

MRI Endoscopy

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BSc in Gastroenterology & Hepatology Course
10th December 2012

MRI Endoscopy

- Case study
- Clinical problem
- Current approach
- Research

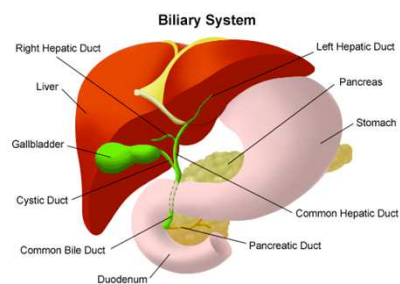
Case study

- GP referral 2005
- 42 yo man
- IT consultant
- Alcohol excess, smoker
- Referred with
 - Increasing stool frequency
 - Pruritis
 - Cholestatic LFT's

Case study

- History
- LFT's
- What next?

Cholestasis



Case study

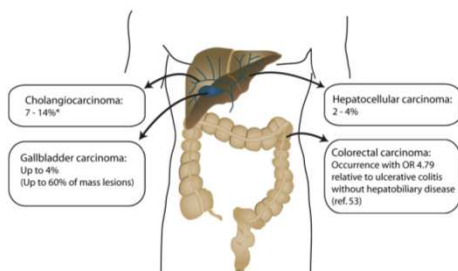
- Liver investigations
 - Blood tests
 - Viruses
 - Autoimmune
 - Genetic conditions
 - Ultrasound

Case study

- +ve ANA
- US: dilated biliary tree at porta / pancreatic head
- ERCP: irregular stricturing and dilatation
- Liver biopsy: mild chronic portal inflammation, widespread bile duct proliferation within the portal tracts
- Colonoscopy: mildly active pancolitis

Case study

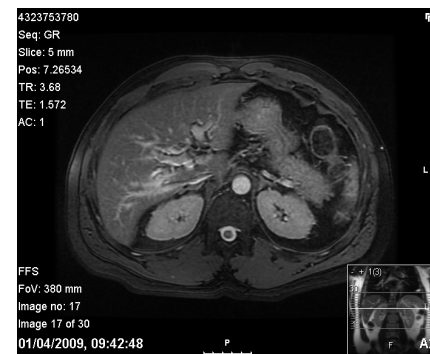
- **Diagnosis: PSC & UC**

PSC and Cancer**Case study**

- **Diagnosis: PSC & UC**
- **Treatment ?**
- No medical treatment.
- Colonoscopy, US, Bloods.
- **Lost to follow-up 2009**

Case study

- **2012: Re-referred**
- Deterioration in LFTs
 - ALT 65, BR 31, alb 36, ALP 405
- US liver
 - Thickened proximal CBD
 - Mild R intrahepatic duct dilatation

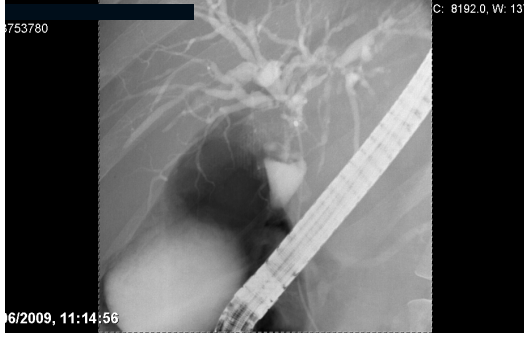


MRCP: Distal CBD normal in calibre, irregular stricture in mid part extending to hilum. Intrahepatic biliary tree mildly dilated on right in keeping with hilar stricture 2.5cm from hilum to upper bile duct.

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Case study

- **CT:**
 - Proximal common hepatic duct abnormal, thick walled with soft tissue enhancement, 2 slightly enlarged lymph nodes superior to the coeliac axis.
- **Serum markers:**
 - Ca 19-9 48 (ULN 33)
 - AFP 1.6 (ULN 6)



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6/2009, 11:14:56

ERCP: irregular hilar stricture. Extends to left and right hepatic ducts

Brushings: atypia (inflammation/ neoplasm)

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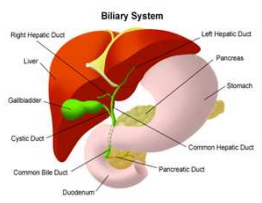
PSC, strictures and diagnostic uncertainty

- 7-14 % lifetime risk Cholangiocarcinoma
- 20% develop a benign dominant stricture
- Difficult to distinguish from cholangiocarcinoma

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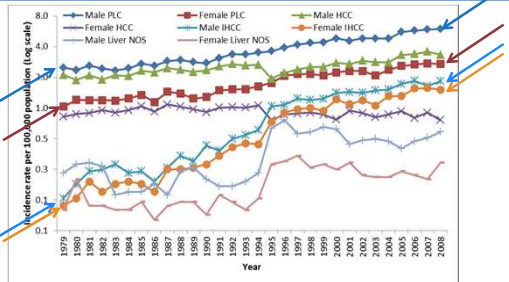
Cholangiocarcinoma - CCA

- Arises from epithelial cells of biliary tree
- >90% adenocarcinoma, <10% squamous
- 20% Intrahepatic, 60% hilar, 20% distal extrahepatic



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CCA - Incidence



Incidence rate per 100,000 population (log scale)

Year

Ninzing G Ladeji, Shahid A Khan, Mary ME Crossey, Andrew V Thillainayagam, Simon D Taylor-Robinson, Mireille B Toledano. Changing trends in the basis of diagnosis, ethnic registration, incidence and mortality of primary liver cancer in the England and Wales. in press

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CCA

- Biliary inflammation / stasis / fibrosis predisposes: PSC, choledochal cysts, cholelithiasis, liver flukes
- Hepatic inflammation / fibrosis : Alcohol, Hepatitis viruses, Cirrhosis
- Tricky to characterise – particularly in patients with preexisting benign biliary disease

Khan SA et al Lancet 2005

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CCA - Diagnosis

- Blood tests
- Radiology
- Endoscopic
- Histology

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CCA - Staging uncertainty

- TNM staging
 - Radiology
 - Laparotomy
- Only 50% of peri-hilar cases having staging laparotomy are ultimately considered suitable for surgery.

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CCA - treatment

- Surgery is the only cure
- Resection is only possible in < 1/3

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ICC

5 year survival: 22-44%

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Peri - Hilar tumours

5 year survival: 27 – 37%

Roux-en-Y Hepaticojejunostomy Procedure performed for injuries and cancer of the bile duct.

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Distal extrahepatic

5 year survival: 10-41%

<http://www.hpbccancer.co.uk/patients/pancreatic-cancer-treatment/>

CCA - treatment

- Surgery is the only cure
 - Resection possible < 1/3
 - 5 year survival 10-40%
- Transplantation
 - Improved survival if response to pre-transplant chemoradiation
- **Kills more people than HCC in UK**

CCA – how can we improve

- Diagnosis
- Screening
- Staging
- Treatment

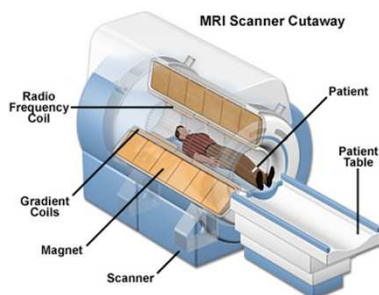
MRI Endoscopy



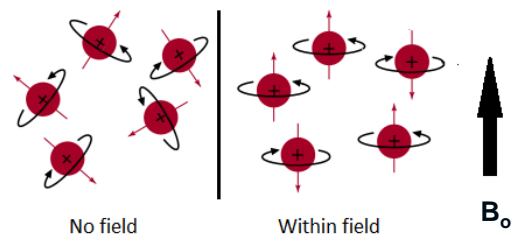
MRI

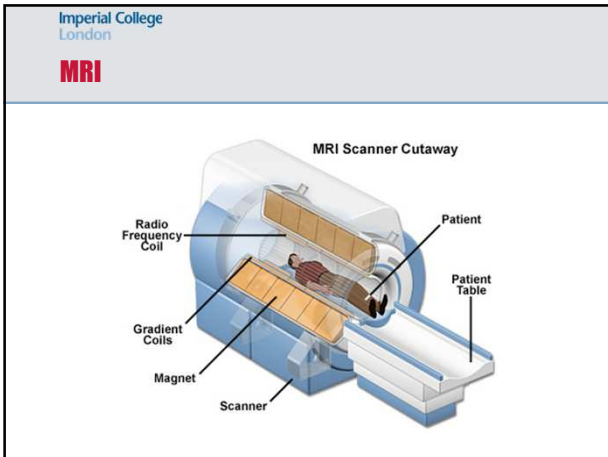


MRI

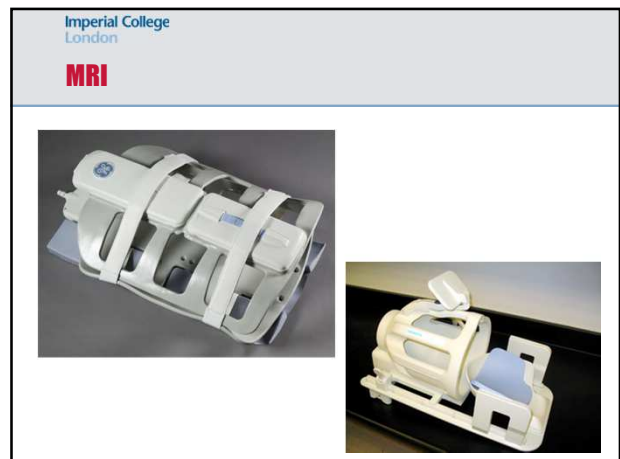
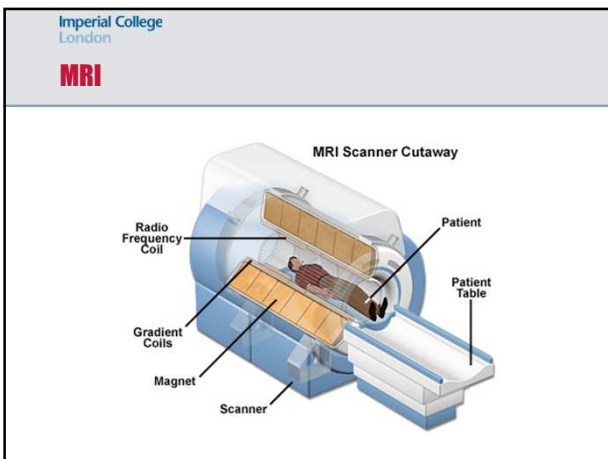


MRI





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- MRI**
- Resonance
 - Exchange of energy between two systems at the same frequency
 - Resonance frequency proportionate to B_0
 - In range of radiofrequency (10^4 Hz)



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- MRI & MRCP**
- Safe
 - Resolution is good - millimeters
 - Signal degraded
 - distance from receiver coil ($1/r^3$)
 - motion artefact
 - **A receiver coil apposed directly to the tissue should allow better resolution**

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- Endoscopy and the biliary tree**
- Side-viewing duodenoscope
 - Bridge permits angulation of catheter
 - Allows:
 - Contrast agent injection
 - Cell sampling
 - Stone removal
 - Stent insertion/removal
 - Pitfalls:
 - Complications
 - 2D imaging
 - No extra-ductal information
-
-
- Yoshida 2004

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MRI and endoscopy

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EPSRC Project aims

Engineering & Physical Sciences Research Council grant to:

- Develop a micro-engineered MR receiver coil with sub-millimeter resolution
- Integrate this into a MR compatible biliary catheter
- Integrate tissue sampling capability
- Build an MR compatible duodenoscope
- Develop a system to compensate for respiratory artefact
- Produce ex vivo high resolution biliary images
- Develop plans for a translational clinical study

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Microcoil Requirements

Device requirements

- Cheap – single use
- MR compatible and sterilisable
- Watertight, electrically safe
- Flexible, to make turn

System requirements

- Include fiducial material to identify position
- Allow tunability
- Allow access to catheter lumens

Endoscan Ltd.

Useable through 3.2mm channel in endoscope, with deflection over bridge

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Operation of RF Detector Coils

Use LC resonator ; performance determined by quality factor $Q = \omega L/R$

L = Inductor
 C = Capacitor
 R = Resistor

C_M and C_T depend on Q-factor and operating frequency; values unknown until coil is built

Capacitors bulky and hard to integrate.

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Prototype probe

- Microcoils integrated onto commercial cytology brush

Ahmad, Taylor-Robinson, Wadsworth et al J. Micromech. Microeng 2009

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Microcoil Development

- Flexible coils fabricated using electroplated Cu on polyimide
- Coils integrated on commercial cytology brush unit
- Innovative design

Ahmad, Taylor-Robinson, Wadsworth et al J. Micromech. Microeng 2009

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Resolution Testing

- Excellent performance obtained in ¹H MRI at 1.5 T
- Sub-millimeter resolution using phantoms

Thread pitch 0.7 mm

Presented at BSG Meeting, Glasgow, 2009

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Ex vivo biliary imaging

- Biliary imaging performed using ex-vivo porcine liver tissue
- Sub-millimetre resolution obtained over large FOV

Axial image of cystic duct

Ahmad, Taylor-Robinson, Wadsworth et al J. Micromech. Microeng 2009

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Ex vivo biliary imaging

Axial images using micro coil

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Ex vivo human liver imaging

Accepted, BASL meeting, London 2009

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Ex vivo human liver imaging

Microcoil
Gall bladder

A B C

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Ex vivo human liver imaging

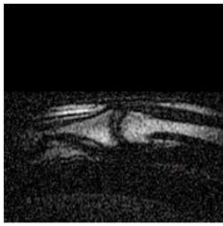
C

Body coil Micro coil

Accepted, BASL meeting, London 2009

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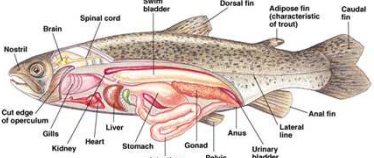
In vivo finger



Sagittal micro coil image

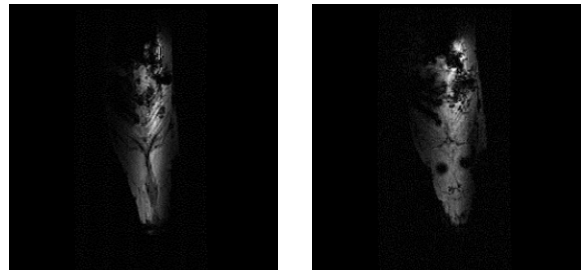
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Ex vivo sardine

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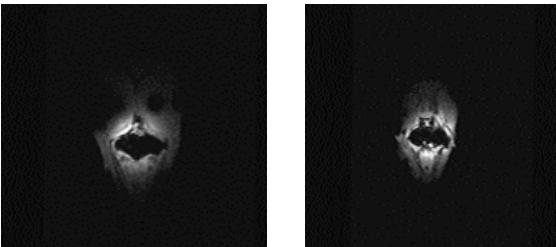
Ex vivo sardine



Sagittal microcoil images

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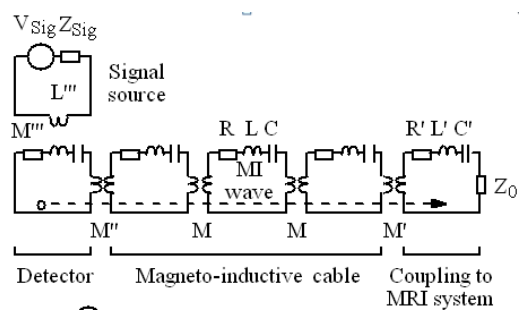
Ex vivo sardine



Axial microcoil images

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Magnetoinductive catheter





Detector Magneto-inductive cable Coupling to MRI system

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Non magnetic duodenoscope

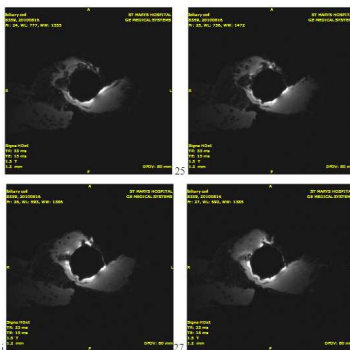
- Completely MR compatible
- Non magnetic accessories
- Fibreoptic, viewed through eyepiece
- MRHA exempt unless commercialised

Non magnetic duodenoscope

Suction, insufflation & light source
all supplied via ultra long umbilicus

Metal parts in titanium and
phosphor-bronze

**Duodenoscope tip receiver coil****Duodenoscope tip receiver coil****Conclusion**

- We have produced a functioning:
 - Microcoil biliary catheter
 - Duodenoscope tip receiver coil
 - MR compatible duodenoscope
- Initial imaging shows great promise

Conclusion

- Obvious applications beyond the biliary tree
- Huge research potential
- Clinical application possible, with high resolution imaging, *in vivo* MRS and targeted

Acknowledgements

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