Gallstone and Bile Duct Disease
The GI Perspective

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Cholelithiasis
Gallstones

• Incidence
  – 10% American adults
• Risk Factors
  – Age
  – Female
  – Obesity
  – Estrogen/OCP/Pregnancy
  – Hyperlipidemia
  – DM
  – Ileal disease/Resection

Cholelithiasis

• Stone
  – 75% cholesterol stones
  – 25% pigment stones
    • Black
    • Brown
• Sludge
### Cholelithiasis

- **Cholesterol Stones**
  - Normal Bile Components
    - Cholesterol
    - Phospholipids
    - Bile salts
    - Bilirubin
    - Proteins
  - Bile salts = keeps cholesterol soluble
    - Micelles of above three components
  - Low bile salts = stone formation
  - High cholesterol concentration = stone formation

### Cholesterol Stones

- Major problem: supersaturated bile (lithogenic)
  - Mechanisms
    - Increased biliary secretion of cholesterol
    - Increased hepatic synthesis of cholesterol
    - Decreased secretion of solubilizing lipids & bile salts

### Cholesterol Stones

- Decreased secretion of solubilizing bile salts
  - Decreased hepatic synthesis of bile acids
  - Bile salt malabsorption
  - Biliary stasis
  - Gallbladder dysfunction
  - Impaired enterohepatic bile salt circulation
Cholithiasis: Role of Enterohepatic circulation

Pigment Stones
- Increased bilirubin load presented to the liver
- Primarily unconjugated bilirubin
- Black Stones:
  - associated with hemolysis
  - Direct increase in unconjugated bilirubin
- Brown Stones
  - associated with stagnant or infected bile
  - Indirect via increase β-Glucuronidase

Clinical Presentation
- 20% develop symptoms
- Biliary colic
  - RUQ/Epigastric pain
  - Last over an hour
  - Occ radiates to right shoulder/back
- Dyspepsia
  - Non-specific

Diagnostic Workup
- Abdominal xray
  - 15% stones visualized
  - Pigmented stones usually radiopaque
- RUQ Ultrasound
  - Examines liver and bile duct
  - Calcified and non-calcified stones
  - Limited by small size
- Endoscopic ultrasound
  - No size limitation
  - Closer examination of bile ducts
  - Limited liver examination
Cholelithiasis

Stone Sludge & Stone

www.med-ed.virginia.edu

Treatment

- Surgery
  - Only if symptomatic, unless
    1. Calcified gallbladder
    2. Sickle cell anemia
- Ursodiol not proven effective
- No medications proven effective
- Not clear if avoiding fatty foods reduces symptoms

Choledocholithiasis

- Usually form in the GB and migrate into the duct
- Exceptions
  - Stasis in the duct (stricture/stenosis)
  - Increased bilirubin within the bile (ie chronic hemolytic anemia)
**Choledocholithiasis**

- **Symptoms**
  - Asymptomatic
  - Cholangitis
    - Fever
    - Jaundice
    - Pain
    - Hypotension
    - Confusion
  - Abnormal LFT
    - Hyperbilirubinemia
    - Elevated Alkaline Phosphatase
    - +/- Transaminitis

  [Charcot’s Triad ⊂ Reynolds’ Pentad]

**Choledocholithiasis**

- **Laboratory Findings: Cholestatic Pattern**
  - WBC usually elevated
  - Elevated bilirubin (primarily conjugated)
  - Elevated alkaline phosphatase
  - Elevated glutamyl transpeptidase (GGT)
  - Normal to mildly elevated aspartate aminotransferase (AST) and alanine aminotransferase (ALT)

**Choledocholithiasis**

- **Imaging**
  - Primary diagnostic modality
  - Ultrasonography
    - Cutaneous
    - Endoscopic ultrasound
  - MRI/MRCP
  - Endoscopic Retrograde Cholangiopancreatography (ERCP)
  - Percutaneous Cholangiogram (PTC)

**Choledocholithiasis**

- **Imaging**
  - Primary diagnostic modality
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**ERCP**

- Side-viewing endoscope passed through the mouth into the second portion of duodenum.
- Major papilla identified and catheter inserted with injection of contrast
- Fluoroscopy utilized to visualize the biliary tree
- Can evaluate for stenosis, filling defects (stones), bile leak

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**Choledocholithiasis ERCP**

**NORMAL**

**CHOLEDOCHOLITHIASIS**

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**ERCP**

| Abnormal major papilla | Sphincterotomy |

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**Choledocholithiasis ERCP – Basket Retrieval**
Choledocholithiasis
Balloon extraction

www.daveproject.org

ERCP

- Highly sensitive and specific for stones
  - 90% sensitivity; 98% specificity
- Offers therapeutics in addition to diagnosis
- Complications
  - Pancreatitis (2-10%)
  - Perforation
  - Bleeding
  - Duct disruption

MRCP

- Magnetic Resonance Cholangiopancreatography
- MRI visualization of the bile duct and pancreatic duct
- T2 weighted imaging – water content
- High Sensitivity and Specificity for stones
- Visualization of abdominal anatomy: pancreas, liver, etc.
### MRCP

- Romaguolo et al Ann Int Med 2003
  - Meta-analysis
  - 92% sensitivity for stones
  - 88% sensitivity for mass

- **Drawbacks**
  - Decreased sensitivity for small stones with normal duct size
  - Unable to sample tissue
  - Poor imaging of ampulla of vater
  - Claustrophobic patients
  - Metal prostheses or implantable devices
  - Contrast

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### Endoscopic Ultrasound

- Ultrasound probe at the end of an endoscope
- Maximum depth of penetration: 5-7cm
- Endoscopic ultrasound – minimal barrier between probe and target (i.e. skin, muscle, fat, bowel, peritoneal cavity)
  - Advantage over percutaneous U/S
  - Improved resolutions
- Frequency adjustable
  - Low frequency: greater depth of penetration, less resolution
  - High frequency: less depth of penetration, high resolution
- Doppler available on both linear and radial echoendoscopes
  - Vascular assessment
Endoscopic Ultrasound

Normal Pancreas Body/Tail

Image not available

EUS
<table>
<thead>
<tr>
<th>Normal CBD</th>
<th>Endoscopic Ultrasound Fine Needle Aspiration</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="Normal_CBDD.png" alt="Image" /></td>
<td><img src="Endoscopic_Ultrasound_Fine_Needle_Aspiration.png" alt="Image" /></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Stone</th>
<th>Pancreas Mass</th>
</tr>
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<tbody>
<tr>
<td><img src="Stone.png" alt="Image" /></td>
<td><img src="Pancreas_Mass.png" alt="Image" /></td>
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</tbody>
</table>
Endoscopic Ultrasound

- Garrow et al. 2007
  - Meta-analysis
    - Sensitivity: 89%; Specificity: 94%
- Tse et al. 2008
  - Meta-analysis
    - Sensitivity: 94%; Specificity: 95%
- Safe procedure
  - Basic endoscopy risks
  - Minimal risk of FNA
- High accuracy for mass identification and malignant diagnosis (w/ FNA and cytology)
- Identification of microlithiasis
  - Tandon 2001 Am J Gastro
  - Use of EUS able to diagnose etiology in 21 of 31 idiopathic pancreatitis cases
  - 16% with microlithiasis

Recommendations Cholelithiasis Workup

- High suspicion
  - Abnormal LFT
  - Ductal dilation
  - Acute gallstone pancreatitis
  - ERCP
- Intermediate suspicion
  - EUS
- Low suspicion
  - MRCP

EUS vs MRCP

- Both high positive and negative predictive value
- Both diagnostic w/o therapeutic benefit
- Both safe procedure
- EUS better for detection/biopsy of small tumors
- EUS better for evaluation for microlithiasis
- EUS better for ampullary evaluation (endoscopic and sonographic)

Summary

- Careful history and physical examination can be a pivotal component in diagnosis of gallstone disease
- While cholelithiasis is often easily diagnosed via RUQ ultrasound, choledocholithiasis can be more difficult
- The diagnostic workup and management of choledocholithiasis depends highly on the level of clinical suspicion
- EUS and MRCP are safe and accurate alternatives to ERCP for diagnosis of choledocholithiasis.
- EUS offers added feature of identification and biopsy of small malignant lesions of the distal bile duct, pancreas head or ampulla that are often not identified on MRCP or CT.
- ERCP should be used as initial modality only if pretest probability is high.
Gallstone and Bile Duct Disease

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Division of General and Gastrointestinal Surgery
The Ohio State University Wexner Medical Center

Common Bile Duct Stones
The Problem

Strategies

Common bile duct stones can be managed/removed...
Pre-operatively
Intra-operatively
Post-operatively
Procedurally (no operation at all)

Strategies - Endoscopic

- Selective Preop ERCP
  - Cost-effective if > 80% probability
- Selective Post-op ERCP
- Intraoperative ERCP
**Strategies - Operative**

- Open common bile duct exploration
- LSCBDE
  - Transcystic Duct (TCCBDE)
  - LS Choledochotomy (LSCD)

**Open Common Bile Duct Exploration**

**Technical considerations:**

- Transcholedochal
- t-tube
- Drainage

**Strategies - Other**

- Percutaneous transhepatic stenting and removal +/- YAG laser fragmentation or EHL
- Laparoscopic assisted transgastric ERCP in post gastric bypass patients

**Common Bile Duct Stones**

- T-tube drainage
**Common Bile Duct Stones**

<table>
<thead>
<tr>
<th>T-tube drainage: Principles</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Stenting of sphincter of Oddi</td>
</tr>
<tr>
<td>2. Long t-tube tract</td>
</tr>
<tr>
<td>3. Elimination of downstream obstruction</td>
</tr>
</tbody>
</table>

**Laparoscopic Common Bile Duct Exploration**

<table>
<thead>
<tr>
<th>Technical considerations:</th>
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<tbody>
<tr>
<td>Experience in advance L/S techniques</td>
</tr>
<tr>
<td>Instrumentation: L/S choledochoscope and supporting instruments</td>
</tr>
<tr>
<td>Time</td>
</tr>
</tbody>
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**Laparoscopic Common Bile Duct Exploration**

<table>
<thead>
<tr>
<th>Technical considerations:</th>
</tr>
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<tbody>
<tr>
<td>Transcystic</td>
</tr>
<tr>
<td>+/− balloon dilation cystic duct stump</td>
</tr>
<tr>
<td>Simple closure of cystic duct</td>
</tr>
<tr>
<td>Transcholedochal</td>
</tr>
<tr>
<td>t-tube</td>
</tr>
<tr>
<td>L/S suturing techniques</td>
</tr>
</tbody>
</table>

**Evaluation of Techniques**

- Effectiveness
- Technical Complexity/Experience
  - Cost
CBDS: The Evidence

CBDS Randomized Trial
LSCBDE vs Postop ERCP

- Initial Clearance Rates 75%
- Final Duct Clearance 100% vs 93%
- Morbidity
  - LSCBDE 7/40 (18%) {3 bile leaks}
  - Postop ERCP 6/40 (15%) {1 bile leak}
- Hospital Stay
  - LSCBDE 1 day (1-26)
  - Postop ERCP 3.5 days (1-11)

CBDS Randomized Trial
Criticism

- No prospective calculation of sample size
- Failure to evaluate quality of life and economic impact
- ERCP results poor relative to reported literature (95% success)
- Hospital stay could depend on timing of ERCP
- Results of LSCBDE cannot be generalized

CBDS Survey
8,433 cases in Germany

- Morbidity 14%
- Mortality 0.6%
- Incidence of CDE
  - 1991 7.4%
  - 1998 3.8%
- Surgeons prefer Postop ERCP (93%)
- LSCBDE does not play a role in Germany

HuttI,TP et al Zentralbl Chir 2002
CBD Stones
Surgeon Experience

- 2434 general surgeons
- # procedures on recertification
Application
- Mean # Cholecystectomies/ Yr = 36
- Mean # CBDE/ Yr = 2
Conclusion: Surgeon experience unlikely to support LSCBDE

LSCBDE vs Postop ERCP
A Decision Analysis

Urbach DR et al Surg Endosc 2001 15: 4-13
Structure of the Decision Model
Assumptions
Estimation of Probabilities

LSCBDE vs Postop ERCP
Assumed Probabilities LSCBDE

IOC Success  94% (80-100)
Sensitivity  89% (80-100)
Specificity  99% (80-100)
Transcystic Success  81% (60-100)
Bile Leak  1.3% (0-5)
LSCBDE Success  67% (40-100)
Bile Leak  2.6% (0-5)
Conversion to Open  56% (0-100)
### LSCBDE vs Postop ERCP

#### Assumed Probabilities ERCP

<p>| | | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>IOC Success</td>
<td>94%</td>
<td>(80-100)</td>
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<tr>
<td>Specificity</td>
<td>99%</td>
<td>(80-100)</td>
</tr>
<tr>
<td>ERCP Success</td>
<td>98%</td>
<td>(80-100)</td>
</tr>
<tr>
<td>Severe Complications</td>
<td>1.1%</td>
<td>(0-5)</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>90%</td>
<td>(80-100)</td>
</tr>
<tr>
<td>Specificity</td>
<td>100%</td>
<td>(80-100)</td>
</tr>
<tr>
<td>Stone Clearance</td>
<td>91%</td>
<td>(80-100)</td>
</tr>
</tbody>
</table>

#### Base Case Cost Assumptions

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Cost</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagnostic ERCP</td>
<td>$1441</td>
<td>(500-2000)</td>
</tr>
<tr>
<td>Therapeutic ERCP</td>
<td>$1971</td>
<td>(1000-3000)</td>
</tr>
<tr>
<td>IOC</td>
<td>$368</td>
<td>(250-1000)</td>
</tr>
<tr>
<td>Transcystic CBDE</td>
<td>$1094</td>
<td>(500-2000)</td>
</tr>
<tr>
<td>LSCBDE(&quot;otomy&quot;)</td>
<td>$1769</td>
<td>(1000-3000)</td>
</tr>
<tr>
<td>Open Chole(conversion)</td>
<td>$1794</td>
<td>(1000-3000)</td>
</tr>
<tr>
<td>Complication Bile Leak</td>
<td>$1178</td>
<td>(500-3000)</td>
</tr>
<tr>
<td>Complication ERCP</td>
<td>$5478</td>
<td>(2000-20000)</td>
</tr>
</tbody>
</table>

### LSCBDE vs Postop ERCP

#### Incremental Cost vs LS Chole

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>LSCBDE</td>
<td>$487.50</td>
</tr>
<tr>
<td>Postop ERCP</td>
<td>$550.10</td>
</tr>
</tbody>
</table>

(LSCBDE (Savings)/Cost $62.60)

#### Cost-Effectiveness Ratio

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>LSCBDE</td>
<td>$496.81</td>
</tr>
<tr>
<td>Postop ERCP</td>
<td>$563.59</td>
</tr>
</tbody>
</table>

{ Routine Preop ERCP 1518.85}
Laparoscopic Common Bile Duct Exploration vs. ERCP: Cost Analysis

Pre-op ERCP > Intra or post-op management of CBDS whether open or L/S

**Laparoscopic Common Bile Duct Exploration vs. ERCP: Cost Analysis**

Intra-op or Post-op ERCP are the most cost effective when skills or instruments to perform L/S CBDE are not available


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**Laparoscopic Common Bile Duct Exploration What you should do!**

ERCP and clearance of duct for “known” CBDS pre-operatively

Attempt to learn advanced laparoscopic techniques in the event an unsuspected CBDS is found at laparoscopic cholecystectomy

Duct clearance (open or L/S techniques) and/or confirmation (IOC) at the time of surgery

---

**Laparoscopic Common Bile Duct Exploration What is really done out there!**

Pre-op ERCP w/ attempts to clear the CBD

Open or L/S CBDE with placement of t-tube if stones remain at cholecystectomy (variable experience)

+- Post-op ERCP

---

**Laparoscopic Common Bile Duct Exploration What you should do?**

Little or no role to leave stones in place and reliance on post-op ERCP for removal unless experience dictates otherwise
<table>
<thead>
<tr>
<th>Complications …</th>
<th>Complications Related Solely to Cholecystectomy…</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bile leak</td>
<td>• Bile leak</td>
</tr>
<tr>
<td>Common bile duct injury</td>
<td>– Common Bile duct, cystic, hepatic or accessory ducts</td>
</tr>
<tr>
<td>Retained stones</td>
<td>• Bile duct injuries</td>
</tr>
<tr>
<td>Infection/Abscess</td>
<td>– Complete transection, partial transection</td>
</tr>
<tr>
<td>Bleeding</td>
<td>• Bowel injuries</td>
</tr>
<tr>
<td></td>
<td>– Duodenum, colon, small bowel</td>
</tr>
<tr>
<td></td>
<td>• Vascular injuries</td>
</tr>
<tr>
<td></td>
<td>– Hepatic arteries, portal vein</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SILS Cholecystectomy</th>
<th>Other Issues to Address Related Solely to Cholecystectomy…</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Conversion to Open is NOT considered a complication</td>
</tr>
<tr>
<td></td>
<td>• Intra-operative Cholangiography</td>
</tr>
<tr>
<td></td>
<td>• Undiagnosed pathology</td>
</tr>
<tr>
<td></td>
<td>– Cancer, liver disease</td>
</tr>
</tbody>
</table>
### Laparoscopic Cholecystectomy...

- Healthy 42 yo female, elective laparoscopic cholecystectomy for symptomatic cholelithiasis
- Re-admitted 3 days post-op with pain and bilirubin of 4.3

### Bile Duct Injury: Transection CT Scan

![CT Scan Image]

### Bile Duct Injury: Transection HIDA Scan

![HIDA Scan Image]

### Bile Duct Injury: Transection ERCP

![ERCP Image]
<table>
<thead>
<tr>
<th>Bile Duct Injury: Transection ERCP</th>
<th>Bile Duct Injury: Transection Intra-Operative</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /></td>
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</table>

<table>
<thead>
<tr>
<th>Bile Duct Injury: Transection PTC</th>
<th>Bile Duct Injury: Transection Intra-Operative Cholangiogram</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image3.png" alt="Image" /></td>
<td><img src="image4.png" alt="Image" /></td>
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</table>
### Bile Leak and/or Injury

<table>
<thead>
<tr>
<th>Drain it...</th>
<th>Internal and External drainage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Internal Drainage</strong>...</td>
<td>– ERCP, PTC</td>
</tr>
<tr>
<td><strong>External Drainage</strong>...</td>
<td>– Control of all bile collections</td>
</tr>
</tbody>
</table>

### Strategies - Other

- **Percutaneous transhepatic stenting and removal +/- YAG laser fragmentation or EHL**
- **Laparoscopic assisted transgastric ERCP in post gastric bypass patients**

### Bile Leak and/or Injury

<table>
<thead>
<tr>
<th>Fix it...</th>
<th>Primary repair vs. reconstruction</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primary repair with internal/external drainage</strong>...</td>
<td>– T-tube, PTC</td>
</tr>
<tr>
<td><strong>Reconstruction</strong>...</td>
<td>– Roux-en-Y Hepaticojejunostomy*</td>
</tr>
<tr>
<td><strong>– Choledochoduodenostomy</strong></td>
<td></td>
</tr>
</tbody>
</table>

### Percutaneous access and removal of CBDS

- **Percutaneous transhepatic choledochoscopic holmium-YAG laser or EHL ablation of biliary tract calculi is a viable alternative for stone clearance in patients incapable of having their stones removed endoscopically and unable or unwilling to undergo surgery.**
**Case:**

73 yo female, s/p open cholecystectomy with abdominal pain, increased lft’s and ultrasound consistent with choledocholithiasis

Unwilling to undergo an additional operative procedure

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<table>
<thead>
<tr>
<th>PTC</th>
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<tbody>
<tr>
<td>![PTC Image]</td>
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</table>

<table>
<thead>
<tr>
<th>ERCP with ES</th>
</tr>
</thead>
<tbody>
<tr>
<td>![ERCP with ES Image]</td>
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</table>

<table>
<thead>
<tr>
<th>Completion cholangiogram after a single treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>![Completion Image]</td>
</tr>
</tbody>
</table>
Case:

62 yo male, s/p laparoscopic cholecystectomy with abdominal pain, increased lft’s and ultrasound consistent with choledocholithiasis

Physiologically high risk to undergo an additional operative procedure on presentation

Percutaneous choledochoscopic view

PTC

Completion cholangiogram after a single treatment
Laparoscopic assisted transgastric ERCP in post gastric bypass patients