Introduction

*Inflammation of the appendix.
*The most common medical abdominal emergency.
Epidemiology

Highest Incidence in 2\textsuperscript{nd} and 3\textsuperscript{rd} decade of life.

Incidence is equal among males and females before puberty
In teenagers and young adults M:F ratio is 3:2 at age 25
Thereafter the greater incidence in males decline

Seasonal variation, more cases between may and august.
Anatomy

The **appendix** is a narrow blind-ended tube that is attached to the posteromedial end of the cecum.

Average length of 6 – 9 cm, Outer diameter 3-8mm and luminal diameter 1-3 mm.

Histologically the appendix consist of three layers The serosa, muscularis layer and submucosa Formed by lymphoid aggregates and neuroendocrine complexes.
• Position: constant at the confluence of the 3 taenia coli of caecum
• Mesoappendix: Arises from the lower surface of the mesentery of terminal ileum
• Appendicular Artery: Branch of Ileo-colic artery – End Artery (pass through mesoappendix)
• 04-06 Lymphatic channels traverse Mesoappendix ----> Ileo-caecal LNs
• Innervation: Superior mesenteric plexuses T10-L1 and vagus nerve
Innervation: Superior mesenteric plexuses T10-L1 and vagus nerve
## Anatomical Positions

<table>
<thead>
<tr>
<th>Anatomical Position</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>RETROCAECAL</td>
<td>74%</td>
</tr>
<tr>
<td>PELVIC</td>
<td>21%</td>
</tr>
<tr>
<td>PARACAECAEL</td>
<td>2%</td>
</tr>
<tr>
<td>SUBCAECAL</td>
<td>1.5%</td>
</tr>
<tr>
<td>PREILEAL</td>
<td>1%</td>
</tr>
<tr>
<td>POSTILEAL</td>
<td>0.5%</td>
</tr>
</tbody>
</table>
The function of the appendix: Used to be thought of as a vestigial remenant.

Immunological organ that secrete immunoglobulin particularly immunoglobulin A and May function as a reservoir for healthy bacteria.

In the base of the crypts of the mucus membrane lies the argentaffin cells which secrete serotonin (most frequent site for carcinoid tumor)
Etiology

• Low dietary fibre and increased consumption of refined carbs
• Improved hygiene and change in normal flora
• Obstruction:
  Faecoliths/ stricture/ Foreign body
Worm infestations: Oxyurus vermicularis
Neoplasms: Ca caecum, carcinoids
Viral
Obstruction of the lumen due to fecaliths or hypertrophy of lymphoid tissue is proposed as the main etiologic factor in acute appendicitis.

The proximal obstruction of the appendiceal lumen produces a closed-loop obstruction, and continuing normal secretion by the appendiceal mucosa rapidly produces distension.

Distension increases from continued mucosal secretion and from rapid multiplication of the resident bacteria of the appendix. This causes reflex nausea and vomiting, and the visceral pain increases.

Capillaries and venules are occluded but arterial inflow continues, resulting in engorgement and vascular congestion.

process soon involves the serosa of the appendix and in turn the parietal peritoneum. This produces the characteristic shift in pain to the right lower quadrant.

As distension, bacterial invasion, compromise of the vascular supply, and infarction progress, perforation occurs
Pathology

- Lymphatic hyperplasia
  - Luminal obstruction
    - Increased intra-luminal pressure
      - Edema, mucosal ulceration
        - Bacterial translocation to submucosa
Resolution

Venous obstruction

Ischaemia of appendix wall

Invasion of muscularis propria, submucosa
Ischemic necrosis of appendix wall

Gangrenous appendicitis

Peritonitis

Appendix filled with pus

Paracecal abscess

Microperforations
Greater omentum and loops of SB become adherant to inflammed appendix walling off the spread of contamination

Phlegmonous mass/appendicular mass

Inflammation resolve with mucus distended organ

Mucocele of appendix
Microbiology:

- The flora of the inflamed appendix differs from that of the normal appendix. About 60% of aspirates of inflamed appendices have anaerobes compared to 25% of aspirates from normal appendices.
- Virtually all grow *Escherichia coli* and *Bacteroides* species on culture.
- 62% *Fusobacterium nucleatum/necrophorum*
- Other usual species (*Peptostreptococcus*, *Pseudomonas*, *Bacteroides splanchnicus*, *Bacteroides intermedius*, *Lactobacillus*).
- Patients with gangrene or perforated appendicitis appear to have more tissue invasion by *Bacteroides*. 
# Bacteriology of perforated appendicitis

<table>
<thead>
<tr>
<th>TYPE OF BACTERIA</th>
<th>PATIENTS (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ANAEROBIC</strong></td>
<td></td>
</tr>
<tr>
<td>B. fragilis</td>
<td>80</td>
</tr>
<tr>
<td>B. thetiaotaomicron</td>
<td>61</td>
</tr>
<tr>
<td>Bilophila wadsworthia</td>
<td>55</td>
</tr>
<tr>
<td>Peptostreptococcus spp</td>
<td>46</td>
</tr>
<tr>
<td><strong>AEROBIC</strong></td>
<td></td>
</tr>
<tr>
<td>E.coli</td>
<td>77</td>
</tr>
<tr>
<td>S.viridans</td>
<td>43</td>
</tr>
<tr>
<td>Group D streptococcus</td>
<td>27</td>
</tr>
<tr>
<td>P.aeruginosa</td>
<td>18</td>
</tr>
</tbody>
</table>
Complications

1. Diffuse peritonitis
2. Perforation of gangrenous appendix (mc in tip and base)
3. Delayed perforation of appendicular abscess.
4. 20% of perforated appendix: adhesions and infertility.
• Risk factors for perforation:
  1. Extremes of age.
  2. Immunosuppression
  3. Diabetes mellitus
  4. Previous abdominal surgery
  5. Use of analgesics
  6. Pelvic appendix, subhepatic
  7. Situs inversus, Midgut malrotation

Children: underdeveloped omentum
Elderly: comorbidities and atrophic
(adhesions) Limit the ability of omentum to wall off the spread of infection
Clinical Presentation

Symptoms

- Loss of appetite
- Appendicitis usually starts with periumbilical and diffuse pain that eventually localizes to the right lower quadrant.
- Nausea (compression in nerves) and vomiting (usually in obstructive appendicitis and children)
• Atypical symptoms include
• Indigestion
• Flatulence and inability to defecate (middle age)
• Constipation (middle age and elderly)
• Diarrhea and retching (pre and post ileal)
• suprapubic pain, dysuria and urinary frequency (pelvic)
Clinical features

• Signs:
  1. Pyrexia
  2. Localized tenderness in RIF
  3. Muscle guarding
  4. Rebound tenderness
  5. Rovsing’s sign
  6. Dunphy sign
  7. Psoas sign
  8. Obturator sign
Area of skin hyperaesthesia bounded by lines joining anterior superior iliac spine, the pubic symphysis and umbilicus.
Special clinical scenarios

- According to position:
  1. Retro-caecal
     - Silent appendix
     - Quadratus lumborum rigidity
     - Psoas sign
     - Loin tenderness
Special clinical scenarios

2. Pelvic
   - Early diarrhoea
   - Increased urinary frequency
   - Deep tenderness over symphysis pubis
   - DRE: Rectovesical pouch/POD tenderness
   - Obturator/Psoas sign +ve
Special clinical scenarios

3. Post-ileal
   - Diarrhoea
   - Marked retching
   - Ill defined tenderness to rt of umbilicus
Special clinical scenarios

• As per age:
  1. Infants
     - Uncommon <36 mths
     - Difficult to diagnose
     - Diffuse peritonitis common
     - High incidence of perforation
Special clinical scenarios

2. Children
   - Vomiting
   - Marked anorexia

3. Elderly
   - High incidence of gangrene & perforation
   - Features of SAIO

4. Obese
   - Diminished signs/ delayed diagnosis
   - Midline/ Laparoscopic approach
5. Pregnancy
   - Most common extra-uterine cause of acute abdomen
   - Delayed presentation
   - Fetal loss
     • 10%
     • Upto 20% : Perforation

Highest rate of appendicitis to cause abortion is in the second trimester.
Differential Diagnosis

1. Children
   - Mesenteric adenitis (pain moves as you move the patient)
   - Meckel’s diverticulitis
   - Gastroenteritis
   - Intussusception
   - HS purpura
   - Lobar pneumonia
2. Adults

- Perforated peptic ulcer
- Torsion of testis (always check genitalia)
- Regional enteritis
- Ureteric colic
- Pancreatitis
- Pyelonephritis
- Crohn’s (mc site is ileocecal vale)
- Medical causes: FMF, DKA, PNH, acute porphyria, herpes zoster

Valentino's syndrome is pain presenting in the RLQ caused by perforated duodenal ulcer.
Differential Diagnosis

3. Adult female
   - Mittelschmerz
   - PID
   - Pyelonephritis
   - Ectopic pregnancy
   - Torsion/rupture of ovarian cyst
   - Endometriosis

Ask about: menstrual cycle, vaginal discharge and back pain important in relation to PID
Differential Diagnosis

4. Elderly
   - Diverticulitis (redundant sigmoid)
   - Intestinal obstruction
   - Ca colon
   - Mesenteric infarction
     (vascular problems / SLE)
Differential Diagnosis for Appendicular Mass

1. Ectopic kidney (may be in RIF)
2. Any retroperitoneal pathology or tumor
Laboratory Findings

- **CBC**: Mild leukocytosis accompanied by a polymorphonuclear prominence (white blood cell count >18,000 cells/mm³ raise the possibility of a perforated appendix with or without an abscess. And the opposite could be due to lymphopenia or septic reaction).
- **C-reactive protein**: elevated but can have up to a 12-hour delay.
- **Urine analysis**: to rule out the urinary tract infection. However, several white or red blood cells can be present from irritation of the ureter or bladder. (RBC in retrocecal)
- **Pregnancy test BHCG**: A decreasing inflammatory response may indicate spontaneous resolution.
# Clinical Scoring Systems

## The Alvarado Score

<table>
<thead>
<tr>
<th>Signs</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Right lower quadrant tenderness</td>
<td>2</td>
</tr>
<tr>
<td>Elevated temperature (&gt;99.1 F)</td>
<td>1</td>
</tr>
<tr>
<td>Rebound tenderness</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Symptoms</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Anorexia</td>
<td>1</td>
</tr>
<tr>
<td>Nausea or vomiting</td>
<td>1</td>
</tr>
<tr>
<td>Migration of pain to right lower quadrant</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Laboratory Values</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Leukocytosis (&gt;10,000 WBC)</td>
<td>2</td>
</tr>
<tr>
<td>Left shift (&gt;75% neutrophils)</td>
<td>1</td>
</tr>
</tbody>
</table>
## Appendicitis Inflammatory Response Score

<table>
<thead>
<tr>
<th>Clinical Characteristic</th>
<th>Score (points)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vomiting</td>
<td>+1</td>
</tr>
<tr>
<td>Pain in right lower quadrant</td>
<td>+1</td>
</tr>
<tr>
<td><strong>Rebound Tenderness</strong></td>
<td></td>
</tr>
<tr>
<td>Light</td>
<td>+1</td>
</tr>
<tr>
<td>Medium</td>
<td>+2</td>
</tr>
<tr>
<td>Strong</td>
<td>+3</td>
</tr>
<tr>
<td>Body temperature $\geq 38.5^\circ C$</td>
<td>+1</td>
</tr>
<tr>
<td><strong>Polymorphonuclear Leukocytes</strong></td>
<td></td>
</tr>
<tr>
<td>70%-84%</td>
<td>+1</td>
</tr>
<tr>
<td>$\geq 85%$</td>
<td>+2</td>
</tr>
<tr>
<td><strong>White Blood Cell Count</strong></td>
<td></td>
</tr>
<tr>
<td>10,000-14,999 cells/L</td>
<td>+1</td>
</tr>
<tr>
<td>$\geq 15,000$ cells/L</td>
<td>+2</td>
</tr>
<tr>
<td><strong>C-Reactive Protein</strong></td>
<td></td>
</tr>
<tr>
<td>10-49 mg/L</td>
<td>+1</td>
</tr>
<tr>
<td>$\geq 50$ mg/L</td>
<td>+2</td>
</tr>
</tbody>
</table>
Imaging Studies

1. Plain Abdominal X-Rays
2. Graded Compression U/S
3. CT
Abdominal XRay

- Fecalith
- loss of psoas shadow
- distention of SB loop or cecum
- air under diaphragm
Plain Abdominal X-Rays

• Appendicololiths picked up in only 10-15% cases
• Can be combined with Barium enema
• Low sensitivity
• Low specificity → 20% of normal Appendices do not fill up
Graded Compression U/S

Longitudinal real-time US scan of a normal appendix. Diameter 0.3 cm. ** psoas muscle, * rectus muscle, x caecum, + terminal ileum
Longitudinal (a) and transverse (b) real-time US scan of acute appendicitis with thickening of the wall (crosses 2), target–sign, diameter > 6 mm (crosses 1) and free fluid surrounding the appendix (+)
computed tomography (CT) scan
- Appendix dilated and the wall is thickened.
- Periappendiceal phlegmon, and free fluid
- Periappendiceal fat stranding
- Thickened mesoappendix
- Fecaliths but their presence is not pathognomonic of appendicitis.
crosses). b contrast-enhanced CT: thickened appendix, mesenteric infiltration around the appendix, inflammatory thickening of the sigmoid colon
Ultrasonography. sensitivity of 55% to 96% and a specificity of 85% to 98%.

(CT) scan 92% to 97% sensitivity, 85% to 94% specificity
Computed Tomography

• Rational use:
  - Elderly
  - Atypical presentations
  - Neoplasms
  - Acute diverticulitis
  - Intestinal obstruction

• MRI: ??
Management of acute appendicitis in adults

Acute appendicitis

- Nonperforated *
  - Unfit for surgery or refuses surgery?
    - Yes
      - Intravenous antibiotics and in-hospital observation
    - No
      - Clinical improvement?
        - Yes
          - Discharge home with oral antibiotics to complete 10-day course
        - No
          - Immediate appendectomy Δ

- Perforated *
  - Septic/unstable patient or free perforation/generalized peritonitis
    - Abscess
      - ≤3 cm
        - Not drainable percutaneously
      - >3 cm
        - Drainable percutaneously

- Stable patient with localized symptoms
  - Phlegmon
    - Appendectomy not feasible; ileocecal resection likely required
  - Appendectomy feasible; ileocecal resection not likely required

Δ: Immediate appendectomy requires additional workup for the presence of an appendiceal neoplasm.

All patients should undergo interval appendectomy to exclude an appendiceal neoplasm; those over 40 should also be offered colonoscopy if they have not undergone routine colonoscopic screening.
Nonperforated

Unfit for surgery or refuses surgery?

Yes

Intravenous antibiotics and in-hospital observation

No

Clinical improvement?

Yes

Discharge home with oral antibiotics to complete 10-day course

No

Immediate appendectomy


Acute appendicitis

Perforated

Septic/unstable patient or free perforation/generalized peritonitis

Stable patient with localized symptoms

Abscess

Phlegmon

Appendectomy not feasible; ileoceleal resection likely required

Appendectomy feasible; ileoceleal resection not likely required

<= 3 cm

> 3 cm

Not drainable percutaneously

Drainable percutaneously

Immediate appendectomy followed by 3 to 5 days of intravenous antibiotics

Percutaneous drainage of abscess and intravenous antibiotics

Intravenous antibiotics and in-hospital observation

Clinical improvement?

Yes

Discharge home with oral antibiotics to complete a 7- to 10-day course, and follow up in 6 to 8 weeks. All patients should undergo interval appendectomy to exclude an appendiceal neoplasms; those over 40 should also be offered colonoscopy if they have not undergone routine colonoscopic screening.

No

Immediate appendectomy followed by 3 to 5 days of intravenous antibiotics
Management of Appendicular mass

• Late presentation
• Clinically mass & fever, Confirm by CT or US
• Admit, Labs, NPO if not vomiting, NG if vomiting, Fluids
Antibiotics (Broad spectrum: ceftriaxone and metronidazole)
Monitor Vitals q4Hrs

• Tx: Conservative mgt (Oschner Sherren’s Regime)
After 24-48Hrs: Improvement (less pain, no vomiting no fever, bowel motion)
Interval appendectomy after 8 weeks
No improvement:
Vomiting, tachycardia, fibrile, increase size of mass

2 possibilities:
1. Bowel obstruction by adhesions
2. Mass became abscess, confirm by CT, tx by CT guided percutaneous drainage and antibiotics
Mass same size:
1. Mass resulting from Crohn’s disease
2. Cecum CA
 Do lower GI endoscopy
Mucocele

Deal with it carefully to avoid rupture

Rupture: pseudomyxoma peritonei (rare, diffuse gelatinous material in the peritoneum, more in females, can also be caused by neoplastic mucus secreting cells, can obstruct ureter –cause renal failure- or IVC.

Tx with open surgery
If it reached cecum: rt hemicolonectomy
# OPERATIVE INTERVENTIONS FOR THE APPENDIX

<table>
<thead>
<tr>
<th>Open Appendectomy</th>
<th>Laparoscopic Appendectomy</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Anesthesia</td>
<td>General Anesthesia</td>
</tr>
<tr>
<td>A right lower quadrant incision at McBurney’s point with a McBurney (oblique) or Rocky-Davis (transverse) right lower quadrant muscle splitting incision if perforated appendicitis is suspected or the diagnosis is in doubt, a lower midline laparotomy can be considered</td>
<td>Typically uses three ports. Typically, a 10- or 12-mm port is placed at the umbilicus, whereas two 5-mm ports are placed suprapubic and in the left lower quadrant.</td>
</tr>
<tr>
<td>Inc risk for surgical site infection</td>
<td>Inc risk of intra-abdominal abscess</td>
</tr>
<tr>
<td>Decreased operative duration</td>
<td>Less pain, shorter length of stay, and quicker return to normal activity</td>
</tr>
</tbody>
</table>
McBurney
Modified McBurney (aka Lanz or Langer’s line incisions)
Rutherford
Morrison extension
Rockey-Davis
Fowler-Weir extension
Laparoscopic Appendectomy

A typical placement for access ports is shown at the umbilicus, left lower quadrant, and lower midline.

A pneumoperitoneum is created and the abdomen is inflated with carbon dioxide.
Purse string Suture.

- continuous stitch paralleling the edges of a circular wound
- wound edges are inverted when tied
- used to close circular wounds, such as hernia or an appendiceal stump
Problems Intra-operatively

1. Appendix not found:
   - Mobilise caecum
   - Taenia coli to be traced to their confluence

2. Appendicular tumour (carcinoid):
   - <2cms: Appendicectomy
   - >2cms: Rt hemicolecction

3. Appendix normal (higher in females, more ddx) tx: Remove it.

4. Abscess and can’t be removed easily
Incidental appendectomy is defined as the removal of a clinically normal appendix during non-appendiceal surgery.

In oncology patients who undergo laprotomy for any cause

Prophylactic removal in: AIDS, handicaps

AIDS patients have a higher incidence of appendicitis and its complications with no leukocytosis.
POSTOPERATIVE CARE AND COMPLICATIONS

**Non perforated.** After either open or laparoscopic appendectomy for nonperforated appendicitis, patients may be started on a clear liquid diet and advanced as tolerated to a regular diet. Antibiotics are not required postoperatively. Most patients are discharged within 24 to 48 hours of surgery. Same-day discharge is feasible, most commonly following a laparoscopic appendectomy.

**Perforated appendicitis** often develop an ileus postoperatively regardless of the surgical approach (open versus laparoscopic). Thus, diet should only be advanced as the clinical situation warrants. Patients may be discharged once they tolerate a regular diet, usually in five to seven days. Three to five days of intravenous antibiotics is recommended for perforated appendicitis after appendectomy.
Post OP Complications

1. Wound infection
2. Intra-abdominal abscess
3. Ileus
4. Portal pyaemia (pyelephlebitis)
5. Adhesive intestinal obstruction
6. Damage to ileoinguinal nerve
7. Recurrent ot stump appendicitis
Notes

Appendectomy in Crohn’s if base is intact

Amyand hernia is a rare form of an inguinal hernia in which the vermiform appendix is located within the hernial sac. It is seen in less than 1% of inguinal hernia. It should not be confused with an appendix-containing femoral hernia, known as De Garengeot hernia.
Appendiceal Tumors

• Carcinoid m.c, neuroendocrine that secrete 5HT = serotonin, Mets to liver
• Adenocarcinoma
• Malignant mucoid adenocarcinoma (pseudomyxoma peritonei if it rupture)
• Lymphoma

Carcinoid tumor either intra-abdominal or extra abdominal
In lungs it’ll give flushing, wheezing