018 Jun 28 [cited 2024 May 10];13(1). Available from: https://pubmed.ncbi.nlm.nih.gov/29988464/
3. Daoud VP, Daoud IM, Rodas E, Rodas EB. Appendicitis. Glob Surg Anesth Man Provid Care Resour Settings [Internet]. 2023 Apr 24 [cited 2024 May 10];163–8. Available from: https://www.ncbi.nlm.nih.gov/books/NBK493193/
4. Bhangu A, Søreide K, Di Saverio S, Assarsson JH, Drake FT. Acute appendicitis: modern understanding of pathogenesis, diagnosis, and management. Lancet (London, England) [Internet]. 2015 Sep 26 [cited 2024 May 10];386(10000):1278–87. Available from: https://pubmed.ncbi.nlm.nih.gov/26460662/
5. Shen Z, Sun P, Jiang M, Zhen Z, Liu J, Ye M, et al. Endoscopic retrograde appendicitis therapy versus laparoscopic appendectomy versus open appendectomy for acute appendicitis: a pilot study. BMC Gastroenterol [Internet]. 2022 Dec 1 [cited 2024 May 10];22(1):1–10. Available from: https://link.springer.com/articles/10.1186/s12876-022-02139-7
6. Zani A, Hall NJ, Rahman A, Morini F, Pini Prato A, Friedmacher F, et al. European Paediatric Surgeons' Association Survey on the Management of Pediatric Appendicitis. Eur J Pediatr Surg [Internet]. 2019 [cited 2024 May 10];29(1):53–61. Available from: https://pubmed.ncbi.nlm.nih.gov/30112745/

7. Antonacci N, Ricci C, Taffurelli G, Monari F, Del Governatore M, Caira A, et al. Laparoscopic appendectomy: Which factors are predictors of conversion? A high-volume prospective cohort study. Int J Surg [Internet]. 2015 Sep 1 [cited 2024 May 10];21:103–7. Available from: https://pubmed.ncbi.nlm.nih.gov/26231996/
8. Ahmed K, Wang TT, Patel VM, Nagpal K, Clark J, Ali M, et al. The role of single-incision laparoscopic surgery in abdominal and pelvic surgery: a systematic review. Surg Endosc [Internet]. 2011 [cited 2024 May 10];25(2):378–96. Available from: https://pubmed.ncbi.nlm.nih.gov/20623239/
9. Ohtani H, Tamamori Y, Arimoto Y, Nishiguchi Y, Maeda K, Hirakawa K. Meta-analysis of the Results of Randomized Controlled Trials that Compared Laparoscopic and Open Surgery for Acute Appendicitis. J Gastrointest Surg. 2012 Sep;16(10):1929–39.
10. Quah GS, Eslick GD, Cox MR. Laparoscopic appendicectomy is superior to open surgery for complicated appendicitis. Surg Endosc. 2019;
11. Li X, Zhang J, Sang L, Zhang W, Chu Z, Li X, et al. Laparoscopic versus conventional appendectomy - a meta-analysis of randomized controlled trials. BMC Gastroenterol. 2010 Nov 3;10.
12. Bolmers MDM, de Jonge J, Bom WJ, van Rossem CC, van Geloven AAW, Bemelman WA, et al. In-hospital Delay of Appendectomy in Acute, Complicated Appendicitis. J Gastrointest Surg [Internet]. 2022 May 1 [cited 2024 May 10];26(5):1063–9. Available from: https://pubmed.ncbi.nlm.nih.gov/35048258/
13. Zorzetti N, Lauro A, Vaccari S, Ussia A, Brighi M, D'andrea V, et al. A systematic review on the cost evaluation of two different laparoscopic surgical techniques among 996 appendectomies from a single center. Updates Surg. 2020 Dec 1;72(4):1167–74.
14. Zorzetti N, Lauro A, Bellini MI, Vaccari S, Dalla Via B, Cervellera M, et al. Laparoscopic appendectomy, stump closure and endoloops: A meta-analysis. World J Gastrointest Surg. 2022 Sep 27;14(9):1060–71.
15. Bao W, Wang J, Tang D, Li L, Meng X. Application and curative effect of laparoscopic purse-string sutures in the treatment of adult acute complicated appendicitis. BMC Surg. 2023 Dec 1;23(1).
16. Shiihara M, Sudo Y, Matsushita N, Kubota T, Hibi Y, Osugi H, et al. Therapeutic strategy for acute appendicitis based on laparoscopic surgery. BMC Surg [Internet]. 2023 Dec 1 [cited 2024 May 10];23(1). Available from: /pmc/articles/PMC10265908/
17. Andr J, Pedraza M, Padilla L, Lozada-martinez ID, Narvaez-rojas AR, Cabrera-vargas LF. Heliyon Single incision laparoscopic appendectomy with surgical-glove port is cost-effective and reliable

in complicated acute appendicitis : A casecontrol multicenter study in Colombia. 2023;9(January).

18. Cirocchi R, Cianci MC, Amato L, Properzi L, Buononato M, Di Rienzo VM, et al. Laparoscopic appendectomy with single port vs conventional access: systematic review and meta-analysis of randomized clinical trials. Surg Endosc [Internet]. 2024 Apr 1 [cited 2024 May 10];38(4):1667–84. Available from: https://link.springer.com/article/10.1007/s00464-023-10659-w
19. Han Y, Yuan H, Li S, Wang WF. Single-incision versus conventional three-port laparoscopic appendectomy for acute appendicitis: A meta-analysis of randomized controlled trials. Asian J Surg. 2024 Feb 1;47(2):864–73.
20. Liu F, Lv Q, Wang CY, Li ZW, Liu XR, Peng D. Single-port laparoscopic appendectomy using new surgical procedure versus conventional three-port laparoscopic appendectomy. Updates Surg [Internet]. 2024 Mar 5 [cited 2024 May 10];1–9. Available from: https://link.springer.com/article/10.1007/s13304-024-01775-w
21. Tsushimi T, Mori H, Sudo M, Minami Y, Ueki K, Tamai M. Single-incision Laparoscopic Appendectomy for acute Appendicitis using a 10-mm Laparoscope and the Glove Port Technique. Pakistan J Med Sci [Internet]. 2017 Mar 1 [cited 2024 May 10];33(2):276. Available from: /pmc/articles/PMC5432688/
22. Li C, Liu Y, Jiang Y, Xu Y, Wang Z. Single-incision compared with conventional laparoscopy for appendectomy in acute appendicitis: a systematic review and meta-analysis. Int J Colorectal Dis [Internet]. 2022 Sep 1 [cited 2024 May 10];37(9):1925–35. Available from: https://link.springer.com/article/10.1007/s00384-022-04231-6
23. Nishida N, Kawano T, Sugita K, Yano K, Kedoin C, Nagano A, et al. Comparison of Transumbilical Laparoscopy-Assisted Appendectomy with Conventional Three-Port Laparoscopic Appendectomy Performed by Pediatric Surgeons in Training for Appendicitis in Children. https://home.liebertpub.com/lap [Internet]. 2024 Apr 2 [cited 2024 May 10];34(4):380–5. Available from: https://www.liebertpub.com/doi/10.1089/lap.2023.0275
24. Isetani M, Arakawa S, Morise Z, Kawabe N, Nagata H, Asano Y, et al. Transumbilical single-incision laparoscopic appendectomy withextracorporeal hand-sewn stump closure in adult patients. Fujita Med J [Internet]. 2021 [cited 2024 May 10];7(4):111. Available from: /pmc/articles/PMC8761822/
25. Ullah S, Ali FS, Shi M, Zhang JY, Liu BR. Is it time for global adoption of endoscopic retrograde appendicitis therapy of acute appendicitis? Clin Res Hepatol Gastroenterol. 2022 Dec

1;46(10):102049.

26. Costamagna G. Acute appendicitis: Will a novel endoscopic "organ-sparing" approach change the treatment paradigm? Gastrointest Endosc [Internet]. 2020 Jul 1 [cited 2024 May 10];92(1):190–1. Available from: http://www.giejournal.org/article/S0016510720302200/fulltext
27. Xu Z, Jin L, Wu W. Clinical efficacy and safety of endoscopic retrograde appendicitis treatment for acute appendicitis: A systematic review and meta-analysis. Clin Res Hepatol Gastroenterol. 2023 Dec 1;47(10):102241.
28. Liu BR, Kong LJ, Ullah S, Xiao M, Sun XZ, Zhang JY, et al. Endoscopic retrograde appendicitis therapy (ERAT) vs appendectomy for acute uncomplicated appendicitis: A prospective multicenter randomized clinical trial. J Dig Dis [Internet]. 2022 Nov 1 [cited 2024 May 10];23(11):636–41. Available from: https://onlinelibrary.wiley.com/doi/full/10.1111/1751-2980.13148
29. Khan S, Ali FS, Ullah S. Endoscopic Retrograde Appendicitis Therapy: Is it Really a Need of the Hour? Ann Surg [Internet]. 2023 Jan 1 [cited 2024 May 10];277(1):E1–4. Available from: https://journals.lww.com/annalsofsurgery/fulltext/2023/01000/endoscopic_retrograde_appendicitis_therapy__is_it.28.aspx
30. Krzyzak M, Mulrooney SM. Acute Appendicitis Review : Background , Epidemiology , Diagnosis , and Treatment. 2020;12(6):10–5.
31. Chung WS, Lin CL, Hsu CY. Women who had appendectomy have increased risk of systemic lupus erythematosus: a nationwide cohort study. Clin Rheumatol [Internet]. 2018 Nov 1 [cited 2024 May 10];37(11):3009–16. Available from: https://link.springer.com/article/10.1007/s10067-018-4192-1
32. Podda M, Gerardi C, Di Saverio S. Response to comment on "Antibiotic treatment and appendectomy for uncomplicated acute appendicitis in adults and children: A Systematic Review and Meta-analysis" by Minneci PC et al. Ann Surg [Internet]. 2019 Dec 1 [cited 2024 May 10];270(6):e122–3. Available from:https://journals.lww.com/annalsofsurgery/fulltext/2019/12000/antibiotic_treatment_and_appendectomy_for.17.aspx