

EMERGENCY LAPAROSCOPIC SURGERY IN CASES OF RUPTURED APPENDICITIS

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Abstract: Acute appendicitis is one of the most frequently seen surgical callers in emergency departments but is routinely managed as an uncomplicated procedure until it becomes complicated (e.g., through rupture). Laparoscopic appendectomy is thought to be a safe alternative to open appendectomy in managing uncomplicated appendicitis, however it has yet to be conclusively shown that laparoscopic appendectomy can be safely performed in patients with perforated appendicitis and peritonitis. To investigate the safety of laparoscopic appendectomy in patients with perforated appendicitis and peritonitis, we performed a retrospective cohort study using data collected from patients imaging-confirmed to have ruptured appendicitis at a tertiary hospital who underwent laparoscopic appendectomy during a three-year period (from January 1 2018 to December 31 2020). We reviewed each patient's medical record for the following: operative variables (operative time, conversion from laparoscopy to open surgery), postoperative recovery (hospital length of stay, readmission), and complications (intra-abdominal abscess, superficial wound infection, deep wound infection) using descriptive statistics.

The mean operative time for laparoscopic appendectomy in patients with ruptured appendicitis was 72.4 minutes, and laparoscopic appendectomy was converted to open appendectomy in 4.9% of cases. The mean length of stay after laparoscopic appendectomy for ruptured appendicitis was 4.8 days. The total complication rate for laparoscopic appendectomy in patients with ruptured appendicitis was 14.1% for those who developed an intra-abdominal abscess and 2.7% for those who developed a superficial wound infection. The appendiceal stump was managed by endoloops (73.4%) and staplers (22.3%).

In experienced hands and using standardized techniques for lavage and removal of the appendix, laparoscopic appendectomy for ruptured appendicitis is a safe and effective procedure with low rates of wound infection and fast recovery time. Laparoscopic appendectomy should be the primary surgical method of management for patients with complicated appendicitis.

Keywords: Laparoscopic appendectomy, ruptured appendicitis, perforated appendix, peritonitis, intra-abdominal abscess, emergency surgery, minimally invasive surgery, surgical site infection, peritoneal lavage, acute abdomen

Introduction

The most common emergency surgical condition worldwide is acute appendicitis, a condition that requires surgical intervention as soon as possible to avoid complications and/or death. Simple appendicitis can be managed medically and/or surgically without difficulty; however, the clinical course of appendicitis changes dramatically after perforation occurs. Perforated appendicitis is defined as an entity characterized by the perforation of the appendiceal wall which allows for contamination of the peritoneal cavity with purulent fluid, stool, and bacteria. Appendicitis that leads to localized peritonitis and increases the risk for sepsis, intra-abdominal abscess formation, and prolonged hospital stays. The historical management of appendicitis has evolved from numerous conservative to open surgical, and more recently laparoscopic techniques of management.

Appendicitis is caused by obstruction of the appendiceal lumen from either faecalith, lymphoid hyperplasia or neoplasia. The obstruction will create a build up of intraluminal pressure and cause venous congestion, and in some cases result in ischemia necrosis of the appendiceal wall. If diagnosis or treatment is delayed (which are typically the case for both paediatric and geriatric populations due to atypical symptoms), the incidence of perforated appendicitis increases significantly. The subsequent contamination of the abdominal cavity turns a localised process into a systemic problem. Consequently, the primary goals of emergency surgery in these scenarios are not only the removal of the septic source (the appendix) but also the thorough decontamination of the peritoneal cavity to prevent postoperative septic complications [2].

Open appendectomy, a procedure that has been used for years as the gold standard treatment for perforated appendicitis, utilizes an open laparotomy or a gridiron incision for surgical access to the abdominal cavity. This allows direct access to the abdominal cavity and enables surgeons to remove pus and other debris mechanically; however, the use of open surgery in these cases increases the risk of postnyx to the patient principally due to the wound. Open methods leave the incisional area exposed to contamination during the course of the procedure, resulting in exceptionally high incidences of both superficial and deep infection at the surgical site after completion of the procedure. Furthermore, because large incisions allow for adequate lavage of all infected material in cases of generalized peritonitis, open surgeries create greater postoperative pain and delayed mobilization than laparoscopically performed appendectomies perform and also have a much higher incidence of incisional hernias and adhesions as a person matures over their life course.[3].

The modality of laparoscopic surgery for the treatment of abdominal pathologies has changed the way that these diseases are managed. Laparoscopic appendectomy, at first, was only used for the treatment of uncomplicated appendicitis because of the anxiety that surrounded the potential for increased intra-abdominal abscess (IAA) development due to the spread of infection from the carbon dioxide pneumoperitoneum throughout the body. Concerns relating to difficulties in the management of friable or necrotic tissue with laparoscopic instrumentation as well as the potential for the manipulation of infected tissue being transmitted to areas of healthy tissue by such instruments led to significant limitations in the use of laparoscopic procedures in general and for the treatment of perforated appendicitis specifically. Despite concerns and limitations regarding the use of laparoscopic appendectomy, however, as technical skills of laparoscopic surgeons have improved and the available technologies have continued to evolve, the contraindications for laparoscopic appendectomy for perforated appendicitis are being re-evaluated. Laparoscopic surgery has now become an option for many complicated appendicitis cases as surgeons claim that this minimally invasive type of surgery is performed with better visibility and diagnostic accuracy during surgery [4]. The biggest advantage of laparoscopy in urgent cases is that the doctor can view the whole area of the abdomen without having to make a large incision. The laparoscopy can also be used for diagnosis when there is some uncertainty, as well as to diagnose and treat a ruptured appendix. The magnified view provided by laparoscopic dissection allows for better dissection than using standard dissecting techniques since you will be able to have a more accurate view of the internal anatomical structure as well as identify any anatomical variations or ectopically located appendices. Another benefit of using suction and irrigation devices, the surgeon would be able to use large volumes of saline in the subphrenic, subhepatic, and pelvic spaces to do a better washout of these areas than performing the surgery with an open incision technique [5]. While the use of minimally invasive surgery continues to increase, the discussion on which surgical approach

to perform on a patient with ruptured appendicitis is still ongoing. The clinical decision-making process will weigh the benefits of smaller incisions i.e., less pain, shorter length of hospital stay, and quicker return to normal activities, against the extra time the operation takes to perform and the potential risk of remaining intra-abdominal collections. Special considerations must also be given to specific patient demographics, such as the obese, where laparoscopy offers distinct advantages by avoiding deep wound complications, and the elderly, who benefit significantly from the reduced physiological stress of minimally invasive surgery.

One of the difficulties of laparoscopic surgery for perforated appendicitis is the management of the appendiceal stump with peritonitis. Often the base of the appendiceal stump has some form of necrosis or gangrene resulting in simple ligation not being an option. In addition, due to the anatomy of the stump, endoloops, staplers or intracorporeal suturing may need to be used in conjunction to secure the stump adequately depending upon the anatomy of the stump. Thus preventing any complications resulting in fecal fistulae that could have major ramifications after discharge. Therefore, the practitioner must demonstrate adequate laparoscopic suturing and tissue handling skills before performing these procedures as an emergency. Further, care must be taken with retrieving the infected specimen to be sure to put the specimen in a retrieval bag, to prevent any gangrenous tissue from coming in contact with the port site, increasing the risk of wound infection.

In conclusion, laparoscopic techniques for performing a ruptured appendicitis are rapidly evolving into a new alternative form of surgical technique. The newer technique for surgical incision procedures is now focusing on more precise methods that result in a minimally invasive surgery; therefore, a quicker recovery, better cosmetic result and a safer surgery. This technique will need to generate adequate clinical outcome evaluations and case-by-case safety profiles of all surgical outcomes and case costs when compared to standard surgical practices. Therefore, it is important for both acute care surgeons and patients to understand this technique's subtleties, including managing complications and its limitations in surgical care provided through modern emergency departments. [6].

Literature Review

Over the last two years, numerous studies have examined the relative effectiveness and safety of laparoscopic appendectomy (LA) versus open appendectomy (OA) for patients who have perforated appendicitis. While it is known that LA should be used as a standard method for treating patients who do not have any problems with their appendicitis, there has previously been debate regarding its use to treat patients with perforated appendicitis. There appears to be increased agreement among experts and practitioners today regarding the use of laparoscopically to treat perforated appendicitis, as surgical techniques, along with postoperative care procedures, have improved over the past 20 years, as evidenced by the available literature.

Operative Time and Technical Complexity

The length of surgery is one of the most commonly reported factors in comparative assessments. In a lot of cases, Archives of Surgery provides evidence that laparoscopic procedures for perforated appendicitis are going to take a longer period to perform than open procedures. There are multiple reasons why this is the case, including set-up times for equipment, the technical difficulties associated with dissecting inflamed and very tissue-like structures, and the extensive peritoneal lavaging that is often necessary with patients having pus or significant contamination. In addition, surgeons performing laparoscopic surgery for an appendiceal rupture often have to be very careful in using advanced energy devices or staplers to achieve hemostasis due to the fragility of the mesoappendix, and this has proven to take significantly more time than clamping and tying in an open placement [9]. Current research suggests that there is a reduction in the difference in length of surgery due to the fact that all surgeons develop better advanced laparoscopic skills the more they practice, and more residency programs are incorporating these techniques into their training at an earlier stage [10].

Postoperative Recovery and Hospital Stay

The literature supports our clinical impression that patients who have laparoscopic appendectomies (LAP) recover faster than patients who have open appendectomies (OAP). In patients with perforated appendicitis, those who receive laparoscopic management (LA) demonstrate earlier return of bowel function than patients managed with open repair (OA). Several factors have been identified as contributing to this difference, which include decreased bowel manipulation and decreased abdominal trauma associated with laparoscopic

procedures [11]. This earlier return of bowel function is correlated with the shorter length of stay (LOS) in these patients. Reports indicate that patients who undergo laparoscopic management of their appendicitis typically have an LOS 1-3 days shorter than patients who undergo open management, leading to significant economic benefits and improved patient throughput in a busy surgical unit [12]. A shorter LOS is also associated with a faster return to normal diet and daily activities, which is especially important for pediatric patients and patients of working age [13].

Pain Management and Quality of Life

Post-operative pain is another important aspect of surgical approaches which can affect the subsequent levels of post-operative analgesic (pain relief) medication use. There is very consistent fall-off in the amount of opioid pain medication utilized by patients after laparoscopic surgery as compared with open surgical procedures. The use of small incisions rather than large muscle-resecting (cutting) incisions during laparoscopic surgery helps spare and preserve the integrity of the abdominal wall, as a result patients have less acute pain after surgery and also have less chronic pain syndrome incidence after undergoing surgery. In general, there is a high level of agreement regarding the cosmetic advantages associated with laparoscopic surgery compared to open surgical procedures. The areas of the body where laparotomy wound incisions are made will typically leave an extensive area of scarring after surgery compared to the scarring associated with small port sites used in laparoscopic surgery which are typically barely visible after healing. The potential for hypertrophic (raised) scarring from laparotomy (open) wounds will also be increased if the open surgical wound is allowed to heal by secondary intention due to heavy contamination of the surgical field [15].

Infectious Complications: Wound Infection vs. Intra-abdominal Abscess

The most controversial area of this topic is the safety profile concerning infectious complications. The literature shows a clear distinction between iliac crest wound infections and intra-abdominal abscesses. There is abundant data supporting that laparoscopic appendectomy significantly reduces the incidence of superficial wound infections. Superficial wound infections and their associated prohibitive costs are very high with open appendectomy due to the requirement of pulling the appendix through the same incision to remove it. Laparoscopic techniques use closed extraction bags to keep the infected specimen from coming into contact with the abdominal wall [16].

The data regarding intra-abdominal abscesses, however, is more complicated. Older studies had suggested that laparoscopic surgery had a higher incidence of abscesses, based on a theory that pneumoperitoneum could disperse bacteria into other areas of the abdomen. However, more extensive reviews and meta-analyses of more recent literature have called this into question. Current evidence indicates that when using appropriate suction and irrigation during a laparoscopic procedure, the rate of intra-abdominal abscess is statistically equivalent to or lower than that of open surgery. The ability to visualize and wash out the pouch of Douglas and the subhepatic spaces under direct visualization is now thought to be a protective factor against infection [17]. In addition, the Trendelenburg positioning of the patient during the lavage facilitates the removal of fluid from the pelvis in a way that is difficult to replicate in an open appendectomy [18].

Pediatric and Special Populations

As a result of the smaller size of the abdomen and physiologic reserve, the use of laparoscopic surgery (LA) in children with perforated appendicitis has come under examination. Studies examining the utilization of LA in the pediatric population have shown that LAP surgery is safe for use in this population, as children receive a significant reduction in traumatic injury. Additionally, it has been noted that a key performance indicator (KPI) when performing LAP surgery in children is converting to open surgery, mainly due to the degree of adhesions present and the clarity of the anatomy [19]. The literature has consistently supported the use of LAP surgery in obese individuals; patients with a high body mass index (BMI) are at a higher risk of developing wound complications and respiratory difficulties with an open surgical procedure. LA reduces these risks, as it provides a better view of the surgical area regardless of the amount of subcutaneous fat present [20].

Cost-Effectiveness

A financial appraisal of emergency laparoscopic surgery for appendix ruptures shows some conflicting

results, with respect to operational costs being greater for laparoscopic surgery due to single-use instruments used (e.g., trocars, staplers/harmonic scalpels). On the contrary, when evaluating the overall hospital costs, the initial direct costs incurred during laparoscopic surgery are frequently cancelled out by lower overall hospital costs associated with reduced lengths of stays and lesser treatment costs incurred as a result of fewer post-surgical wound complications. It has been argued that in healthcare systems where bed occupancy is a critical bottleneck, the faster discharge associated with LA makes it the more cost-effective strategy overall [21].

Surgical Technique Variations

Finally, several technical modifications have been reviewed in relation to improving outcomes in ruptured patients. The notably debated topic at present is the "irrigate versus suction" comparison. Although traditional teaching emphasizes copious amounts of irrigation, some evidence suggests that performing excessive amounts of irrigation may dilute the immune factors found within the peritoneal cavity or spread infections throughout the abdomen, which would then lead to the conclusion that localized suction would be considered superior to irrigation. Despite some support for thorough lavage in cases of generalized peritonitis [22], the majority of professional guidelines continue to support thorough lavage.

Additionally, the ongoing debates on the regular use of abdominal drains are inconclusive. Some studies demonstrate a correlation between drain placement and decreased abscess formation, while others show that abdominal drains can facilitate the development of infection and also create unnecessary discomfort without any demonstrated clinical benefit [23].

In conclusion, the literature currently supports the use of laparoscopic surgery versus the standard open approach to treat patients with ruptured appendicitis as safe, effective, and clinically advantageous over the open approach in the areas of wound morbidity and recovery time. Although performing laparoscopic surgery for ruptured appendicitis presents both technical challenges, the continued evolution of surgical skills and technologies will continue to establish laparoscopic surgery as an establishment method to treat patients with ruptured appendicitis.

Methods and Materials

Study Design and Setting

The purpose of this research study was to conduct a retrospective analysis of the clinical outcomes of laparoscopic surgery for patients with perforated appendicitis (PA). This study has been carried out at a large teaching hospital with 24-hour emergency surgical services. The three-year research period provided sufficient data to analyze clinical parameters for both laparoscopic and open appendectomy (OA) performed on PA patients as compared to current clinical standards of care for similar patients, and where possible, to a cohort of OA patients performed at the same time as LA [24].

This research study was approved by the institution's ethics committee prior to data extraction. In accordance with the Declaration of Helsinki, patient confidentiality was assured by the de-identification processes during data extraction. Because this was a retrospective study, the IRB waived the requirement of informed consent for subjects involved in this study [25].

Study Population

The study population consisted of patients who were admitted to the Department of General Surgery to meet the following criteria: they must have been admitted through the Emergency Department with a diagnosis of acute appendicitis. To ensure studying the specific pathology of interest, thorough screening for this study was performed by using an initial clinical diagnosis (Alvarado score) and confirming the diagnosis via imaging (CT scanning of abdomen and pelvis using contrast for adults and ultrasound imaging for children and pregnant women). [26].

Inclusion and Exclusion Criteria

This study only contains cases that were included in the final analysis based on strict inclusion and exclusion criteria to provide the most homogenous sample possible. To that end, only patients with confirmed intraoperative findings of “ruptured,” “perforated,” or “gangrenous appendicitis with free fluid” were included in the final analysis.

Table 1. Study Inclusion and Exclusion Criteria.

Criteria Category	Inclusion Criteria	Exclusion Criteria
Diagnosis	Radiologically confirmed acute appendicitis with evidence of perforation (free air, abscess, extraluminal fecalith).	Uncomplicated, early-stage acute appendicitis (catarrhal or phlegmonous).
Operative Finding	Intraoperative confirmation of rupture/perforation or gangrene with purulent peritonitis.	Normal appendix (negative appendectomy) or incidental appendectomy during other procedures.
Patient Demographics	Age > 5 years (no upper age limit). Both genders.	Infants < 5 years (due to different physiological responses). Pregnant patients (trimesters 2 & 3).
Surgical Approach	Primary intention to perform Laparoscopic Appendectomy.	Primary Open Appendectomy (planned laparotomy due to previous extensive surgeries or hemodynamic instability).
Medical History	Patients with ASA score I, II, or III.	Patients with coagulopathy, severe COPD prohibiting pneumoperitoneum, or ASA score IV/V.

Surgical Protocol and Standardization

In order to limit bias introduced by the surgeon's ability, only the procedures performed by, or under the direct supervision of, a surgeon with advanced laparoscopic surgical certification were included in the analysis, and the procedure was standardized, to provide uniformity in the data collected.

Anesthesia and Positioning:

General anesthesia was administered to all study subjects with endotracheal intubation. Patients received IV prophylactic antibiotics (most commonly second generation cephalosporin in combination with metronidazole) 30 minutes prior to incision. All patients were positioned supine with their left arm tucked. In cases where pelvic dissection was anticipated to be prolonged or where visualization of the pelvis would be enhanced, urinary catheters were placed [27].

Trocar Placement and Pneumoperitoneum:

The standard technique involved three ports. Initial placement of the 10-mm or 12-mm umbilical (or supra-umbilical) port was performed using an open Hasson method and incorporated use of 12-14 mmHg in the maintenance of pneumoperitoneum. The two additional ports (5-mm working ports) were located in the suprapubic area and in the left iliac fossa. This created a triangle in the arrangement of the ports, which optimally facilitated manipulation of the appendix and visualization of the right iliac fossa [23].

Operative Technique for Ruptured Cases:

The purpose of a diagnostic laparoscopy is to access and inspect the abdominal cavity to see if there are signs of contamination and/or if there is peritonitis localized vs generalized. Once the diagnosis was complete, the patient was placed in the lithotomy position with the right hip elevated.

The following steps of the procedure were carried out as outlined below:

1. Dissection - Adhesions on the omentum and surrounding structures were separated/dissected bluntly. The mesoappendix was divided with an energy device (bipolar) or an ultrasonic shear.
2. Stump Management - An endoloop (Vicryl) or linear stapler was used to secure the base of the appendix depending on the size and condition of it; if the base of the appendix was necrotic and there were large amounts of necrotic tissue then an intracorporeal suture (e.g. z-stitch or purse-string) would have been used to secure the base of the appendix.
3. Specimen Extraction - The ruptured appendix was placed into a retrieval bag prior to being removed through the umbilicus so that virulent contamination was not transferred to the wound [26].
4. Peritoneal Lavage - Extensive lavage of the abdominal cavity was performed with warm saline, at least three litres of saline lavage fluid used, or until the aspirate of the abdominal cavity was clear. The areas of greatest concern for the surgeon included the sub-hepatic area, paracolic gutter region, and pouch of Douglas.
5. Drainage - The decision regarding the placement of drains depends primarily on whether localized abscess cavities exist and whether hemostasis was achieved.

Table 2. Standardized Surgical Variables Recorded.

Variable	Definition/Unit of Measurement
Operative Time	Time from skin incision to skin closure (minutes).
Lavage Volume	Total volume of saline used for irrigation (mL).
Conversion	Change from laparoscopic to open incision (Gridiron or Midline).
Drain Placement	Presence of a silicone drain post-operation (Yes/No).
Intraoperative Complications	Bowel injury, vascular injury, or equipment failure.

Postoperative Management

The postoperative care pathway was also standardized. Intravenous antibiotics were continued for a minimum of 3 to 5 days, depending on the clinical resolution of sepsis (afebrile for 24 hours and normalizing white blood cell count). Pain management involved a multimodal approach utilizing NSAIDs and minimal opioids. Early mobilization was encouraged starting 6 hours post-surgery. Oral intake was initiated generally on postoperative day 1, pending the return of bowel sounds and absence of nausea [27].

Data Collection and Outcome Measures

Data were extracted from electronic medical records into a structured database. The primary outcome measures focused on the safety and efficacy of the procedure.

1. Primary Outcomes:

- **Length of Hospital Stay (LOS):** Calculated from admission to discharge.
- **Infectious Complications:** Specifically, the rates of Superficial Surgical Site Infection (SSI) and Intra-abdominal Abscess (IAA). IAA was defined as a fluid collection confirmed by CT/US requiring drainage or prolonged antibiotics appearing after discharge [18].

2. Secondary Outcomes:

- **Return of Bowel Function:** Time to first flatus and tolerance of solid diet.
- **Readmission Rate:** Unplanned readmission within 30 days of discharge.
- **Reoperation Rate:** Need for a second surgical intervention for complications (e.g., bowel obstruction, leakage, abscess drainage).

Statistical Analysis

The consortium utilized standard statistical software, including SPSS version 25, for data analysis. Continuous variables (age, BMI, surgical time, length of stay) were assessed for normality using the Shapiro-Wilk test. Normal distribution data were reported as a mean $\pm$ standard deviation (SD) and compared using the Student's t-test. Data that were not normally distributed were reported as a median (interquartile range) and compared/described using the Mann-Whitney U test. Categorical variables (gender, complications, conversion rates) were reported as frequency/percentage and compared/described using Chi-square or Fisher's exact test when applicable, with $p < 0.05$ determined to be statistically significant. Multivariate logistic regression analysis was conducted to determine independent risk factors for the occurrence of operative intra-abdominal abscesses.

Results

Demographic and Clinical Characteristics

There were 615 patients who had an appendectomy during the study; of those 184 were included in this analysis based on having ruptured/perforated appendicitis and received laparoscopic treatment with criteria set by the authors for inclusion.

The results show the demographic distribution favored males and that there is a wide range of ages (18-92) because this condition has a worldwide prevalence.

The average age for the patients in the study was 34.5 years (± 14.2). A proportion (22%) of those patients could be classified as obese (BMI > 30 kg/m²) who represent a patient population that commonly has difficulties undergoing open surgery, however laparoscopy allowed treatment of these patients in a safe and effective manner. The presenting symptoms were often delayed with an average time of 48.6 hours from onset of symptoms until the patient arrived at the hospital; this correlates with the advanced pathology present in patients with perforation.

Table 3. Demographic and Preoperative Clinical Characteristics (N=184).

Characteristic	Value (n / % / Mean $\pm$ SD)
Total Patients	184 (100%)
Gender	Male: 102 (55.4%) Female: 82 (44.6%)
Age (years)	34.5 $\pm$ 14.2
Body Mass Index (kg/m²)	27.8 $\pm$ 5.6
ASA Classification	I: 98 (53.3%) II: 71 (38.6%) III: 15 (8.1%)
Leukocyte Count (x10⁹/L)	16.4 $\pm$ 4.1
C-Reactive Protein (mg/L)	115.3 $\pm$ 45.2
Duration of Symptoms (hrs)	48.6 $\pm$ 12.4
Fever ($>38^{\circ}\text{C}$) at Admission	145 (78.8%)

Intraoperative Findings and Technical Outcomes

This intraoperative evaluation revealed the severity of the disease in all patients who underwent surgery for appendicitis. Of the patients, 35% had generalized peritonitis (purulent fluid in two or more quadrants) and 65% had localized collections or abscesses around the appendix.

The average time for the procedure was 72.4 minutes (± 18.5 minutes); this is longer than a standard uncomplicated appendectomy (30 – 40 minutes), but reflects the level of difficulty involved in dissecting through inflamed tissues along with the extensive peritoneal lavage required post-operatively to adequately clean the abdominal cavity. On average, there was 3.2 liters of irrigation fluid used during surgery.

Open conversion was performed in 9 (4.9%) patients. The predominant reasons for conversion included:

1. Dense adhesions causing difficulty in safely dissecting (n = 4);
2. Difficulty in identifying the appendix within the surrounding inflammatory mass (n = 3);
3. Uncontrolled bleeding from the mesoappendix (n = 1);
4. Suspected cecal injury requiring open repair (n = 1).

Statistically, patients over age 60 and those whose symptoms had been present for greater than 72 hours had a higher rate of conversion.

Table 4. Intraoperative Parameters.

Parameter	Result
Operative Time (min)	72.4 $\pm$ 18.5
Peritonitis Severity	Localized: 120 (65.2%) Generalized: 64 (34.8%)
Appendiceal Base Condition	Intact/Firm: 110 (59.8%) Necrotic/Gangrenous: 74 (40.2%)
Stump Closure Method	Endoloops: 135 (73.4%) Stapler: 41 (22.3%) Intracorporeal Suture: 8 (4.3%)
Drain Placement	112 (60.9%)
Conversion to Open	9 (4.9%)

Postoperative Recovery and Hospital Course

Data on postoperative recovery support the physiological advantages of the laparoscopic technique in treating ruptured appendicitis. Although there was significant pathology present, bowel function returned much sooner than expected. The average time to the first bowel movement was 26 hours after the operation, and almost all patients could tolerate soft foods on postoperative day 2.

The average length of stay (LOS) in hospital postoperatively was 4.8 ± 2.1 days. This is longer than a typical hospital LOS for simple appendicitis cases, but much shorter than historical data that reports a 7–10 day LOS for patients who had a ruptured appendix and were treated with open laparotomy. The main reason that patients in this study stayed longer in the hospital was due to needing intravenous antibiotics rather than controls for pain or wound healing.

Postoperative pain levels, measured using the Visual Analog Scale (VAS), were consistently low. The average VAS score at 1 day postoperatively was 3.4/10, dropping to 1.8/10 by day 3. Therefore, 85% of the patients in this cohort did not require any opioid analgesics after the first 24 hours; they were effectively treated with NSAIDs and paracetamol only.

Complications and Morbidity

The analysis of complications is central to evaluating the safety of laparoscopy in contaminated fields. The overall complication rate was 14.1%.

Infectious Complications:

The rate of Superficial Surgical Site Infection (SSI) was very low, only 2.7% (5 cases of infection). The infections were very small infections (most being minor infections at port sites) and were treated with conservative methods (dressing changes or oral antibiotics). This result supports the idea that using extraction bags provides a protective benefit.

There were 14 cases of Intra-abdominal Abscess (IAA) (7.6%). This is consistent with the rate of perforated appendicitis found in the literature from around the world. Of the 14 cases of IAA, 10 cases were treated with CT-guided percutaneous drainage and antibiotics, while 4 cases were treated using laparoscopic re-exploration and lavage. A statistical analysis showed that the independent risk factors for IAA were "generalized peritonitis (generalized infection inside the abdomen)" and "obesity."

Other complications reported included four cases of prolonged postoperative ileus and three patients with urinary retention. No cases of fecal fistula or iatrogenic bowel injury were documented in the laparoscopic group. Mortality in this population was not recorded.

Table 5. Postoperative Complications Profile.

Complication Category	Number of Patients (n)	Percentage (%)	Management Strategy
Intra-abdominal Abscess (IAA)	14	7.6%	10 Percutaneous Drainage 4 Surgical Lavage
Superficial Wound Infection (SSI)	5	2.7%	Local care / Oral Antibiotics
Prolonged Ileus (>72 hrs)	4	2.2%	Nasogastric tube / NPO
Urinary Retention	3	1.6%	Catheterization
Pneumonia / Respiratory	0	0.0%	N/A
Total Morbidity	26	14.1%	

Antibiotic Utilization and Readmission

All patients received intravenous antibiotics. The mean duration of IV therapy was 4.2 days. Upon discharge, 60% of patients were prescribed a course of oral antibiotics to complete a 7-day total regimen. The readmission rate within 30 days was 3.8% (7 patients). The primary causes for readmission were recurrent abdominal pain (n=2), fever requiring evaluation for abscess (n=4), and non-specific vomiting (n=1).

Comparison of Outcomes by Subgroups

A sub-analysis was performed with the purpose of assessing outcomes based upon comorbidities present. Obese (BMI >30) vs. Non-Obese: Obese patients had a slightly Increased mean operative time than that of Non-Obese patients (85 minutes versus 68 minutes; $P<0.05$) however there were no statistically significant differences noted In Length of Stay (LOS) or Wound Infections. This shows that laparoscopy Is the recommended operative method for patients who are obese, as It produces a much lower morbidity than that produced by large incisions in thick subcutaneous tissue [36].

Elderly (>65 years): The elderly patient subgroup had a longer mean LOS compared to the younger population (6.5 days versus 4.2 days); the reason for this was most likely due to the elderly population having a much longer functional recovery time and needing to manage pre-existing comorbidities. The laparoscopic approach was well tolerated by patients in this age group with no cardiopulmonary complications [37].

In conclusion, the results support the intra-operative safety and effectiveness of laparoscopic appendectomy for patients with ruptured appendicitis compared to open appendectomy. The Incidence of wound Infection, operative time and intra-abdominal abscess rates were all relatively low using the laparoscopic approach. The conversion rate to open appendectomy using laparoscopy is minimal and implies that in properly trained hands, the laparoscopic approach is appropriate for the vast majority of perforated appendicitis patients.

Discussion

The results of this retrospective cohort study further establish that laparoscopic appendix removal (LA) for ruptured appendices is not only possible; it may be better than open surgery. In our investigation involving 184 patients, only 4.9% converted to an open operation, which is less than the global average for all complicated appendiceal procedures, which ranges from 1%-10%. Therefore, with appropriate surgical experience, it should be possible to perform as much of the Las using minimally invasive methods even when the primary challenges presented by inflammatory tissue/adhesions arise [27].

A contentious issue among surgeons is the postoperative incidence of intra-abdominal abscesses (IAA). Our study demonstrated that IAA rates are 7.6%; although more than an uncomplicated appendectomy, it is commensurate with or sometimes less than the reported rates for open appendectomy perforation. This suggests that performing extensive lavage of the abdominal cavity (an average of 3.2 liters for our sample) and using direct visualisation to include deep-yet-accessible areas such as the pouch of Douglas drastically decrease the probability of leaving residual infection. Furthermore, there exists no validity to the concern that pneumoperitoneal pressure causes the propagation of bacteria when appropriate suction-irrigation protocols are utilized [28]

The reduction in superficially infected surgical sites (SSI's) was the most important finding of this study. The SSI rate observed (2.7%) is a marked decrease from historical open surgery (SSIs) rates which were >15%-20% for dirty wounds. This reduction can be attributed to the use of specimen retrieval bags (SRBs) to minimize contact between patients with gangrenous appendicitis and the inside of their abdominal walls. In addition to the reduction in SSIs, the prompt return of bowel function and relatively short length of stay (4.8 days) indicates the physiological advantages to minimizing abdominal wall injury due to major surgery. All of these things help to get patients to return to full activity sooner and to reduce their rate of long-term disability [29].

Conclusion

Overall, laparoscopic appendectomy can be used as a safe and effective means of treating ruptured appendicitis surgically via laparoscopic surgery. While advanced disease from peritonitis with necrotic tissue often requires more complex surgical techniques, this minimally invasive surgical technique provides additional benefits compared to open surgery, including reduced healing complications due to the skin, less pain following the procedure, and shorter time spent in hospital. Though laparoscopic appendectomy does require a longer operative time (as compared to open appendectomy) and advanced surgical skill sets to perform thorough lavage and manage an appendiceal stump, the significant reduction in overall morbidity after a laparoscopic appendectomy represents an acceptable justification for adopting laparoscopic appendectomy as standard of care for patients with perforated appendicitis at hospitals with access to appropriate equipment and skilled surgeons and therefore, that conversion to open surgery should only be performed when there is a severe presence of adhesions or hemodynamic instability which prevent achieving a laparoscopic view safely.

Reference:

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