The Impact of Endoscopic Ultrasound

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Truptesh H. Kothari, MD; MS
Assistant Professor, Medicine
Interventional Endoscopist, Strong Memorial and Highland Hospital
Director, Developmental Endoscopy Lab at UR (DELUR)
Division of Gastroenterology & Hepatology
University of Rochester Medical Center , Rochester NY

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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

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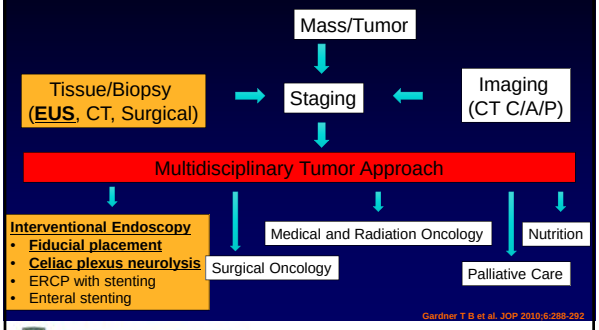
Multidisciplinary Cancer Care Algorithm



Gardner T B et al. JOP 2010;6:288-292

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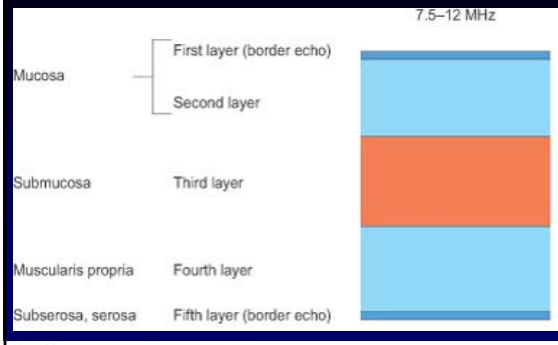
Basic Anatomy: EUS layers



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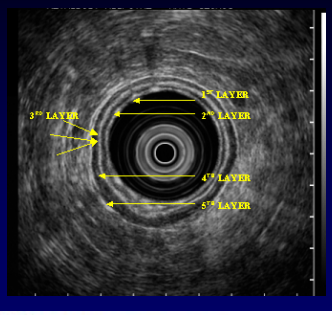
Basic Anatomy: EUS layers



First layer: Hyperechoic- interface b/w lumen and mucosa

Second layer: Hypoechoic- deep mucosa including muscularis

Third layer: Hyperechoic- submucosa

Forth layer: Hypoechoic- muscularis propria

Fifth layer: Hyperechoic- adventitia

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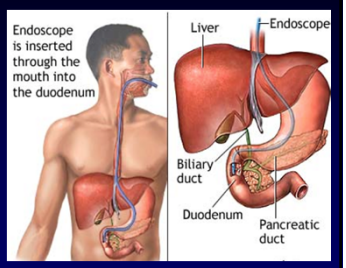
Introduction to EUS Anatomy

- 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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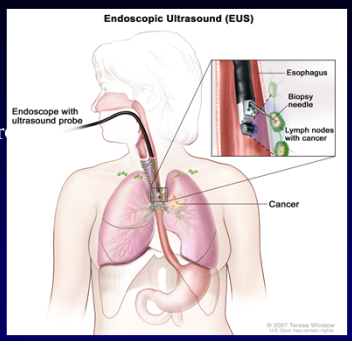
EUS Anatomy

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



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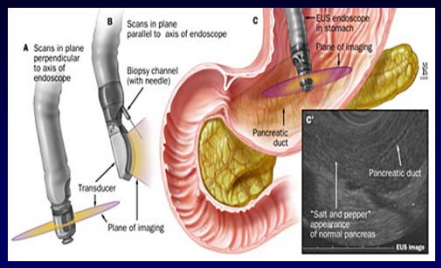
Equipment

- Radial
- Linear



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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

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Doppler Images

Color Doppler (Color Flow)

Power Doppler

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Linear Echoendoscope

- **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

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Linear Array Echoendoscope EUS-FNA

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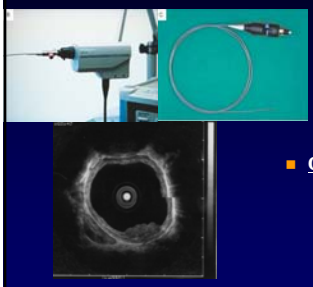
Mini-Probes



- **Pros:**
  - Surface evaluations through the scope
  - Through therapeutic endoscope
  - Used for small or flat lesions b/c 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

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Technique

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

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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

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Indications

- Therapeutic applications:
  - FNA
  - Fine needle injection: celiac plexus block, fiducial placement
  - Pseudocyst drainage
  - EUS guided ERCP

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Tumor Staging and Tissue acquisition

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Cancer Staging

EUS Staging Accuracy Compared to Path

Indication	n	T stage	N stage
Esophageal CA	739	85%	79%
Gastric CA	1163	78%	73%
Pancreatic CA	155	90%	78%
Ampullary CA	94	86%	72%
Rectal CA	19	84%	84%

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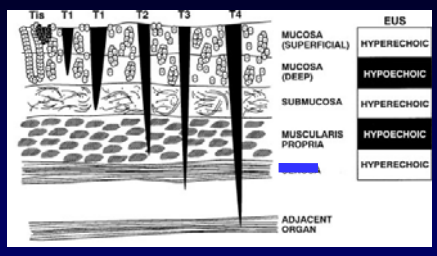
Esophageal Cancer



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Esophageal Cancer

What is the optimal method for staging?

COMPARISON OF ACCURACY OF CT AND EUS IN THE LOCOREGIONAL STAGING OF ESOPHAGEAL CANCER

Technique	No. of patients	T accuracy (%)	N accuracy (%)
CT	1154	45 (40–50)	54 (48–71)
EUS	1035	85 (59–92)	77 (50–90)

Hawes & Fockens, Endosonography 2007.

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Esophageal Cancer

T1 N0 Disease

T3 N1 Disease

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Esophageal Cancer

Referred for EMR

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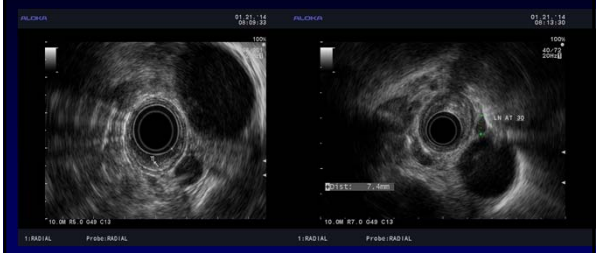
Esophageal Cancer



T1 N1 Disease

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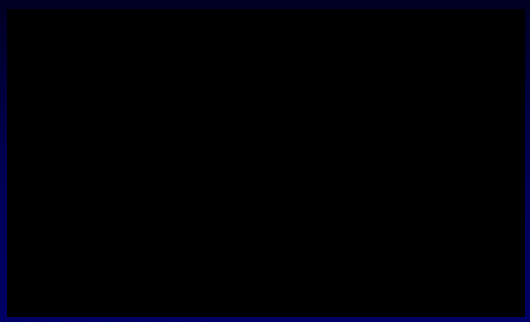
FNA of 7 mm periesophageal node



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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

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Gastric disease- Gastric Cancer

- 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

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Gastric disease- Gastric Cancer

T Staging of EUS vs. CT & MRI

	Year	*n*	EUS	CT	MRI
Kuntz et al., Semin Surg	1999	82	73%	51%	48%
Pollowski et al.,	2004	88	63%	44%	-
Endoscopy	2004	63	88%	83%	-
Bhandari et al., GIE					
			75%	59%	48%

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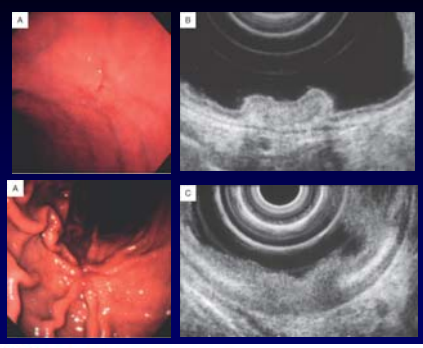
Gastric disease- Gastric Cancer



Early Gastric Cancer
60-75% survival

Advanced Gastric Cancer
20-35% Survival

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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

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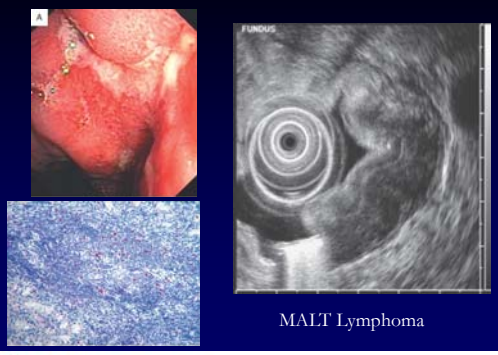
Gastric Disease- Large Gastric Folds



MALT Lymphoma

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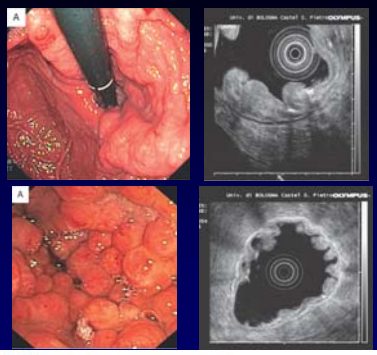
Gastric disease- Large Gastric Folds



Pt with perforated DU + large gastric folds

Zollinger-Ellison Syndrome

Pt with cerebreform stomach, hypoalbuminemia, anemia, and diarrhea

Menetrier's Disease

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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

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Gastric disease- Submucosal Gastric Lesions

Etiology	EUS layers	EUS appearance
GISTs	4th or 2nd	Hypoechoic mass
Aberrant pancreas	2nd, 3rd, and/or 4th	Hypoechoic or mixed echogenicity
Lipoma	3rd	Hyperechoic
Carcinoids	2nd and/or 3rd	Mildly Hypoechoic, homogenous
Granular cell tumor	2nd or 3rd	Homogenous mass w/ smooth borders
Cysts	3rd	Anechoic, round or oval
Varices	3rd	Anechoic, tubular, serpiginous
Inflammatory polyp	2nd &/or 3rd	Hypoechoic, homogeneous
Glomus tumor	3rd or 4th	Hypoechoic, smooth margin
Metastatic depositis	Any or all	Hypoechoic, heterogenous

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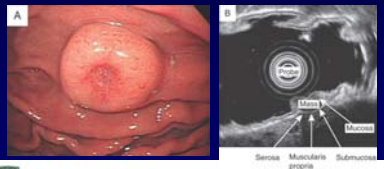
Gastric disease- Submucosal Gastric Lesions

Malignant GIST



Carcinoid

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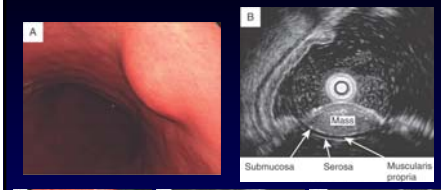
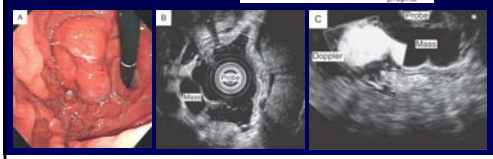
Gastric disease- Submucosal Gastric Lesions



Lipoma



Varices

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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

Faigel et al. J Clin Onc 1997;15:1439-43
Faigle et al. Diagn Cytopath 1998;18:98-109

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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

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Pancreatic mass FNA

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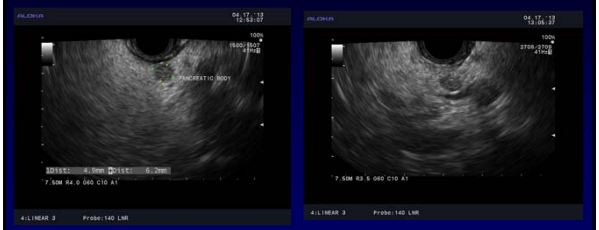
Neuroendocrine lesions: Insulinoma



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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

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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%)

Brugge et al. Gastro 2004 126:1330-36.

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Pancreatic Cysts

Simple Cyst

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

Pseudocyst

Thin-walled anechoic cyst

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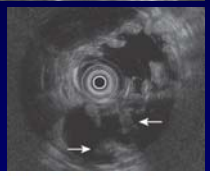
Pancreatic Cysts

Serous Cystadenoma

"honeycomb" appearance
Multiple small, microcysts
Often may have a central calcification



Mucinous Cystadenoma

Papillary projections into the cyst cavity

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Pancreatic cyst FNA

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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

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Chronic Pancreatitis

EUS Criteria for diagnosing Chronic Pancreatitis	
Parenchymal Criteria	Hyperechoic Foci Hyperechoic Strands Hypoechoic Lobules Cysts
Ductal Criteria	Dilatation Dilated Side Branches Main Duct Irregularity Hyperechoic Duct Margins Stones

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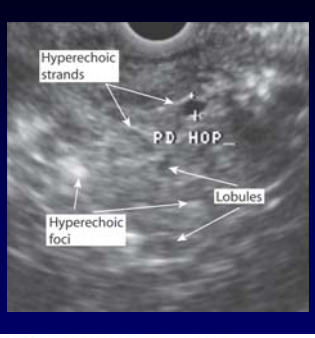
Chronic Pancreatitis



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Chronic Pancreatitis

- How accurate is EUS in making the diagnosis?

126 patients
Unexplained chronic Abd pain
or suspected chronic pancreatitis

↓

126 underwent ERCP & EUS

↙ ↘

NPV > 85%
Less than 3 criteria
In moderate to severe disease

PPV > 85%
More than 6 criteria
in moderate to severe dz

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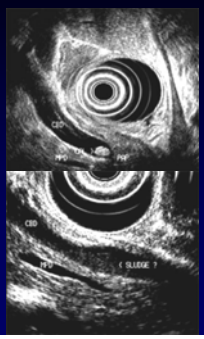
Sahai et al. GIE 1998; 48:18-25.

Hepatobiliary Disease- Bile Duct Stones

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



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Bile Duct Stones

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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

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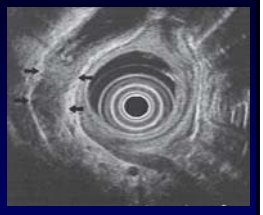
Hepatobiliary Disease- Bile Duct Tumors

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



CBD cholangiocarcinoma

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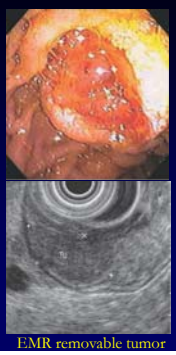
Hepatobiliary Disease- Ampullary Tumors

- 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

EMR removable tumor

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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%

Harewood et al., Am J Gastro 2005; 100:808-816.

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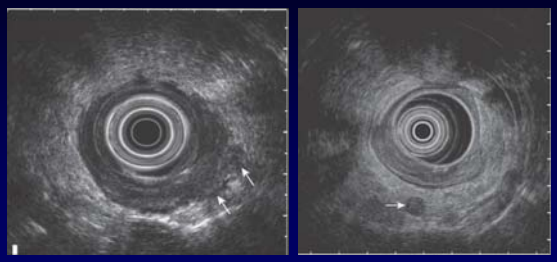
Rectal Cancer

T3 N0 lesion

T1 N1 lesion



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Perivaginal mass FNA

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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

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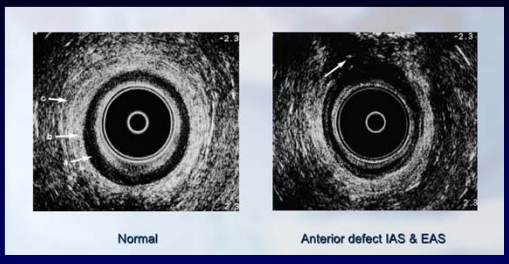
Anorectal Disease- Anal Sphincter



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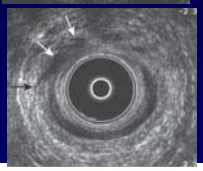
Anorectal Disease- Anal Sphincter Abnormalities



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

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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

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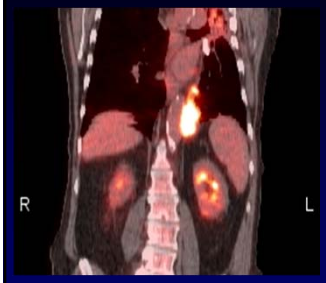
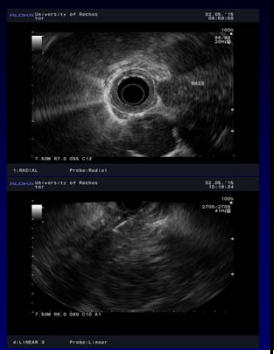
Lung mass FNA





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Malignant Mediastinal Masses

SUMMARY OF STUDIES EVALUATING THE OPERATING CHARACTERISTICS OF EUS-FNA FOR DIAGNOSING MALIGNANT MEDIASTINAL LESIONS

Reference	Year	n	Sensitivity (%)	Specificity (%)	Accuracy (%)	PPV
Giovannini et al.[64]	1995	24	81	100	83	–
Silvestri et al.[65]	1996	27	89	100	–	–
Gress et al.[7]	1997	52	95	81	96	–
Hunerbein et al.[66]	1998	23	89	83	87	–
Serna et al.[67]	1998	21	86	100	–	–
Wiersema et al.[68]	2001	82	96	100	98	94
Fritscher-Ravens et al.[23]	2000	153	92	100	95	–
Wallace et al.[69]	2001	121	87	100	–	–
Devereaux et al.[26]	2002	49	–	–	94	–
Larsen et al.[44]	2002	79	92	100	94	100
Hernandez et al.[70]	2004	59	–	–	84	–
Savides & Perricone[71]	2004	59	96	100	98	100
Eloubeidi et al.[19]	2005	104	93	100	97	100
Overall		91	97	100	97	99

Hawes & Fockens, Endosonography 2007.

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Posterior Mediastinal Masses

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

DIAGNOSTIC ACCURACY OF EUS-FNA FOR SARCOIDOSIS

Reference	Year	n	Sensitivity (%)	Specificity (%)
Fritscher-Ravens et al.[31]	2000	19	100	94
Wildi et al.[33]	2004	28	89	96
Annema et al.[32]	2005	50	82	–
Overall			90	95

Hawes & Fockens, Endosonography 2007.

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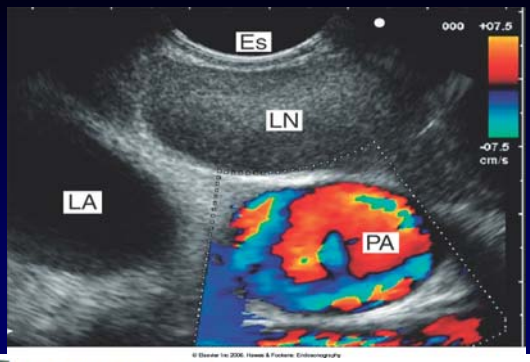
Subcarinal LN Linear EUS



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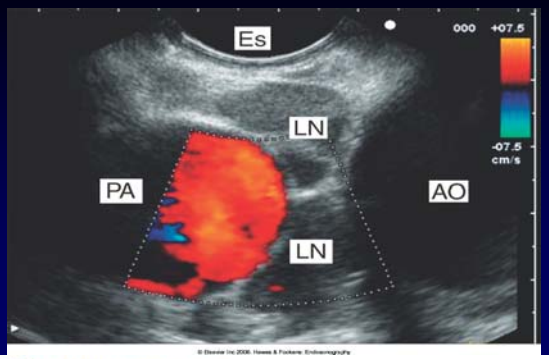
AP Window LN Linear EUS



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EUS-FNA FOR ADRENAL GLAND EVALUATION

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

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ADRENAL MASS FNA: LINEAR ARRAY EUS FNA

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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

DeWitt J et al. Am J Gastroenterol. 2003 Sep;98(9):1976-81

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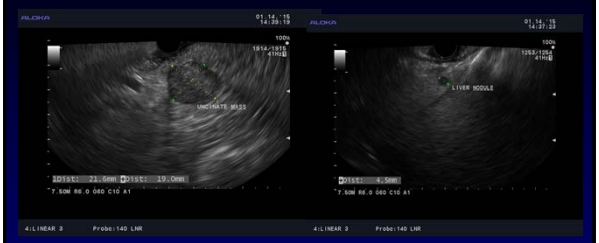
Evaluate for liver metastasis



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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

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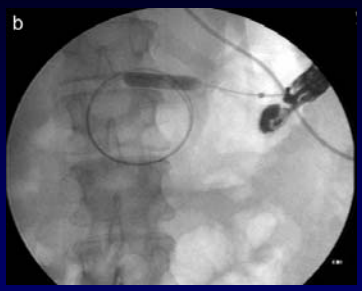
Therapeutic Applications of EUS



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Pancreatic Pseudocyst Drainage

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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**

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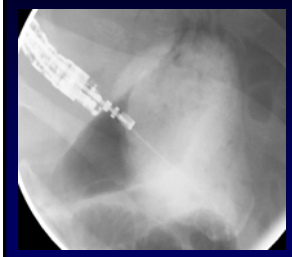
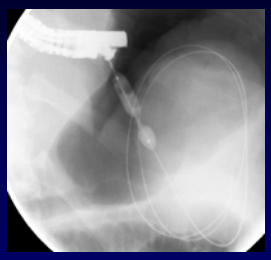
Endoscopic Cystgastrostomy

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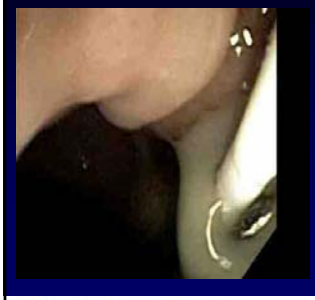
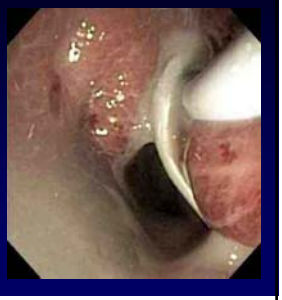
Endoscopic Cystgastrostomy

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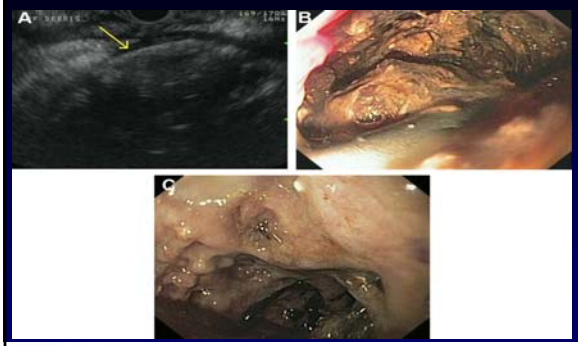
Necrosectomy



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Clash of the Titans: Endoscopy vs Surgery

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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%)

Varadarajulu S, Lopes TL, Wilcox CM, et al. EUS versus surgical cyst-gastrostomy for management of pancreatic pseudocysts. Gastrointest Endosc 2008;68:649–55.

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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……!!!!!

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EUS Fine Needle Injection:

Pain management & Fiducial placement

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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

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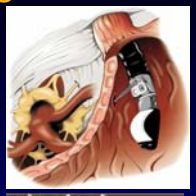
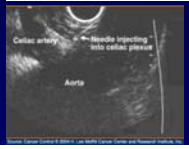
EUS-Guided Celiac Plexus Block or Neurolysis

- Celiac Plexus Block – injection of steroids (triamcinolone)/long acting anesthetic (bupivacaine)
- Celiac Neurolyisis – injection of ethanol
- EUS allows real time imaging and visualization of celiac ganglion & vascular structures





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Gold fiducial placement for Cyberknife frameless radiation

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

Pishvaian AC,et al. Endosc 2006;64(3):412–7.

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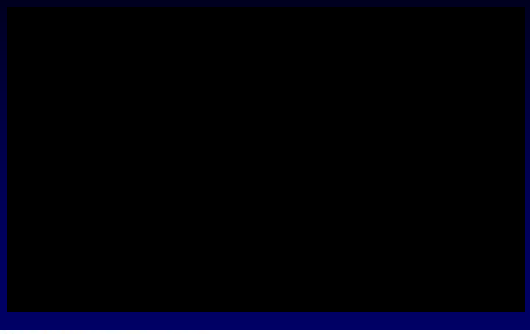
EUS guided fiducial placement



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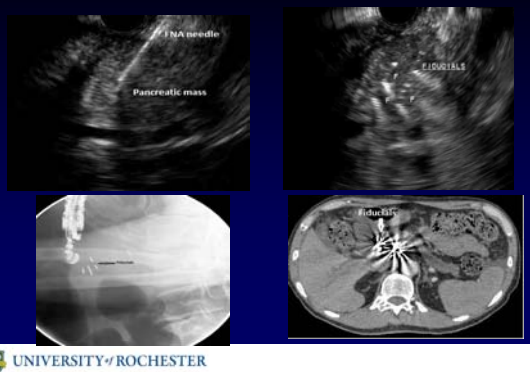
EUS guided Fiducial placement



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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

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Palliation of Jaundice

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

EUS Guided ERCP !

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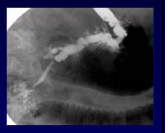
EUS Guided Biliary & Pancreatic drainage

EUS guided CBD access

- 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%.



EUS guided PD access

Abu Dayyeh BK.*Gastroenterol Hepatol (N Y)* 2012; **8**(7):450-456.

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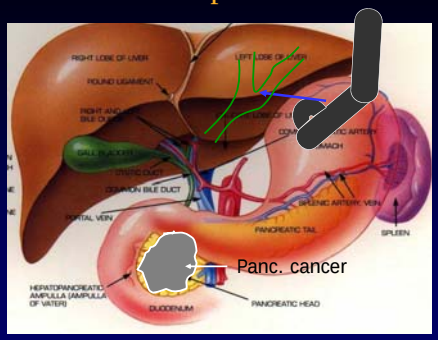
EUS GUIDED Hepatico-Gastrostomy



Sahai GIE 1998;47:AB37

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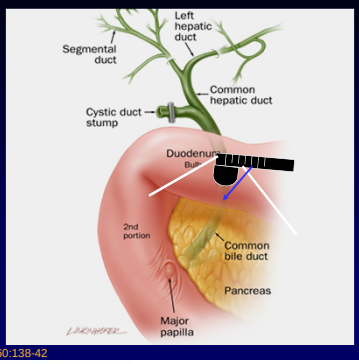
EUS GUIDED CHOLEDOCHO-DUODENOSTOMY



Kahaleh GIE 2004;60:138-42

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EUS guided ERCP

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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….!!!

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THANK YOU!!

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