

# Modern imaging techniques in the medical curriculum

Prof. András Palkó  
University of Szeged, Hungary

**Radiology**

**=**

**diagnostic imaging + therapeutic intervention  
guided by imaging procedures**

**OR**

**the art of interpreting visual information by the  
use of very complex equipment creating very  
complex images**

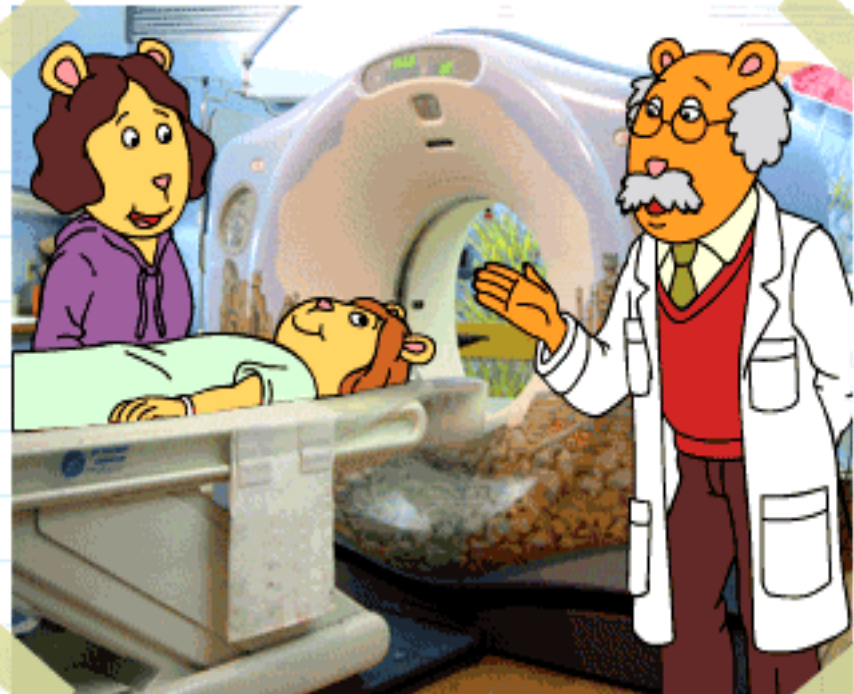
## Radiology

close 

Have you ever wondered what you look like on the inside? You can find out in **Radiology**, where they have cool machines that can take pictures of the inside of your body.

These pictures are called X-rays, and they help your doctors find out what's going on inside

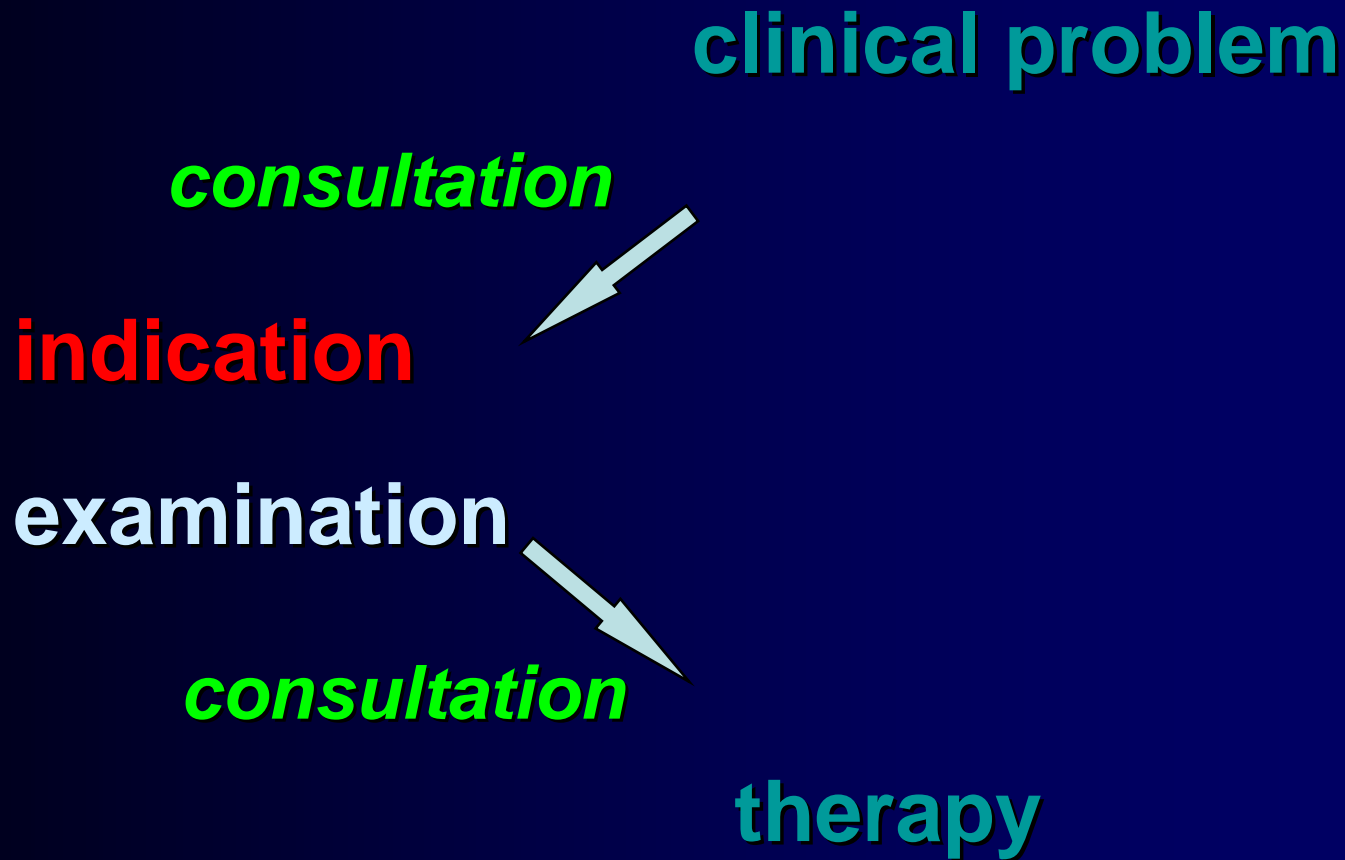
you. You might have other special picture tests done, like an MRI or a CAT scan. It doesn't hurt when they take these pictures, but some of the machines can be pretty noisy. (Pal was happy to find out that there are no real cats in the CAT scan machine.)



# DIAGNOSTIC IMAGING

- **Purpose: create visible image of morphology and function of the human body**
- **Image: visual information (visualization in 2 or 3 D, vector, curve, spectrum, etc.)**
- **To bring about an image:**
  - **Energy has to be conducted to the body**
  - **Interaction of the energy and the components of the body**
  - **Detection of the modified energy**
  - **Visualization of the detected pattern**

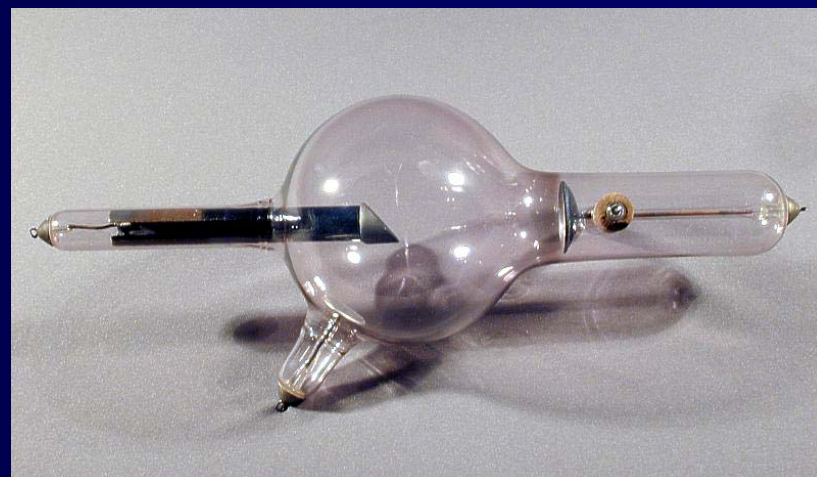
# DIAGNOSTIC IMAGING



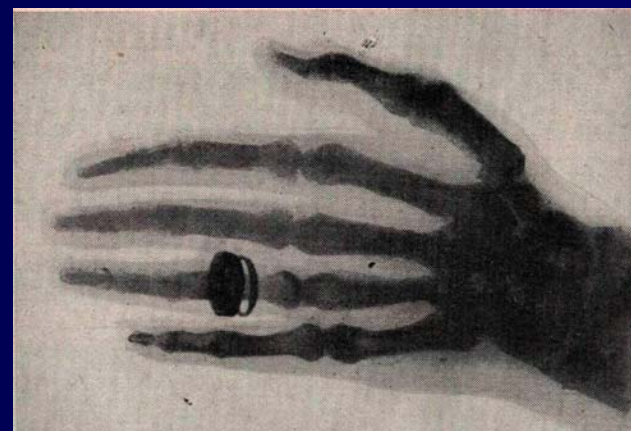
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**1895**



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# DIAGNOSTIC IMAGING

- Roentgen: x-ray 1895
- Cannon: contrast material (bismuth) 1896
- Krause: “ (barium) 1904
- Graham: brachial arteriography 1923
- “ : cholecystography 1923
- Swick: i.v. pyelography 1928
- Donald: ultrasound (sonar) 1950
- Seldinger: catheter-technique 1953
- Hounsfield: CT 1967
- Lauterbur: MR 1973





# The „avalanche”

teranostics

PACS, RIS  
teleradiology

US

MR

fMR

intervention

CT

MD-CT

double contrast

Ba

iodine

non-ionic

Gd

US

fluorosc.

image intensifier

DSA

DF

X-ray radiogr.

tomography

CR, DDR

Magic mountain

1900

1925

1950

1975

2000

2010

## Trends of development

- full digital imaging
- „intelligent” equipments
- 3D, virtual reality, functional imaging
- genetically modified, molecular markers
- biologically specific contrast materials
- PACS, neural network, automatic image reading and interpretation



- *fast, personalized, easily generated and interpretable information*
- *shorter way to diagnosis*

# Trends of development



Star Trek - tricorder

## Stagnation or progress?

- Time to duplication of biological/medical knowledge
  - 1975: 30 years
  - 2000: 10 years
  - 2025: ??

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## Stagnation or progress?

- Time to duplication of biological/medical knowledge
  - 1975: 30 years
  - 2000: 10 years
  - 2025: ??



Thomas W. Lawson, 1902



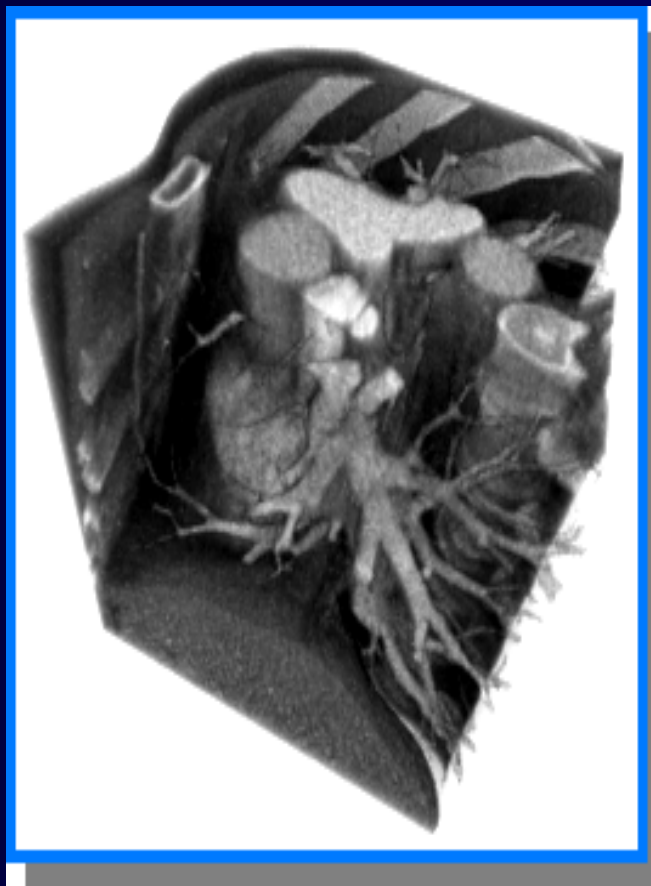
Clermont, 1807



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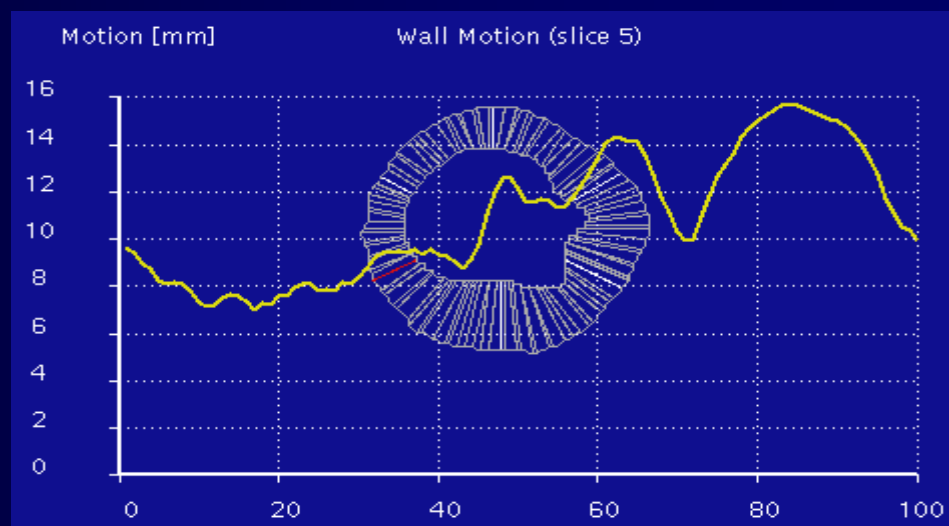
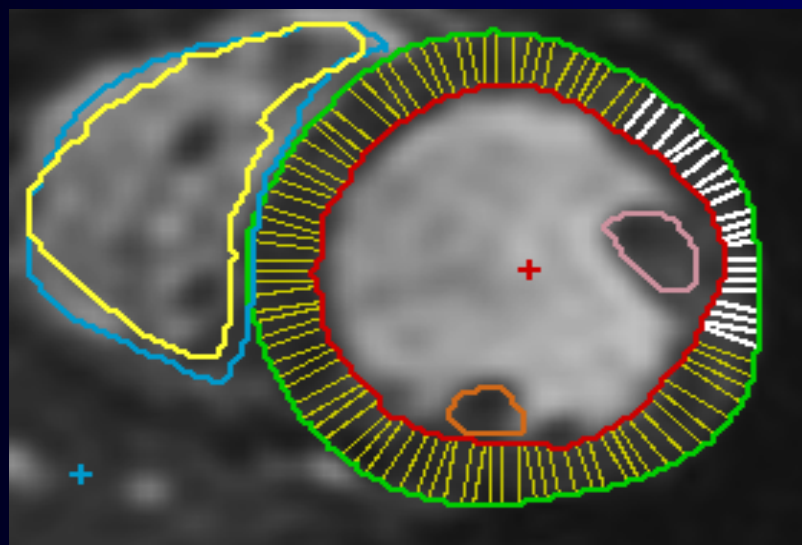
**Where we are today?**

# Cardio-CT

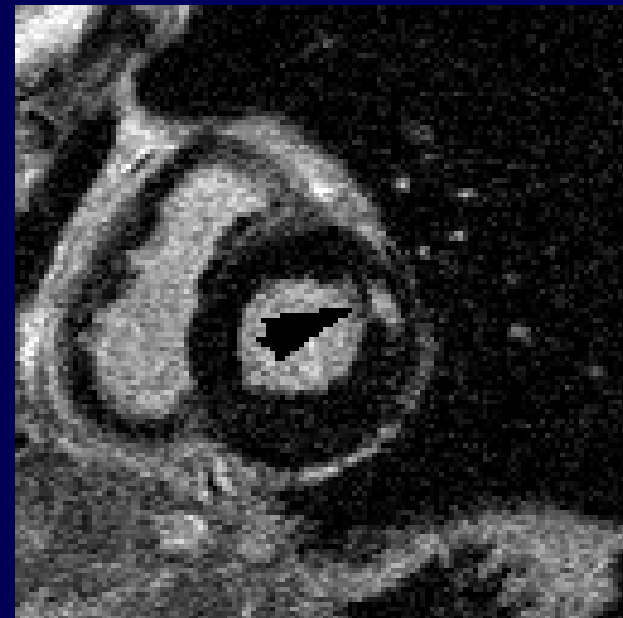




# Cardio-MR



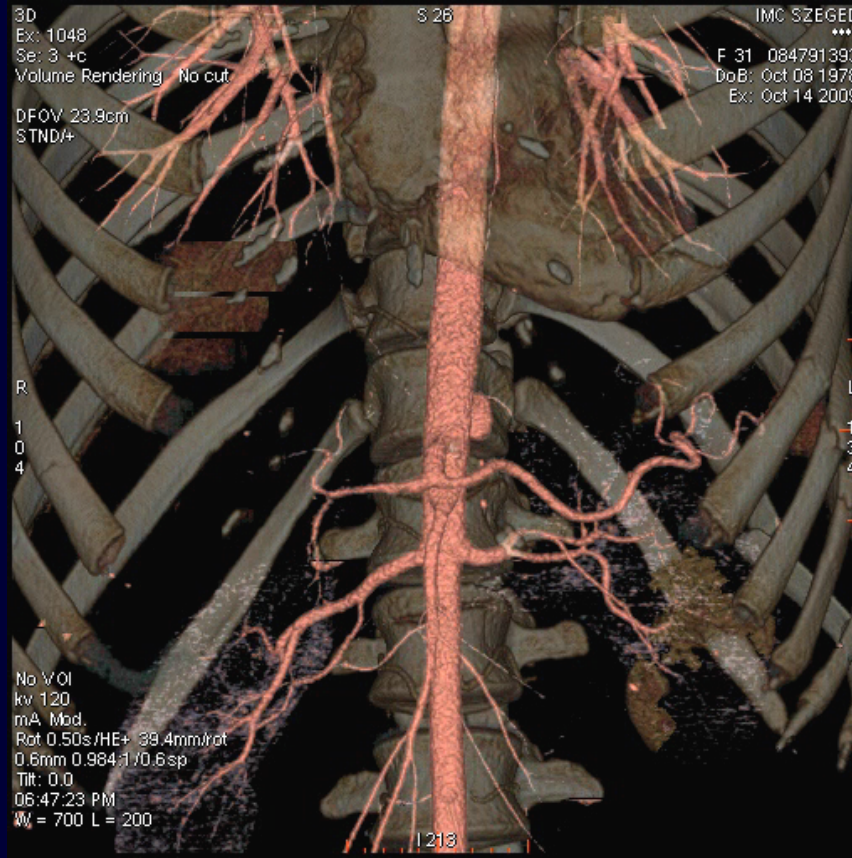
# Cardio-MR



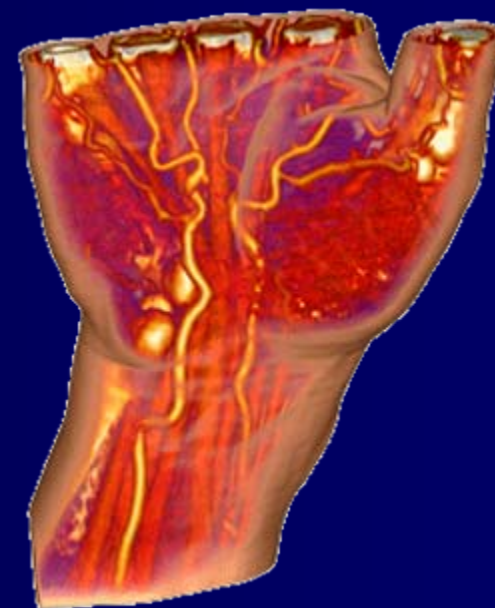
# MR-phlebography



# CT-arteriography



# CT-arteriography

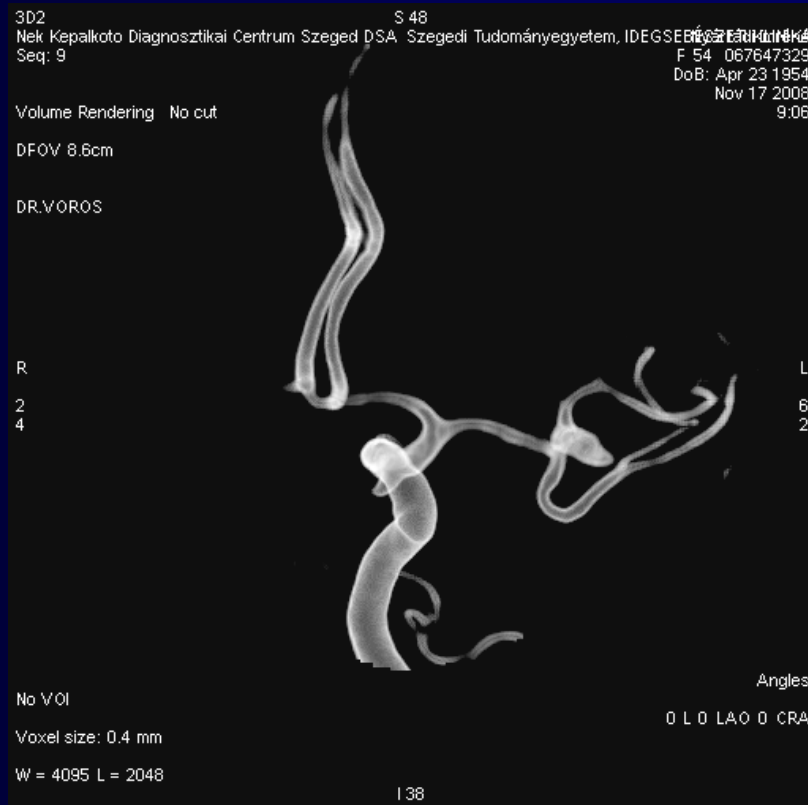


# CT-arteriography

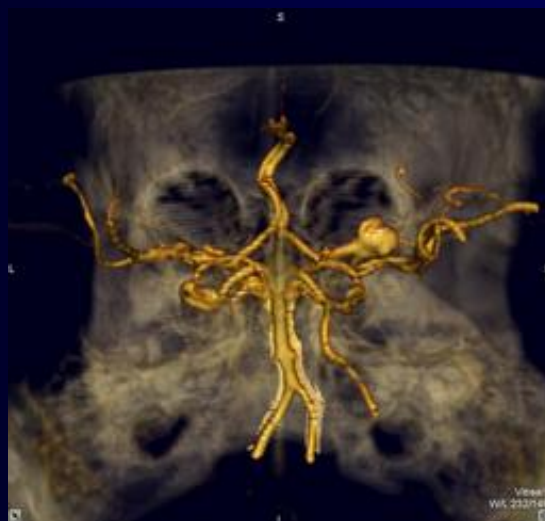




# DSA

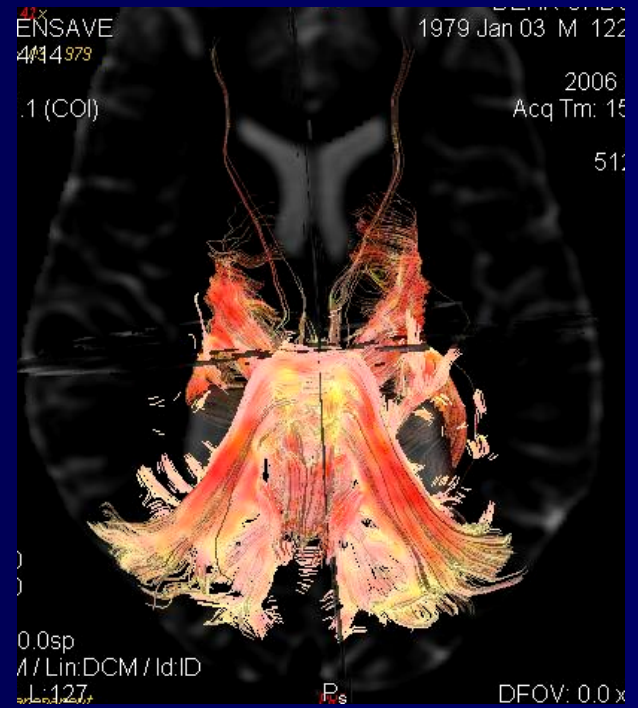
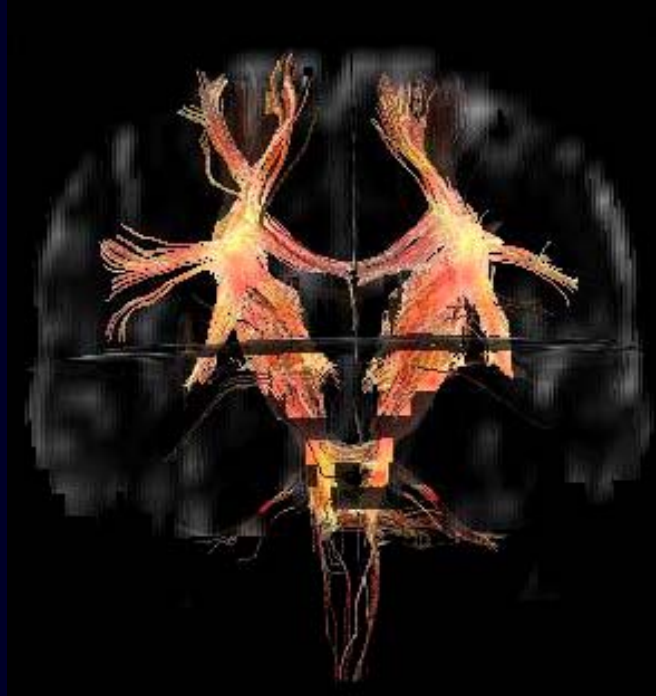


# CT-arteriography

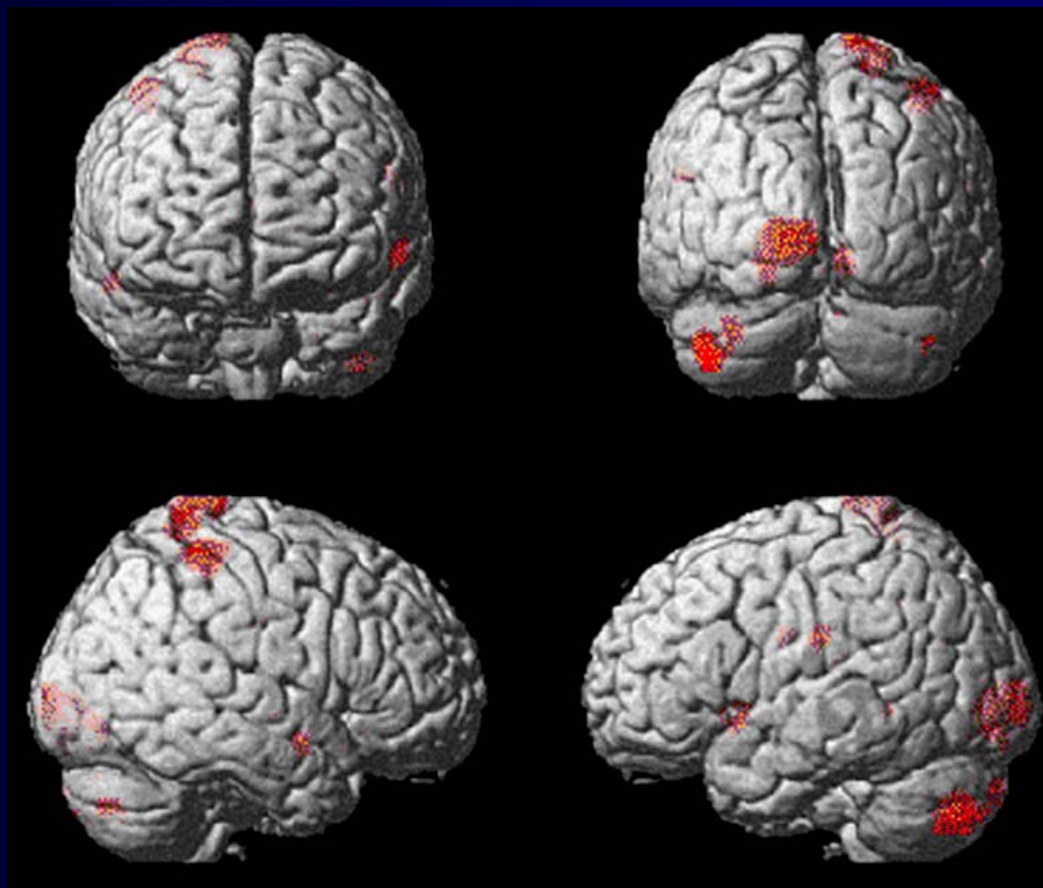




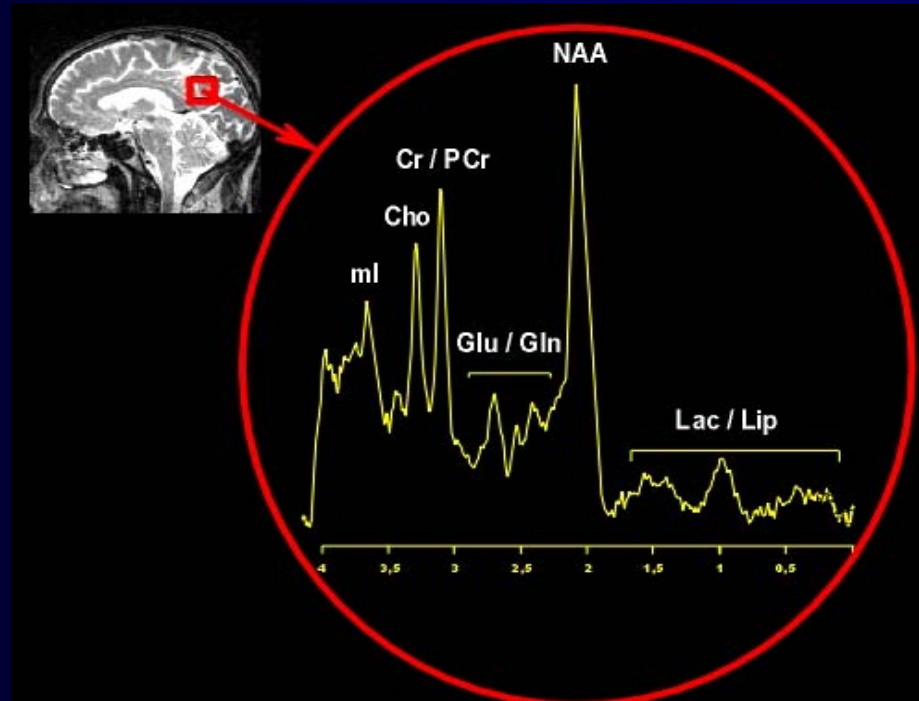
# MR-tractography



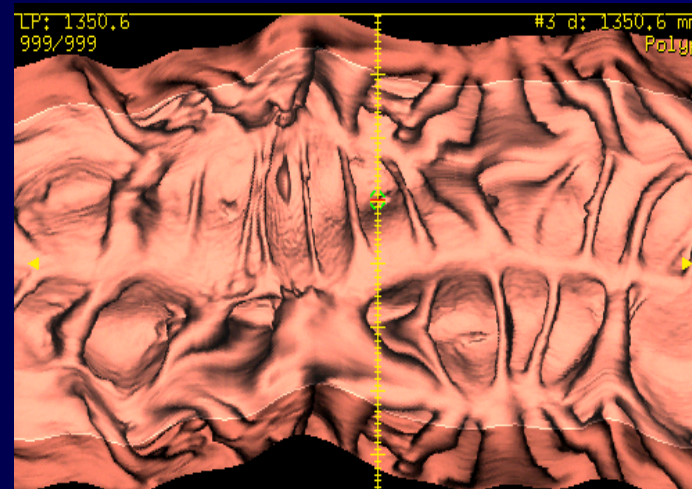
# Functional MRI



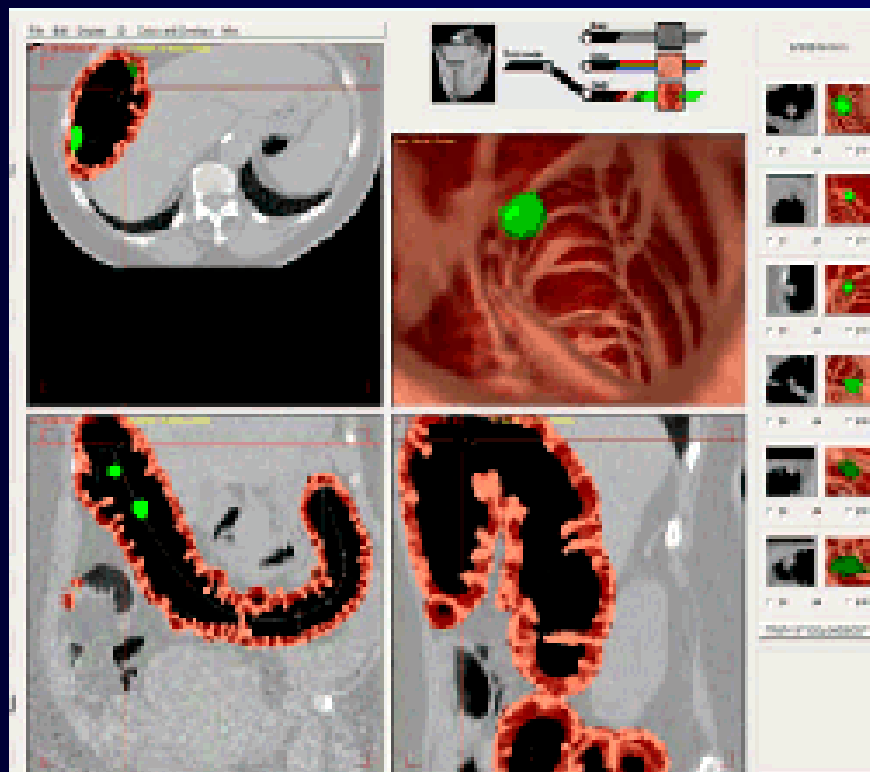
# MR-spectroscopy



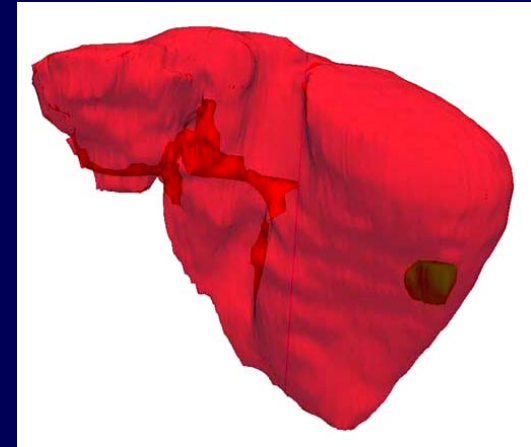
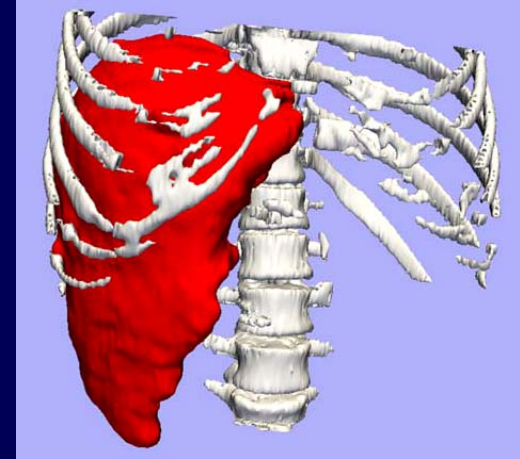
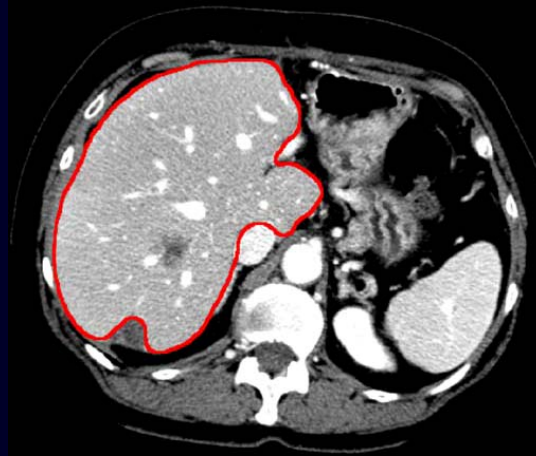
# CT-endoscopy



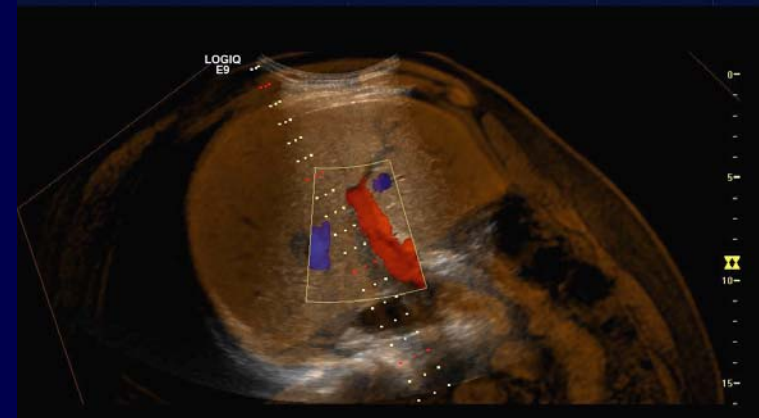
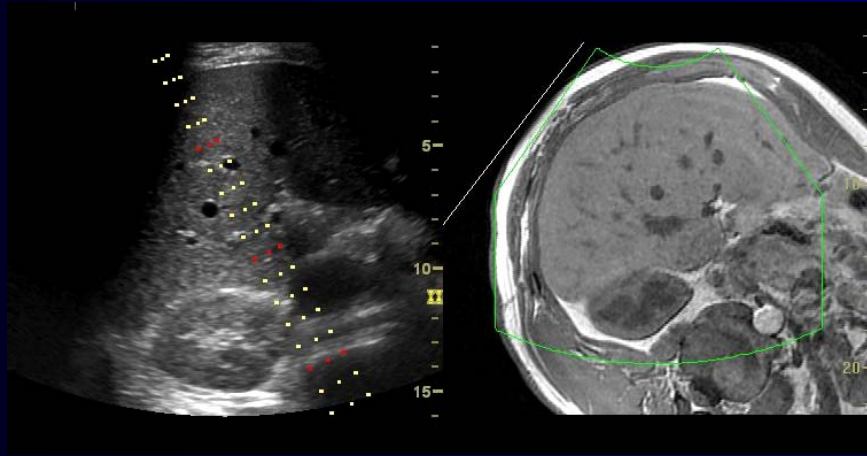
# Computer-assisted detection



# Automatic segmentation



# Hybrid imaging (UH - CT/MR)



# Hybrid imaging (PET/SPECT – CT/MR)



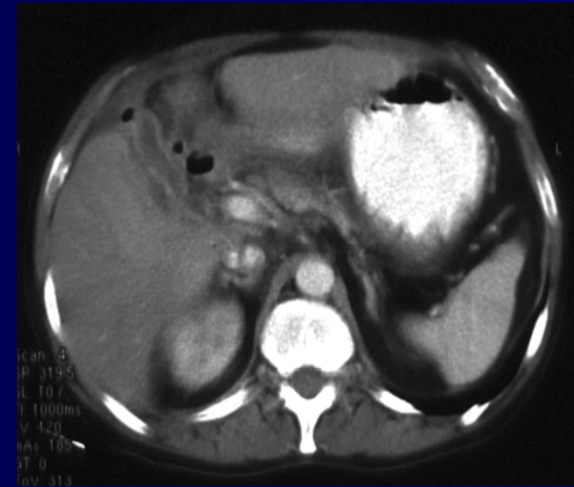


## Dilemmas of development:

- is the application financeable?
  - *high-tech = high cost ?*
  - *expensive = unnecessary ?*
- are the results applicable in practice?
  - *marketing or real need ?*
- does it make sense?
  - *does better sensitivity automatically bring better specificity?*
  - *does better imaging provide functional/cellular/molecular/genetical additional information?*
  - *does it result in better therapy/survival?*
- will the development fragmentize radiology?

## Dilemmas of development:

lower back pain – MRI vs. acute abdomen – CT



# How can we separate the tailings from the wheat?

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# How can we separate the tailings from the wheat?

- **Prospective, randomized, multicentre study**
- **Evidence-based medicine**
- **Health technology assessment**



Eur Radiol (2008) 18: 457–467  
DOI 10.1007/s00330-007-0716-9

HEPATOBIILIARY-PANCREAS

Renate Hammerstingl  
Alexander Huppertz  
Josy Breuer  
Thomas Balzer  
Anthony Blakeborough  
Rick Carter  
Lluís Castells Fusté  
Gertraud Heinz-Peer  
Werner Judmaier  
Michael Laniado  
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Didier G. Mathieu  
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Peter Reimer  
Maximilian F. Reiser  
Philip J. Robinson  
Kohkan Shamsi  
Michael Strotzer  
Matthias Taupitz  
Bernd Tombach  
Gianluca Valeri  
Bernhard E. van Beers  
Thomas J. Vogl  
For the European EOB-study  
group

**Diagnostic efficacy of gadoxetic acid  
(Primovist)-enhanced MRI and spiral CT  
for a therapeutic strategy: comparison  
with intraoperative and histopathologic  
findings in focal liver lesions**

to identify changes in therapeutic management.

### Materials and methods

The study was designed as a prospective, multicenter, open-label, within-patient comparison of the diagnostic performance of gadoxetic acid-enhanced MRI and CT in terms of detection and differential diagnosis of focal liver lesions with a corresponding blinded reading. The study was approved by a central ethics committee and the local ethics committee at each study center. All patients gave their written informed consent.

Patients with a age of at least 18 years, known or suspected focal liver lesions, who had been scheduled for CT, and liver surgery were included in the study. Exclusion criteria were previous injection of gadoxetic acid, any other investigational product (within 30 days prior to study entry), other contrast material within 24 h prior to or after administration of the study medication, and injection of any liver-specific agent within 2 weeks prior to the study. Also excluded were pregnant or lactating women, clinically unstable patients, patients scheduled for biopsy or liver surgery within 24 h post-administration of the study medication or patients with a known anaphylactoid or anaphylactic reaction to any other drug.

### Patients

A total of 162 patients received gadoxetic acid, of which 31 were excluded from the efficacy analysis due to a missing valid SOR for the whole liver (26 patients) and major protocol deviations (five patients). Thus, the data from the remaining 131 patients (78 male, 53 female; with a mean

flow velocity of 3–5 ml/s. The scans were obtained with 100–150 kV and 180–300 mAs using a slice thickness of 5–8 mm with a pitch of 1–2.

### MRI

All centers had high-field-strength (1.0–1.5 Tesla) MRI systems and used a phased array surface coil covering the whole liver. Before contrast material administration, patients were imaged with a T2-weighted fast spin-echo (FSE)/ turbo spin-echo (TSE) sequence [ $\geq 3,000/90$ -120 (repetition time in ms/echo time in ms), matrix  $192 \times 256 \times 256$ , slice thickness 5–8 mm, gap 0–2 mm], and a T1-weighted gradient recalled echo (GRE) sequence with chemically-selective fat suppression (FS) and without FS (100–200/4–8; flip angle, 70–80°) using a matrix of  $160 \times 192 \times 256$ , slice thickness of 5–8 mm, gap 0–2 mm. Immediately after contrast material administration, dynamic imaging in the arterial, portal venous and equilibrium phase was performed using the T1-weighted GRE sequence without FS. Twenty minutes postinjection, the T1-weighted sequence with FS and the T2-weighted FSE/TSE sequence were repeated. For all sequences, field of view was adjusted as small as possible to include the abdomen only but not to exceed 400 mm.

### Liver-specific MRI contrast agent

Gadoxetic acid (SH L 569 B, Gd-EOB-DTPA, Primovist), a liver-specific hepatocyte-directed MRI contrast agent, was obtained from Bayer Schering Pharma AG, Berlin, Germany [20, 21, 43]. All patients received 0.025 mmol/kg body weight (BW) dose of a 0.25 mol/l gadoxetic acid

and analysis) were performed immediately before MRI, 2–4 h as well as 20–28 h post injection and evaluated for clinically significant changes.

### Efficacy evaluation

The primary efficacy parameter, lesion detection included the number, size, and segmental localization of lesions in the liver. Gd-EOB-DTPA MRI, and CT were evaluated separately. In the overall evaluation, Gd-EOB-DTPA MRI was compared with CT.

As a secondary variable, the performance of Gd-EOB-DTPA MRI and CT in the differential diagnosis of focal liver lesions was evaluated. This diagnosis was based on the lesion morphology, enhancement pattern, evaluation of dynamic parameters and tumor-vascular differentiation of the individual lesion. Lesion classification aimed at differentiating between benign, malignant or not assessable lesions. Lesion characterization referred to the specific lesion type.

Image evaluation was performed as an on-site assessment by one clinical investigator in each center. Separately an off-site assessment by three experienced and independent abdominal radiologists (M.L., D.G.M., P.J.R.), who were not involved in the clinical investigation and fully blinded to all patient-related information, was obtained. The blinded reading was performed in a core lab for digital image management.

### Standard of reference (SOR)

The SOR was defined as the combination of histopathology for the resected part of the liver and intraoperative (IO) US for the non-resected segments. Surgical specimens

of the entire liver. Each lesion was documented as accurately as possible according to size and segmental localization using one section of the liver map. For each individual lesion the imaging maps were compared with the map of the SOR by an independent radiologist to verify the same location of the lesion in all the modalities (i.e., lesion tracking).

### Change in surgical therapy

The planned surgical procedure was given at three different timepoints by the clinical investigators: before the MR imaging procedure, before contrast application on the basis of the unenhanced MR images and the Gd-EOB-DTPA MRI. The potential planned procedures were liver transplantation, hemihepatectomy, segmentectomy and atypical segmentectomy. The planned therapy was compared with the surgical procedure finally performed.

### Statistical analysis

The primary objective of the study was to calculate the sensitivity in lesion detection. Only lesions with the same location in the imaging procedure and the SOR were considered to be correctly detected. The alternative hypothesis tested in this study was that the sensitivity of a first (Gd-EOB-DTPA MRI) and a second test procedure (CT) positively differs verified by the SOR. The comparison of two test procedures, was then based upon differences between sensitivities of the two test procedures in the individual patient (paired differences). An adjusted  $\chi^2$  test, which takes into account the clustered nature of the data [23], i.e., multiple diagnostic observations within the same patient, was used for hypothesis testing at a 5%

**Table 1** Sensitivity of lesion detection for Gd-EOB-DTPA MRI and spiral CT

| Diagnostic procedure         | Reader                | <i>n</i> <sup>a</sup> | Sensitivity (%) | 95% CI              |
|------------------------------|-----------------------|-----------------------|-----------------|---------------------|
| Gd-EOB-DTPA MRI              | <b>Average reader</b> | <b>129</b>            | <b>72.74</b>    | <b>67.57, 77.91</b> |
|                              | Reader 1              | 129                   | 79.47           | 73.92, 85.02        |
|                              | Reader 2              | 129                   | 68.54           | 62.77, 74.31        |
|                              | Reader 3              | 129                   | 70.20           | 64.06, 76.34        |
| Bi-phasic enhanced spiral CT | <b>Average reader</b> | <b>126</b>            | <b>70.59</b>    | <b>64.96, 76.23</b> |
|                              | Reader 1              | 126                   | 76.09           | 70.37, 81.82        |
|                              | Reader 2              | 126                   | 70.71           | 64.25, 77.16        |
|                              | Reader 3              | 126                   | 64.98           | 58.71, 71.26        |

<sup>a</sup>Total number of patients with at least one SOR lesion

modalities and the correlation between different readers in different modalities were taken into account. In addition, the results of the single readers are displayed.

Since the majority of therapeutic options in the presence of focal liver lesions require information on a segmental

level, an evaluation on this level was performed by assessing the involvement of liver segments by focal liver lesions. Sensitivity and specificity for “segment affected/not affected by lesion” were estimated in the common way:

$$\text{sensitivity} = \frac{\text{number of true positive segments}}{(\text{number of true positive segments} + \text{number of false negative segments})}$$

$$\text{specificity} = \frac{\text{number of true negative segments}}{(\text{number of true negative segments} + \text{number of false positive segments})}$$



heart mri - PubMed result - Windows Internet Explorer  
 http://www.ncbi.nlm.nih.gov/sites/entrez

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 mouse heart mri  
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 fetal heart mri  
 sarcoidosis heart mri  
 amyloidosis heart mri

Titles with your search terms:  
 Bone marrow-derived stromal cells home to and remain in [Am J Physiol Heart Circ Physiol. 2008]  
 MRI in nonischemic acquired heart disease. [J Magn Reson Imaging. 2008]  
 Comparison of contrast-enhanced MRI with (18)F-FDG PET/201Tl SPECT in [J Nucl Med. 2007]

1. [Benefits of catheter thrombectomy during carotid stenting: a preliminary study.](#)  
 Hernandez E, Goel N, Dougherty KG, Strickman NE, Krajcer Z.  
 Tex Heart Inst J. 2009;36(5):404-8.  
 PMID: 19876415 [PubMed - in process]  
[Related articles](#)

2. [Risk assessment with cardiac magnetic resonance imaging in hypertrophic cardiomyopathy.](#)  
 Gosling OE, Bellenger N, Spurrell P.  
 Heart. 2009 Nov;95(22):1843. No abstract available.  
 PMID: 19875370 [PubMed - in process]  
[Related articles](#)

3. [Effects of high-dose modified-release nicotinic Acid on atherosclerosis and vascular function a randomized, placebo-controlled, magnetic resonance imaging study.](#)  
 Lee JM, Robson MD, Yu LM, Shirodaria CC, Cunnington C, Kyllintreas I, Digby JE, Bannister T, Handa A, Wiesmann F, Durrington PN, Channon KM, Neubauer S, Choudhury RP.  
 J Am Coll Cardiol. 2009 Nov 3;54(19):1787-94.  
 PMID: 19874992 [PubMed - in process]  
[Related articles](#)

4. [Remifentanyl to Facilitate High-Resolution Computed Tomography Imaging of the Chest or Magnetic Resonance Imaging in Infants.](#)  
 Joshi G, Tobias JD.

Kész Internet | Védett mód: bekapcsolva 100%

The screenshot shows a web browser window displaying a PubMed search result. The search query 'virtual ct colonoscopy' is entered in the search bar and circled in red. Below the search bar, the results are displayed as 'Results: 1 to 20 of 1173', with '20' also circled in red. The first four search results are listed, each with a checkbox, a title, authors, journal information, and PMID. The search results are sorted by 'Recently Added'.

**Search Results:**

- 1. [Diarrhea-Predominant Irritable Bowel Syndrome Is Associated With Diverticular Disease: A Population-Based Study](#)  
Jung HK, Choung RS, Locke GR 3rd, Schleck CD, Zinsmeister AR, Talley NJ.  
Am J Gastroenterol. 2009 Oct 27. [Epub ahead of print]  
PMID: 19861955 [PubMed - as supplied by publisher]  
[Related articles](#)
- 2. [Contrast-enhanced CT colonography with 64-slice MDCT compared to endoscopic colonoscopy in the follow-up of patients after colorectal cancer resection](#)  
Amitai MM, Fidler H, Avidan B, Portnoy O, Apter S, Konen E, Hertz M.  
Clin Imaging. 2009 Nov-Dec;33(6):433-8.  
PMID: 19857803 [PubMed - in process]  
[Related articles](#)
- 3. [Liposarcoma of the colon presenting as an endoluminal mass](#)  
D'Annibale M, Cosimelli M, Covello R, Stasi E.  
World J Surg Oncol. 2009 Oct 23;7(1):78. [Epub ahead of print]  
PMID: 19852822 [PubMed - as supplied by publisher]  
[Related articles](#) [Free article](#)
- 4. [\[Extrapancreatic tumors in intraductal papillary mucinous neoplasm of the pancreas\]](#)  
Oh SJ, Lee SJ, Lee HY, Paik YH, Lee DK, Lee KS, Chung JB, Yu JS, Yoon DS.  
Korean J Gastroenterol. 2009 Sep;54(3):162-6. Korean.  
PMID: 19844152 [PubMed - in process]  
[Related articles](#) [Free article](#)

**Filter your results:** All (1173)  
[Review \(233\)](#)  
[Free Full Text \(299\)](#)

**Also try:**

- ▶ virtual ct colonoscopy
- ▶ ct colonoscopy screening
- ▶ ct colonoscopy nejm

**Titles with your search terms**

- ▶ Comparison of CT colonography, colonoscopy, sigmoidoscopy and fecal occult blood testing in patients with colorectal adenomas [Gut. 2009]
- ▶ Polyp size and advanced histology in patients undergoing colonoscopy [Gastroenterology. 2008]
- ▶ Colonography by CT, MRI and PET/CT combined with conventional colonoscopy [World J Gastroenterol. 2008]

» See more...



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But if somebody does not like sweating, may try to sneak the climbing...

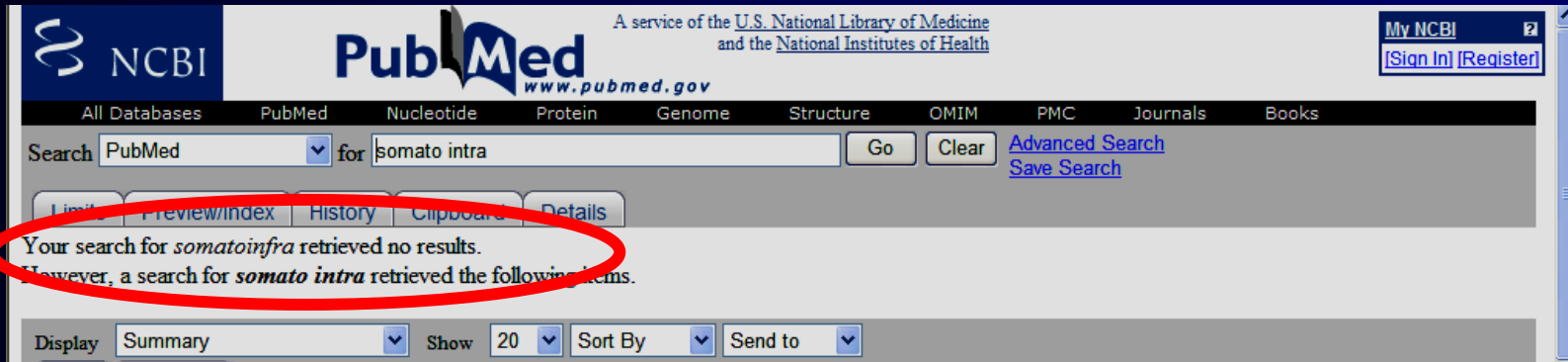




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# Somatoinfra

## Publication !?!?



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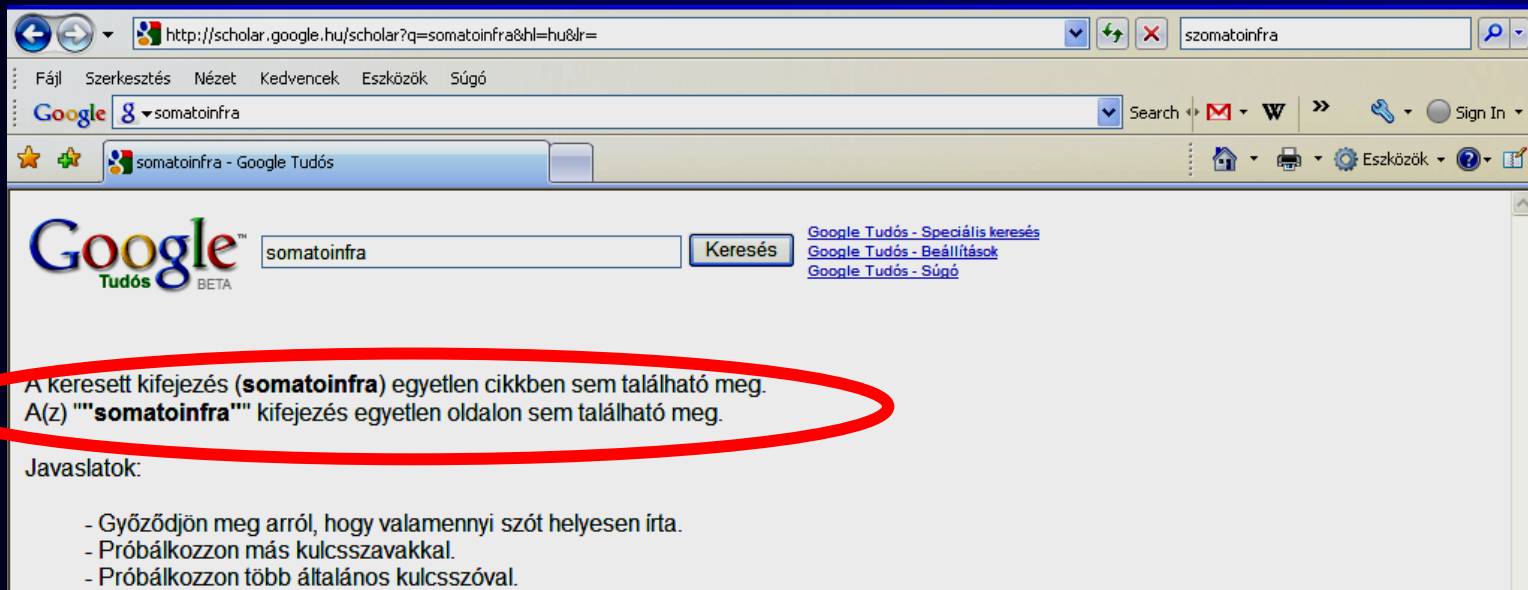
All Databases PubMed Nucleotide Protein Genome Structure OMIM PMC Journals Books

Search PubMed for somato intra   [Advanced Search](#)  
[Save Search](#)

Your search for *somatoinfra* retrieved no results.  
However, a search for *somato intra* retrieved the following items.

Display Summary Show 20 Sort By Send to

The screenshot shows the Medscape website interface. At the top, there are navigation links for Medscape, MedscapeCME, eMedicine, Drugs, MEDLINE, and All. A search bar contains the text 'somatoinfra' and a 'SEARCH' button. Below the search bar, a message in a light orange box states: 'We're sorry, your search for **somatoinfra** did not match any documents in Medscape and eMedicine.' This message is circled in red. At the bottom of the page, there are links for 'About Medscape', 'Privacy Policy', 'Terms of Use', 'WebMD Health', 'WebMD Corporate', 'Help', and 'Contact Us'. A copyright notice at the very bottom reads: 'All material on this website is protected by copyright, Copyright © 1994-2009 by Medscape. This website also contains material copyrighted by 3rd parties.'



The screenshot shows a Google Scholar search interface. The search bar contains the text "somatoinfra" and the "Keresés" button is visible. Below the search bar, a red oval highlights the following text: "A keresett kifejezés (somatoinfra) egyetlen cikkben sem található meg. A(z) ""somatoinfra"" kifejezés egyetlen oldalon sem található meg." Below this message, there is a section titled "Javaslatok:" followed by three bullet points: "- Győződjön meg arról, hogy valamennyi szót helyesen írta.", "- Próbálkozzon más kulcsszavakkal.", and "- Próbálkozzon több általános kulcsszóval."

http://scholar.google.hu/scholar?q=somatoinfra&hl=hu&lr=  
szomatoinfra

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A keresett kifejezés (somatoinfra) egyetlen cikkben sem található meg.  
A(z) ""somatoinfra"" kifejezés egyetlen oldalon sem található meg.

Javaslatok:

- Győződjön meg arról, hogy valamennyi szót helyesen írta.
- Próbálkozzon más kulcsszavakkal.
- Próbálkozzon több általános kulcsszóval.



# Why is it a problem if we don't make our homework?

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# Why is it a problem if we don't make our homework?

- Moral considerations



# Why is it a problem if we don't make our homework?

- ~~Moral considerations~~



# Why is it a problem if we don't make our homework?

- ~~Moral considerations~~
- Unethical money-making



# Why is it a problem if we don't make our homework?

- ~~Moral considerations~~
- ~~Unethical money making~~

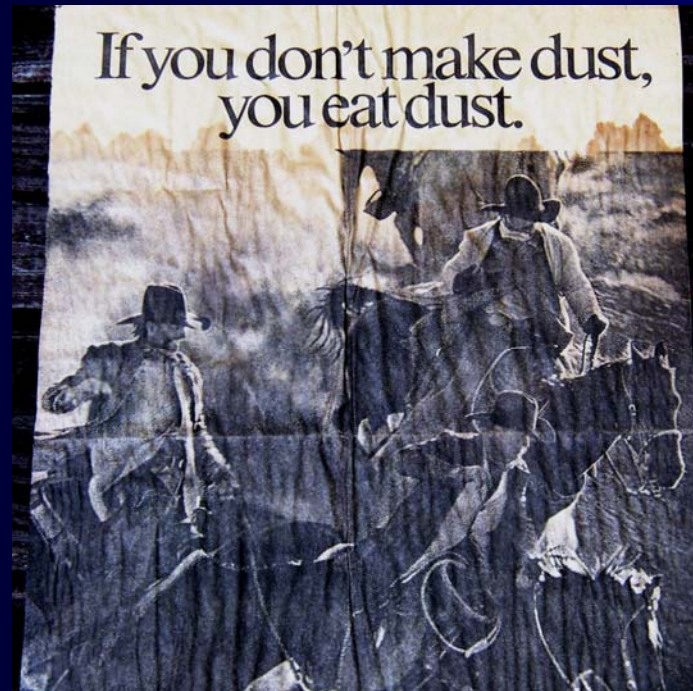


# Why is it a problem if we don't make our homework?

- ~~Moral considerations~~
- ~~Unethical money making~~
- We make the impression that the patient had undergone a relevant, well-established test, consequently he/she will
  - either undergo further, unnecessary, expensive, risky examinations (downstream effect),
  - or – even worse – will give rise to false sense of being disease-free







**... but there are situations in which it is more righteous to eat some dust...**



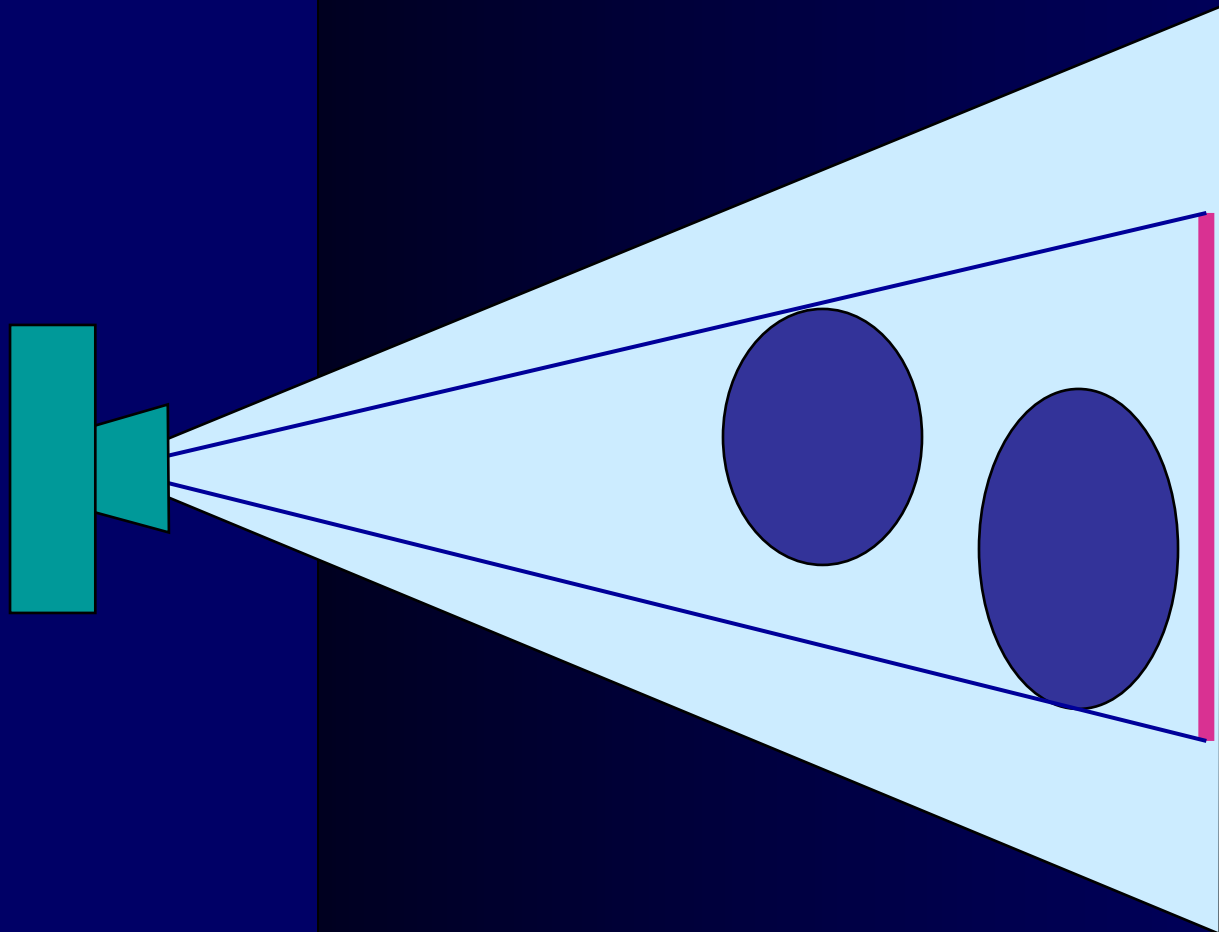
# Radiology lecture

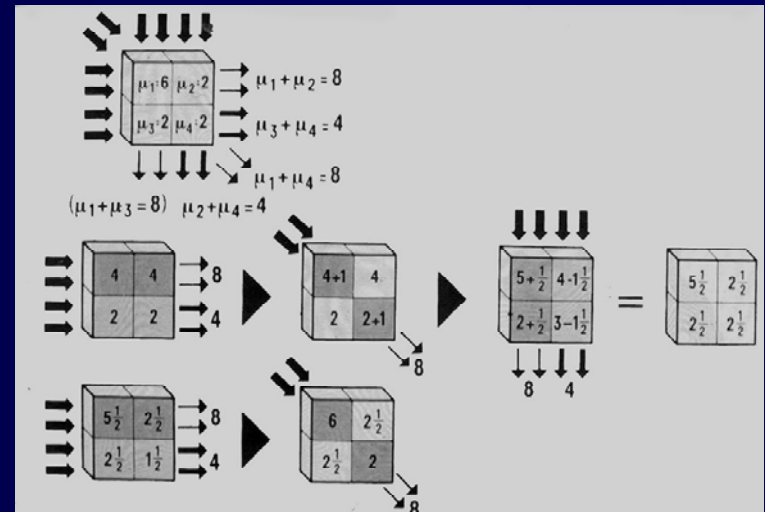
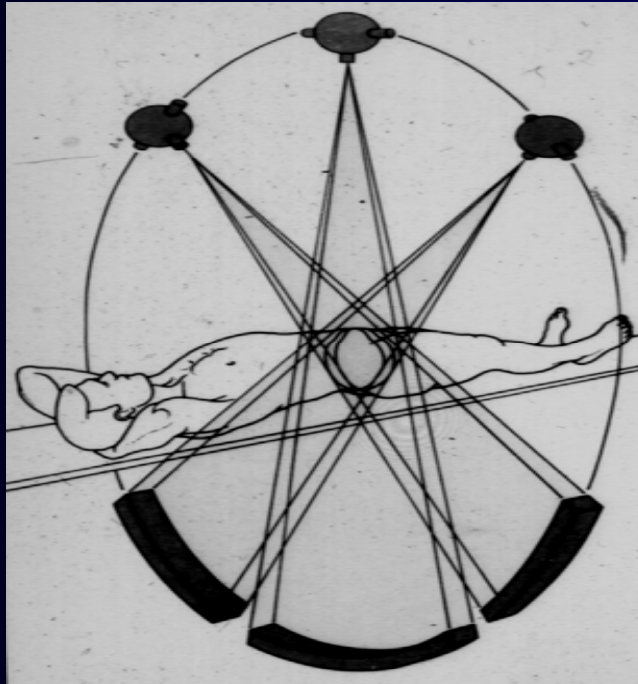
take it easy

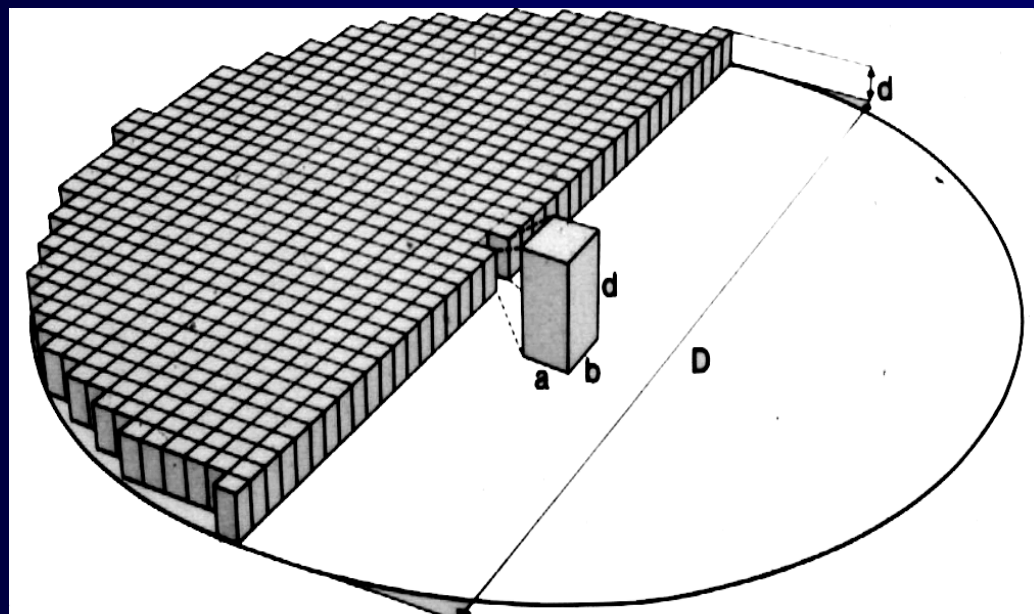
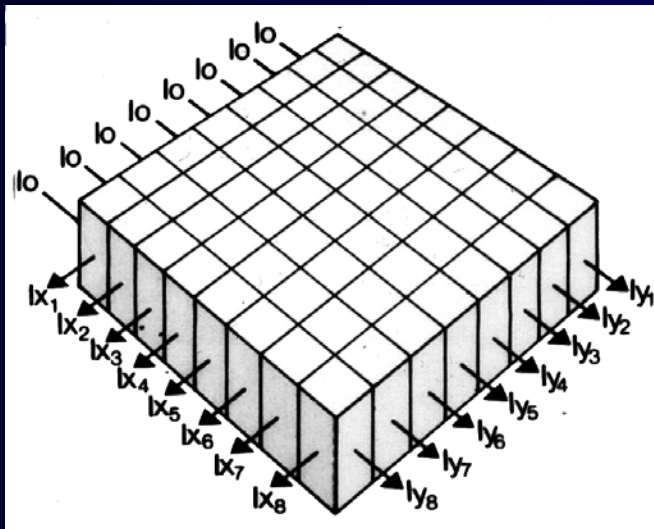


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# Computed tomography

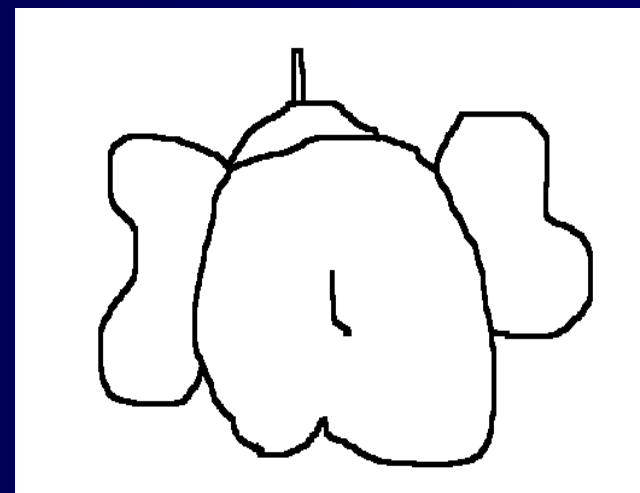
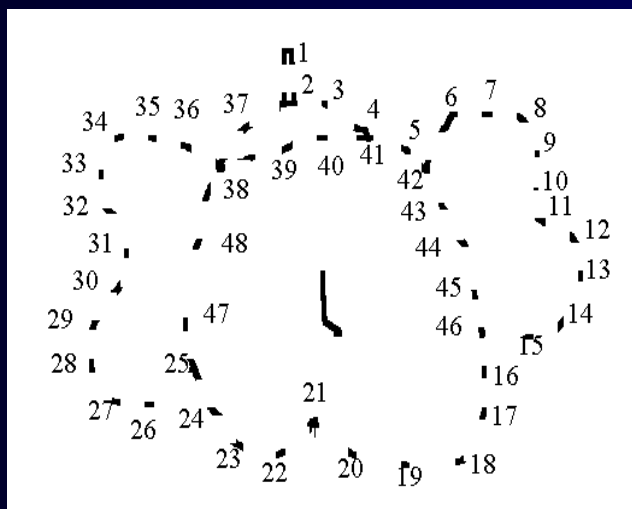








|    |    |    |    |
|----|----|----|----|
| +1 | -4 | +2 | +5 |
| +3 | +1 | 0  | -2 |
| -2 | 0  | +1 | -4 |
| -6 | +5 | +2 | +1 |

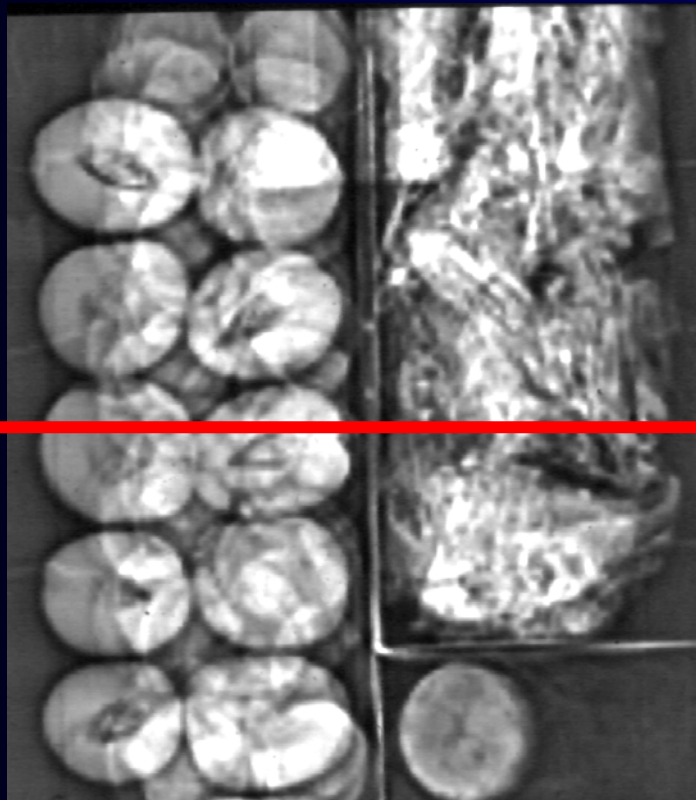




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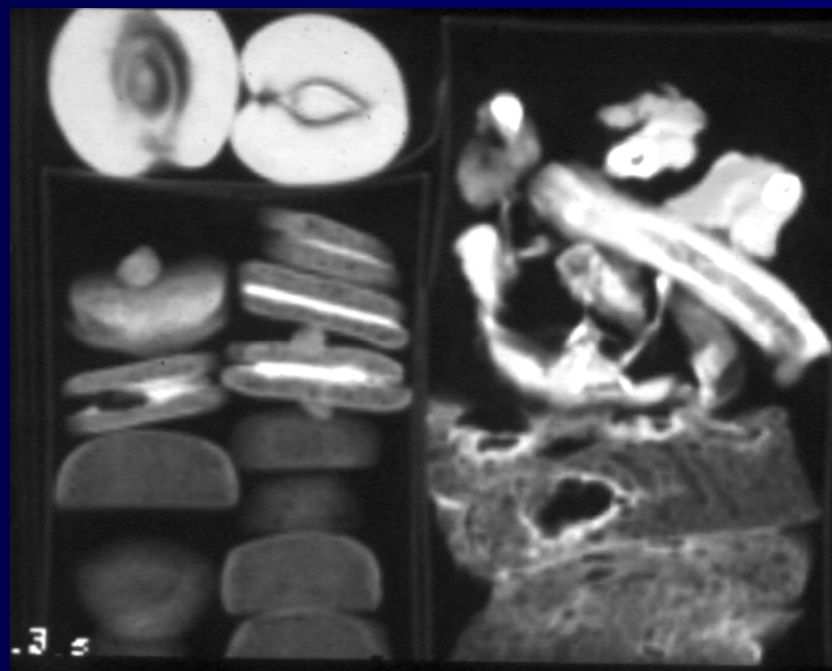
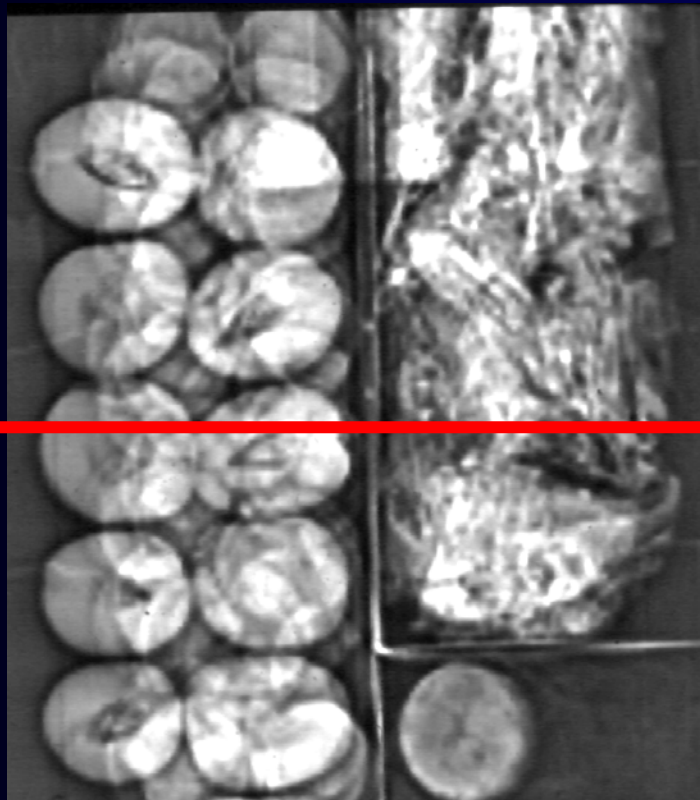


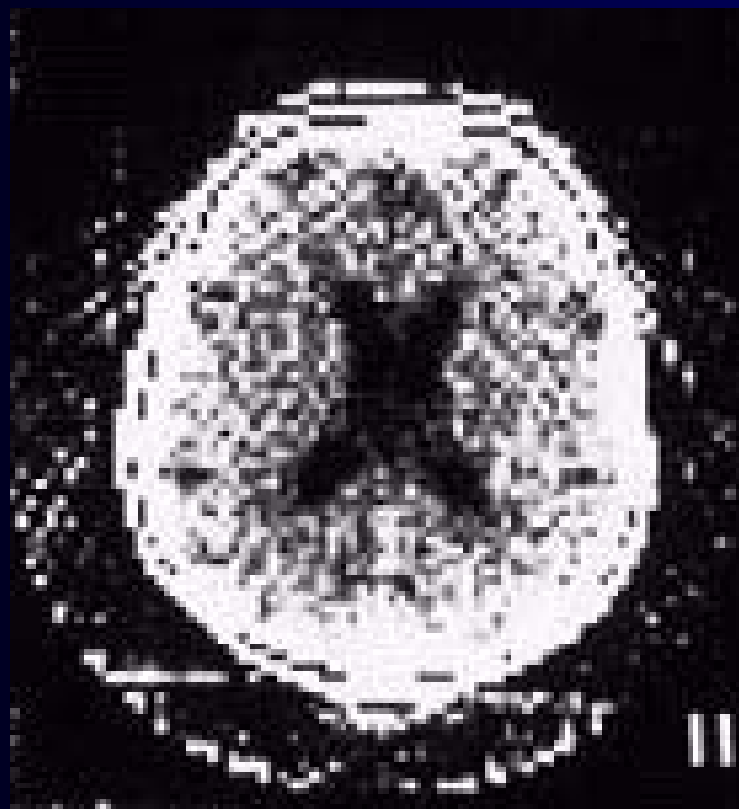
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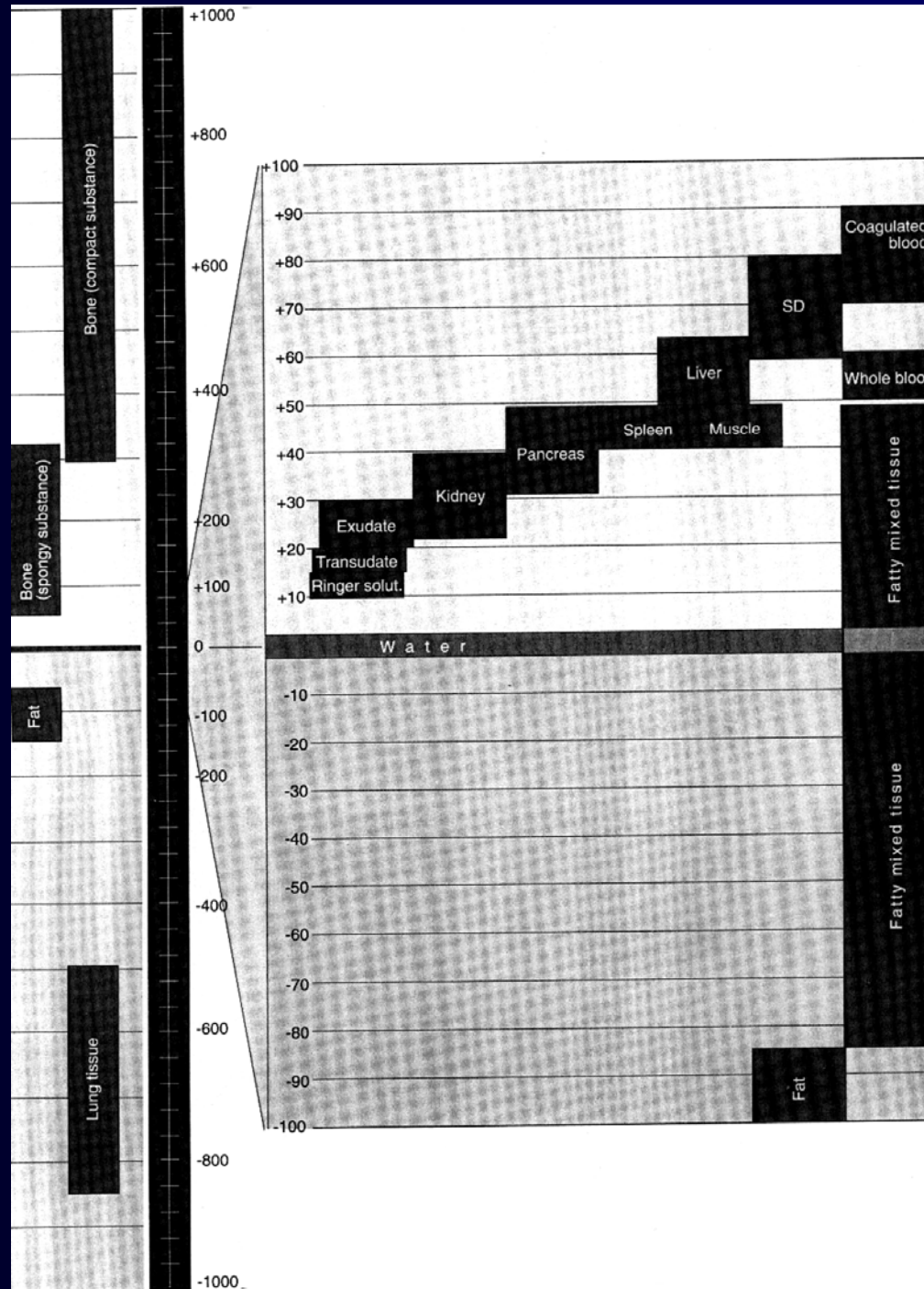


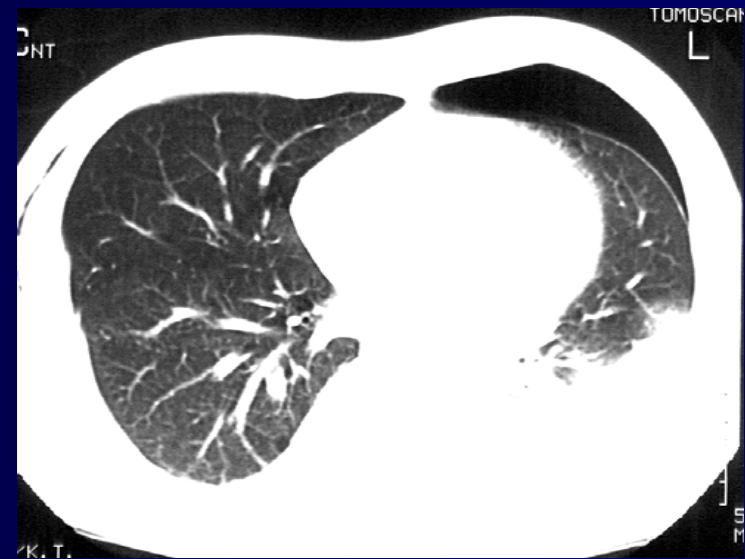
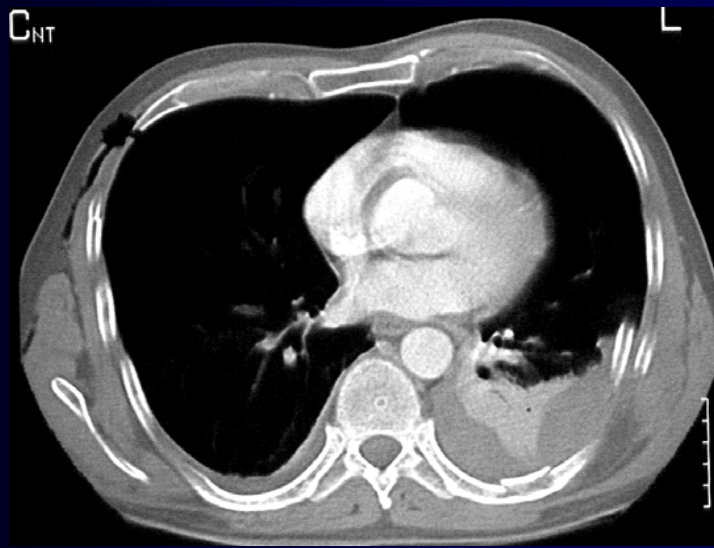


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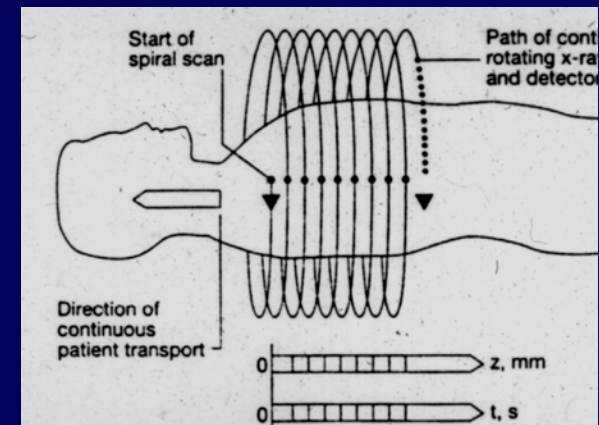


# Helical CT

Continuous table feed & tube rotation

Continuous data acquisition

Volumetric data-set

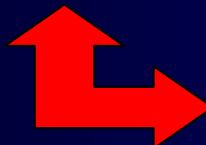


## Multislice CT

- multislice (2 - 360 detector-rows)
- subsecond scan-time
- „ultrasound paradigm”
- cardiological applications
- „whole body” imaging
- virtual endoscopy



**3D applications**



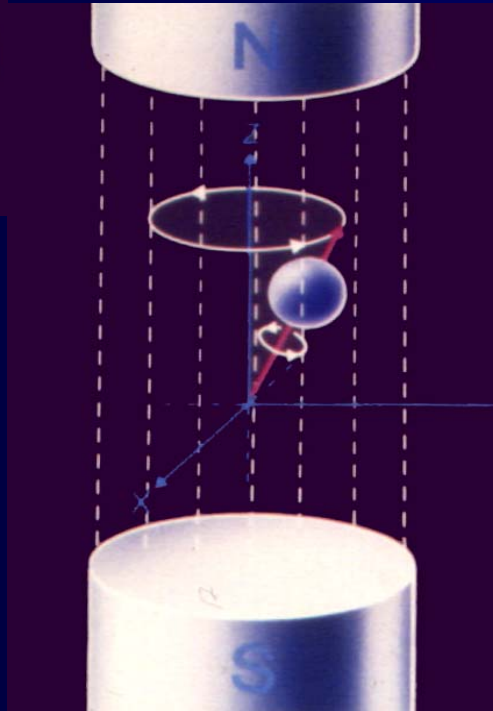
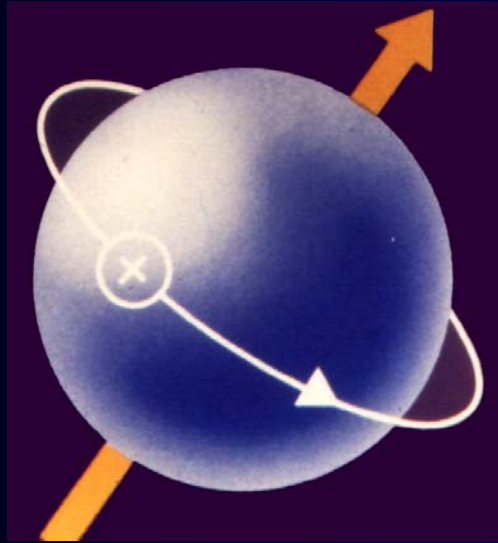
**EURATOM directive:  
ALARA principle**

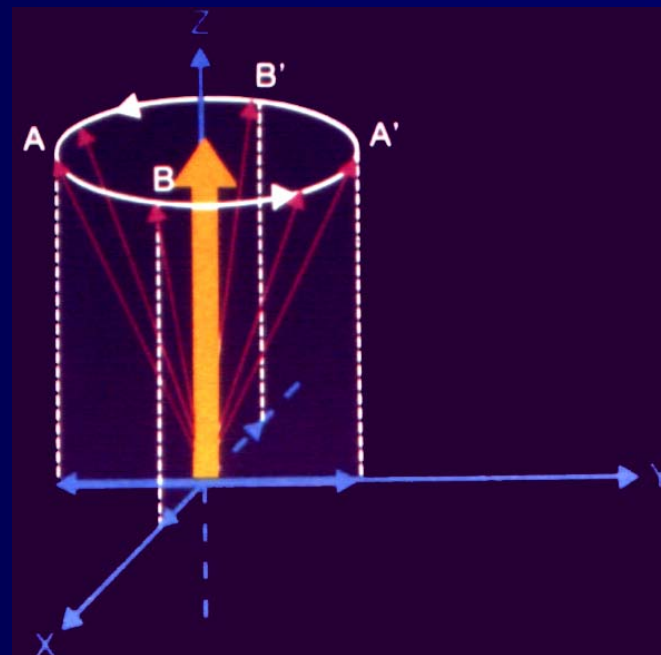
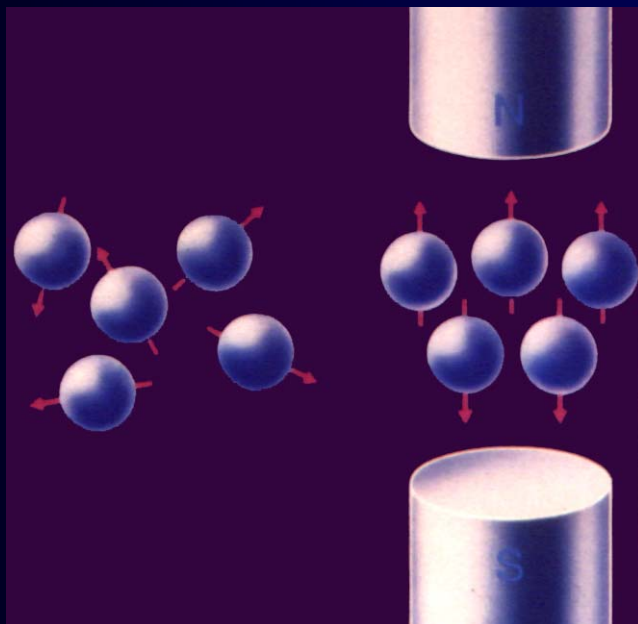


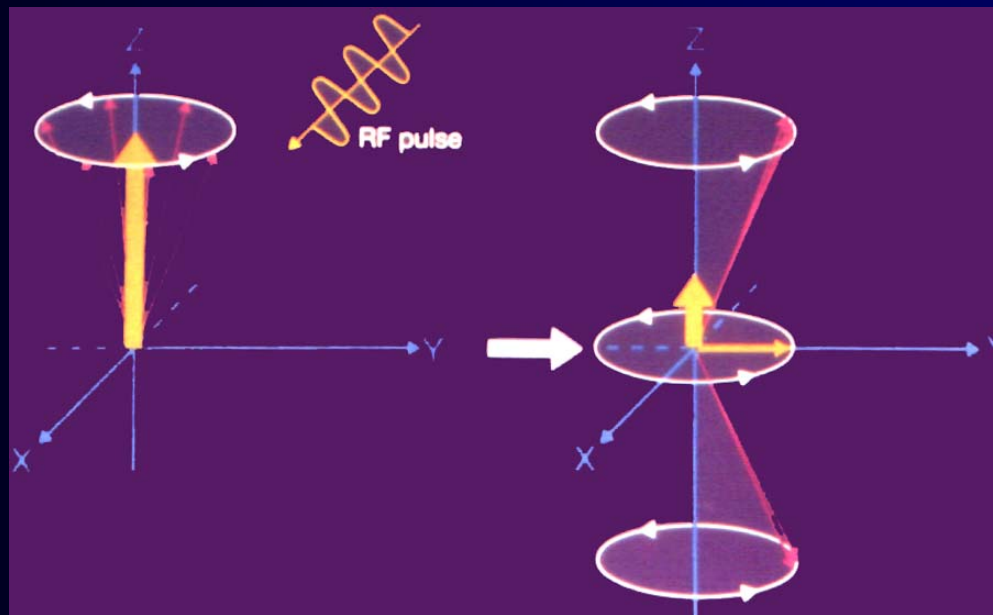
# Magnetic resonance imaging

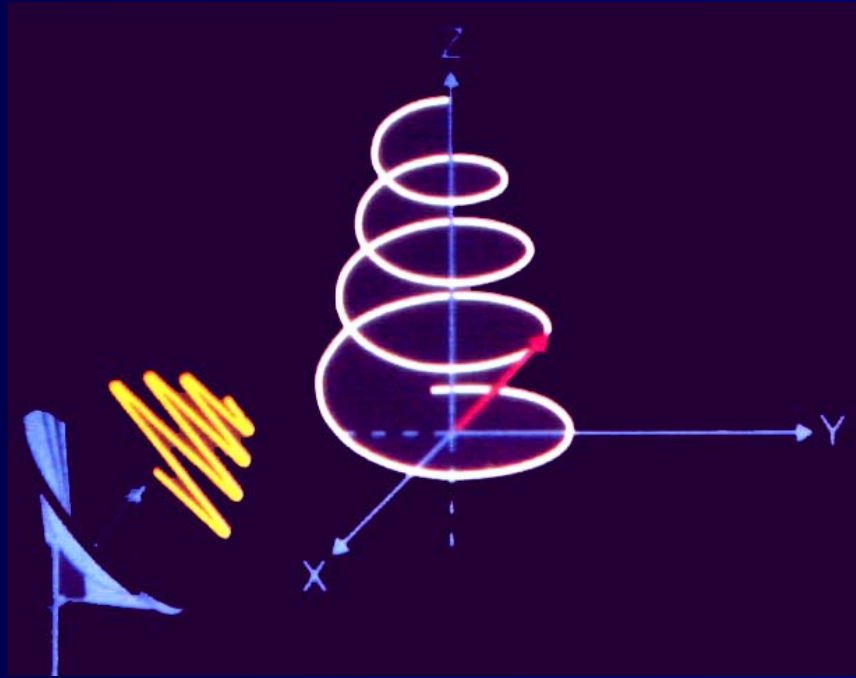
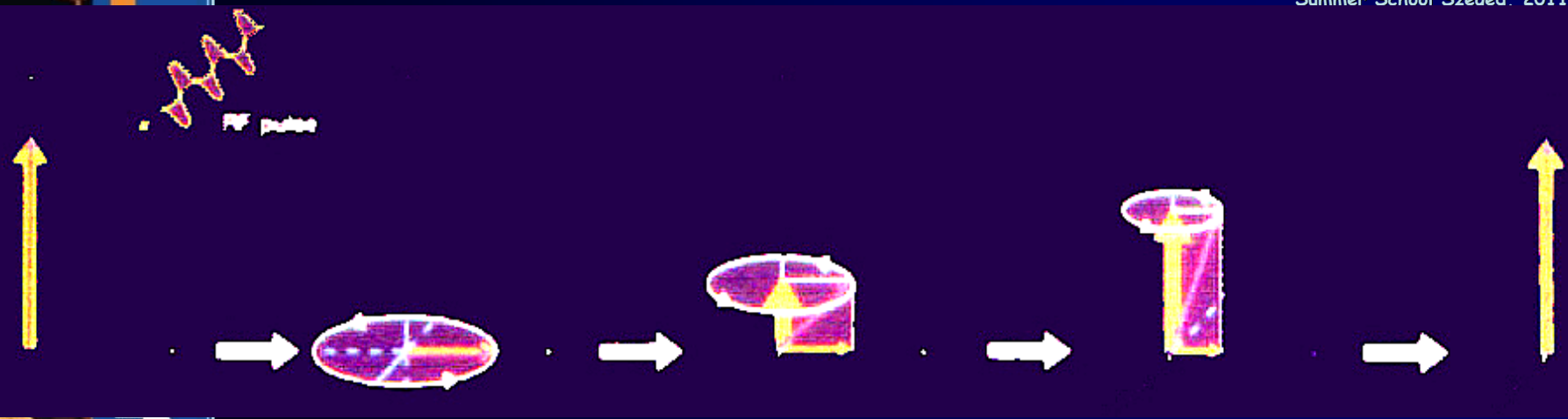
Lauterbur, Mansfield (1973) – Nobel-prize



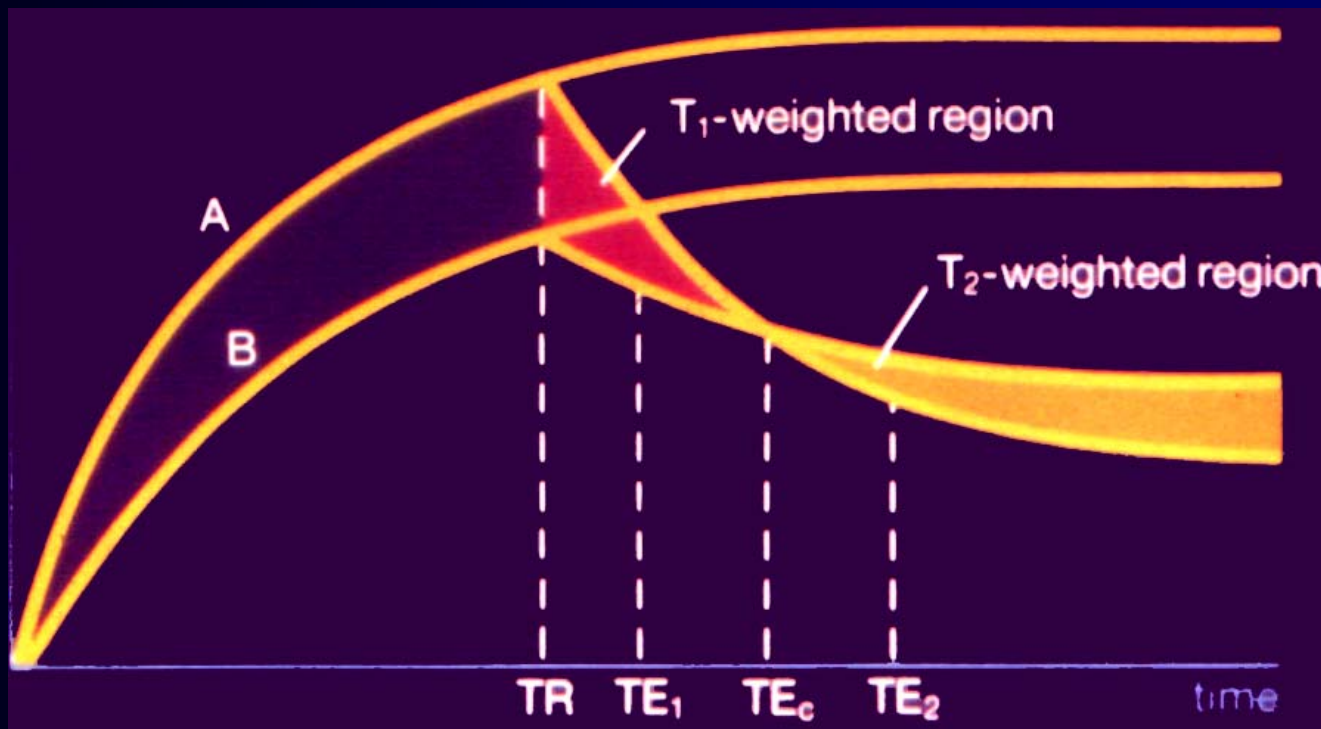


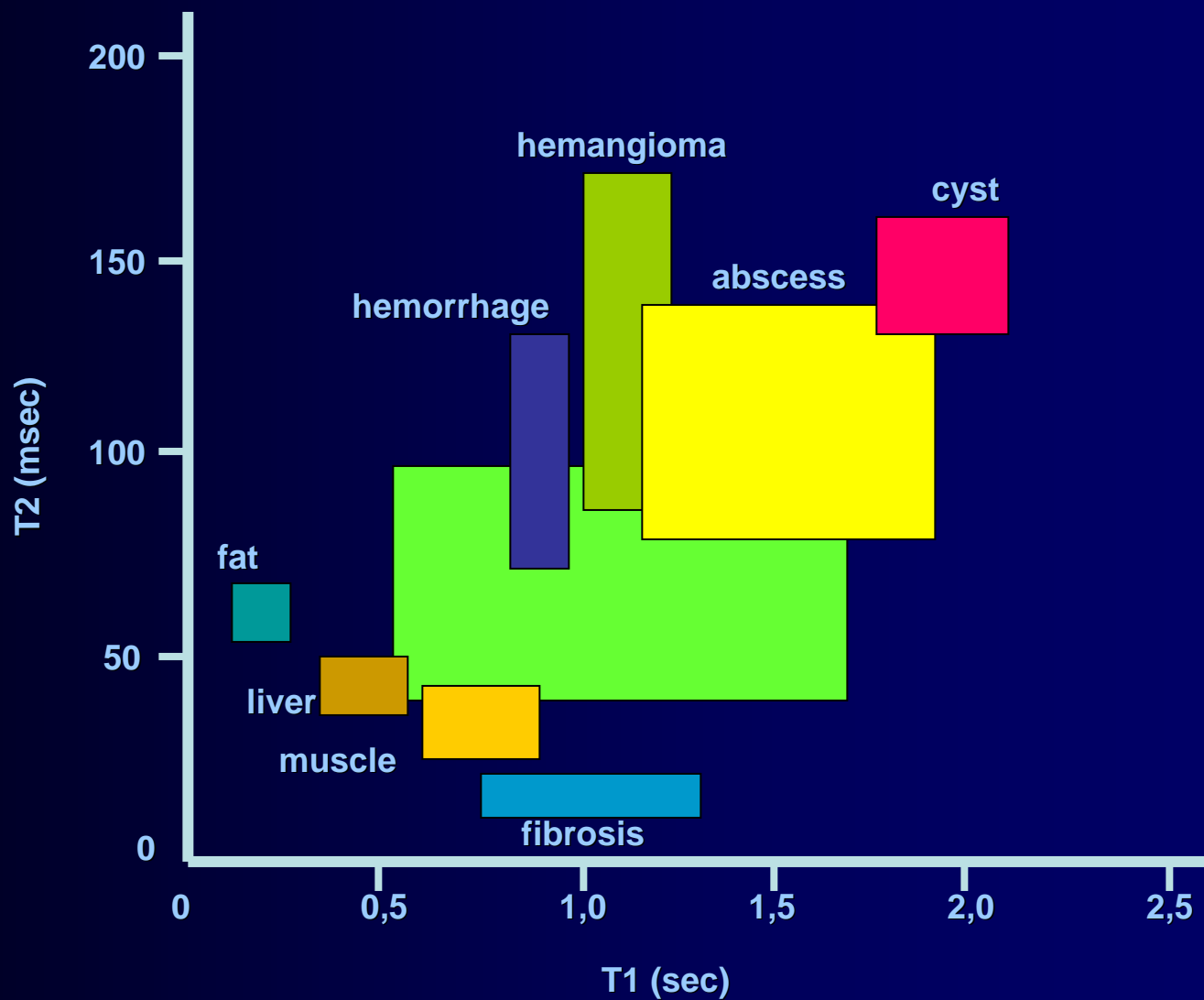






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**SZEGEDI TU**

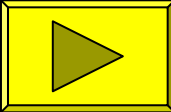




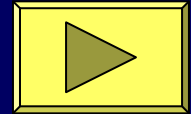
# Radiology seminar

## case-based, problem-solving

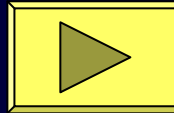
History



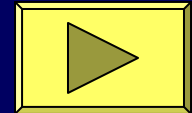
Clinical Data



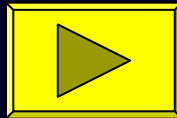
Plain X-ray examination



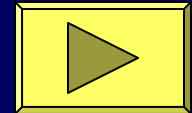
CT



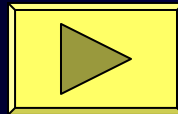
Sonography



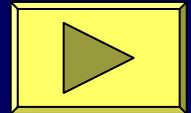
MR



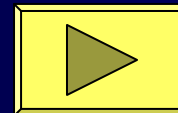
Contrast media enhanced X-ray examination



Other methods



Diagnosis and discussion



Liver 01





## Summary

- **Don't teach radiology – teach what radiology is good for**
- **Teach for the future – listen to research results**
- **Lecture – you are the "added value"**
- **Practical/seminar – clinically oriented**

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*Thank you for your kind attention*

