Innovations in EUS

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Basic innovations

- Development of EUS Imaging with radial mechanical transducers
- Development of Electronic Linear transducer technology
- Development of EUS guided Intervention
  - Biopsy
  - Therapy
Past-Present-Future

- **1980-1986** Development of endoscopes and mini-probes with mechanical transducers and basic studies
- **1986-1991** Establishing indications of EUS imaging with mechanical transducers
- **1991-2000** Development electronic transducer technology and EUS-FNA
- **2000-2008** Establishing indications of EUS guided interventions (Biopsy and therapy).
1980–1986. Development of endoscopes and mini-probes with mechanical transducers and basic studies

Wall layers of the GI tract (Olympus)

Courtesy of Lok Thio 1986
1986-1991. Establishing indications of EUS imaging with mechanical radial scanning transducers:

- Staging and evaluation of resectability of GI cancer, GI lymphoma
- Evaluation of GI tract pathology (large gastric folds, submucosal tumors, impressions, vascular malformations, egc)
- Extra-hepatic obstruction
- CBD stones-and microlithiasis
- Pancreatitis
- Neuroendocrine tumors
- Cystic pancreatic tumors

First prototype curved linear array endoscope
(1988, Hitachi/Pentax EC 124)

Pentax/Hitachi, FG 32 UA
Early needle developments

Cook Denmark

1991

Hancke/Vilmann needle 1991-1993
Medi-Globe
EUS guided intervention:
Thorax
Upper abdomen
Pelvis

EUS guided intervention is able to reach regions that can either not be reached by other imaging modalities or are too minute to targeted.
### Biopsy

**Staging:**
- GI cancer
- Lung cancer

**Primary diagnoses:**
- Mediastinal lesions
- Lymph nodes
- Submucosal tumours
- Pancreas and biliary tract
- Adrenals

### Therapy

- Injection
- Drainage and Stenting
- Miscellaneous
  - Implantation
  - Coagulation
- Resection of lesions
- Suturing
- NOTES

✓ in 28 of 31 patients a final diagnosis could be obtained, regarding evaluation of cancer involving the mediastinum
✓ 20 patients were found to have mediastinal involvement
✓ no mediastinal metastases were found in 8 patients (by surgery).
✓ The accuracy of EUS-FNA and EBUS-TBNA, in combination, for diagnosis of mediastinal cancer was 100% (95% CI 83-100%).

EUS-FNA and EBUS-TBNA seems to be complementary methods.
EUS guided Injection

- **Injection of vessels** (EUS guided angiotherapy of refractory gastrointestinal bleeding. Am J Gastroenterol. 2008)
- **Celiac plexus Neurolysis**
- **Anti-tumor therapy**
  - Ethanol lavage (GI Endosc. 2005; 61:746-52)
  - Local chemotherapy (DDW 2005, W1252)
  - Immunotherapy (DDW 2005, W1219)
  - Gene therapy (Clin Cancer Res. 2003;9:555-61)

- **Cholangio, lymph- and pancreatography**
- **Tattooing**
Anti-tumor therapy: Ethanol lavage


- 25 pts with cystic lesions
  - Mean diameter of 19 mm
  - Mean CEA of 5916 ng/ml
- Concentration of ethanol used 5 to 80%
- 5 patients have had a resection
  - Benign mucinous cystic neoplasm
  - "attenuated" or "ablated" epithelium
- 8 patients have resolution of the cyst on CT scan
- No episodes of pancreatitis or abdominal pain

Matthes K, Enqiang L, Brugge WR. EUS-Guided Oncogel (Paclitaxel) Injection Provides Therapeutic Drug Concentrations into the Porcine Pancreas. GI Endosc 2007;65:456-6. (animals)


- A total of 8 mL 95% ethanol was injected into the tumor.

- RESULTS: The patient was discharged and exhibited no further hypoglycemic episodes, and her general condition improved rapidly.

- Based on clinical, morphologic, and biochemical criteria, a durable complete remission of the tumor was achieved.
EUS guided injection: cholangio, lymph- and pancreatography

With or without Rendez-vous


Kahaleh M et al. Interventional Endoscopic Ultrasound Cholangiography: Mid-Term Follow-Up of 18 Cases. DDW 2005, W1226.


EUS guided drainage of cysts, necroses, abscesses.

- **Direct guided by EUS**
  - Needle (19 G)
  - Needle knife
- **Assisted by EUS**
  - Optimal localisation by EUS with subsequent endoscopic management and guidewire insertion followed by a range of different approaches

One randomized study between EUS guided method and “blind” endoscopic method. (DDW 2008)
Needle and guidewire introduction
EUS guided drainage

• Abscess drainage
  - Kahaleh M. EUS drainage of a mediastinal abscess. Gastrointest Endosc. 2004;60:158-60

• Necrosectomy
  - Matthes H. Endoscopic transgastric EUS guided drainage and necrosectomy of infected pancreatic pseudocysts. DDW 2005,

• Gall bladder fossa fluid drainage

• Hematoma drainage
  - Piraka C. Evolving role of interventional endoscopic ultrasound. DDW, W1270
EUS-guided transmural cholecystostomy


**PATIENTS:** Nine elderly or high-risk patients diagnosed with acute cholecystitis.

**INTERVENTIONS:** All inflamed gallbladders were drained by EUS-guided transmural cholecystostomy.

**MAIN OUTCOME:** Clinical resolution of acute cholecystitis.
EUS guided cholangio-or pancreatico-enterostomy

- Trans-duodenal drainage
- Trans-gastric drainage
- Trans-jejunal drainage

- Failure by ERCP
- Pyloric/duodenal stenosis
- Complete obstruction of the CBD/pancreatic duct
- B II/gastrectomy with Roux-en-Y anastomosis

Courtesy of Eike Burmeister
<table>
<thead>
<tr>
<th>Author(s) and Year</th>
<th>Technique and Stent Type</th>
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<tbody>
<tr>
<td>Wiersema et al., 1996</td>
<td>EUS-guided needle placement</td>
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<tr>
<td>Sahai et al., 1998</td>
<td>Animal model (stent)</td>
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<tr>
<td>Giovannini M. et al., Endoscopy 2001, 33</td>
<td>2-step technique stent</td>
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<tr>
<td>Burmester E. et al., GI Endoscopy 2003, 57</td>
<td>1-step technique stent</td>
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<td>Niehaus J. et al., GI Endoscopy 2003, 57</td>
<td>1-step technique stent/revision</td>
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<td>Giovannini M. et al., Endoscopy 2003, 35</td>
<td>1-step technique stent</td>
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<tr>
<td>Giovannini M et al., Endoscopy 2004, 35</td>
<td>1-step technique self-expanding stent</td>
</tr>
<tr>
<td>Kahaleh M. et al., GI Endoscopy 2004, 60</td>
<td>1-step technique stent</td>
</tr>
<tr>
<td>Bories E et al., Endoscopy, 2007;39:287-91</td>
<td>2-step technique metal stents</td>
</tr>
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EUS guided Coagulation (FDT and RF)


Aim: The feasibility and safety of EUS-guided photodynamic therapy of the pancreas was studied in a porcine model.

- Injection of porfimer sodium
- 19-gauge needle was inserted into the pancreas, the liver, the spleen, and the kidney under EUS guidance.
- Quartz optical fiber passed through the EUS needle

RESULTS: Localized tissue necrosis was achieved in all organs, without significant complication.

Endoscopy 2008;40:321-6

14 ablations were performed in 14 pigs

CONCLUSIONS: Selective transluminal RF ablation of the pancreas under EUS control in a living pig model is feasible. The new flexible bipolar probe creates an ablation area with extent related to the duration of application, and with fewer complications than conventional RF ablation techniques.
Miscellaneous:

- Implantation
  - Fiducials
  - Radioactive seeds
- Portal vein catherisation
- TIPS via stomach and hepatic veins
- Suturing
  - Gastropexy
  - Trans-gastric endosurgery (NOTES)
Implantation: Fiducials


**image-guided stereotactic radiosurgery**

Radiographic markers (or fiducials) implanted at the tumor site are used as reference points by the system to target the radiation beams.

EUS-guided fiducial placement was successful in a total of 11 of 13 patients (84.6%). A total of 3 to 6 fiducials were placed in each patient.

The locations of the tumors: retrocrural area, porta hepatis, gastroesophageal junction, mediastinum, thoracic paraspinal area, and pancreas.
EUS Guided Brachy-therapy


22 patients with advanced pancreatic cancer. All 22 patients were successfully implanted with 125I seeds via EUS, with a median of 10 seeds and a maximum of 30 seeds per procedure.

- 15 pt's with unresectable pancreatic adenocarcinoma.
- A mean number of 22 radioactive seeds per patient were implanted.
- Moderate local tumor effect and showed some clinical benefit in 30% of the patients in this study.
2008-2016.

• Imaging?
• Accessories?
• New applications?
• EUS guided biopsy?
• Therapy?
Imaging

- Tissue Harmonic Imaging
- Second Harmonic
- Pulse Inversion
- Power pulse inversion
- Echo Contrast Ultrasound
- Image fusion: Sono-MR/CT
- Elastography
- 3-D

- Electronic radial scanning EUS was performed in 108 patients with pancreatic lesions (58 cystic, 50 solid).
- US images acquired by fundamental imaging at a frequency of 7.5 MHz were compared with those acquired by tissue harmonic imaging by using transmitting and receiving frequencies of, respectively, 4.0 and 8.0 MHz at the same scanning plane.
- For solid lesions, tissue harmonic images were significantly clearer than fundamental images for visualizing boundary.

CONCLUSIONS: US images acquired by tissue harmonic imaging appear to be clearer compared with those acquired by fundamental imaging.
Possible indications of elastography: tactile Imaging

- Selection of lymph nodes for EUS-FNA if multiple?
- Exclusion of EUS-FNA?
- Evaluation of focal lesions of the pancreas
- Targeted biopsy (Ln, pancreas)
- Other diseases
  - Submucosal tumors
  - Adrenals
  - Acute pancreatitis
  - Mucosal tumours

Development of real-time quantitative analysis is desired

Patients: 83

Sensitivity increase: 71% to 91%
Specificity increase: 83% to 93%

Figure 1. Endoscopic ultrasound image of chronic pancreatitis. Regular vascularisation is shown with detection of venous vessels using contrast-enhanced power Doppler scanning in combination with power Doppler.

Figure 2. Endoscopic ultrasound image of ductal adenocarcinoma of the pancreas. Irregular vascularisation is shown with detection of only arterial and no venous vessels using contrast-enhanced power Doppler scanning in combination with pw-Doppler.
Low mechanical index

- Prototype echoendoscopes
  - Contrast-enhanced harmonic EUS
  - Apparent perfusion and vessel images were observed in pancreatobiliary carcinomas, GI stromal tumors, and lymph-node metastases.

EUS guided NOTES: Accessories

- Anastomoses
- GEA
- Gallbladder

Courtesy: Annette Fritscher-Ravens
Aim: to develop new transgastric endosurgical approaches to lymph nodes including node tagging, guidewire directed hot biopsy, suturing, radio frequency ablation, transgastric lymphadenectomy.

In conclusion

• Innovations in EUS have mainly been driven from improvements in Imaging, development of electronic linear transducer technology and of EUS guided interventions
• The combination of high resolution imaging and precise targeting of minute lesions makes EUS a true minimal invasive modality.
• Only a few randomised comparisons with established therapies
• A huge potential for new developments in EUS
• EUS will possibly challenge other more invasive methods in the near future.