The Impact of Endoscopic Ultrasound

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Objectives
- Understand and identify the role of Endoscopic Ultrasound (EUS) in diagnosis of gastrointestinal disorders.
  - Types of EUS scopes
  - Where is EUS helpful?
- Understand where EUS is used for therapy
  - EUS-directed therapy (FNA, fiducial, celiac plexus block)
  - EUS complementing ERCP
  - As an alternative to surgery and IR

Multidisciplinary Cancer Care Algorithm

Mass/Tumor

Imaging (CT C/A/P)

Multidisciplinary Tumor Approach

Interventional Endoscopy
- Fiducial placement
- Celiac plexus neurolysis
- ERCP with stenting
- Endoscopic stenting

Medical and Radiation Oncology

Surgical Oncology

Nutrition

Palliative Care
**Basic Anatomy: EUS layers**

- **First layer:** Hyperechoic - interface b/w lumen and mucosa
- **Second layer:** Hypoechoic - deep mucosa including muscularis
- **Third layer:** Hyperechoic - submucosa
- **Fourth layer:** Hypoechoic - muscularis propria
- **Fifth layer:** Hyperechoic - adventitia

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**Introduction to EUS Anatomy**

- What can we see and access?
  - Entire pancreas
  - Entire extrahepatic bile duct and bifurcation
  - Left liver and much of the right liver
  - Ampulla
  - Rectum and perirectal areas
  - Adrenals
    - Left is easier than right

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**Introduction to EUS Anatomy**

- What can we see and access?
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  - Ampulla
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  - Adrenals
    - Left is easier than right
EUS Anatomy

- Nodes
  - Celiac
  - Peripancreatic
  - Perigastric/gastrohepatic
  - Hilum of liver
  - Mediastinal
  - Perirectal

Equipment

- Radial
- Linear

Radial Array Endoscope

**Pros:**
- Full 360° scan angle
- Forward-oblique optics
- Color/Power Doppler
- Preferred for tumor staging and submucosal luminal lesions

**Cons:**
- Cannot perform therapeutics
Doppler Images

Pros:
- Scanning range: 180°
- Elevator like ERCP
- Can perform therapeutics/FNA
- Color Doppler & Power Doppler for interpreting blood flow conditions

Cons:
- Not cross-sectional
- Not 360 degrees
- Harder to completely visualize mucosa/submucosa

Linear Echoendoscope

Pros:
- Scanning range: 180°
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- Not cross-sectional
- Not 360 degrees
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Linear Array Echoendoscope

EUS-FNA
**Mini-Probes**

**Pros:**
- Surface evaluations through the scope
- Through therapeutic endoscope
- Used for small or flat lesions because it is easier to localize lesions endoscopically

**Cons:**
- Depth of penetration and evaluation is limited
- Cannot perform therapeutics

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**FNA NEEDLE**

- 25, 22 and 19 gauge
- Disposable
- Variable position locking syringe & stopcock.

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**Core biopsy NEEDLE**

- 25, 22 and 19 gauge
- Disposable
- Variable position locking syringe & stopcock.
- Designed to obtain core tissue
**Technique**

- **Preparation**
  - As for normal upper GI endoscopy
- **Sedation**
  - Fentanyl and midazolam
  - Propofol/GA
- **Antibiotic prophylaxis**
  - Usual indications + biopsy / therapeutics

**Indications**

- **Staging cancers:**
  - Esophageal, gastric, pancreatico-biliary, ampullary, rectal, lung
- **Confirming EMR potential**
  - T1 disease, excluding sub-mucosal involvement
- **Diagnosis and follow up of benign lesions**
  - Submucosal lesions and pancreatic cysts
- **Investigating RUQ pain and pancreatitis**

**Indications**

- **Therapeutic applications:**
  - FNA
  - Fine needle injection: celiac plexus block, fiducial placement
  - Pseudocyst drainage
  - EUS guided ERCP
Tumor Staging and Tissue acquisition

Cancer Staging

*EUS Staging Accuracy Compared to Path*

<table>
<thead>
<tr>
<th>Indication</th>
<th>n</th>
<th>T stage</th>
<th>N stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Esophageal CA</td>
<td>739</td>
<td>85%</td>
<td>79%</td>
</tr>
<tr>
<td>Gastric CA</td>
<td>1163</td>
<td>78%</td>
<td>73%</td>
</tr>
<tr>
<td>Pancreatic CA</td>
<td>155</td>
<td>90%</td>
<td>78%</td>
</tr>
<tr>
<td>Ampullary CA</td>
<td>94</td>
<td>86%</td>
<td>72%</td>
</tr>
<tr>
<td>Rectal CA</td>
<td>19</td>
<td>84%</td>
<td>84%</td>
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</tbody>
</table>
Esophageal Cancer

What is the optimal method for staging?

<table>
<thead>
<tr>
<th>Technique</th>
<th>No. of patients</th>
<th>T accuracy (%)</th>
<th>N accuracy (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT</td>
<td>1154</td>
<td>65 (60–70)</td>
<td>54 (68–71)</td>
</tr>
<tr>
<td>EUS</td>
<td>1035</td>
<td><strong>85 (59–92)</strong></td>
<td>77 (50–90)</td>
</tr>
</tbody>
</table>

Hawes & Fockens, Endosonography 2007

Esophageal Cancer

T1 N0 Disease

T3 N1 Disease

Referred for EMR
Esophageal Cancer

T1 N1 Disease

FNA of 7 mm periesophageal node

Esophageal Cancer

- What does EUS add?
  - EUS is superior to CT for T- and N-staging
  - EUS-FNA allows for documentation of lymph node status
  - EUS/EUS-FNA should be done in all patients in whom resection is being considered
EUS plays a large role in gastric cancer staging

- **Primary Role:** Selecting tumors appropriate for EMR, superior for T staging
- **Secondary Role:** complementing CT for N staging

### T Staging of EUS vs. CT & MRI

<table>
<thead>
<tr>
<th>Year</th>
<th>n</th>
<th>EUS</th>
<th>CT</th>
<th>MRI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kuntz et al., Semin Surg</td>
<td>1999</td>
<td>82</td>
<td>73%</td>
<td>51%</td>
</tr>
<tr>
<td>Polowski et al., Endoscopy</td>
<td>2004</td>
<td>88</td>
<td>63%</td>
<td>44%</td>
</tr>
<tr>
<td>Bhandari et al., GIE</td>
<td>2004</td>
<td>63</td>
<td>88%</td>
<td>83%</td>
</tr>
</tbody>
</table>

- Early Gastric Cancer: 60-75% survival
- Advanced Gastric Cancer: 20-35% survival
Gastric Disease- Large Gastric Folds

- EUS is the most accurate imaging method
- Dictates management
  - Do nothing
  - Endoscopic biopsy
  - Snare biopsy
  - FNA

Causes of Thick Gastric Folds

- "MALT Lymphoma"
- "Linitis Plastica"
- Menetrier’s Disease
- "H pylori infection"
- Zollinger-Ellison Syndrome
- "Gastric Varices"
- Eosinophilic gastritis
- Granulomatous gastritis
- Gastritis cystica profunda
- GAVE
- Kaposi’s sarcoma
- Gastric anisakiasis

Gastric Disease- Large Gastric Folds

Pt with perforated DU + large gastric folds

Zollinger-Ellison Syndrome

Pt with cerebiform stomach, hypoalbuminemia, anemia, and diarrhea

Menetrier’s Disease

MALT Lymphoma
Submucosal Lesions

- Most seen in stomach
- Submucosal lesions often cannot be seen on CT or MRI
- EUS is very good at diagnosing these lesions
  - Layer of origin
  - Internal echo characteristics
  - FNA
- EUS can determine resectability

Gastric disease - Submucosal Gastric Lesions

<table>
<thead>
<tr>
<th>Etiology</th>
<th>EUS layers</th>
<th>EUS appearance</th>
</tr>
</thead>
<tbody>
<tr>
<td>GISTs</td>
<td>4th or 2nd</td>
<td>Hypoechoic mass</td>
</tr>
<tr>
<td>Aberrant pancreas</td>
<td>2nd, 3rd, and/or 4th</td>
<td>Hypoechoic or mixed echogenicity</td>
</tr>
<tr>
<td>Lipoma</td>
<td>3rd</td>
<td>Hyperechoic</td>
</tr>
<tr>
<td>Carcinoids</td>
<td>2nd and/or 3rd</td>
<td>Mildly hypoechoic, homogenenous</td>
</tr>
<tr>
<td>Granular cell tumor</td>
<td>2nd or 3rd</td>
<td>Homogenous mass w/ smooth borders</td>
</tr>
<tr>
<td>Cysts</td>
<td>3rd</td>
<td>Anechoic, round or oval</td>
</tr>
<tr>
<td>Varices</td>
<td>3rd</td>
<td>Anechoic, tubular, serpiginous</td>
</tr>
<tr>
<td>Inflammatory polyp</td>
<td>2nd &amp;/or 3rd</td>
<td>Hypoechoic, homogenous</td>
</tr>
<tr>
<td>Glomus tumor</td>
<td>3rd or 4th</td>
<td>Hypoechoic, smooth margin</td>
</tr>
<tr>
<td>Metastatic deposits</td>
<td>Any or all</td>
<td>Hypoechoic, heterogenous</td>
</tr>
</tbody>
</table>

Gastric disease - Submucosal Gastric Lesions

- Malignant GIST
- Carcinoid
Gastric disease- Submucosal Gastric Lesions

| Lipoma | Varices |

EUS for Pancreatic Tumors

- Sensitivity = 90%
- Specificity = 100%
- Accuracy = 94%
- For lesions as small as sub-cm
- Yield is enhanced with on-site cytopathologist
- FNA primary tumor, LNs, & liver lesions
- Evaluate for vascular invasion


EUS Advantages over CT-guided Biopsy

- Ability to sample lesions (including lymph nodes) too small to be identified by US, CT or MRI
- Minimizing the risk of needle track seeding
- Ability to obtain accurate local staging
Pancreatic mass FNA

Neuroendocrine lesions: Insulinoma

Hepatobiliary Disease-
Pancreatic Cysts

- Pancreatic cystic lesions once thought rare are now much more common due to MD-CT/MRI
- EUS plays a critical role in differentiating benign vs. malignant lesions
Pancreatic Cysts

How can EUS make a diagnosis?
- Cyst Morphology: is suggestive but not diagnostic
  - Solid/cystic mass
  - Thick wall
- Dilated pancreatic duct
- Intramural growth
- FNA Cytology: high variability
  - Sensitivity 55% - 89%
- Cyst fluid tumor markers:
  - CEA, CA 19-9, CA 72-4, CA 125 & CA 15-3
  - Accuracy of CEA (79%) vs. Morphology (51%) vs. Cytology (59%)

Pancreatic Cysts

Simple Cyst
Thin-walled, no solid component, no debris and normal surrounding pancreas

Pseudocyst
Thin-walled anechoic cyst

Serous Cystadenoma
"honeycombs" appearance
Multiple small, microcysts
Often may have a central calcification

Mucinous Cystadenoma
Papillary projections into the cyst cavity
Pancreatic cyst FNA

Hepatobiliary Disease-
Chronic Pancreatitis

- Diagnosis of chronic pancreatitis can be difficult
- Abdominal Imaging (CT & MRI) for advanced disease
- ERCP has risks & is best in advanced disease
- EUS is highly accurate in the diagnosis of chronic pancreatitis and is relatively non-invasive

Chronic Pancreatitis

<table>
<thead>
<tr>
<th>EUS Criteria for diagnosing Chronic Pancreatitis</th>
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<tbody>
<tr>
<td>Parenchymal Criteria</td>
</tr>
<tr>
<td>Hyperechoic Foci</td>
</tr>
<tr>
<td>Hyperechoic Strands</td>
</tr>
<tr>
<td>Hypoechoic Lobules</td>
</tr>
<tr>
<td>Cysts</td>
</tr>
<tr>
<td>Ductal Criteria</td>
</tr>
<tr>
<td>Dilatation</td>
</tr>
<tr>
<td>Dilated Side Branches</td>
</tr>
<tr>
<td>Main Duct Irregularity</td>
</tr>
<tr>
<td>Hyperechoic Duct Margins</td>
</tr>
<tr>
<td>Stones</td>
</tr>
</tbody>
</table>
Chronic Pancreatitis

How accurate is EUS in making the diagnosis?

- 126 patients with unexplained chronic abdominal pain or suspected chronic pancreatitis
- 126 underwent ERCP & EUS
- PPV > 85%
- More than 6 criteria in moderate to severe disease
- NPV > 85%
- Less than 3 criteria in moderate to severe disease


Hepatobiliary Disease- Bile Duct Stones

- EUS is an excellent non-invasive method to diagnose CBD stones
- EUS sensitivity 81% - 100%
- MRCP sensitivity 87% - 100%
Bile Duct Stones

- Consider EUS to diagnose CBD stones:
  - Patients with mid- to low-probability choledocholithiasis
  - High clinical suspicion but negative MRCP
  - Hospitals with poor MRCP expertise
  - Permanent pacemakers
  - Cerebral aneurysm clips
  - Claustrophobic patients
  - Morbidly obese patients

Hepatobiliary Disease- Bile Duct Tumors

- Malignant CBD strictures
  - Brushings alone have poor yield (desmoplastic)
  - EUS allows:
    - Evaluation of stricture
    - Locoregional staging
    - FNA for diagnosis
Hepatobiliary Disease- Ampullary Tumors

- **Ampullary Tumors**
  - EUS T-staging accuracy 78%
  - EUS N-staging accuracy 62%
  - Superior to CT and MRI
  - If diagnosed early can be removed endoscopically

Cannon et al., GIE. 1999; 49:349-357

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Anorectal Disease- Rectal Cancer

- **What is EUS role in Rectal Cancer?**
  - **T-staging**: EUS is superior to CT & MRI
    - EUS accuracy: 85%
    - CT accuracy: 65-75%
    - MRI accuracy: 75-85%
  - **N-staging**: EUS is not superior to CT & MRI
    - EUS accuracy: 75%
    - CT/MRI accuracy: 70-80%


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Rectal Cancer

- **T3 N0 lesion**
  - [Image]

- **T1 N1 lesion**
  - [Image]
Perivaginal mass FNA

Anorectal Disease- Anal Sphincter Abnormalities

- EUS is a simple and accurate test to evaluate the Internal & External anal sphincters
- EUS is able to image sphincter defects
- Rectal EUS is probably the single most important test for patients with fecal incontinence

Anorectal Disease- Anal Sphincter

Normal | Anterior defect IAS & EAS
Anorectal Disease- Anal Sphincter Abnormalities

25 yo female s/p obstetric injury from delivering a 5 Kg baby

Anteriorly- No IAS, No EAS

55 yo female with fecal incontinence developing years after vaginal delivery with obstetric trauma

Non-small cell lung cancer

- Can EUS be used to aid in Lung Cancer staging?
  - Assess for lymph node metastases
  - Assess mediastinal tumor invasion
  - Provide tissue diagnosis in lung tumors adjacent to the mediastinum

Lung mass FNA
Malignant Mediastinal Masses

<table>
<thead>
<tr>
<th>Reference</th>
<th>Year</th>
<th>n</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
<th>Accuracy (%)</th>
<th>PPV</th>
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</thead>
<tbody>
<tr>
<td>Giovannelli et al.</td>
<td>1995</td>
<td>24</td>
<td>81</td>
<td>100</td>
<td>83</td>
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<tr>
<td>Silver et al.</td>
<td>1996</td>
<td>27</td>
<td>84</td>
<td>100</td>
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<td>Gess et al.</td>
<td>1997</td>
<td>52</td>
<td>95</td>
<td>86</td>
<td>94</td>
<td>-</td>
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<td>Hanzer et al.</td>
<td>1998</td>
<td>29</td>
<td>89</td>
<td>82</td>
<td>87</td>
<td>-</td>
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<tr>
<td>Soria et al.</td>
<td>1998</td>
<td>25</td>
<td>85</td>
<td>100</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Wietrzcinska et al.</td>
<td>2005</td>
<td>87</td>
<td>94</td>
<td>100</td>
<td>98</td>
<td>94</td>
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<tr>
<td>Gillies et al.</td>
<td>2005</td>
<td>125</td>
<td>87</td>
<td>100</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Vital et al.</td>
<td>2008</td>
<td>26</td>
<td>86</td>
<td>100</td>
<td>93</td>
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<td>Strambini et al.</td>
<td>2010</td>
<td>19</td>
<td>96</td>
<td>100</td>
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<td>-</td>
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<td>Hernandez et al.</td>
<td>2014</td>
<td>59</td>
<td>-</td>
<td>-</td>
<td>84</td>
<td>-</td>
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<tr>
<td>Aeder &amp; Henriau</td>
<td>2014</td>
<td>56</td>
<td>94</td>
<td>100</td>
<td>94</td>
<td>94</td>
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<tr>
<td>Muhlstedt et al.</td>
<td>2015</td>
<td>74</td>
<td>93</td>
<td>100</td>
<td>91</td>
<td>100</td>
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</table>

Overall 91% 97% 100% 97% 99%


Posterior Mediastinal Masses

- What is the diagnostic accuracy of EUS-FNA in benign mediastinal disease?

<table>
<thead>
<tr>
<th>Diagnostic Accuracy of EUS-FNA for Sarcoidosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference</td>
</tr>
<tr>
<td>--------------------</td>
</tr>
<tr>
<td>Friehscher-Ravens et al.</td>
</tr>
<tr>
<td>Will et al.</td>
</tr>
<tr>
<td>Annema et al.</td>
</tr>
</tbody>
</table>

Overall 90% 95%


Subcarinal LN Linear EUS
### EUS-FNA FOR ADRENAL GLAND EVALUATION

<table>
<thead>
<tr>
<th>STUDY</th>
<th>N</th>
<th>SITE</th>
<th>SUCCESS</th>
<th>PASSES</th>
<th>MALIGNANT %</th>
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</thead>
<tbody>
<tr>
<td>Eloubeidi GIE 2004</td>
<td>31</td>
<td>Left Adrenal</td>
<td>100%</td>
<td>4.5</td>
<td>13/31 (42%)</td>
</tr>
<tr>
<td>Dewitt Endoscopy 2007</td>
<td>38</td>
<td>Left Adrenal</td>
<td>100%</td>
<td>3.6</td>
<td>8/38 (21%)</td>
</tr>
<tr>
<td>Eloubeidi GIE 2008</td>
<td>4</td>
<td>Right Adrenal</td>
<td>100%</td>
<td>4</td>
<td>3/4 (75%)</td>
</tr>
<tr>
<td>Kaul Endoscopy 2012</td>
<td>2</td>
<td>Right Adrenal</td>
<td>100%</td>
<td>5</td>
<td>2/2 (100%)</td>
</tr>
</tbody>
</table>

### ADRENAL MASS FNA: LINEAR ARRAY EUS FNA
Clinical Utility of EUS FNA for Diagnosing Liver Lesions

- Sensitivity of EUS-FNA for the diagnosis of malignancy range from 82 to 94%

EUS FNA: LIVER METASTASIS

Evaluate for liver metastasis

Tissue Acquisition & Staging: Summary

- EUS FNA allows access to anatomically difficult to sample areas
- EUS and FNA has a high accuracy and sensitivity and specificity in tumor staging
- Expands the horizons for further therapeutic interventions:
  - Celiac plexus block
  - Fiducial placement
  - Biliary drainage
Therapeutic Applications of EUS

Pancreatic Pseudocyst Drainage

Indications for Intervention

- **Absolute indications**
  - Symptomatic: pain, rapid enlargement
  - GI Luminal Obstruction
  - Complications: infection, bleeding

- Traditionally drained by surgery or percutaneously by IR

- Current standard is EUS-guided approach
Clash of the Titans: Endoscopy vs Surgery

Pancreatic Pseudocyst Drainage
Endoscopic vs Surgical: RCT

- Lower post procedural hospital stay 2.65 vs 6.5 days
- Direct cost saving of $5,738 per case in the EUS group
- In complex pseudocysts endoscopy may be employed but surgery can be considered first line in appropriate patients.
- Complications: Infection (0% – 8%), bleeding (0% - 5%), retroperitoneal perforation (0% - 5%)


Pseudocyst Drainage: Summary

- Endoscopic management is considered first-line therapy and is effective
- Endoscopic drainage can be accomplished with minimal morbidity and does not complicate surgical approach.
- Not all peripancreatic cysts are pseudocysts
- Close co-operation between the TITANS……!!!!!
EUS Fine Needle Injection: Pain management & Fiducial placement

 Patients with pancreatic cancer and chronic pancreatitis often have severe debilitating pain
 Pain is mediated through neurons in the celiac plexus
 Injection of medications into this nerve plexus can provide pain relief
 Traditionally has been performed under CT guidance
 EUS guided approach is now standard

Celiac Plexus Block & Neurolysis

- Patients with pancreatic cancer and chronic pancreatitis often have severe debilitating pain
- Pain is mediated through neurons in the celiac plexus
- Injection of medications into this nerve plexus can provide pain relief
- Traditionally has been performed under CT guidance
- EUS guided approach is now standard

EUS-Guided Celiac Plexus Block or Neurolysis

- Celiac Plexus Block – injection of steroids (triamcinolone)/long acting anesthetic (bupivacaine)
- Celiac Neurolysis – injection of ethanol
- EUS allows real time imaging and visualization of celiac ganglion & vascular structures
Gold fiducial placement for Cyberknife frameless radiation

- Traditionally placed by CT or surgery
- With advent of EUS fiducials can be easily and safely placed in:
  - Pancreas
  - Celiac nodes
  - Adrenal glands
  - Mediastinum


EUS guided fiducial placement

EUS guided Fiducial placement
EUS-FNI: Summary

- EUS allows for safe and feasible access to celiac plexus and ganglion for neurolysis or block.
- Gold fiducials can be safely placed in mediastinal and abdominal malignancy with EUS access.
- Highly targeted radiotherapy can be delivered.

Palliation of Jaundice

If ERCP fails, is there an alternative to PTC or surgical drainage?

EUS Guided ERCP!

EUS Guided Biliary & Pancreatic drainage

- ERCP fails in 3-12% of cases:
  - Difficult/ altered anatomy
  - Tumor at ampulla
- EUS guided rendezvous is feasible and has a pooled success rate of 83%.
Summary

- Interventional EUS has revolutionized medical-surgical management
- Significant shift in management paradigms
- Multidisciplinary management is critical
- Significant advantage in era of health care reform
- Minimally invasive therapeutic EUS options continue to develop
- This is just the beginning…!!!