



Appendicitis module: **PRE/POST TEST**

1. Which of the following is the most common cause of appendicitis?
 - a. Abdominal adhesions
 - b. Colitis
 - c. **Obstruction (fecalith)**
 - d. Traumatic injury

While acute appendicitis is an infectious process, it starts with an obstructive etiology. The appendix is a narrow, blind-ending pouch that can easily be obstructed from lymphoid hyperplasia in the pediatric population or from fecalith, food matter, pills, masses, parasites, or fibrosis in adults.

Obstruction results in impaired drainage, mucus production, secretions, and overgrowth of bacteria in the blind-ending lumen. This increases the pressure within the lumen leading to impaired venous and lymphatic drainage and local ischemia. Progression in the ischemic process (usually after 48 hours) may lead to full thickness gangrene and thus perforation.

2. Which of the following patient criteria would most strongly cause you to choose open surgical management over laparoscopic management of acute appendicitis?
 - a. Patient has a leukocyte count greater than 20,000
 - b. Patient has morbid obesity with BMI > 40
 - c. Patient presents with a fever > 40 C
 - d. **Patient has multiple adhesions from prior lower abdominal surgeries**

There are multiple contraindications to laparoscopic appendectomy, including hemodynamic instability, hypotension, cardiovascular compromise, coagulopathy, abdominal wall sepsis, large ventral hernia, and extensive adhesions from previous RLQ or pelvic surgery. High leukocytosis, obesity, and fever may make appendectomy more difficult, but are not contraindications.

3. How urgently must laparoscopic appendectomy be performed following diagnosis of acute appendicitis?
 - a. Within 1 hour
 - b. Within 12 hours
 - c. **Within 24 hours**
 - d. Within one week

Performing a laparoscopic appendectomy 12-24 hours before surgery was not associated with an increased risk of perforation. However, delaying for > 48 hours was associated with increased risk of surgical site infections and other complications. As patients await surgery, they should be admitted to the hospital and receive IV hydration, pain control, and antibiotics. For certain patients, interval appendectomy is the more appropriate choice. Interval appendectomies involve administering antibiotics and performing surgery 4-6 weeks later. For patients with perforated appendicitis with abscess or phlegmon, interval



appendectomy allows local inflammation to subside and lowers the risk of postoperative abscess or enterocutaneous fistula.

4. Which of the following is an advantage of laparoscopic over open management of acute appendicitis?

- a. No requirement for peri-operative antibiotics
- b. Use of spinal anesthesia
- c. Lower equipment cost
- d. Decreased risk of wound infection

Laparoscopic appendectomy is associated with lower wound infection rates compared to open appendectomy. However, there is an increased risk of intra-abdominal abscesses in laparoscopic appendectomy.

5. Which of the following is true regarding the use of antibiotic treatment versus surgical management of appendicitis?

- a. Overall complication rates are significantly lower in patients treated with antibiotics
- b. Antibiotic therapy for appendicitis decreases length of hospital stay
- c. Among patients who receive antibiotics for appendicitis, 100% will eventually undergo appendectomy
- d. Antibiotics are a reasonable management option for both complicated and uncomplicated appendicitis

Antibiotics have been shown to be noninferior to surgery in the management of acute appendicitis through various randomized control trials, including the CODA and APPAC trials. In the CODA trial, overall complication rates at 30 days were shown to be higher in patients receiving antibiotics, compared to those who underwent appendectomy (8.1% vs. 3.5%). In the APPAC trial, length of hospital stay was statistically significantly shorter in the surgical group than the antibiotics group. Among patients who initially receive antibiotics, 25%-30% will eventually undergo appendectomy for recurrent appendicitis. While more studies are warranted, we generally discourage the use of nonoperative management in resource-limited settings with hospital access problems.

6. What is the standard pressure of pneumoperitoneum for a standard transabdominal laparoscopic procedure in adults?

- a. 5 mm Hg
- b. 10 mm Hg
- c. 15 mm Hg
- d. 20 mm Hg

A pressure of 15 mmHg is commonly used, allowing sufficient insufflation without compromising respiration or hemodynamics in a patient with normal cardiovascular reserve.



7. What is the proper positioning of a patient undergoing laparoscopic appendectomy?
- Supine position, Trendelenberg, left arm tucked with surgeon and camera on right side
 - Supine position, Trendelenberg, left arm tucked with surgeon and camera on left side
 - Prone position, reverse Trendelenberg, both arms tucked with surgeon and camera on right side
 - Supine position, reverse Trendelenberg, right arm tucked with surgeon and camera on right side.

The patient should be placed in supine position. The right upper limb might be extended for IV line and BP cuff access by the anesthesia team. The left upper limb bearing a pulse oximeter can be safely tucked in at the patient's side. This allows for movement of the surgeon, who should be positioned at the left side of the table. The monitor is placed on the opposite side (right side), either directly across the operating team or towards the foot of the bed. The scrub nurse and instrument stand are positioned towards the foot of the bed. In order to have a good view of the appendix intraoperatively, the patient may need to be placed in Trendelenburg, with a left tilt of the table.

8. Which of the following trocars should be placed first during a laparoscopic appendectomy?
- Camera port at RUQ
 - Camera port at umbilicus
 - Instrument port at LLQ
 - Instrument port at suprapubic region

The most common site of entry for the first trocar is the periumbilical region due to the absence of fat or muscle between the skin and peritoneum at this location. The midline abdominal wall is absent of important vessels and nerves and is thus a preferred initial access site.

9. Which of the following demonstrates the basic steps of a laparoscopic appendectomy?
- Trocar placement, locate appendix, bluntly dissect cecum base, divide the mesoappendix, divide appendix base, remove appendix
 - Locate appendix, trocar placement, bluntly dissect cecum base, divide appendix base, remove appendix
 - Trocar placement, locate appendix, divide the mesoappendix, divide appendix base, bluntly dissect cecum base, remove appendix
 - Trocar placement, locate appendix, divide appendix base, divide the mesoappendix, bluntly dissect cecum base, remove appendix

10. While performing a laparoscopic appendectomy, you quickly dissect the mesoappendix and notice mild bleeding. Which of the following is the next best step?
- Convert to open appendectomy
 - Apply direct pressure with the instrument to control the bleeding



- c. Control the bleeding by ligating the ileocolic artery
- d. Turn down pneumoperitoneum and observe

Small bleeding may be controlled laparoscopically. You can first try to apply direct pressure to the site of bleeding using an atraumatic laparoscopic grasper. For larger bleeding sites, direct tamponade with a gauze inserted through the larger port may help. Cautery is probably the most commonly used technique to control minor bleedings laparoscopically and controls the majority of cases. Ligation is also an alternative method to control intraoperative bleeding, although it might be technically difficult for many surgeons. If the bleeding cannot be controlled laparoscopically, then you would convert to open. Ignoring the issue by reducing insufflation and observing would not be appropriate. Ligation of the ileocolic artery would cause ischemia to the cecum as it is part of the main trunk.

History, physical exam and investigations

- 1) You are called to see a 21-year-old female in the emergency department presenting with a 2-day history of periumbilical pain associated with anorexia. Which of the following questions is the most important to ask first?
 - a) When was your last normal menstrual period?
 - b) How many glasses of alcohol do you drink in a week?
 - c) What surgeries have you had in the past?
 - d) Do you have diarrhea?

Appendicitis classically presents with a vague, periumbilical pain and anorexia. The pain migrates to the right lower quadrant or iliac fossa and is associated with nausea and vomiting. This classic presentation only occurs in 50% of patients. Most patients do not give a clear history of vague periumbilical pain, instead present with right lower quadrant pain. Most patients in sub-Saharan countries present with right lower quadrant pain.

For females of reproductive age, the first questions you should ask are about their sexual and menstrual history in order to quickly help rule out other obstetric and gynecological etiologies of abdominal pain (ectopic/ruptured ectopic pregnancy, pelvic inflammatory disease, ovarian torsion, cyclical ovulatory pain, endometriosis).

Past surgical history, specifically abdominal and pelvic surgeries, is also very important to ascertain for diagnosis as well as management (for example, adhesions from prior surgery could be causing obstruction and/or change operative technique). It is also important to ask any patient presenting with abdominal pain about bowel movements. However, diarrhea in particular is only 9-24% sensitive and 58-65% specific for appendicitis¹. Regardless, for a female of reproductive age, it is paramount to ascertain menstrual and sexual history to first rule out life-threatening reasons for abdominal pain, such as ectopic pregnancy. To learn more about the pre-surgical and surgical management of ectopic pregnancy, please check out our other module on Ectopic Pregnancy.

Deep Dive: Pathophysiology of appendicitis:

While acute appendicitis is an infectious process, it starts with an obstructive etiology. The appendix is a narrow, blind-ending pouch that can easily be obstructed from lymphoid



hyperplasia in the pediatric population or from fecalith, food matter, pills, masses, parasites, or fibrosis in adults.

Obstruction results in impaired drainage, mucus production, secretions, and overgrowth of bacteria in the blind-ending lumen. This increases the pressure within the lumen.

The distended lumen exerts an increase in pressure (stretch) on the appendix wall. Distention and stretch are sensed by the body as visceral pain and thus vague since most midgut structures can elicit such pain.

The persistence of distention leads to impaired venous and lymphatic drainage, and thus local appendiceal ischemia. Once the bacteria spread to the visceral or parietal peritoneum, a somatic (localized) right lower quadrant pain is noted, usually around McBurney's point, which is found one-third of the distance between the right anterior superior iliac spine and the umbilicus.

Progression in the ischemic process (usually after 48 hours) may lead to full thickness gangrene and perforation, which can either be localized (walled-off or contained by omentum, small bowel and cecum) or cause overt peritonitis.

1. Petroianu A. Diagnosis of acute appendicitis. Int J Surg. 2012;10(3):115-9. doi: 10.1016/j.ijso.2012.02.006. Epub 2012 Feb 17. PMID: 22349155.

- 2) The patient is not married or sexually active. She has a regular menstrual cycle. She denies dysmenorrhoea, is having regular bowel movements, and has never had surgery before. She says she now feels the pain at the right lower quadrant. Which of the following conditions is she least likely to have?
- a) Endometriosis
 - b) Acute appendicitis
 - c) Inflammatory bowel disease**
 - d) Mittelschmerz (cyclical ovulatory pain)

Causes of acute abdominal pain that are often confused with acute appendicitis include acute mesenteric adenitis, cecal diverticulitis, Meckel's diverticulitis, acute ileitis, Crohn's disease, acute pelvic inflammatory disease, torsion of ovarian cyst or graafian follicle, intestinal tuberculosis and acute gastroenteritis. Frequently, no organic pathology is identified. Obtaining an antecedent history of a viral infection (mesenteric adenitis or gastroenteritis) and a cervical exam in women (exquisite tenderness with motion in pelvic inflammatory disease) are essential before planning any intervention. Detailed menstrual history can help distinguish *mittelschmerz* (no fever or leukocytosis, mid-menstrual cycle pain) and ectopic pregnancy. Appendicitis is rare in children under the age of 2 years and most common in patients between 10-30 years old.

Differential diagnosis of right lower quadrant pain^{1,2}

Children	Women	Others
Mesenteric adenitis	Ectopic pregnancy	Peptic ulcer disease
Acute gastroenteritis	Ruptured or torsion ovarian cyst	Inflammatory bowel disease
Intussusception	Endometriosis	Acute cholecystitis



Meckel's diverticulitis	Acute pelvic inflammatory disease	Colitis, enterocolitis, typhlitis
Pneumonia	Cyclic ovulatory pain	Diverticulitis (Cecal or Meckel's)
Constipation	Ovarian torsion	Hernia (Amyand or De Garengeot)

1. Dahdaleh FS, Heidt D, Turaga KK. The Appendix. In: Brunicaardi F, Andersen DK, Billiar TR, Dunn DL, Kao LS, Hunter JG, Matthews JB, Pollock RE. eds. *Schwartz's Principles of Surgery, 11e*. McGraw Hill; 2019. Accessed February 16, 2022.

2. COESCA Curriculum, Chapter on the Appendix

3) Which of the following is the most common location of an inflamed appendix?

- a) Pelvis
- b) Retrocecal
- c) Retroperitoneal
- d) Subcecal

The retrocecal location is the most common location (64%). History and physical examination will often help identify the correct location of an inflamed appendix. Rovsing's, Blumberg's, Psoas and Dunphy's signs will be positive for intra-peritoneal appendicitis.

Rovsing's sign – Pain in the right lower quadrant with palpation of the left lower quadrant. This is due to movement of the irritated peritoneum and indicates an intra-peritoneal appendix.

Blumberg's sign – Pain upon removal of pressure rather than application of pressure to the right lower quadrant. This indicates an intra-peritoneal appendix.

Psoas sign – Pain on extension of the right hip or pain on flexion of the right hip against resistance from the examiner's hand. This is due to irritation of the peritoneum overlying the psoas muscle and indicates an intra-peritoneal appendix.

Dunphy's sign – Pain with cough. This reflects peritoneal irritation and indicates intra-peritoneal appendix.

Obturator sign – Pain on flexion and internal rotation of the right hip. This is due to irritation of the peritoneum overlying the obturator muscle by the inflamed appendix and indicates a pelvic appendix (32%)

4) The patient has stable vitals other than a low-grade fever. Her white blood cell count is 14×10^9 cells/L. When you palpate her left lower quadrant, she complains of pain on the right. What is her most likely diagnosis?



- a) Mittelschmerz (Cyclical ovulatory pain)
- b) Ruptured ectopic pregnancy
- c) Pyelonephritis
- d) Acute appendicitis

Given the frequency of appendicitis, the many ways in which it can present, and the potential associated morbidity, it should always be high on the differential diagnosis for abdominal pain.

The above history and physical examination reveal the classical presentation of acute appendicitis. Using the clinical score like the Alvarado score this patient's score is greater than 7, corresponding to a high likelihood of appendicitis.

The Alvarado Score ¹	
Signs	
Right lower quadrant tenderness	2
Elevated temperature > 37.7 °C (> 99.9 °F)	1
Rebound tenderness	1
Symptoms	
Anorexia	1
Nausea or vomiting	1
Migration of pain to right lower quadrant	1
Laboratory Values	
Leukocytosis (>10.000 WBC)	2
Left shift (>75% neutrophils)	1

A score of 1-3 indicates a low likelihood of appendicitis

A score of 5 or 6 is compatible with diagnosis of acute appendicitis and imaging should be considered

A score of 7 or 8 indicates a probable appendicitis

A score of 9 or 10 indicates a very probable appendicitis

1. Alvarado A. A practical score for the early diagnosis of acute appendicitis. Ann Emerg Med. 1986;15(5):557-64.

5) What is the most cost-effective imaging modality that would be appropriate for our patient if diagnosis needed to be confirmed?

- a) Plain radiographs
- b) Abdominal ultrasound
- c) Abdominal CT scan with contrast
- d) Magnetic resonance imaging (MRI)



Ultrasound (US) and CT scan are both acceptable modalities for imaging in suspected appendicitis. However, a CT scan of the abdomen and pelvis costs three times more than an ultrasound, making US the more cost-effective option¹. A contrast-enhanced CT scan is slightly more accurate in diagnosing acute appendicitis, with a sensitivity of 96%, specificity of 96%, and positive predictive value (PPV) of 97%. US has a comparable PPV ranging from 90-95%. Diagnostic findings of acute appendicitis on US include non-compressibility of the appendix, diameter > 6 mm, single wall thickness > 3 mm, a target sign, and vascular changes (hypervascular in early stages followed by hypovascularity in later stages)².

1. Reich B, Zalut T, Weiner SG. An international evaluation of ultrasound vs. computed tomography in the diagnosis of appendicitis. *Int J Emerg Med*. 2011;4:68. Published 2011 Oct 29. doi:10.1186/1865-1380-4-68

2. Mostbeck G, Adam EJ, Nielsen MB, et al. How to diagnose acute appendicitis: ultrasound first. *Insights Imaging*. 2016;7(2):255-263. doi:10.1007/s13244-016-0469-6

Management

6) Which of the following modalities of managing acute appendicitis remains controversial?

- A) Intravenous antibiotics only precluding necessity of surgery
- B) Antibiotics followed by interval appendectomy
- C) Laparoscopic appendectomy
- D) Open Appendectomy

Appendectomy, open or laparoscopic, is a standard treatment of acute appendicitis. Non-operative management of acute appendicitis has proven to be successful in many patients, and antibiotics have been shown to be noninferior to surgery in the management of acute appendicitis through various randomized control trials (APPAC and CODA)^{1,2}. However, there is a higher rate of recurrence, complications (gangrene, perforation) and readmission for patients treated solely with antibiotics (8.1% vs. 3.5%)¹. It is overall more costly, considering the numerous follow up visits and longer length of stay.³ Approximately 25-30% of patients who are initially treated with antibiotics will eventually undergo appendectomy for recurrent appendicitis^{1,2}. Though more studies are warranted, we generally discourage the use of nonoperative management in resource-limited settings with hospital access problems.

In some cases, initial nonoperative management with antibiotics followed by interval appendectomy in 4-6 weeks is most appropriate. These conditions include perforated appendicitis and appendicitis with abscess or phlegmon. Interval appendectomy refers to appendectomy following a successful course of non-operative management of appendicitis to prevent future attacks or identify any other appendiceal disease, e.g. malignancy.

1. CODA Collaborative, Flum DR, Davidson GH, et al. A Randomized Trial Comparing Antibiotics with Appendectomy for Appendicitis. *N Engl J Med*. 2020;383(20):1907-1919. doi:10.1056/NEJMoa2014320



2. Salminen P, Paajanen H, Rautio T, et al. Antibiotic Therapy vs Appendectomy for Treatment of Uncomplicated Acute Appendicitis: The APPAC Randomized Clinical Trial. *JAMA*. 2015;313(23):2340–2348. doi:10.1001/jama.2015.6154
3. . Sceats LA, Ku S, Coughran A, et al. Operative Versus Nonoperative Management of Appendicitis: A Long-Term Cost Effectiveness Analysis. *MDM Policy Pract*. 2019;4(2):2381468319866448. Published 2019 Aug 17. doi:10.1177/2381468319866448

7) You counsel this patient on the available treatment options for acute appendicitis. Her mother would like to know the difference between the two available surgical options at your hospital (open vs. laparoscopic), because the concept of laparoscopy is new to her. Which of the following is an advantage of open appendectomy over laparoscopic appendectomy?

- a) Better cosmetic results
- b) Earlier return to work
- c) Better visualization in obese patients
- d) Shorter operation time

Open appendectomy, compared with laparoscopic appendectomy, may be associated with shorter operative times and lower operating room costs. However, the overall cost of hospital stay is similar between open and laparoscopic approaches.¹

Laparoscopic appendectomy is appropriate for all patients without conventional contraindications to laparoscopy.

Contraindications and advantages to laparoscopic appendectomy	
Contraindications	Advantages
Hemodynamic instability	Shorter hospital stay
Complicated appendicitis	Decreased postoperative pain
Extensive adhesions	Earlier return to work
Abdominal wall sepsis	Lower rate of wound infection
Large ventral hernia	Early food tolerance
Gross coagulopathy	Better cosmetic result
Advanced stage of pregnancy	Better visualization of intra-abdominal organs



A laparoscopic approach is preferred in obese patients who may need a larger incision for an open approach and tend to develop surgical site infections more frequently. Laparoscopy, especially in females, provides a diagnostic advantage, as pelvic and intra-abdominal organs can be visualized directly. Compared to open surgery, laparoscopic appendectomy is associated with less pain, shorter hospital stay and quicker return to normal activities.¹ Patients who have extensive adhesions from prior abdominal surgeries should undergo open, not laparoscopic appendectomy depending on the experience of the surgeon, as the laparoscopic approach can be more difficult and visualization may be impaired. Laparoscopic appendectomy is also associated with lower wound infection rates, though with increased risk of intraabdominal abscess compared to open appendectomy.²

1. Biondi, A., Di Stefano, C., Ferrara, F. et al. Laparoscopic versus open appendectomy: a retrospective cohort study assessing outcomes and cost-effectiveness. *World J Emerg Surg* 11, 44 (2016). <https://doi.org/10.1186/s13017-016-0102-5>

2. Krisher SL, Browne A, Dibbins A, Tkacz N, Curci M. Intra-abdominal Abscess After Laparoscopic Appendectomy for Perforated Appendicitis. *Arch Surg*. 2001;136(4):438–441. doi:10.1001/archsurg.136.4.438

8) This patient is quite ill shortly after arrival to your consultation room. She begins vomiting and becomes increasingly weak. Her temperature is 39 degrees Celsius, pulse is 124, respiratory rate is 24, and her blood pressure are 125/75. Which of the following would **not** be an appropriate next step?

- a) IV Antibiotics
- b) Bowel Prep
- c) Foley catheter
- d) IV hydration

Preoperative preparation of a patient for appendectomy usually depends on the clinical picture. Most patients need varying degrees of fluid resuscitation. A Foley catheter may be inserted in order to monitor urine output and guide fluid resuscitation. A nasogastric tube (NGT) is sometimes required to decompress the stomach before induction of anesthesia. Patients with fever may get an antipyretic. Antibiotics should be given 30 – 60 minutes prior to the surgical incision if not already started. A bowel prep is not necessary and may even be harmful in the management of appendicitis.

9) The patient and her mother are glad to know that there is a treatment option that will permit her to return home faster, and so they have decided on laparoscopic appendectomy. You have not identified any possible contraindications for laparoscopy. What type of anesthesia is preferred to perform laparoscopic appendectomy?

- a) General anaesthesia
- b) Local infiltration only
- c) Spinal anaesthesia
- d) IV Sedation



General anaesthesia with endotracheal intubation is preferred, accompanied sometimes by an orogastric or NGT and a Foley catheter. Tubes are removed at the end of the case, but NGT might be kept for longer periods if more decompression is required. General anesthesia is the preferred modality for laparoscopic appendectomy to reduce aspiration risks, abdominal discomfort, and hypercapnia secondary to carbon dioxide pneumoperitoneum. Local infiltration and IV sedation would not be suitable for managing the intraoperative sedation required and postoperative pain. Some feasibility studies have demonstrated the safety of spinal epidural anesthesia in laparoscopic appendectomy, though this approach is not widely practiced. Epidural anesthesia is associated with risk of right shoulder pain, abdominal discomfort, anxiety, and nausea/vomiting related to pneumoperitoneum¹.

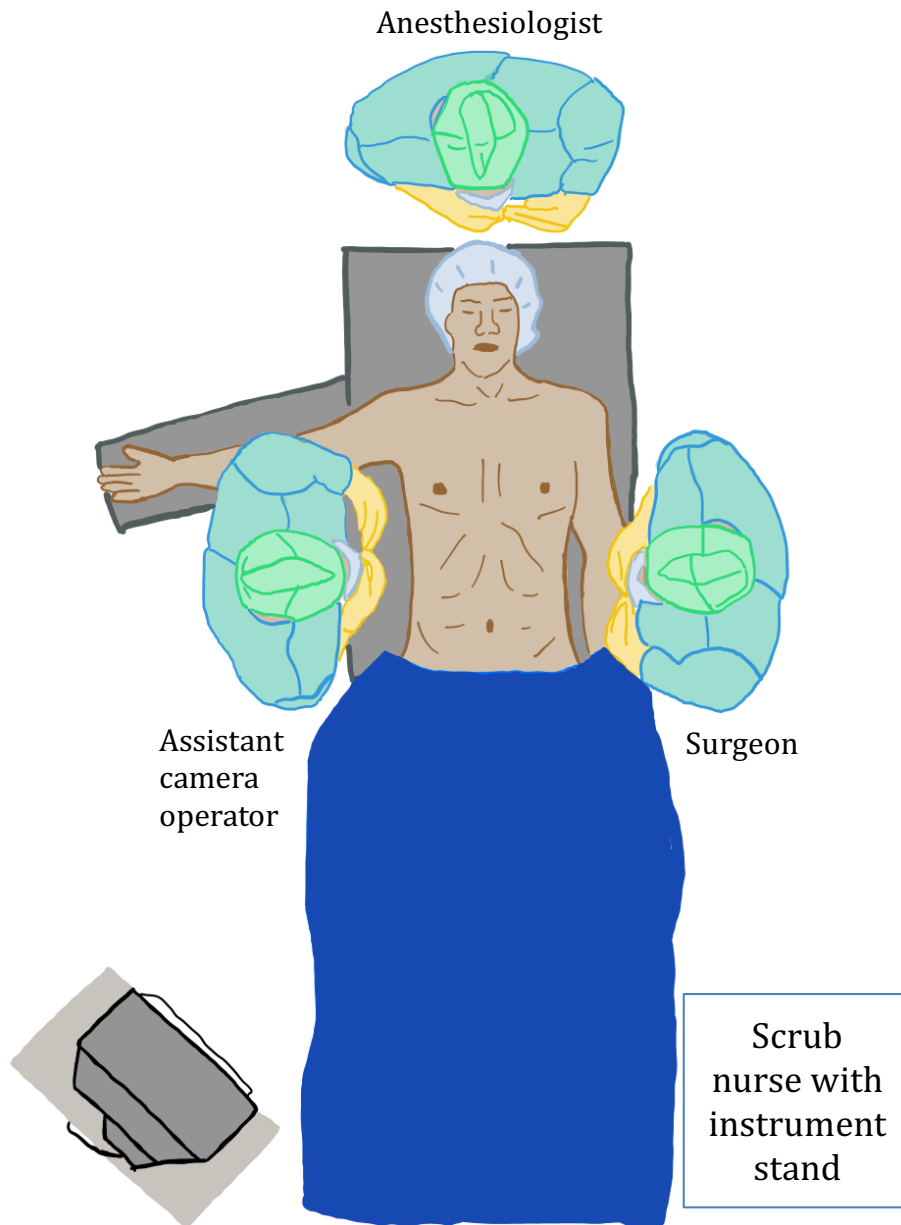
1. Erdem VM, Donmez T, Uzman S, Ferahman S, Hatipoglu E, Sunamak O. Spinal/epidural block as an alternative to general anesthesia for laparoscopic appendectomy: a prospective randomized clinical study. *Wideochir Inne Tech Maloinwazyjne*. 2018;13(2):148-156. doi:10.5114/wiitm.2018.72684

10) Anesthesia has been induced and the patient is intubated without issue. The nurse anesthetist, who has never assisted with a laparoscopic appendectomy, is unsure of how you want to position this patient. She is concerned because she needs to be able to access the IV line during the case and would like to know if you'd like her to adjust the position of her machine. How will you position your patient?

- a) Left lateral decubitus
- b) Low lithotomy, left arm extended
- c) Prone, right arm tucked
- d) Supine, left arm tucked**

The patient should be placed in supine position. The right upper limb might be extended for IV line and BP cuff access by anesthetists. The left upper limb bearing a pulse oximeter can be safely tucked in at the patient's side. This allows for movement of the surgeon, who should be positioned at the left side of the table. The monitor is placed on the opposite side (right side), either directly across the operating team or towards the foot of the bed. The scrub nurse and instrument stand are positioned towards the foot of the bed. In order to have a good view of the appendix intraoperatively, the patient may need to be placed in Trendelenburg, with a left tilt of the table.¹

1. Rosales A., Montorfano L., Rosenthal R.J. (2020) Laparoscopic Appendectomy. In: Rosenthal R., Rosales A., Lo Menzo E., Dip F. (eds) *Mental Conditioning to Perform Common Operations in General Surgery Training*. Springer, Cham. https://doi.org/10.1007/978-3-319-91164-9_31



11) The patient's abdomen is prepped and draped. During the time out, the patient and diagnosis are clearly and correctly identified. Preoperative administration of antibiotics has been confirmed. The following are acceptable ways to access the abdomen laparoscopically **except**?

- a) Direct visualization with optical trocar
- b) Hasson open entry
- c) Lanz incision**
- d) Veress needle insufflation



Veress needle, direct visualization or open Hasson technique are all acceptable ways to establish laparoscopic access. The approach remains the surgeon's preference. A Lanz incision is used for open appendectomy.

The Hasson entry refers to an open method in which an incision is made through the abdominal wall under direct visualization. This technique increases safety due to direct visualization of all layers of the abdominal wall. However, it requires a longer operation time.

The Veress entry refers to the closed method in which the Veress needle is used to puncture through the layers of the abdominal wall. It is advantageous due to the short amount of time needed for the procedure, but it carries a higher risk of major vascular and viscus injury.

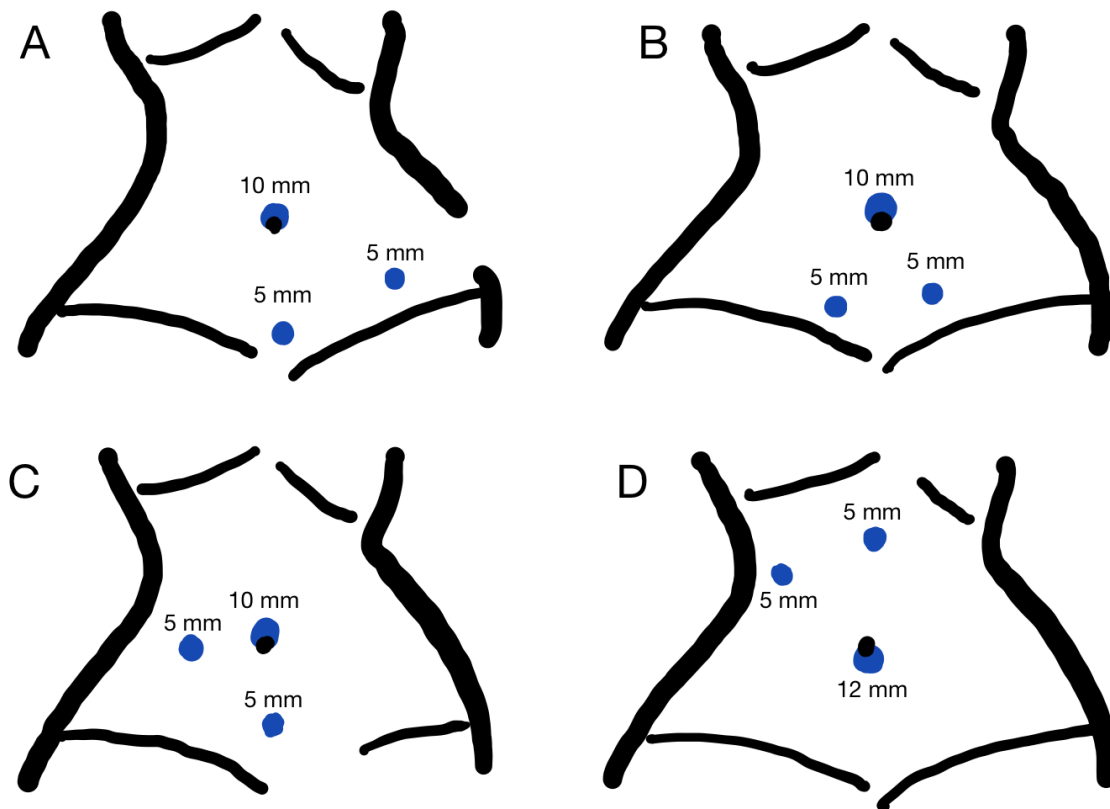
In entry through direct visualization, a camera is inserted into a clear optical trocar which is advanced through the layers of the abdominal wall, allowing visualization of each layer of the abdominal wall as the trocar is placed.

12) If you had decided to use the Veress needle approach for intra-abdominal access. Where should you place the needle?

- a. Periumbilical
- b. Right flank
- c. Right lower quadrant
- d. Right upper quadrant

The most common site of entry for either open or closed techniques is at the periumbilical region due to the absence of fat or muscle between the skin and peritoneum at this location. When there is concern for an umbilical hernia or adhesions, alternate sites may be used. The midline abdominal wall is absent of important vessels and nerves and is thus a preferred initial access site.

13) You ultimately decide to make a small semilunar infraumbilical incision and enter the abdomen via the Hasson technique. Of the following, which arrangement of trocars would be least **appropriate** for an appendectomy?



The correct answer is d

A, B, and C are all reasonable options for trocar placement in laparoscopic appendectomy. A 10-12mm trocar should be placed first at the umbilical port and direct visualization should be performed for placement of the remaining 5mm ports. Appropriate locations for 5mm trocar placement include LLQ and suprapubic (a), left of midline 1cm above the pubic ramus and 2cm above and medial to the left anterior superior iliac spine (b), and RLQ and suprapubic (c). Additional trocar placement options include LLQ and RUQ or R mid-abdomen, and LLQ and RLQ directly above appendix¹. Answer choice D does not demonstrate appropriate trocar locations, as this placement prevents necessary access to the appendix.

1. Korndorffer JR Jr, Fellingner E, Reed W. SAGES guideline for laparoscopic appendectomy. *Surg Endosc.* 2010;24(4):757-761. doi:10.1007/s00464-009-0632-y

14) You have successfully established entry to the abdominal cavity. Which gas would be preferred for insufflation?

- a. CO₂
- b. Room air
- c. 100% O₂
- d. 100% H₂



CO₂ is the most commonly used gas for insufflation because it is non-flammable, colorless, and highly soluble in blood. Room air can be used in resource-limited areas. Both hydrogen and oxygen should not be used due to their flammability.

15) What insufflation pressure would you use to achieve adequate pneumoperitoneum?

- a. 10 mm Hg
- b. 15 mm Hg**
- c. 25 mm Hg
- d. 35 mm Hg

A pressure of 15 mmHg is commonly used, allowing sufficient insufflation without compromising respiration or hemodynamics in a patient with normal cardiovascular reserve.

16) You inflate the abdomen with CO₂ to a set insufflation pressure of 15 mm Hg. You place trocars, beginning with the 10mm periumbilical camera port. You place the patient into steep Trendelenburg, and insert the first trocar to the left of midline 1cm above the pubic ramus under direct vision. You place the second 5mm port 2cm above and medial to the left anterior superior iliac spine. Which of the following are the next steps in performing a laparoscopic appendectomy?

- a. Locate the appendix, bluntly dissect cecum base, divide mesoappendix, divide appendix base, remove appendix**
- b. Locate appendix, divide mesoappendix, bluntly dissect cecum base, remove appendix
- c. Divide mesoappendix, bluntly dissect cecum base, divide appendix base, remove appendix
- d. Locate appendix, divide appendix base, bluntly dissect cecum base, divide mesoappendix, remove appendix

Following insufflation and trocar placement, the surgeon must locate the appendix and begin to bluntly dissect the appendix from the cecum base to avoid unintentional ligation of small bowel or cecum. The patient should be rotated with the left side down while in Trendelenburg to retract small bowel. Two graspers should be placed through the 5mm trocars, to grasp the omentum and small bowel. Beginning with identifying the right colon, the surgeon should follow the taeniae coli down to the base of the cecum, which leads to the appendix. The surgeon should then use the grasper to clutch the appendix tip through the suprapubic port, holding it towards the LUQ to visualize the mesoappendix and appendiceal base. The mesoappendix should then be divided, followed by division of the appendix base. The mesoappendiceal line and appendiceal stump should be visualized for bleeding. If bleeding is present, hemostasis should be attained with pressure, sutures, or endoscopic clips. The operative area and pelvis can be irrigated and suctioned with the suction irrigator, which is controlled by the right hand through the suprapubic port if necessary. Once hemostasis and irrigation is completed, the appendix should be removed using the umbilical port. Port sites should be closed with suture and application of local analgesia for postoperative pain control.



17) You have gone through all the preliminary steps of the surgery successfully and are about to remove the appendix. However, your hand slips and your instrument plunges deep. Your camera view starts to fill with blood. You try to suction, but the patient is profusely bleeding and you cannot easily identify a source. What is the best next step?

- a. Abort the procedure immediately and close the skin
- b. Make a vertical midline incision to allow surgical access to the great vessels and apply direct pressure on site of bleeding
- c. Perform balloon aortic occlusion
- d. Use your laparoscopic grasper to blindly apply direct pressure

Although mild bleeds can be controlled laparoscopically, large vessel lacerations cannot generally be repaired laparoscopically, and thus, the safest approach would be to perform an exploratory laparotomy through a midline incision. The bleeding can be controlled and repaired directly in an open fashion.

Aortic balloon occlusion would assume an aortic injury. However, this bleeding could be venous or from a mesenteric vessel. Furthermore, balloon occlusions are not the fastest way to achieve hemorrhage control.

Small bleeding may be controlled laparoscopically. You can first try to apply direct pressure to the site of bleeding using an atraumatic laparoscopic grasper. For larger bleeding sites, insert 4x8 in. gauze sponges through a 10 mm port and hold pressure against the bleeding area. Cautery is probably the most commonly used technique to control minor bleedings laparoscopically and controls the majority of cases. Ligation is also an alternative method to control intraoperative bleeding, although it might be technically difficult for many surgeons. If the bleeding cannot be controlled laparoscopically, then you would convert to laparotomy. Aborting the procedure and closing the skin would not be appropriate.

17) Another patient on whom you successfully performed a laparoscopic appendectomy without any intraoperative complications returns on post-operative day 10 with complaints of abdominal pain, anorexia, vomiting and fever for 2 days. She is found to have a temperature of 38.7 degrees Celsius, pulse 120, blood pressure of 100/60 and respiratory rate of 24. She is very tender in the right lower quadrant with peritonitis. What is the most likely diagnosis?

- a. Ileus
- b. Abscess
- c. UTI
- d. Mittelschmerz

This patient most likely has an intraabdominal abscess due to her clinical signs and postoperative timeline. The rate of intra-abdominal abscess following laparoscopic appendectomy is 2.2% for acute appendicitis and 24% for perforated appendicitis, making it one of the more frequent postoperative complications.¹ Common presenting symptoms of intraabdominal abscess include fever, abdominal pain, anorexia, nausea, vomiting, rectal



tenderness, and occasionally peritonitis and hemodynamic instability. Abscesses are normally treated with fluid resuscitation, IV antibiotics, percutaneous drainage, or surgery depending on patient profile, extent of abscess, and resource availability. Abscesses commonly appear within 30 days of a procedure, most commonly around day 10².

1. Krisher SL, Browne A, Dibbins A, Tkacz N, Curci M. Intra-abdominal Abscess After Laparoscopic Appendectomy for Perforated Appendicitis. *Arch Surg.* 2001;136(4):438–441. doi:10.1001/archsurg.136.4.438
2. Clark JJ, Johnson SM. Laparoscopic drainage of intraabdominal abscess after appendectomy: an alternative to laparotomy in cases not amenable to percutaneous drainage. *J Pediatr Surg.* 2011;46(7):1385-1389. doi:10.1016/j.jpedsurg.2011.01.003