International Journal of Multiphysics
Volume 18, No. 3, 2024
ISSN: 1750-9548

An Overview on Treatment of Acute Appendicitis and Its Complications

Ahmed M. Mahgoub, Abdalla Ahmed Mohamed Ahmed, Hatem Mohamed, Mohamed Abdalla Zaitoun, Ahmed Shafik Mohamed El hefnawy

Department of General Surgery, Faculty of Medicine, Zagazig University, Egypt

***Corresponding author:** Abdalla Ahmed Mohamed Ahmed,

E-mail: abdalla.ahmed5061@gmail.com

Abstract:

Background: Acute appendicitis is the most common abdominal surgical emergency worldwide, with lifetime risk estimated at 7–8%. It typically results from obstruction of the appendiceal lumen, leading to inflammation, ischemia, and potential perforation. Prompt diagnosis and treatment are essential to reduce morbidity and mortality.

Keywords: Acute appendicitis; Appendectomy; Antibiotic therapy; Laparoscopic surgery; Perforated appendicitis; Postoperative complications; Intra-abdominal abscess; Surgical site infection.

Introduction:

Acute appendicitis remains a major clinical challenge, affecting all age groups but most commonly young adults, and is considered the leading cause of emergency abdominal surgery **(1).**

Historically, appendectomy has been the gold standard for treatment, but increasing evidence suggests that selected patients with uncomplicated appendicitis may be successfully managed with antibiotic therapy alone **(2)**.

Laparoscopic appendectomy has become widely adopted, offering advantages over open surgery such as reduced postoperative pain, faster recovery, and lower wound infection rates **(3).**

Despite advances in surgical and perioperative care, complications such as perforation, intra-abdominal abscess, and surgical site infections still occur, particularly in cases of delayed diagnosis or complicated appendicitis **(4).**

I) Non-complicated acute appendicitis:

1- Conservative:

Preference is given to the combination of metronidazole and ciprofloxacin. From the group of third- -generation cephalosporins, ceftazidime can also be selected. During IV treatment maintain nil by mouth. If there is clinical improvement after 2 days, treatment can be switched to oral administration of antibiotics for an additional 10 days **(5).**

2-Operative:

Although studies on the conservative treatment of appendicitis vary in quality, there is agreement regarding the percentage of successful treatment and recurrence within 1 year. If appendectomy cannot be performed within 12 h, the above-described policy can be safely applied to treat acute appendicitis. Given the relatively high risk of recurrence of acute appendicitis, consideration should be given to performing an appendectomy when in the vicinity of a surgical facility **(5).**

II) Complicated cases of acute appendicitis:

Appendicular abscess:

Appendicular abscesses caused by complicated acute appendicitis may be treated by safe and effective manner; through US-guided percutaneous drainage with high technical and clinical success rates, low incidence of complications and shorter hospital stay **(6).**

Appendicular mass:

Immediate appendectomy in appendicular mass is a safe and effective alternative to classical conservative management. The most important morbidity after immediate appendectomy is wound infection. Protection of the wound during surgery using broad-spectrum antibiotics may decrease the infection rate **(7).**

Perforated Appendicitis:

The optimal management of perforated appendicitis remains controversial. Many studies advocate for antibiotics and an interval appendectomy whereas others suggest that performing an appendectomy at the time of presentation decreases post-operative morbidity **(8)**.

III) Approaches of appendectomy:

Open appendectomy:

Incision:

- **McBurney's incision**: this conventional approach involves making an approximately 5 cm incision at the lateral border of the right rectus muscle at the midpoint between the umbilicus and right anterior-superior iliac spine **(9).**
- **Lanz crease incision**: The same as gridiron with the skin incision is placed transversely. It is called bikini incision that gives better cosmetic results **(10).**
- **Rutherford Morrison's muscle cutting incision:** It is usually modification done in an originally placed McBurney's incision as an extension to have better approach. Here internal oblique and transverse abdominis muscle are cut laterally. It is often done in higher or difficult or subhepatic appendix (**11).**
- **Fowler-Weir (Fowler-Davis; Rockey-davis) approach:** Here extension of the original McBurney's incision is done medially and below by cutting lateral part of the rectus sheath. It is used in pelvic appendix or to feel the right ovary properly (**11).**
- **Lower midline incision:** It is used in case of peritonitis due to burst appendicitis (**11)**.

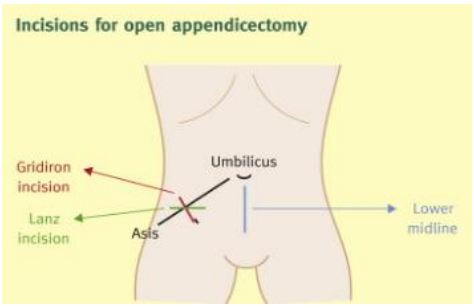

Fig. 1: Showing Incisions for open appendicectomy **(12).**

Steps of operation:

1-Exploration and mobilization of the appendix:

Transverse 2 to 2.5 cm incision was made over the lateral border of Right Rectus muscle at the marked site. Anterior rectus sheath was incised in line with the skin incision and rectus muscle retracted medially.

Transversalis fascia and peritoneum was incised. Small Langenbeck retractors were useful for the procedure. With index finger appendix is palpated and delivered with help of babcocks forceps. In difficult cases Caecum is identified and subsequently appendix is delivered **(13).**

2-Division of Meso-Appendix:

Develop a window between the appendix base and the mesoappendix and apply a single pair of clamps. Alternatively, divide the meso-appendix between serially applied hemostats and ligate each with 2-0 or 3-0 vicryl, until the base of the appendix has been dissected free **(14).**

3-Management of appendiceal stump:

Take a straight hemostat clamp, shortly squeeze the appendix base 4–6 mm from the cecum, and subsequently place it 3 mm distal to that. Double-ligate the appendix base with 2-0 PG. Using a scalpel, transect the appendix just distal to the hemostat, Using forceps, invert the stump into the previously placed purse-string suture and tie that while gradually withdrawing the hemostat (**14).**

4-Closure of Incision:

Close the peritoneum with continuous 3-0 Vicryl sutures , Close the internal oblique and transversus muscles as a single layer with interrupted sutures of 2-0 sutures. Close the external oblique aponeurosis with continuous or interrupted sutures of 2-0 prolene, polydioxanone (PDS), or Vicryl, Close the skin loosely for the majority of cases. But if intraperitoneal pus or a gangrenous appendix were present, either leave the skin incision open or consider placing a small penrose drain (**14).**

Complications after open appendicectomy:

Paralytic ileus:

After modern anesthesia this complication does not normally occur or is no more than transient. Persistent vomiting may indicate the threat of some serious complication such as paralytic ileus or acute dilatation of the stomach, a condition which requires prompt gastric decompression. This is effective in relieving distension, not only of the stomach, but also of the greater part of the small bowel, since intestinal peristalsis is inhibited by gastric dilatation, and is restored when this is relieved. The naso-gastric tube should normally be retained until there is an evidence of peristaltic activity as shown by bowel sound on auscultation or by the passage of flatus per rectum **(15).**

Reactionary haemorrhage:

Due to slipping of ligature of the appendicular artery can be life threatening. Tachycardia, palor, dropping haemoglobin and packed cell volume PCV are the indicators. Emergency reexploration with transfusion of blood is needed. Clots are removed. Bleeding artery is identified and ligated securely (**11).**

Residual abscess:

Development of an intraabdominal abscess (IAA) after appendectomy is a rare but serious complication and is associated with significant morbidity. The risk is significantly increased in cases of complicated appendicitis **(16).**

Portal pyaemia:

Is nowadays rare due to availability of proper antibiotics. However, it can occur if there is immunosuppression. It presents with fever, chills, jaundice and tender, smooth, soft palpable liver. It is treated with adequate antibiotics (**11).**

Adhesions:

Small bowel obstruction occurs in less than 1% of patients after appendectomy for uncomplicated appendicitis and in 3% of patients with perforated appendicitis who are followed for 30 years. About one half of these patients present with bowel obstruction during the first year**(17)**

Right direct inguinal hernia:

Occasionally, the iliohypogastric nerve or the ilioinguinal nerve. Such an injury will result in some degree of late muscle atrophy of the lower part of the internal oblique and transversus abdominis muscles, as well as the rectus abdominis, and the possible development of inguinal hernia. It is always good practice to avoid damaging nerves whenever possible **(18).**

Wound sepsis:

Wound infection following an appendectomy for a perforated appendicitis is another cause of fever. It can be prevented by delaying closure of the skin. When a wound abscess is detected, open the overlying skin for drainage (**14).**

Respiratory problems:

These include conditions such as bronchitis, pneumonia and pulmonary atelectasis. They are most liable to occur in older patients. Also pulmonary embolism is a major complication of any operation and may occur without warning as in phlebothrombosis in the veins of lower limbs or of pelvis **(19).**

Laparoscopic appendectomy:

Laparoscopic appendectomy (LA) in expert hands is now quite safe and effective. It is an excellent alternative for patients with acute appendicitis (**20).**

Laparoscopic appendectomy is a safe method for treating complicated appendicitis compared with open appendectomy. LA for complicated appendicitis is associated with a reduced mortality, total morbidity, wound infection, respiratory complications and ileus without a higher incidence of intraabdominal abscess **(21).**

LA should now be considered the routine approach for patients presenting with complicated appendicitis **(21).**

Operative Technique:

Position of the Patient and the Surgeon:

The patient is placed supine in operation table in a 15° Trendelenburg position. Rotation to the left can be useful. In this position, the ascending colon is slightly suspended from the lateral wall and the small intestine falls away from the operative field. The surgeon stands on the patient's left side. The assistant stands on the surgeon's left side. A pneumo-peritoneum is created in standard fashion using the Veress needle technique **(22).**

Trocar Placement:

Total 3 trocar should be used. Two 10 mm, umbilical and left lower quadrant trocar. One 5 mm right upper quadrant trocar. The right upper quadrant trocar can be moved below the bikini line in females (**20).**

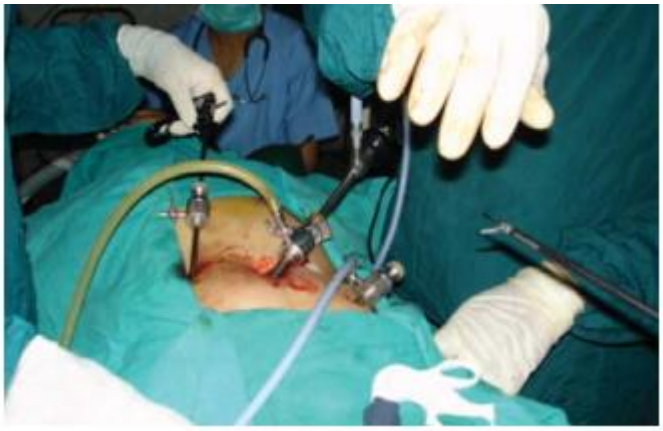

Fig. 2: Port position in appendicectomy (**20)**

Identification, mobilization and transection of the Appendix:

Another options for dividing the mesoappendix are using the Ligasure or hook diathermy from the distal end of the artery to its cecal base, but it should be done carefully with a fully retracted appendix, especially when becoming closely to the cecum which may be friable in severe peritonitis. Also harmonic or vessel sealing devices or stapler could be used safely, but they are more costly and usually disposable devices **(23).**

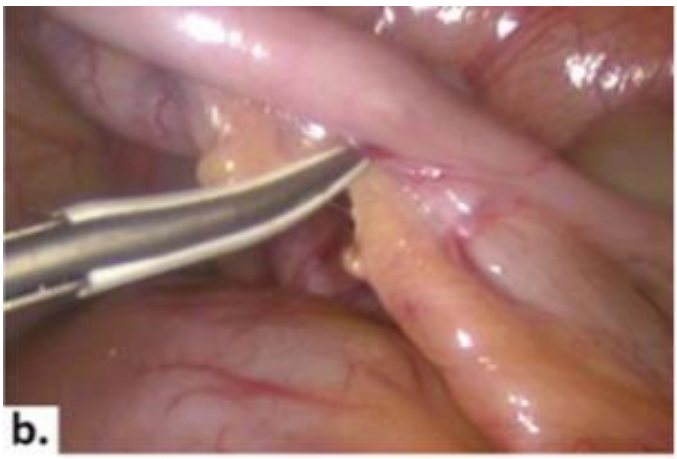

Fig. 3: Securing mesoappendix by LigaSure **(24)**

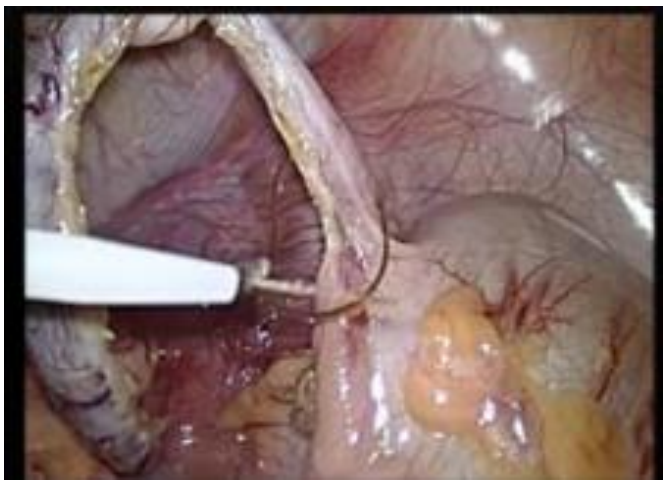

Fig. 4: Endloop technique: ligation of the base of the appendix **(25).**

Stapler Appendicectomy:

The stapling devices make laparoscopic appendectomy simpler and faster. The multifire stapler is introduced though a 12 mm port. The appendix may be transacted by inserting an ENDO GIA instrument via the RUQ trocar (blue cartridge, 3.5), closing it around the base of the appendix and firing it. For perforated appendicitis with or without an intraabdominal abscess, a drain is left in the RLQ and pelvis.

Extracorporeal knot (Meltzer, Roeder or Tayside knot) should be preferred over stapler, depending on the surgeon's expertise (**20).**

Extraction of Appendix:

The specimens were retrieved through a 10 mm port. If appendix diameter was bigger and was expected not to fit into port then part of surgical glove was cut and used as bag. After retrieval of appendix peritoneal cavity was washed especially RIF area with vigorous amount of normal saline **(26).**

Irrigation and Drainage:

After retrieval of appendix peritoneal cavity was washed especially RIF area with vigorous amount of normal saline **(26).**

Complications of laparoscopic appendectomy:

Although laparoscopic appendectomy is considered both feasible and safe, certain serious complication may ensue. It must be emphasized that more than one half of the complications related to laparoscopy are related to the entry technique **(27**).

1-Bleeding:

Bleeding may occur from the mesoappendix, omental vessels or retroperitoneum. Bleeding is usually recognized intraoperatively via adequate exposure, lighting and suction (**20).**

2-Visceral Injury:

Factors which may account for delayed diagnosis of bowel perforation include unrecognized intraoperative bowel trauma, injury outside of the operative field, thermal injury with delayed tissue necrosis, and pericolic abscess formation with subsequent perforation **(28).**

3-Wound Infection:

Proper tissue retrieval technique is required to prevent wound infection after appendectomy. It is recognized by erythema, fluctuation and purulent drainage from port sites. The absence of wound infections after laparoscopic appendectomy can be attributed to the practice of placing the appendix in a sterile bag or into the trocar sleeve prior to removal from the abdomen. The regular use of retrieval bag is a very good practice for preventing infection of the wound (**20).**

4-Leakage of Purulent Exudates:

It is usually seen intraoperatively while dissecting appendix. Copious irrigation and suction followed by continued antibiotics can prevent this complication until patient is afebrile with a normal white blood cell count. Retrieval bag should be used to prevent the spillage of infected material from the appendiceal lumen (**20).**

5-Intra-abdominal Abscess:

The incidence of intra- abdominal abscess especially with perforated or gangrenous appendicitis is high. It can be diagnosed by ultrasonography or computed tomography as a fluid collection which contained pus at ultrasound guided aspiration or drainage, even some abscesses resolved with antibiotic therapy alone **(29).**

6-Hernia:

A major advantage of laparoscopic surgery is that the incidence of ventral hernia 4.7% is lower than that with a laparotomy incision 18.7%. Hernias that develop at the trocar site usually result from the lack of closure or improper closure of trocar wounds and in most instances, are a preventable complication. It is generally agreed that 5-mm trocar wounds do not need closure, while larger trocar wounds require closure because hernia formation occurs more frequently and the risk of bowel incarceration (Richter hernia) is high **(30).**

7-Incomplete Appendectomy:

Stump appendicitis (SA) is defined as the inflammation of the remnant of the cecal appendix after an appendectomy, whether due to impaction of a fecalith or secondary to an ischemic process, the probability of developing SA is estimated to be about 1/50,000 cases throughout life **(31).**

References:

1. Bhangu, A., Søreide, K., Di Saverio, S., Assarsson, J. H., & Drake, F. T. (2015). Acute appendicitis: Modern understanding of pathogenesis, diagnosis, and management. *The Lancet, 386*(10000), 1278–1287. https://doi.org/10.1016/S0140-6736(15)00275-5

2. Salminen, P., Paajanen, H., Rautio, T., Nordström, P., Aarnio, M., Rantanen, T., Tuominen, R., Hurme, S., Mecklin, J. P., Sand, J., Jartti, A., Rinta-Kiikka, I., & Grönroos, J. M. (2015). Antibiotic therapy vs appendectomy for treatment of uncomplicated acute appendicitis: The APPAC randomized clinical trial. *JAMA, 313*(23), 2340–2348. https://doi.org/10.1001/jama.2015.6154

3. Sauerland, S., Jaschinski, T., & Neugebauer, E. A. (2010). Laparoscopic versus open surgery for suspected appendicitis. *Cochrane Database of Systematic Reviews, 2010*(10), CD001546. https://doi.org/10.1002/14651858.CD001546.pub3

4. Andersson, R. E. (2011). Short- and long-term mortality after appendectomy in Sweden 1987 to 2006: Influence of appendectomy diagnosis, sex, age, and surgical method. *Annals of Surgery, 253*(3), 467–473. https://doi.org/10.1097/SLA.0b013e318207edf4

5. Wojciechowicz, K. H., Hoffkamp, H. J., & van Hulst, R. A. (2010). Conservative treatment of acute appendicitis: An overview. International Maritime Health, 62(4), 265–272.

6. Doaa OR, Hatem MA, Fady MH, Mohamed AA, Saleh M (2022): Appendicular Abscess: Immediate Surgery or Percutaneous Drainage? ZUMJ-1910-1581, Volume 28, Issue 4, July 2022(644-652.

7. Bülent K, Barış S, Cengiz E, Rıza K (2012): Immediate appendectomy for appendiceal mass, Ulus Travma Acil Cerrahi Derg 2012;18 (1):71-74., doi: 10.5505/tjtes.2012.07448.

8. Caitlin AF, Caroline K, Valeria M, Giselle P, Heba Z, Michelle Z, Dale B, Brandon B (2024): The contemporary management of perforated appendicitis in adults: To operate or wait? Surgery Open Science 20 (2024) 242–246

9. Noah JS, Richdeep SG, Shahzeer K (2012). The Evolution of the Appendectomy: From Open to Laparoscopic to Single Incision, Hindawi Publishing Corporation Scientifica Volume 2012, Article ID 895469, 5 pages

10. Berger D, Jaffe B (2010): Appendix in Schwartz's Principles of Surgery 9th Edition. Editor-in-Chief, F Charles Brunicardi, 30:2043-2082.

11. Sriram BM (2014): SRB's Surgical Operations: Text and Atlas., jaypee Brothers Medical Publishers, ISBN 978-93-5025-121-8., 1322 pages 732: 752.

12. Chandrasekaran TV, Natalie Johnson (2014): Acute appendicitis, Surgery (Oxford), Volume 32, Issue 8,Pages 413-417, ISSN 0263-9319

13. Sundaravadanan BS, Sudarshan PB, Prabu SS (2017): Mini incision appendectomy: an analysis of 70 cases, Int Surg J. 2017 Mar;4(3):896-898.

14. Matthew Z, Andreas MK (2022): Appendectomy (Open, Laparoscopic). In: Scott-Conner, C.E.H., Kaiser, A.M., Nguyen, N.T., Sarpel, U., Sugg, S.L. (eds) Chassin's Operative Strategy in General Surgery. Springer, Cham.

15. Thomson JE, Kruger D, Jann-Kruger C, Kiss A, Omoshoro-Jones JAO, Luvhengo T, Brand M (2015): Laparoscopic versus open surgery for complicated appendicitis: a randomized controlled trial to prove safety. Surgical endoscopy, 29(7), pp.2027-2032.

16. Shogo T, Kanji I, Takahiro U, et al. (2013): Management of Postoperative Intraabdominal Abscess in Laparoscopic versus Open Appendectomy. Osaka City Medical Journal., 59, 1-7

17. Andersson REB (2001). Small bowel obstruction after appendicectomy. Br J Surg 2001 Oct;88(10):1387–91.

18. Skandalakis J, Colborn GL, Weidman TA, Foster R, Kingsnorth A (2004): Skandalakis' surgical anatomy. McGraw Hill Companies, Incorporated. chapter 17: 289:292.

19. Schwartz S (2007):"Principles of surgery (Vol. 1)".McGraw-Hill Companies ;138.

20. Mishra RK (2013): Practical Laparoscopic Surgery, Jaypee Brothers Medical Publishers, ISBN: 978-93-5025-941-2., 595 pages 196:204.

21. Gaik SQ, Guy DE, Michael RC (2019): Laparoscopic appendicectomy is superior to open surgery for complicated appendicitis, Surgical Endoscopy, 33:2072–2082

22. Schwartz's(2014): principles of surgery, 10e (pp. 1242-1259). McGraw hill

23. Szavay P (2019): Laparoscopic Management of Acute Appendicitis. In: Esposito, C. et al. (eds) ESPES Manual of Pediatric Minimally Invasive Surgery. 1st ed. Springer Nature Switzerland AG; 323–327.

24. Mahmoud A, Mohamed A, Abdallah T (2024): Securing Mesoappendix during Laparoscopic Appendicectomy: Ligation vs. Ligasure, The Egyptian Journal of Surgery, July 2024, Vol. 43, No. 3: 841-845, ISSN: 1110-1121.

25. John M, Kimberly S, Basil A, Pruitt (2007): The appendix, Sabiston Textbook of Surgery E-Book., 19 edition., Edited by Courtney M. Townsend, R. Daniel Beauchamp, B. Mark Evers, Kenneth L. Mattox., Elsevier Health Sciences, 2012., ISBN 1455738085, 9781455738083., 2152 pages., 1376:1379.

26. Jabbar, N., KHAN, M. Z., & CH, A. A. (2011). LAPAROSCOPIC APPENDICECTOMY: CLIP-CLOSURE OF APPENDIX STUMP. The Professional Medical Journal, 18(02), 233-236.

27. Maurin, M-P, Mullins, RA, Singh, A and Mayhew, PD (2020): A systematic review of complications related to laparoscopic and laparoscopic-assisted procedures in dogs. Veterinary Surgery.; 49: O5– O14

28. Lam A (2016): Bowel Injury After Laparoscopy: Late Presentation. In Gynecologic and Obstetric Surgery, John Wiley & Sons, Ltd. Pages 227: 229 ISBN: 9780470657614

29. Shogilev D, Duus N, Odom S, Shapiro N (2014): "Diagnosing appendicitis: evidence-based review of the diagnosing approach " The Western Journal Of Emergency Medicine, 15 (7): 859-71.

30. Kleif J, Vilandt J, Gögenur I (2016): Recovery and convalescence after laparoscopic surgery for appendicitis: a longitudinal cohort study. J Surg Res; 205:407–18.

31. Alberto VC, Juan P, Arribas M, Carlos MS, Raul A, Cuevas B, Luis M, Zamora D, Marcos JC (2021): Stump appendicitis after laparoscopic appendectomy; laparoscopic management and literature review, International Journal of Surgery Case Reports, Volume 84, 106156, ISSN 2210-2612.