Overview

- A (brief) history of gallbladder surgery
- Anatomy
  - Anatomical variations
- Physiology
- Pathophysiology
- Diagnostic imaging of the gallbladder
- Natural history of cholelithiasis
- Case presentations of the spectrum of gallstone disease
- Summary
History of Gallbladder Surgery
Prior to the late 1800s, doctors treated gallbladder disease with a cholecystostomy, due to the fear that removing the organ would kill patients.

Carl Johann August Langenbuch (director of the Lazarus Hospital in Berlin, Germany) practiced on a cadaver to remove the gallbladder, and in 1882, performed a cholecystectomy on a patient. He was discharged after 6 weeks in the hospital.

By 1897 over 100 cholecystectomies had been performed.

https://en.wikipedia.org/wiki/Carl_Langenbuch
Gallbladder Surgery: A Relatively Recent Change

- In 1985, Erich Mühe removed a patient’s gallbladder laparoscopically in Germany.

- In 1987, Philippe Mouret (a French gynecologic surgeon) performed a laparoscopic cholecystectomy.

- In 1992, the National Institutes of Health (NIH) created guidelines for laparoscopic cholecystectomy in the United States, essentially transforming surgical practice.
Anatomy and Abnormal Anatomy
Conventional hepatic arterial anatomy

Conventional hepatic artery anatomy; the CHA gives off the GDA and continues as the PHA, which splits into RHA and LHA. In the surgical literature, 55-70% of the population has this configuration; in the largest DSA study, 61%.

Covey et al. Variant hepatic arterial anatomy revisited: DSA performed in 600 patients. Radiology 2002; 224: 542-547.

http://www.slideshare.net/pryce27/rsna-final-2
Right hepatic artery

Origin
- Proper hepatic artery
- SMA (12%)
- Celiac trunk (double hepatic artery)

Destination
- Segments 5-8

Recognized by
- Distribution to right lobe of liver


http://www.slideshare.net/pryce27/rsna-final-2
Replaced or accessory right hepatic artery

Replaced right hepatic artery (12%)
- No right hepatic artery from PHA
- Instead originates from the SMA, or rarely the right phrenic artery or other

Accessory right hepatic artery (5.5%)
- Right hepatic artery from PHA
- Second right hepatic artery from elsewhere
  - Usually SMA
  - Also GDA, LGA, celiac axis, right phrenic artery


http://www.slideshare.net/pryce27/rsna-final-2
Physiology
Simplified overview of the bile acid biosynthesis pathway derived from cholesterol


http://dmd.aspetjournals.org/content/37/5/1035
Gallbladder Function: Absorption and Secretion

- Main function of the gallbladder is to concentrate and store hepatic bile and to deliver bile into the duodenum in response to a meal.

- In the fasting state, approximately 80% of the bile secreted by the liver is stored in the gallbladder.
The gallbladder mucosa has the greatest absorptive power per unit area of any structure in the body.

Epithelial cells of the gallbladder secrete at least two important products into the gallbladder lumen: glycoproteins and hydrogen ions.

liver: 
*secretin* stimulates duct cells

gallbladder: 
*CCK* triggers contractions

duodenum: 
intestinal phase stimuli trigger secretion of *CCK* and *secretin*

Sphincter of Oddi: 
*CCK* causes relaxation
A. Fasting
1. Sphincter of Oddi contracted
2. Gallbladder filling

B. Response to a meal
1. Sphincter of Oddi relaxed
2. Gallbladder emptying
Pathophysiology
Gallstone Types

- Gallstones form as a result of solids settling out of solution

- Major organic solutes in bile are bilirubin, bile salts, phospholipids, and cholesterol

- Gallstones are classified by their cholesterol content
  - Cholesterol stones
    - Western countries: approximately 80% of gallstones
  - Pigment stones
    - Black
      - Western countries: approximately 15-20%
    - Brown
      - Only a small percentage of stones in Western countries
Cholesterol Stones

- Pure cholesterol stones are uncommon and account for less than 10% of all stones
  - Typically occur as single large stones with smooth surfaces

- Most other cholesterol stones contain variable amounts of bile pigments and calcium, but are always greater than 70% cholesterol by weight
  - Usually multiple stones of varying sizes
  - May be hard and faceted, or irregular, mulberry-shaped, and soft
  - Colors range from whitish yellow and green to black
  - Less than 10% of cholesterol stones are radiopaque

Source: Gallbladder and the Extrahepatic Biliary System, Schwartz's Principles of Surgery, 10e


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The common primary event in the formation of cholesterol stones is supersaturation of bile with cholesterol.

High bile cholesterol levels and cholesterol gallstones are considered as one disease.

Cholesterol is highly nonpolar and insoluble in water and bile.

Cholesterol solubility depends on the relative concentration of cholesterol, bile salts, and lecithin (the main phospholipid in bile).

Supersaturation is caused by cholesterol hypersecretion rather than by a reduced secretion of phospholipid or bile salts.
Pigment Stones

- Pigment stones contain less than 20% cholesterol and are dark because of the presence of calcium bilirubinate.

- Black stones and brown stones have very little in common aside from cholesterol content and should be considered separate entities.

https://www.flickr.com/photos/jian-hua_qiao_md/3953725382
Black Pigment Stones

- Typically small, brittle, black, and sometimes spiculated
- Formed by supersaturation of calcium bilirubinate, carbonate, and phosphate
  - Most often secondary to hemolytic disorders such as hereditary spherocytosis and sickle cell disease, and in those with cirrhosis
- Almost always form in the gallbladder
- In Asian countries such as Japan, black stones account for a much higher percentage of gallstones than in the Western hemisphere
Brown Pigment Stones

- Typically less than 1 cm in diameter, brownish-yellow, soft, and often mushy

- Can form either in the gallbladder or in the bile ducts
  - Typically secondary to bacterial infection caused by bile stasis

- Precipitated calcium bilirubinate and bacterial cell bodies compose the major part of the stone

- Typically found in the biliary tree of Asian populations and are associated with stasis secondary to parasite infection

- In Western populations, brown stones occur as primary bile duct stones in patients with biliary strictures or other common bile duct stones that cause stasis and bacterial contamination
Diagnostic Imaging of the Gallbladder
Plain Abdominal X-Ray

- X-ray
  - 10-15% of gallstones seen on X-ray
  - Air in the biliary tree
Ultrasound

- Gold standard for diagnosis of cholelithiasis

- \(~85\%\) sensitive for gallstones

- False negative results in only 5\% of patients (small stones or contracted gallbladder)

- Typically misses stones in the CBD
Ultrasound of normal gallbladder

http://www.derryimaging.com/body-map/ultrasound/
Ultrasound of gallbladder with gallstones

Ultrasound of gallbladder “sludge”

Ultrasound of cholecystitis

http://www.radiologyassistant.nl/en/p43a0746accc5d/gallbladder-wall-thickening.html
Ultrasound vs. CT of Cholecystitis

http://www.radiologyassistant.nl/en/p43a0746accc5d/gallbladder-wall-thickening.html
Radionuclide scan (HIDA)

Acute cholecystitis – HIDA scan
Higher accuracy than ultrasonography

Normal HIDA scan
- Tracer in GB
- Tracer in CBD
- Tracer in small bowel

Acute cholecystitis
- Non-filling of GB
- Tracer in CBD
- Tracer in small bowel


http://www.slideshare.net/shaffar75/ultrasound-of-the-gallbladder
Magnetic Resonance Cholangiopancreatography (MRCP)

https://mrimaster.com/anatomy/biliary%20system%20anatomy%20(mrcp)/
Percutaneous transhepatic cholangiography (PTC)
Endoscopic retrograde cholangiopancreatography (ERCP)

https://www.ceessentials.net/article41.html
Natural History of Cholelithiasis

Source: Gerard M. Doherty: Current Diagnosis & Treatment: Surgery, 14th Edition
www.accessmedicine.com
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Spectrum of Gallbladder Disease
Spectrum of Gallstone Disease

- Asymptomatic cholelithiasis
- Biliary colic (chronic cholecystitis or symptomatic cholelithiasis)
- Acute cholecystitis
  - Calculous cholecystitis
  - Acalculous cholecystitis
  - Mirizzi’s syndrome
- Choledocholithiasis
- Ascending cholangitis
- Gallstone pancreatitis
- Gallstone ileus
- Biliary dyskinesia
- Benign gallbladder tumors
- Gallbladder carcinoma
53 year old female presented for evaluation after she underwent an echocardiogram which incidentally identified a 3-cm gallstone.

She denied abdominal pain, nausea, vomiting, diarrhea, or constipation.

RUQ US demonstrated cholelithiasis (a large gallstone measuring 3 cm) without gallbladder wall thickening, pericholecystic fluid, or a sonographic Murphy’s sign.
hey, buddy - be a good helper and hold this for me for a while.

OTAY!

I'm helping!

BIG HELPER!

I'm a good helper.
Asymptomatic cholelithiasis

- Approximately 30% of people with cholelithiasis end up having surgery
- Symptoms of gallstone disease generally do not change in severity
- Each year, approximately 2% of patients with asymptomatic gallstones develop symptoms
- Presence of gallstones in a person with asymptomatic or mildly symptomatic disease is **not** an indication for cholecystectomy
- Reasons to recommend cholecystectomy in asymptomatic cholelithiasis
  - Large stones (> 2 cm in diameter) – they produce acute cholecystitis more often than small stones
  - Calcified gallbladder – often associated with carcinoma
I just wanned to make you happy...

SAVE GALLBLADDER

project.theawkwardyeti.com
Case #2

- 29 year old female presented complaining of episodic abdominal pain and abdominal bloating approximately 1 hour after eating

- RUQ US demonstrated cholelithiasis with a 1.6 cm gallstone and diffuse gallbladder wall thickening without pericholecystic fluid, and a negative sonographic Murphy’s sign

- HIDA demonstrated chronic cholecystitis (non-filling of the gallbladder at 45 minutes, but eventual filling at 4 hours)
where ya headed, gall bladder?

I haffa get removed...

well that's OUTRAGEOUS! WHY?!
on account of I maked all these stones...

seriously?

they're removing you for that?

hey bladder, lookin' good. I made these for you...
Biliary Colic (Chronic Cholecystitis)

- Most common form of symptomatic gallbladder disease
- Signs/symptoms
  - Caused by transient gallstone obstruction of the cystic duct
  - Right upper quadrant pain, but can be epigastric or left abdominal pain
- Diagnosis
  - RUQ ultrasound
  - Gallstones can be demonstrated in about 95% of cases, and a positive reading for gallstones is almost never in error
  - About 2% of patients with gallstone disease have normal ultrasound studies
Biliary Colic (Chronic Cholecystitis) (continued)

- **Complications**
  - Predisposes to acute cholecystitis, common duct stones, and adenocarcinoma of the gallbladder
  - Complications are infrequent

- **Treatment**
  - **Medical**
    - Avoiding fatty foods
    - Dissolution of stones – ursodiol (Actigall)
  - **Surgical**
    - Cholecystectomy is indicated in most patients with symptoms
Case #3

- 31 year old male presented complaining of epigastric pain, nausea, and vomiting
- On admission to the emergency department, blood pressure was 180/107. WBC was 7.4
  - CT angio chest/abdomen/pelvis demonstrated no evidence of an aortic dissection and no intraabdominal findings
- Discharged home
- Presented again 12 hours later with RUQ pain and WBC was 14.9 with a left shift of 80.4% neutrophils
- RUQ ultrasound demonstrated gallbladder wall thickening of 0.6 cm, cholelithiasis, trace pericholecystic fluid, and a positive sonographic Murphy’s sign
Acute Cholecystitis

- In 80% of cases, acute cholecystitis results from obstruction of the cystic duct by a gallstone

- Pathologic changes in the gallbladder
  - Gangrene and perforation may occur as early as 3 days after onset, but most perforations occur during the second week
  - In cases that resolve spontaneously, acute inflammation has largely cleared by 4 weeks

- About 20% of cases of acute cholecystitis occur in the absence of cholelithiasis (acalculous cholecystitis)
  - Most cases occur in patients hospitalized with some other illness
  - Common in trauma victims and patients receiving TPN
Acute Cholecystitis (continued)

- **Signs/symptoms**
  - RUQ pain and tenderness
  - Murphy’s sign
    - Inspiratory arrest with right subcostal region palpation during inspiration
  - Nausea and vomiting are present in about half of patients, but the vomiting is rarely severe
  - Fever (usually 38°C to 38.5°C)
    - High fever and chills are uncommon and should suggest the possibility of complications or an incorrect diagnosis

- **Labs**
  - WBC elevated
  - LFTs should be normal

- **Imaging**
  - US
  - HIDA
Acute Cholecystitis (continued)

- Complications
  - Suppurative cholecystitis (empyema)
  - Gangrene
  - Emphysematous cholecystitis
  - Perforation – total incidence about 10%
    - Localized perforation with pericholecystic abscess
    - Free perforation with generalized peritonitis
    - Perforation into an adjacent hollow viscus with formation of a fistula (cholecystenteric fistula)
Acute Cholecystitis (continued)

- **Treatment**
  - IV fluids
  - IV antibiotics
  - Laparoscopic (open) cholecystectomy
  - Percutaneous cholecystostomy

- **Prognosis**
  - Overall death rate of acute cholecystitis is about 5%
Algorithm for Management of Acute Cholecystitis

- RUQ pain, tenderness, RUQ US positive
  - Yes → Advanced disease, toxic
  - No → Good operative risk
    - Yes → Early cholecystectomy (or cholecystostomy)
    - No → Non-operative management
      - Yes → Prompt improvement
        - Yes → Late cholecystectomy
        - No → Prompt improvement
      - No → Prompt improvement

Adapted from: Gerard M. Doherty: Current Diagnosis & Treatment: Surgery, 14th Edition
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Case #4

- 46 year old female presented complaining of RUQ pain
- Labs
  - WBC count 6.8
  - Total bilirubin 5.8
  - Alkaline phosphatase 182
  - AST 237
  - ALT 516
- RUQ US demonstrated cholelithiasis without gallbladder wall thickening or pericholecystic fluid, and a slightly dilated CBD (0.8 cm) without dilated intrahepatic bile ducts
- ERCP demonstrated a stone in the distal CBD, which was removed
what is it, gall bladder? can't you see I have a lot to do?

I maked these

you made STONES?

YOU'RE JUST SUPPOSED TO HOLD WHAT I GIVE YOU!

GET OUT! GO ON!

I maked these
Choledocholithiasis

- Approximately 15% of patients with cholelithiasis have stones in the bile ducts
- Common duct stones are usually accompanied by others in the gallbladder, but in 5% of cases, the gallbladder is empty

- Two possible origins for common duct stones
  - Secondary common duct stones
    - Stones develop within gallbladder and pass through cystic duct into CBD
    - Cholesterol stones
  - Primary common duct stones
    - Stones develop within CBD
    - Pigment stones
Choledocholithiasis (continued)

- **Symptoms**
  - RUQ, epigastric or sub-sternal pain with referred pain to the right scapula
  - Intermittent chills/fever
  - Jaundice
  - Transient darkening of urine
  - Pruritis

- **Labs**
  - AST/ALT, Alkaline phosphatase, and bilirubin all elevated
  - WBC may be elevated or normal
Choledocholithiasis (continued)

- Imaging
  - X-ray
  - US
  - CT
  - MRCP
  - ERCP
Choledocholithiasis (continued)

- **Complications**
  - Intra-hepatic abscesses
  - Hepatic failure or secondary biliary cirrhosis
  - Acute pancreatitis
  - Erosion of a CBD stone through the ampulla → gallstone ileus
  - Hemorrhage (hemobilia)

- **Treatment**
  - Antibiotics if cholangitis is suspected
  - ERCP
  - Cholecystectomy with cholangiogram
  - Common bile duct exploration
Natural History of Choledocholithiasis

- Gallbladder stones: 100
  - Cholangitis: 3
  - Biliary colic: 2
  - Pancreatitis: 1
  - Jaundice: 3
  - Asymptomatic common duct stones: 6
    - Suppurative cholangitis: Rare

Adapted from: Gerard M. Doherty: Current Diagnosis & Treatment: Surgery, 14th Edition
www.accessmedicine.com
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Case #5

- 28 year old male presented complaining of severe epigastric abdominal pain, nausea, vomiting, and chills
- History of a laparoscopic cholecystectomy 3 weeks prior
- Febrile (101.4 °F)
- Labs
  - WBC 10.8
  - Total bilirubin 7.1
  - Alkaline phosphatase 199
  - AST 130
  - ALT 408
- CT abdomen/pelvis demonstrated intra- and extra-hepatic biliary ductal dilatation
- ERCP demonstrated a stone in the CBD, which was extracted
Ascending cholangitis

- Bacterial infection of obstructed biliary ducts

**Causes**

- Choledocholithiasis
- Biliary stricture
- Neoplasm

**Less common:**

- Chronic pancreatitis, ampullary stenosis, pancreatic pseudocyst, duodenal diverticulum, congenital cyst, and parasitic invasion
- Iatrogenic cholangitis may complicate transhepatic or T-tube cholangiography

- **Higher chance of ascending cholangitis once the duct is colonized with bacteria**

  - Predominant organisms (in decreasing frequency) are *E. coli, Klebsiella, Pseudomonas, Enterococci, and Proteus*
Ascending cholangitis (continued)

- Diagnosis is mostly clinical, although RUQ ultrasound can demonstrate dilated intra- and extra-hepatic ducts

- Charcot’s triad – present in only 70% of cases
  - RUQ pain
  - Fever
  - Jaundice

- Reynolds’ pentad
  - Charcot’s triad
  - Altered mental status
  - Hypotension
Ascending cholangitis  (continued)

- **Treatment**
  - Antibiotics
  - ERCP
  - PTC
  - Common bile duct exploration
Case #6

- 46 year old female presented complaining of two days of severe abdominal pain, which started in the epigastrium and became diffuse, associated with nausea and vomiting

- Labs
  - WBC 21.2
  - Total bilirubin 2.3
  - Alkaline phosphatase 126
  - AST 99
  - ALT 170
  - Lipase 8059

- RUQ US demonstrated a distended gallbladder with mild wall thickening, small pericholecystic fluid, non-mobile stones, and a mildly dilated CBD (0.9 cm)

- MRCP demonstrated acute pancreatitis with extensive peripancreatic infiltration and acute peripancreatic fluid collections, cholelithiasis, choledocholithiasis, and mild biliary dilatation
Pancreatitis

Hi Pancweas!

I maked these!

you like dem?
Gallstone Pancreatitis

- Acute pancreatitis due to biliary obstruction
- Diagnosis is mostly clinical (history, physical exam, labs)
  - RUQ ultrasound demonstrates cholelithiasis
  - CT can be used to find necrotizing pancreatitis, fluid collections, or other complications but is not technically required to make the diagnosis
- Treatment is supportive initially
- Cholecystectomy with cholangiogram prior to discharge from the hospital if the pancreatitis is mild or moderate to avoid a recurrent episode
  - ~30% will recur within 6 weeks if CBD is not cleared prior to discharge
Gallstone Ileus

- A mechanical intestinal obstruction caused by a large gallstone lodged in the lumen
- It occurs more often in women, and the average patient age is about 70 years
- Usually presents with obvious small bowel obstruction
- The obstructing gallstone enters the intestine through a cholecystenteric fistula located in the duodenum, colon, or, rarely, the stomach or jejunum
- Stones that cause gallstone ileus are almost always 2.5 cm or more in diameter
Gallstone Ileus (continued)

- Imaging
  - Abdominal X-ray may show a radiopaque gallstone
  - Pneumobilia will be seen in about 40% of cases

http://radiopaedia.org/articles/gallstone-ileus
Gallstone Ileus (continued)

- Treatment
  - Emergency laparotomy and removal of the obstructing stone through a small proximal enterotomy
  - Leave gallbladder alone at emergency laparotomy

- The death rate from gallstone ileus remains about 20%, largely because of the poor general condition of elderly patients at the time of laparotomy
# Summary

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<td>Yes (constant)</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>US HIDA</td>
<td>1) Antibiotics 2) Laparoscopic cholecystectomy 3) Percutaneous cholecystostomy</td>
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<tr>
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<td>No</td>
<td>No</td>
<td>Yes</td>
<td>MRCP</td>
<td>1)ERCP 2) Laparoscopic cholecystectomy</td>
</tr>
<tr>
<td>Ascending cholangitis</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Clinical US</td>
<td>1) Antibiotics 2) ERCP 3) PTC 4) CBD exploration</td>
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<tr>
<td>Gallstone pancreatitis</td>
<td>Yes (Epigastric)</td>
<td>Maybe</td>
<td>Yes</td>
<td>Yes</td>
<td>Clinical US CT</td>
<td>1)Supportive 2) Laparoscopic cholecystectomy</td>
</tr>
</tbody>
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Post-Cholecystectomy Syndrome

- A heterogeneous group of disorders affecting patients who continue to complain of symptoms after cholecystectomy.
- The usual reason for incomplete relief after cholecystectomy is that the preoperative diagnosis of chronic cholecystitis was incorrect.
- An organic cause for the symptoms is more likely to be discovered in patients with severe episodic pain than in those with other complaints.
- Abnormal liver function studies, jaundice, and cholangitis are other manifestations that indicate residual biliary disease.
- Patients with suspicious findings should be studied by ERCP or PTC.
Benign Gallbladder Tumors

- The differentiation from gallstones is based upon observing whether a shift in position of the projections follows changes in posture of the patient, since stones are not fixed.

- Cancer should be suspected in any polypoid lesion that exceeds 1 cm in diameter.

- Polyps
- Adenomyomatosis
- Adenomas
Gallbladder Carcinoma

- An uncommon neoplasm that occurs in elderly patients
- Associated with gallstones in 70% of cases
- The risk of malignant degeneration correlates with the length of time gallstones have been present
- Prevalence in women compared to men is approximately 2:1
- Histology – adenocarcinoma is the most common
  - Scirrhous (60%)
  - Papillary (25%)
  - Mucoid (15%)
Gallbladder Carcinoma  (continued)

- Early direct invasion of the liver and hilar structures and by metastases to the common duct lymph nodes, liver, and lungs

- Carcinoma can be incidentally found after cholecystectomy, where the tumor is confined to the gallbladder

- Symptoms
  - Right upper quadrant pain
  - Obstruction of the cystic duct by tumor sometimes initiates an attack of acute cholecystitis
  - Other cases present with obstructive jaundice and, occasionally, cholangitis due to secondary involvement of the common duct
Gallbladder carcinoma – Imaging
Gallbladder Carcinoma: Complications and Prevention

- **Complications**
  - Intra-hepatic, pericholecystic or within the gallbladder abscesses

- **Prevention?**
  - Incidence of gallbladder cancer has decreased in recent years as the frequency of cholecystectomy has increased
  - Estimated that one case of gallbladder cancer is prevented for every 100 cholecystectomies performed
Gallbladder Carcinoma: Surgical Treatment

- In the few cases when cancer has not penetrated the muscularis mucosae, cholecystectomy alone should suffice
- Small invasive carcinoma discovered by the pathologist
  - Reoperation to perform a wedge resection of the liver bed plus regional lymphadenectomy
- Localized carcinoma
  - Cholecystectomy along with en bloc wedge resection of an adjacent 3-5 cm of normal liver and dissection of the lymph nodes in the hepatoduodenal ligament
- More extensive hepatectomies (e.g., right lobectomy) are not worthwhile
- There is little that surgery can offer in cases with hepatic metastases or more distant spread
Gallbladder Carcinoma: Prognosis

- Radiotherapy and chemotherapy are not effective palliative measures
- About 85% of patients are dead within a year after diagnosis
- The 10% of patients who survive more than 5 years:
  - Carcinoma was an incidental finding during cholecystectomy for symptomatic gallstone disease
  - An aggressive resection has removed all gross tumor
"Nurse, get on the internet, go to SURGERY.COM, scroll down and click on the 'Are you totally lost?' icon."
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