Role of Imaging in Oncology

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Basic information in Oncology

- **Tumor staging is one of the most important prognostic factors , it determines therapy** (operability, radio-, chemotherapy planning)
- **Imaging is of great importance in cancer management**
  - DETECTION and EVALUATION of tumor
- **Precise evaluation** is only possible using strict technical criteria, **standard protocols** and **correct image interpretation – our responsibility is high**

Role of imaging
in the Oncologic Decision Process

early detection, precise tumor mapping, to give information of tumor volume, structure, vascular nature

- **To detect** tumor (to finde the primary and metastasis)
- **To stage** prior to treatment, T / N / M
  - To give comparable information of tumor volume and structure
  - To finde nodal metastases
  - To finde distant metastases
- **To evaluate therapy response**
- **To fix a baseline** status following initial therapy,
- **To follow the patient - to finde the early recurrent TU**
- **To restage the tumor** for the best therapy

To give information about the „nature" of the disease
To perform guided tissue sampling (biopsy)

- **Imaging plays an important role also in planning radiotherapy**

Imaging modalities

- **Anatomic imaging modalities**
  - Conventional X-ray – mammography (digital)
  - Angiography – Digital Subtraction Angiography (DSA)
  - US
  - **CT – MD-CT** (for tu evaluation ≥16 detector rows)
  - **MRI –** (high magnetic field strength, 1.5T-3T)
- **Functional, molecular, metabolic imaging modalities**
  - RN
    - SPECT-CT
    - PET/CT
  - DW-MRI, DCE-MRI, MRSI, tissue specific CA-MRI, perfusion CT, CE-US

Functional-, molecular-, metabolic imaging

imaging biomarkers in oncology

NEW measurements, *qualitative, semiquantitative, quantitative*

(partly in the routine examinations / partly in clinical research)

Molecular- / functional data

DW-MRI *based on: water diffusion restriction because of TU cell density, -integrity, with qualitative-, and quantitative (ADC measurement) information*

Perfusion DCE-MRI *based on: vascularisation, vascular permeability, with* qualitative, semiquantitative *(time-enhancement curve) information (may be also* quantitative)

Tissue specific CA *(hepatocyta-, RES specific)*

MRSI *based on: biochemical status of molecular products*

CE-US *based on: tumor neo-vascularisation*

Perfusion CT *based on: perfusion alteration because of tumor vascularisation*

SPECT/CT, PET/CT *(using isotop tracers, based on: different metabolic processes)*

CXR

The role of convenional radiography in the evaluation of tumor cases is limited

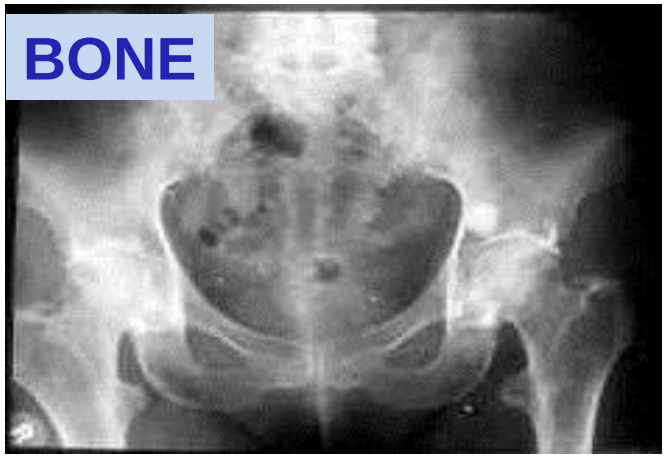
To day Digital

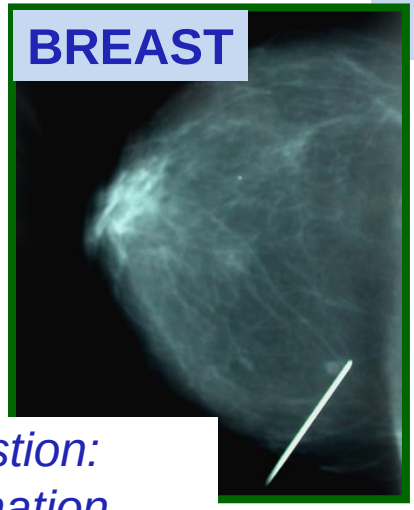
- *Easy access, cheep*
  - Bone
  - Lung
  - Breast
  - Abdomen
  - Gastro-intestinal tract

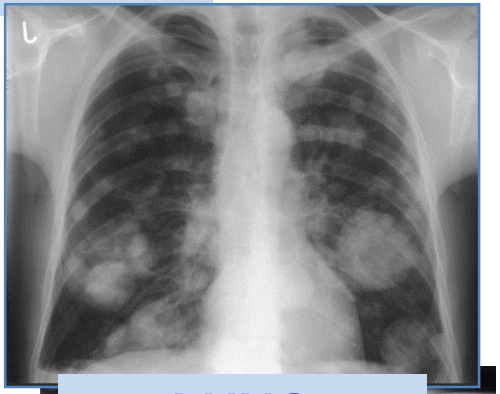
Tomosynthesis – renewed, digital tomography for the lung and breast

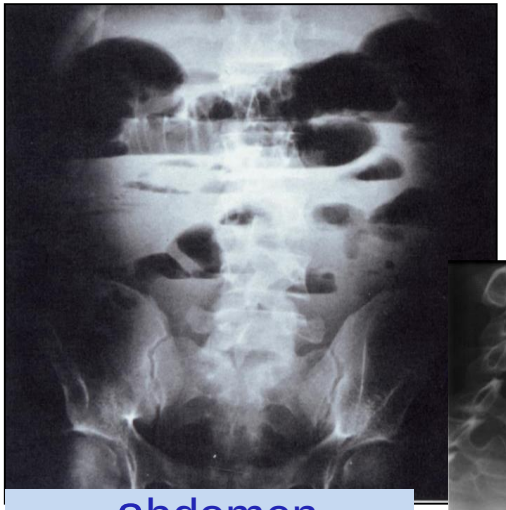
Main QUESTION: is the information enough??

CXR in oncology



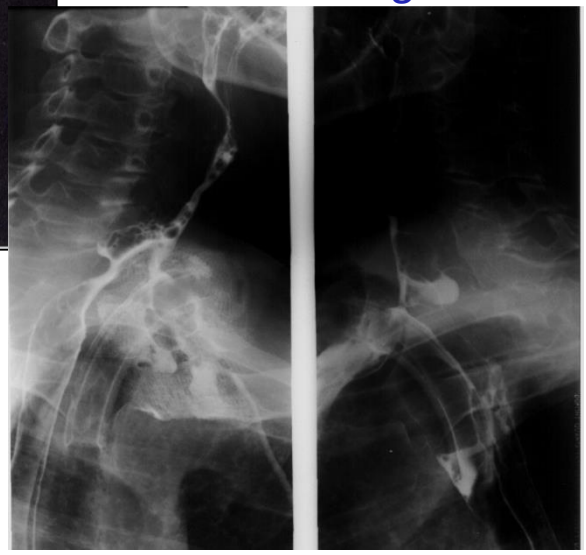




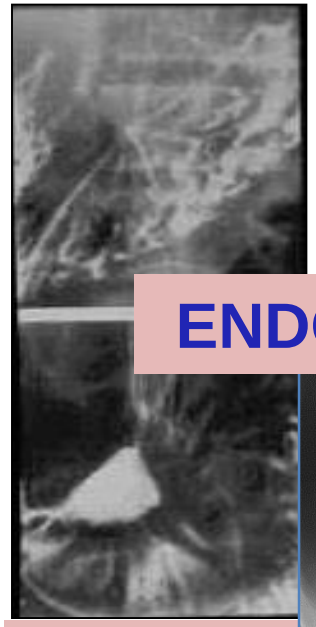


abdomen
Ileus? perforation?

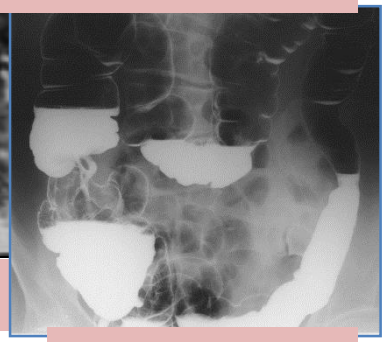
Question: information will be enough ??



esophagus
Swallowing function



stomach



ENDOSCOPY!

colon

BONE

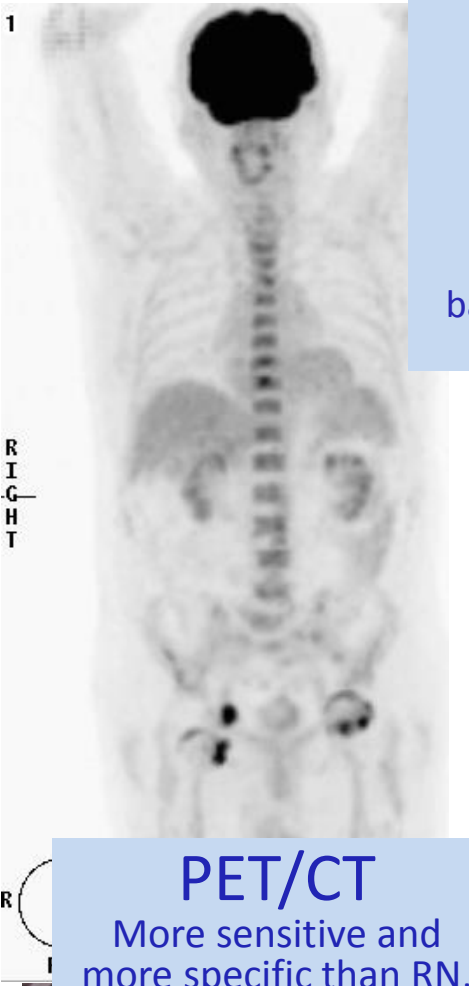
Spine metastasis

RN-

osteoscan

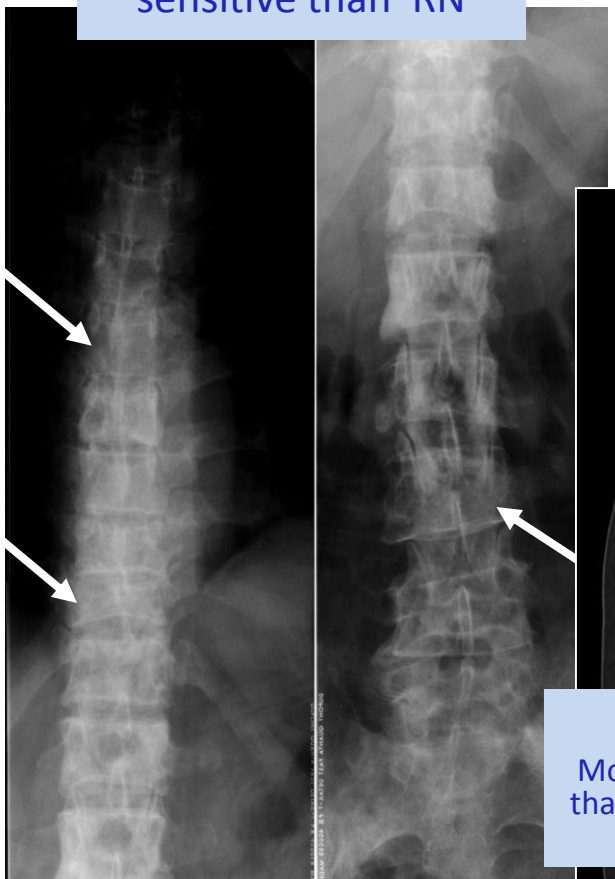
Tc-99m diphosphonate, Very sensitive, but less specific

based on: osteoblast activity



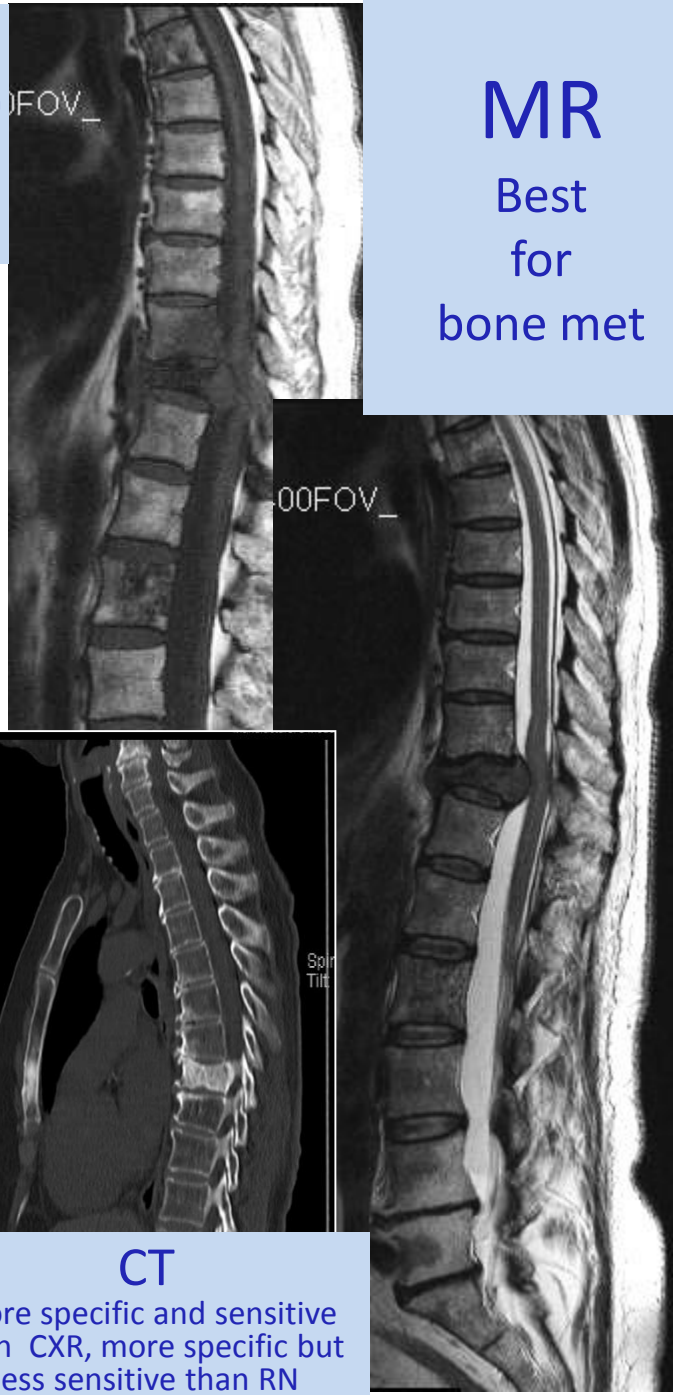
CXR

More specific but less sensitive than RN



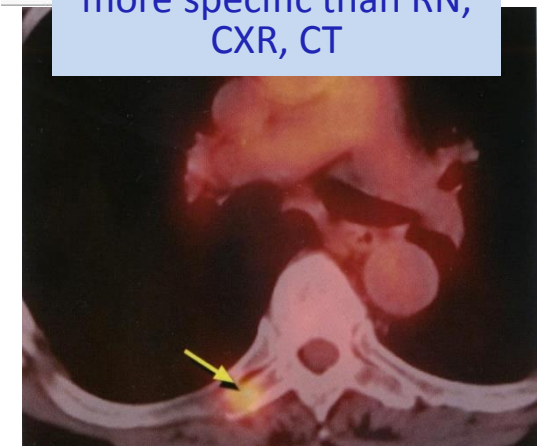
MR

Best for bone met



PET/CT

More sensitive and more specific than RN, CXR, CT



CT

More specific and sensitive than CXR, more specific but less sensitive than RN

Ultrasonography

excellent for the soft tissue

Advantages:

- Easy access, cheep
- Excellent soft tissue resolution
- Non invasive, non ionising, good tolerable
- Real-time information
- Flow information

Clinical applications

- Transcutan – abdominal, pelvic, neck, breast, extremities
- Endocavital, - rectal, -oesophageal, - endoscopic US
- Intraoperative US
- US guided biopsy/drainage

Disadvantages :

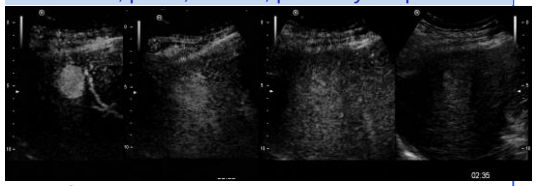
- Lack of complex information
- Difficulties in the evaluation of
  - Deep structures
  - Big lesions
- Lack of bone evaluation
- Subjective
- Techniques dependent

Methods

- Gray scale
- Doppler
- **CE-US**
- US-elastography

CE-US - HCC

arterial, portal, venous, parenchymal phases

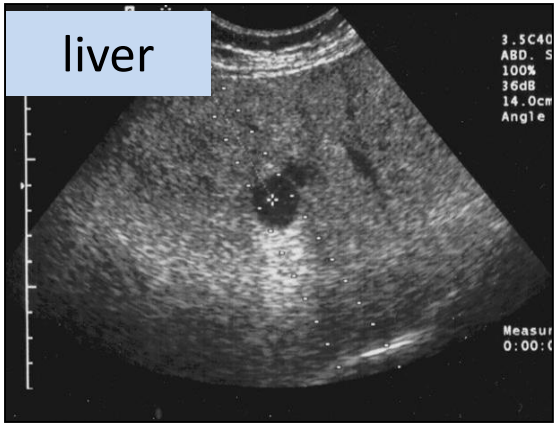


US is not the standard tool for tumor evaluation

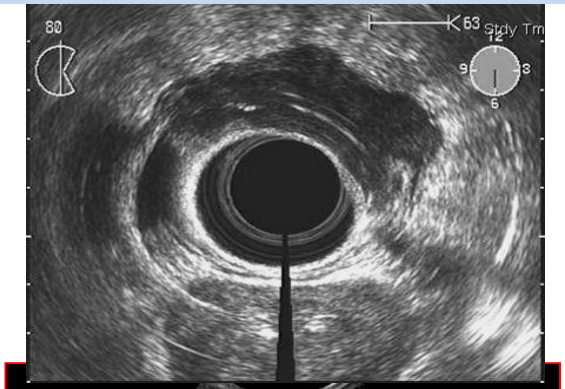
US
excellent soft tissue resolution

BUT
lack of complex information

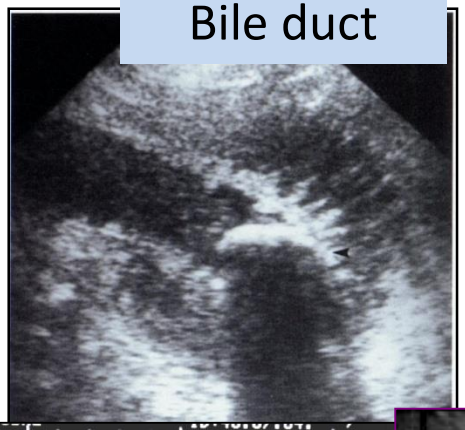
liver



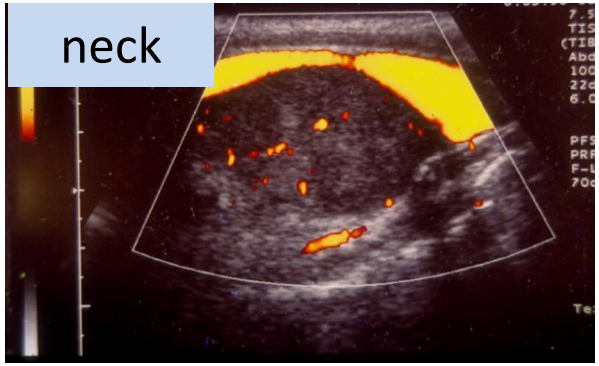
Endorectal US-in rectal ca

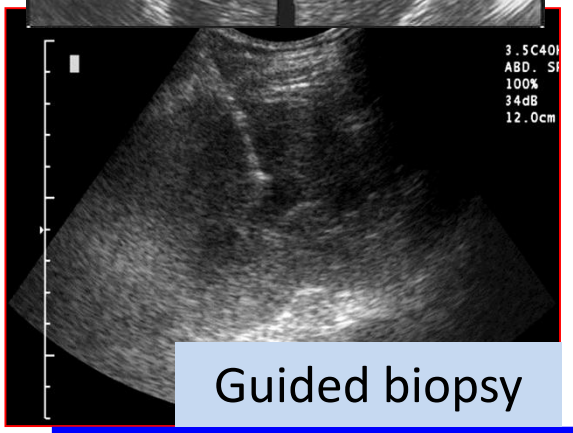


Bile duct

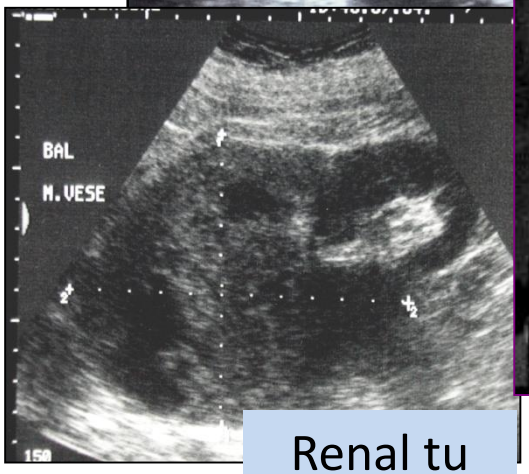


neck

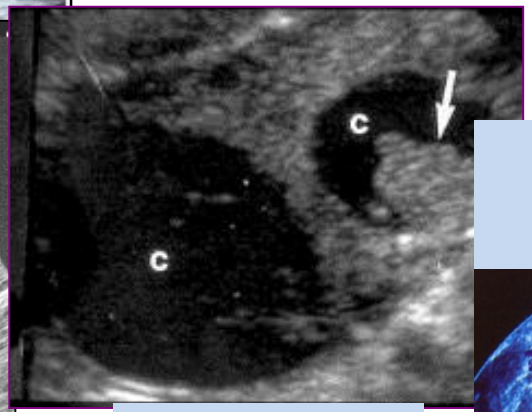




Guided biopsy

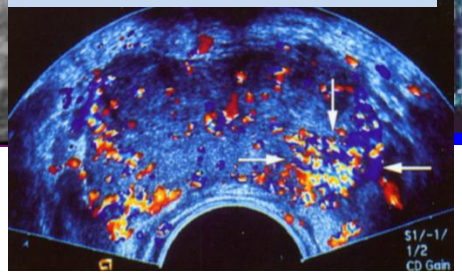


Renal tu



Ovarian ca

Endorectal US-
in prostate ca



CD-US

Advantages of MD-CT

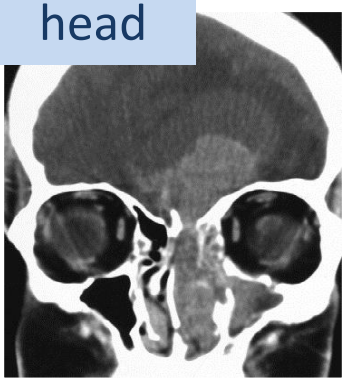
Complex information of the tumor & tumor spread
(for tu evaluation ≥16 detector rows)

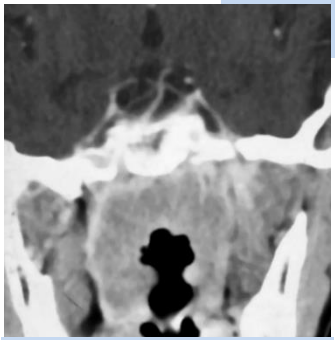
- Quick, tolerable, informative
- Whole body information
- High spatial & High contrast resolution
- Volumetric measurement – Multiplanar-, 3D information
- Good soft tissue information using contrast agent
- Excellent temporal resolution in the contrast enhanced dynamic phases
- Best demonstration of bone cortex / trabeculae / tiny bone lamellas (*BUT not for the bone marrow*)
- Delineation of calcification

Disadvantage: ionising radiation

CT – Quick, informative, BASIC method for cancer patients!

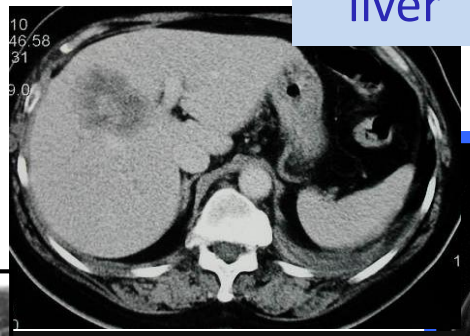
head



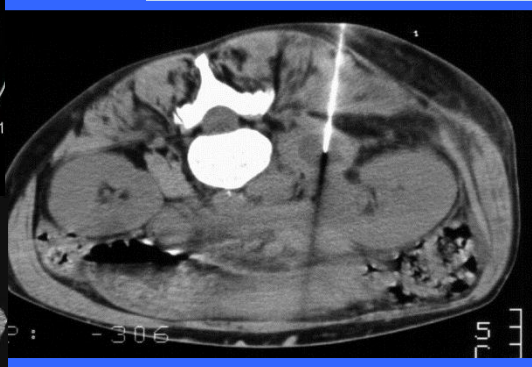


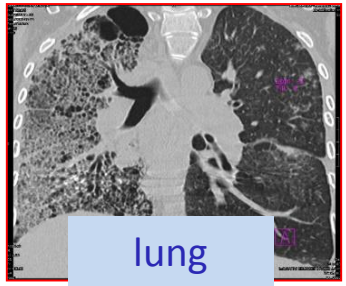
Skull base, neck

liver

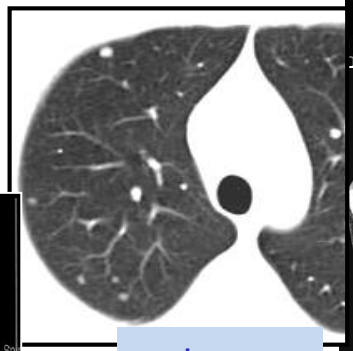


Guided biopsy

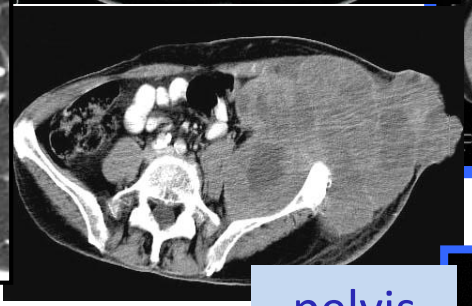




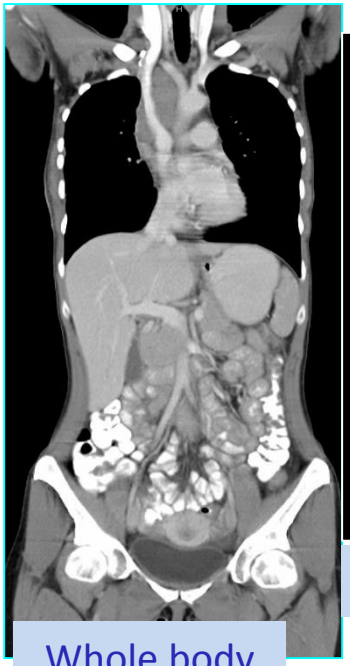
lung



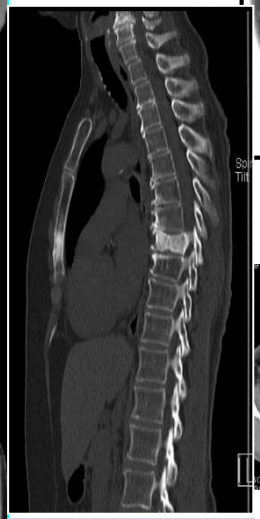
lung



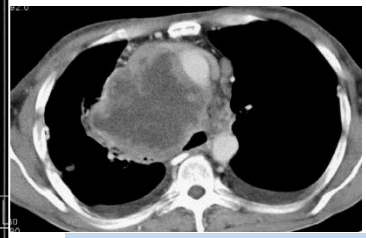
pelvis



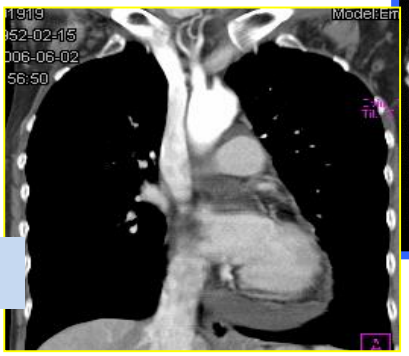
Whole body

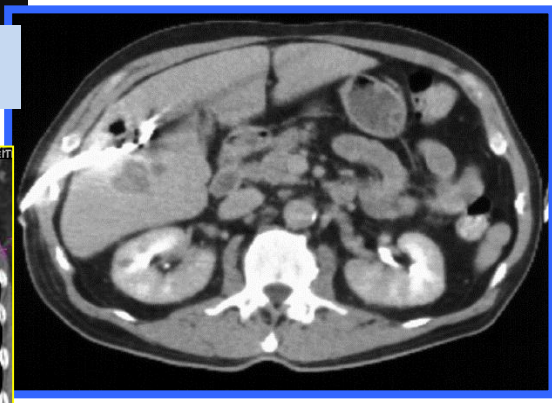


Bone, spine



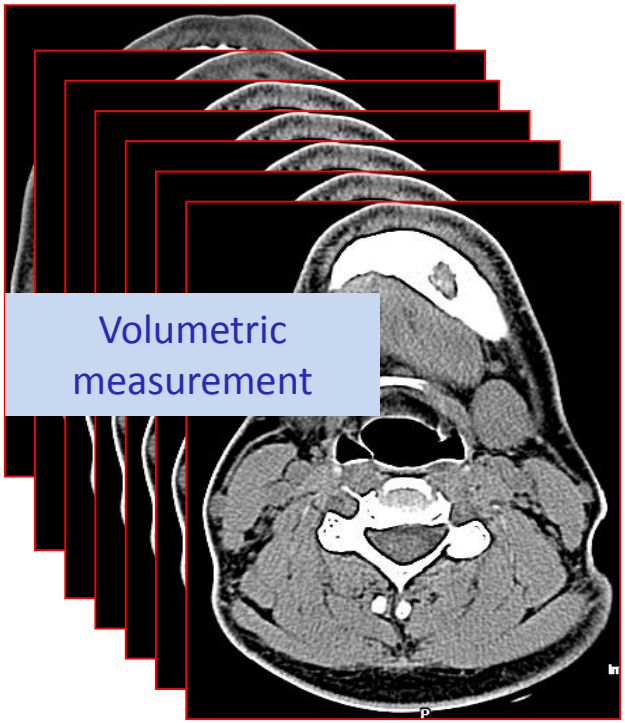
mediastinum



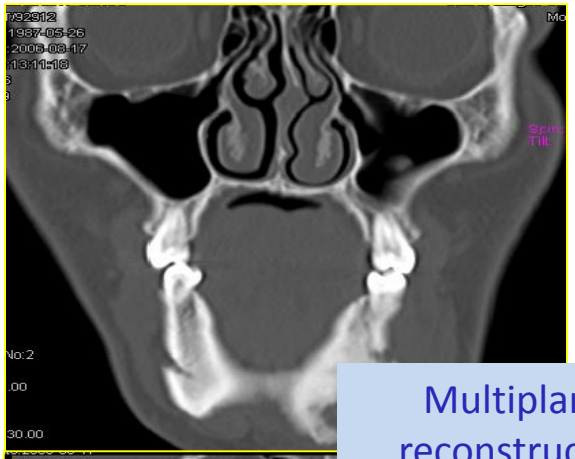


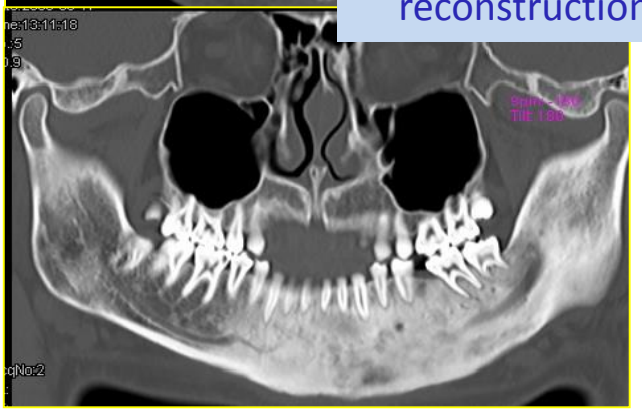
Guided drainage

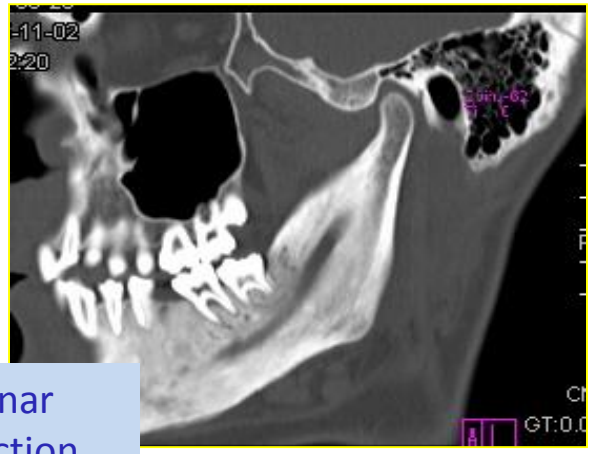
MD-CT -Volumetric measurement – Multiplanar-, 3D information



Volumetric measurement

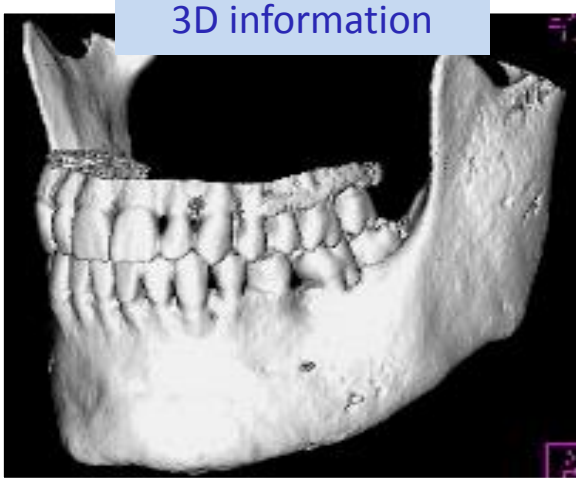






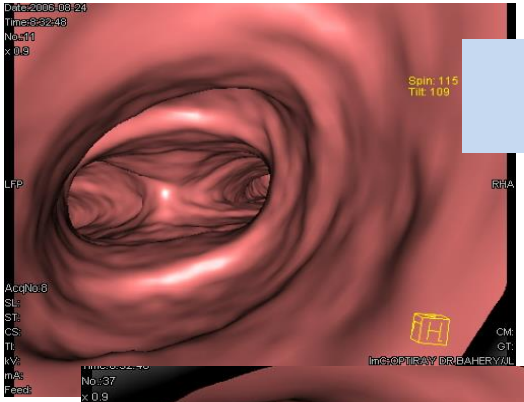
Multiplanar reconstruction

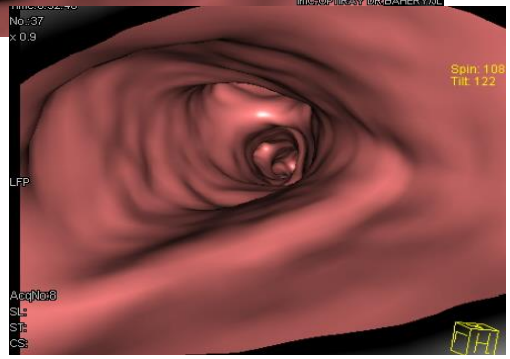
3D information

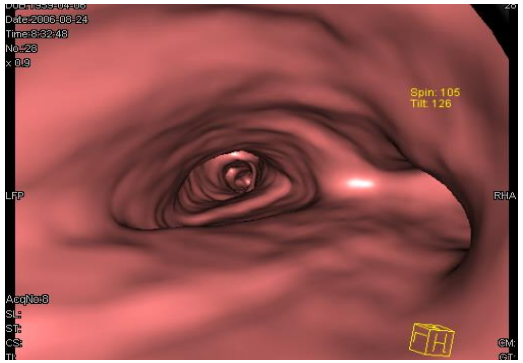


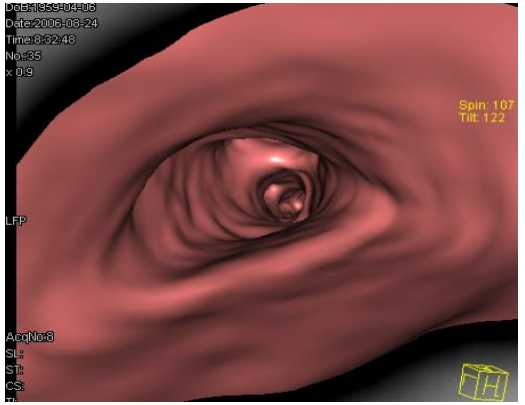
MDCT

Virtual endoscopy



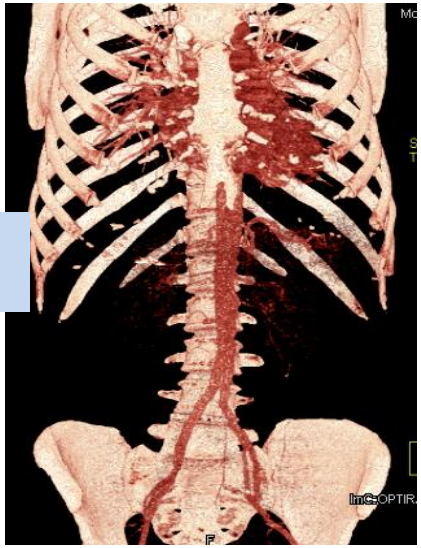


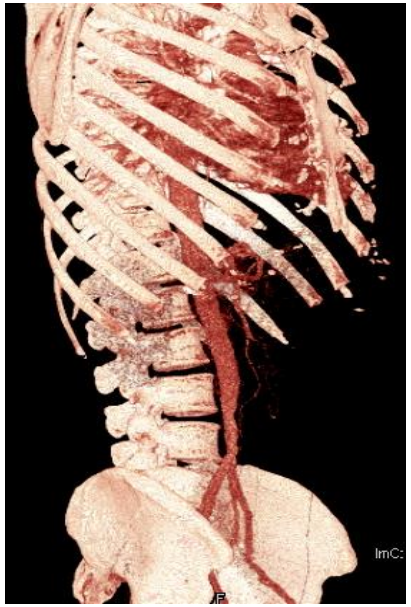




based on volumetric data collection

CT- Angiography





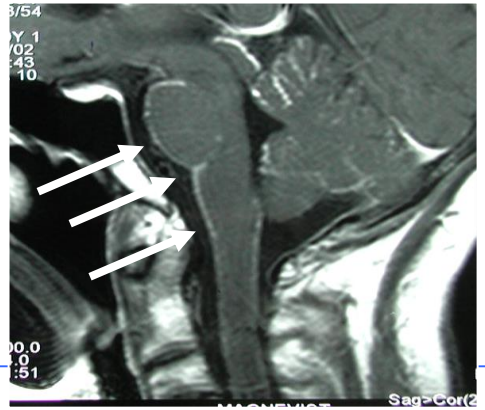
Magnetic Resonance Imaging- MRI

excellant multiparametric modality

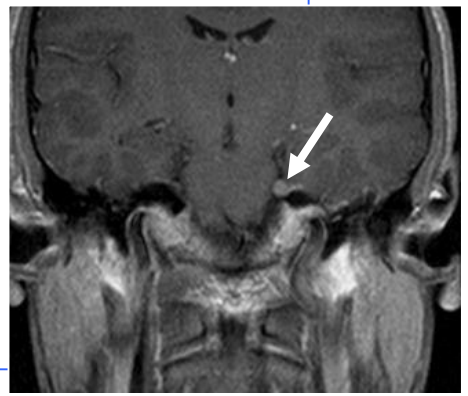
with High spatial & High contrast Resolution

- **Best soft tissue evaluation** of intracranial-, perineural spread, spine head and neck, pelvis, upper abdomen, breast, extremities
- **Tissue specific information:** fat, melanin, blood, etc. Extracellular-, hepatocyta-, RES-specific contrast agents
- **Functional information:** diffusion-weighted MRI (DW-MRI), dynamic contrast enhanced MRI (DCE-MRI), MR-spectroscopy (MRSI)
- **Flow sensitivity**
  - MR angiography

without ionising radiation



Lepto-meningeal TU spread



Perineural (N.V.) TU spread

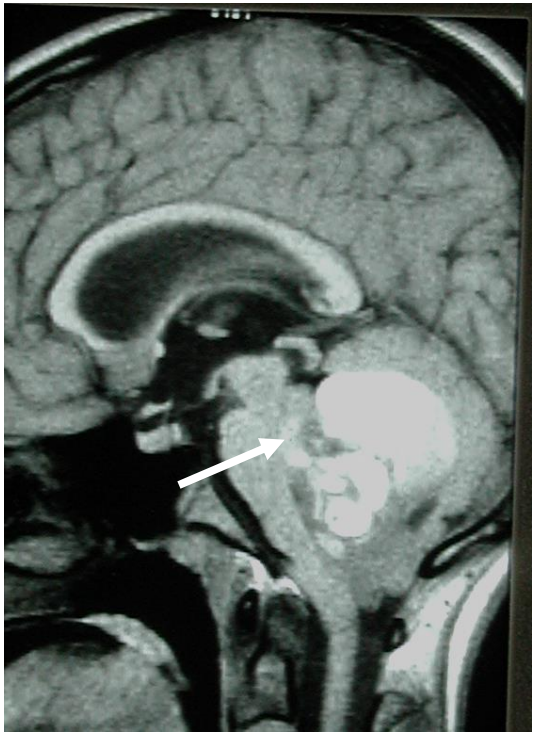
Bests of MultiParametric MRI (MP-MRI)

(Using: native T1-,T2-w, with / without FS, CE-T1, DW-, DCE-MR)

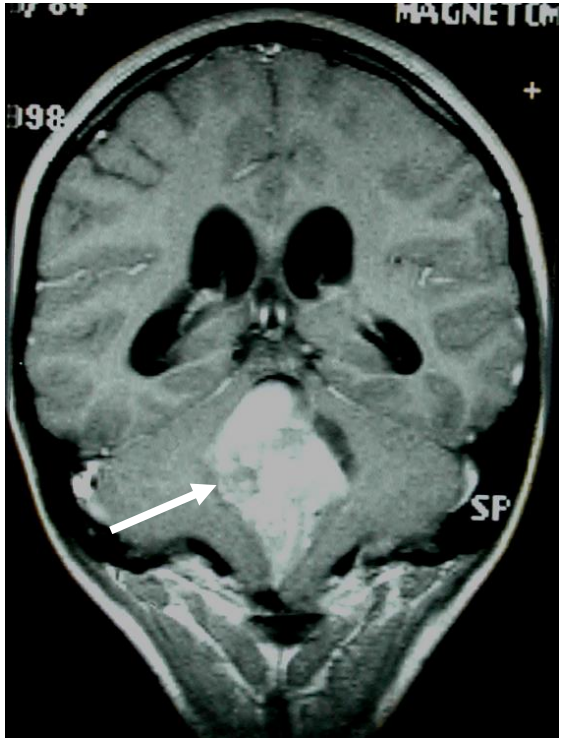
-
- **Brain tu– CT+MRI= 80% improvement in assessment of Tu volume**
- **H&N (best local tu stage, best intracranial-, perineural extension, lgl evaluation) - MRI Acc > 90%**
- **Liver foci –** (using also tissue specific contrast agent)
- **Pelvis**
  - **Prostate ca–CT+MR=> 90% -**
  - **Gynecological tu's – MR Acc > 90% -**
  - **Rectal ca – MR Acc >90% improvement in staging**

MEDULLOBLASTOMA in the IV. ventricle
MRI- CE-T1-w images

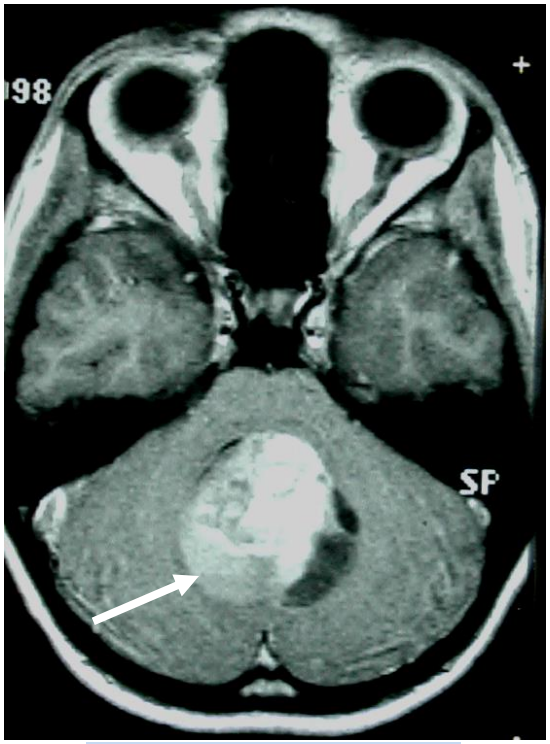
Best multiplanar evaluation of intracranial tumors



Sagital

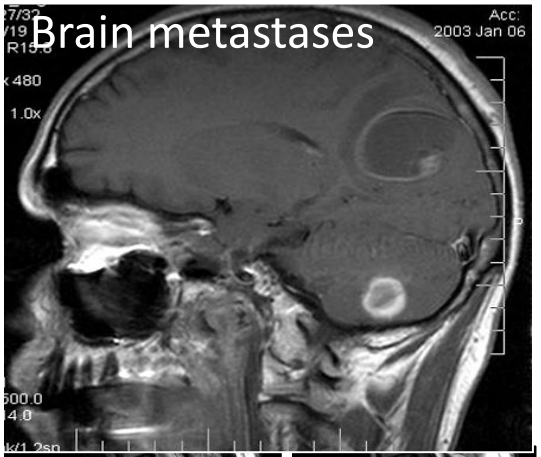


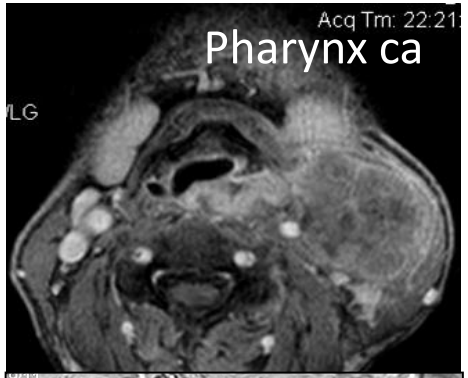
Coronal

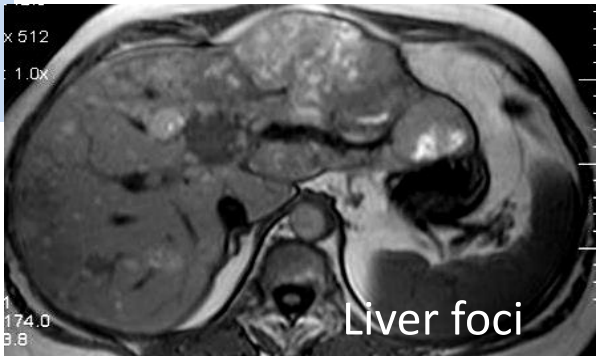


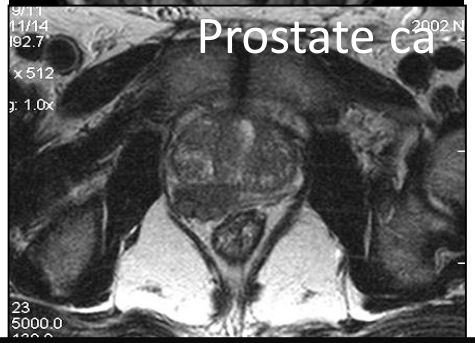
Axial

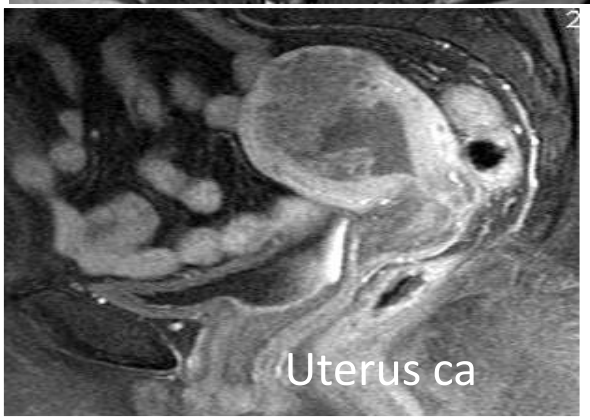
To day: MRI- Basic method

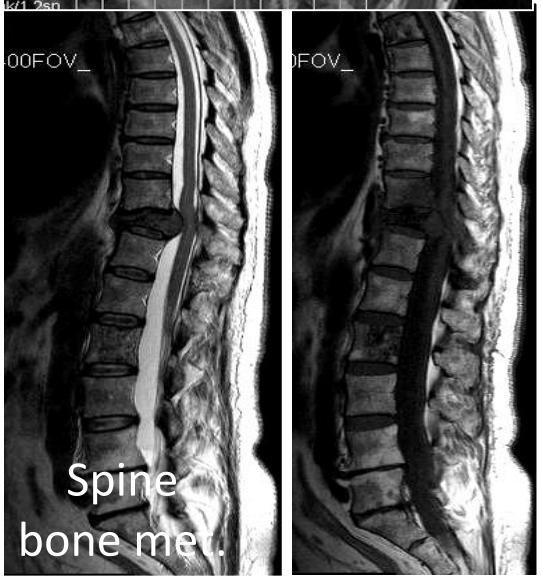


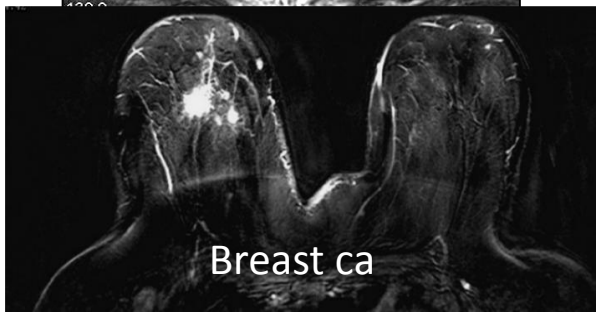


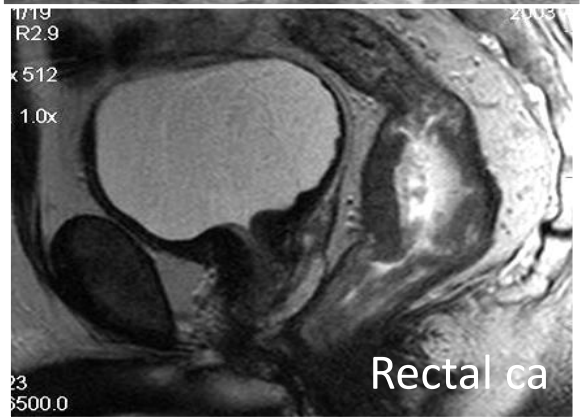








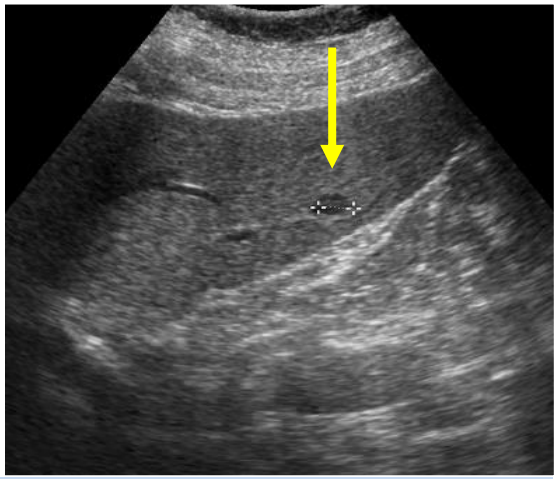




Tissue specific information

Two malignant primary tumors

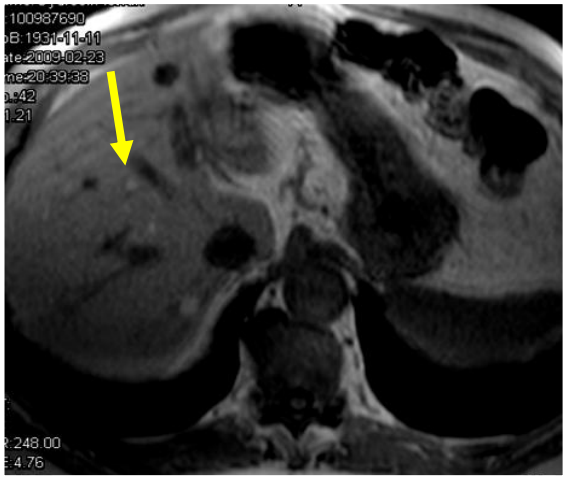
Colon ca / ocular malignant melanoma

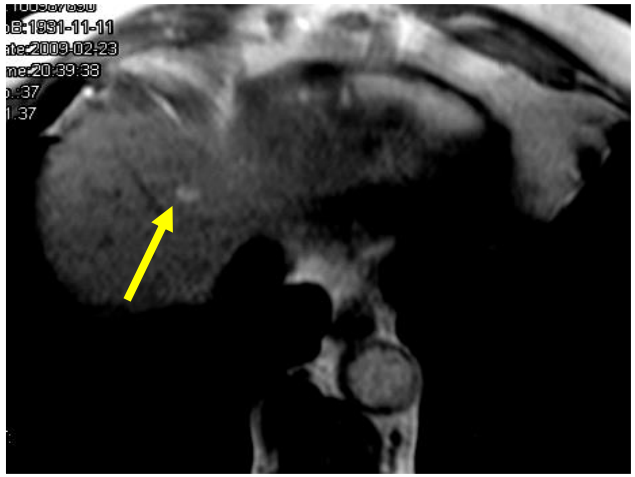


US – unspecific density
It might be metastasis

MRI: specific for MM metastasis

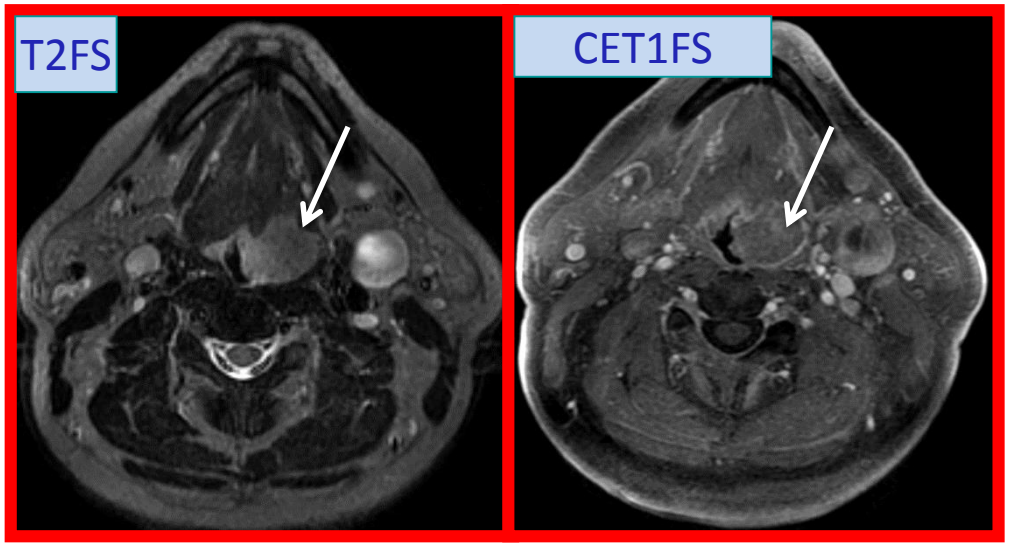
High signal intensity T1-w foci in the liver - because of melanin content



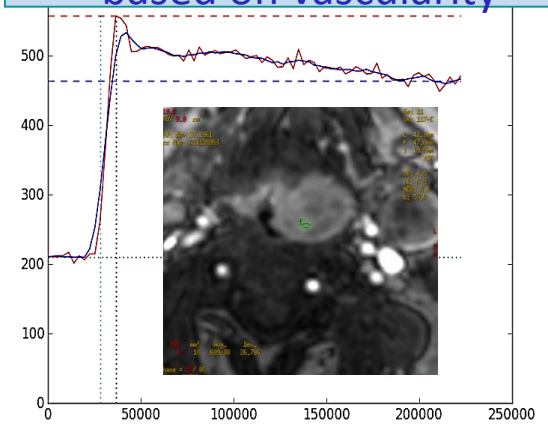


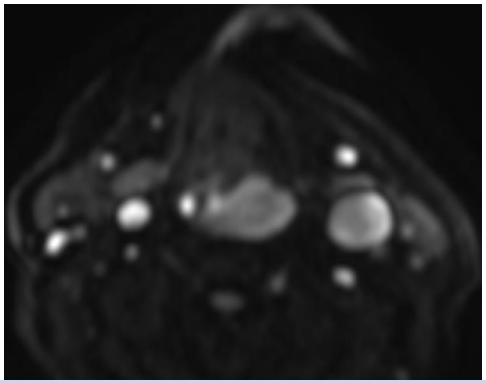
DG: MM mets

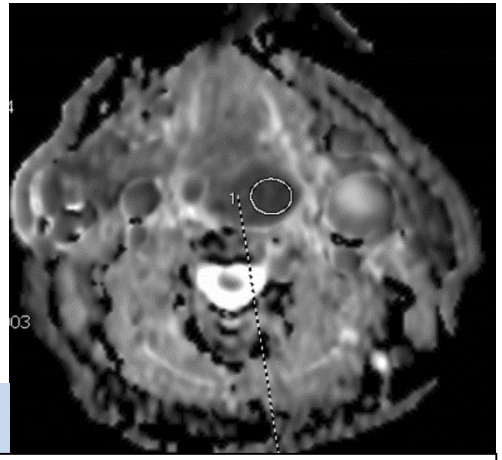
MP-MRI – anatomic and functional measurements in mesopharynx CA (native T1-,T2-w, CE-T1FS, DW-, DCE-MR)



Perfusion DCE-MRI
Time-enhancement curve
based on vascularity

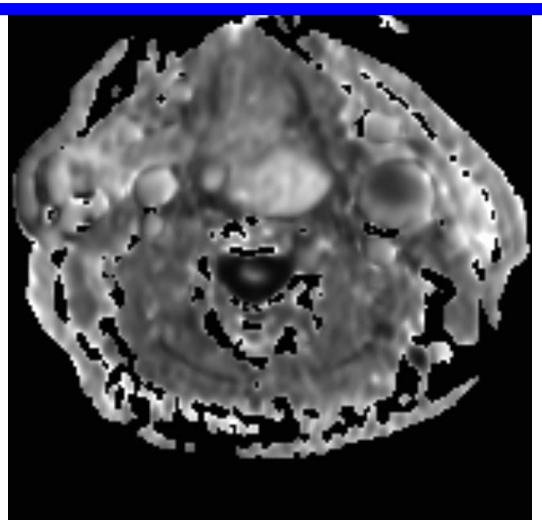






DW-MRI: based on TU cell density
b-value: 1000 s/mm^2

ADC: 0.743 x 10^{-3} mm^2/sec



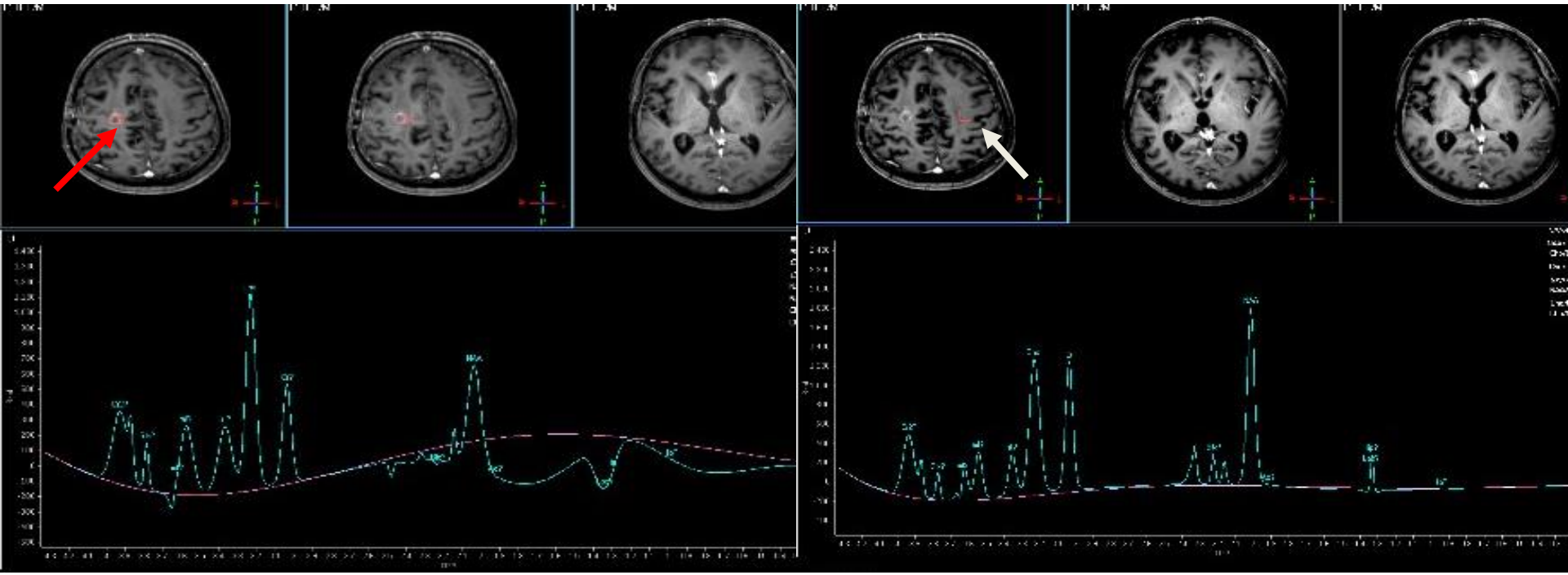
MR spectroscopy (MRSI) –

*(*biochemical analysis *of molecular products)*

Recurrent brain tu- could be detected earlier

Tumor side (R)

Normal side (L)



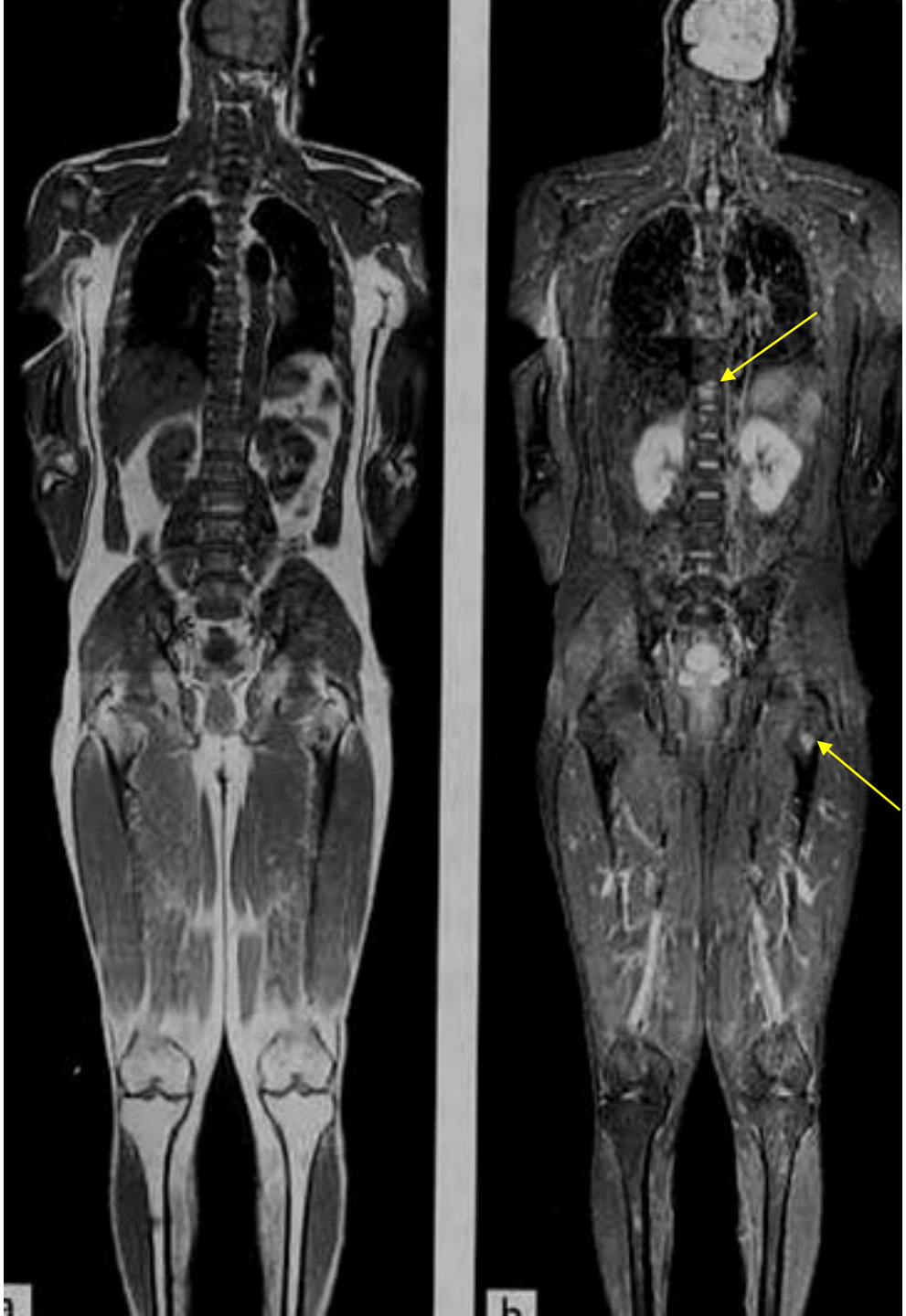
Cholin pick ↑

NAA ↓

N-acetylaspartate

Cholin ↓

NAA ↑



- Whole body MRI

Sensitive and specific for bone marrow changes (metastasis)

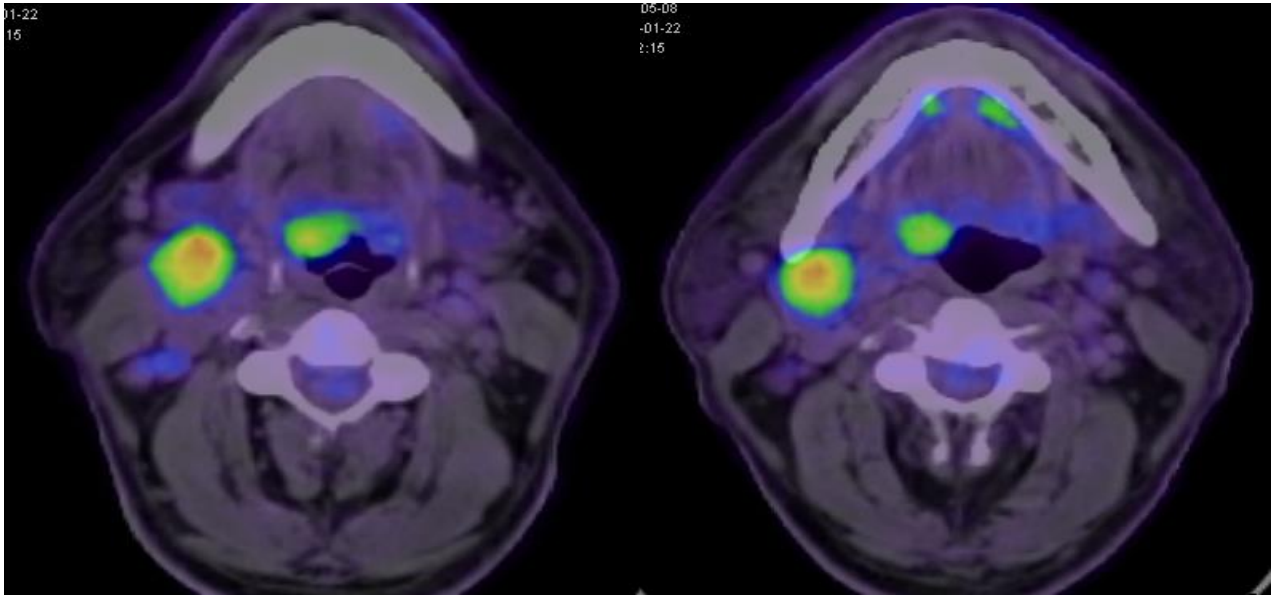
- T1-w
- STIR

- + DW-MR
- + CE-T1FS

PET/CT: hybrid modality anatomic - metabolic imaging

- **PET/CT** – ***hardware fusion of PET and CT***
- Whole body- complex information of the
- **PET: sensitive for metabolic activity-**
  - **Tracer FDG (**F18FluoroDeoxyGlucose)**– glucose alternative**
- **CT: basic anatomic** information
- **Clinical applications: ≈90% oncology**
  - **Staging – distant metastasis**
  - **Therapy response**
  - **Postherapeutic evaluation**
  - **To detect recurrent tumor**
  - **Restaging**
  - **To seek unknown primary**

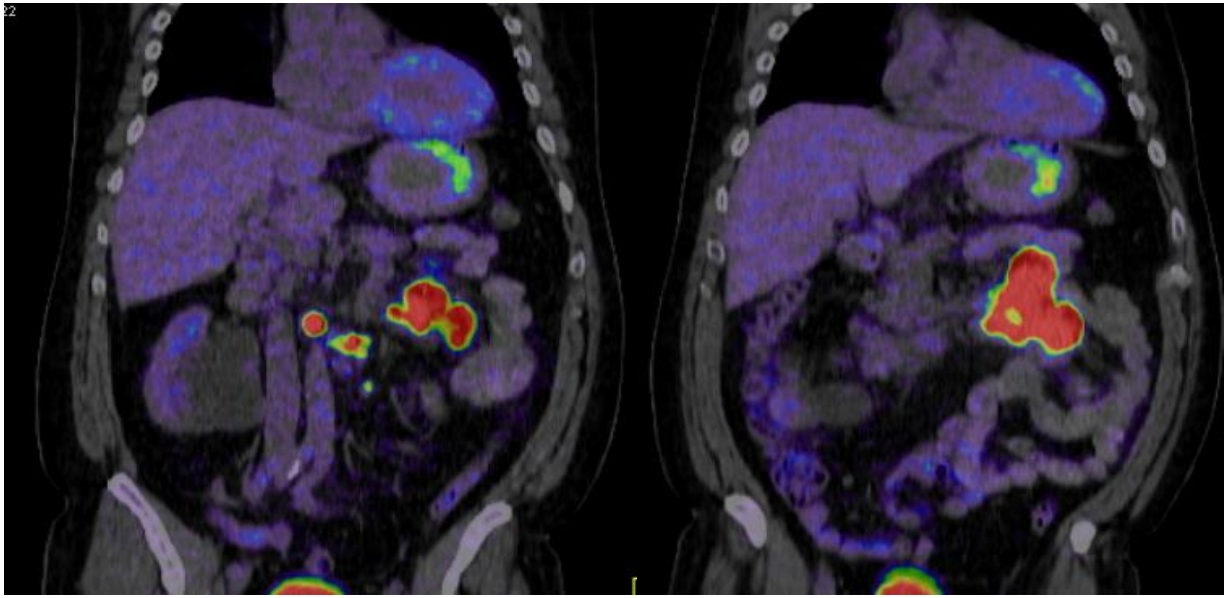
- **PET/MR : promising data – one-stop-shop examination (COSTS?)**



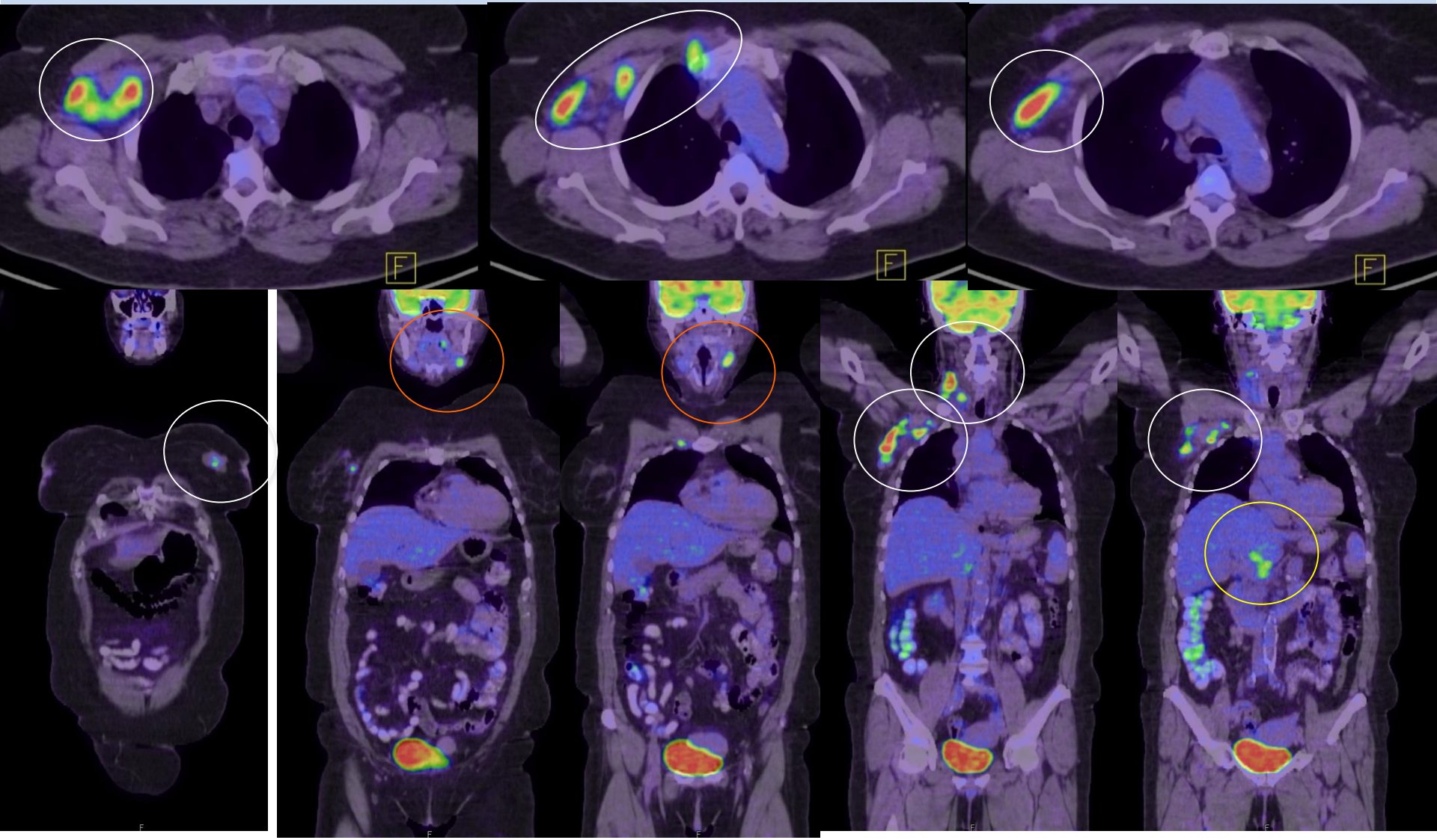
FDG-PET/CT

Two primaries

1. Radix linguae + N met
2. Non-Hodgkin-Lymphoma in the abdomen



FDG-PET/CT – whole body information
three primary tumors
(left mesopharynx-, right breast-, cholangio ca)vasol



Tasks of Interventional onco-radiology

Diagnostic

- **Diagnostic angiography - DSA**

  vascular morphology, neovascularisation, cancer vessels

- **Guided biopsy**

  (US-,CT-,MR-,CXR)

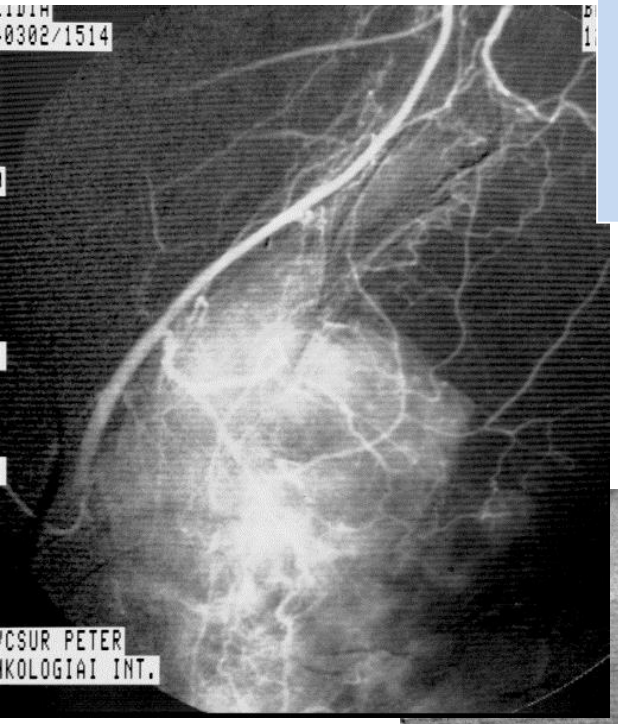
  - FNAB – fine needle aspiration biopsy for cytology
  - core biopsy for histology

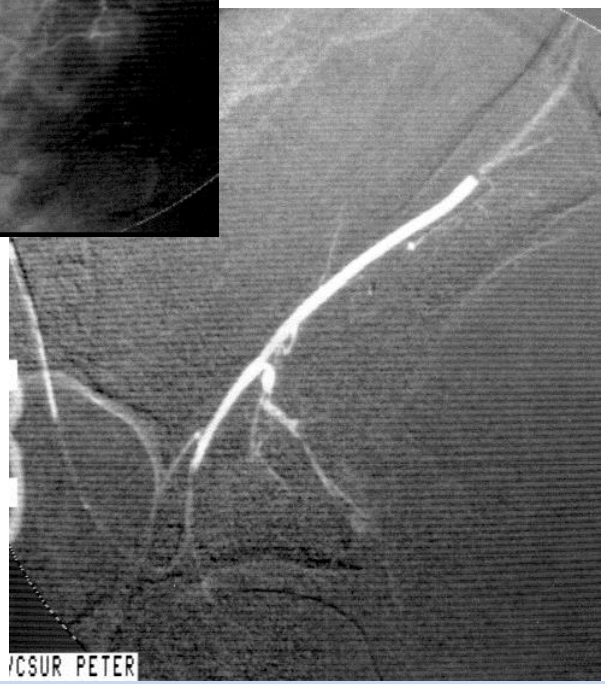
Therapeutic

- **Intravascular therapy - DSA**
  - TU embolisation,
  - TU chemoperfusion
  - Dilatation, stanting
- **Tumor ablation** (with radiofrequency-, (RFA) Laser wawe, percutan ethanol injection (PEI), focused US)

DSA -TH

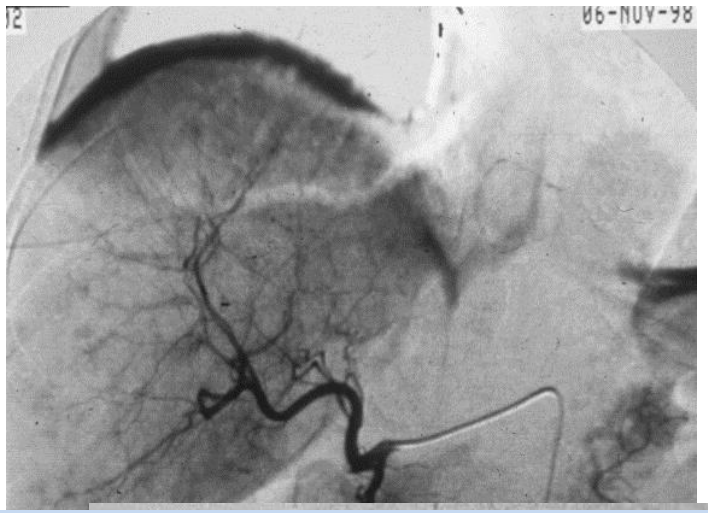
Localized cancer



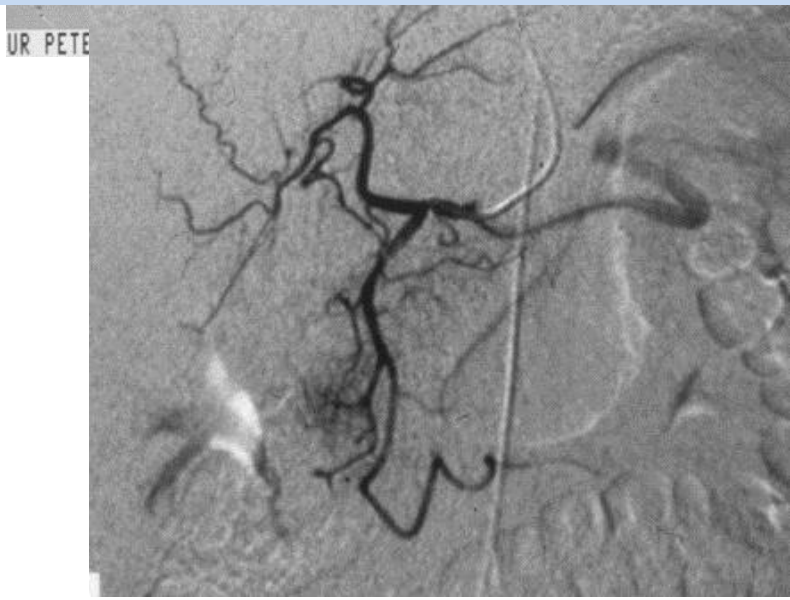


Chemoembolisation

Cancer vessels have been closed

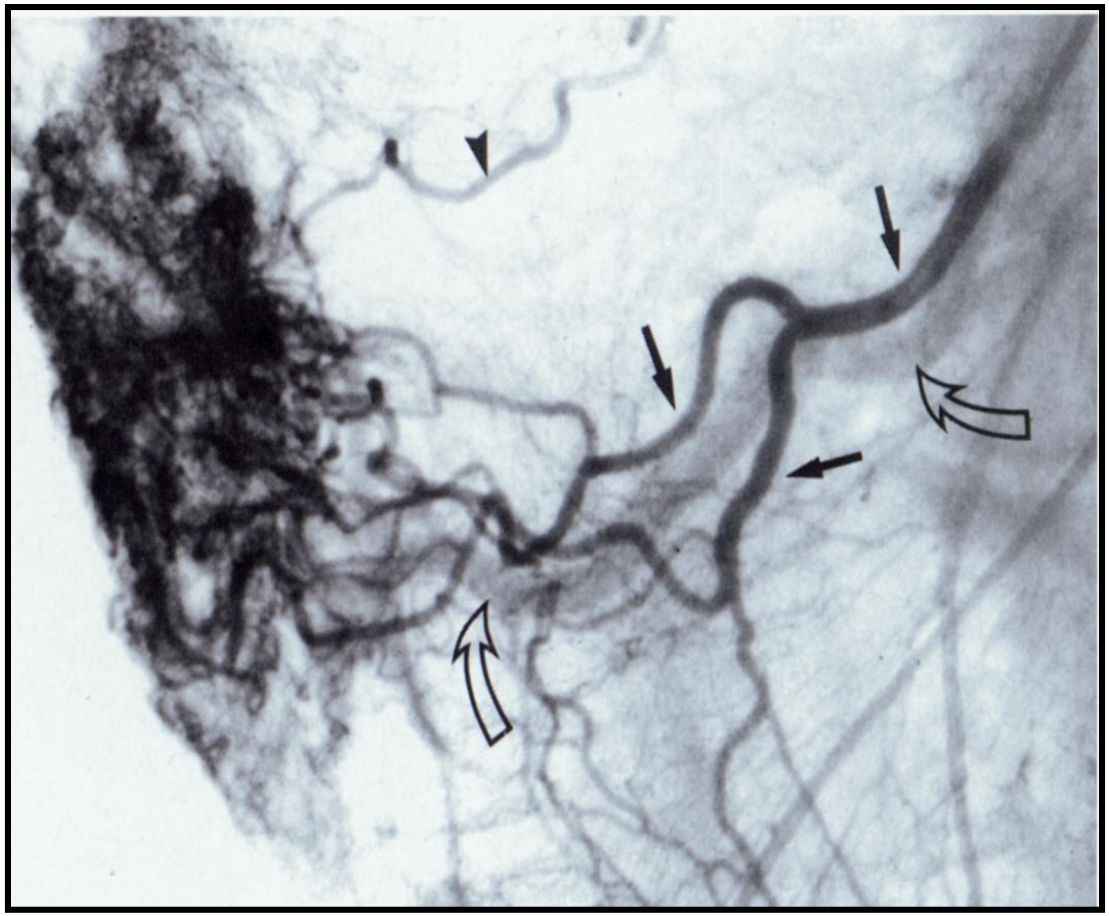


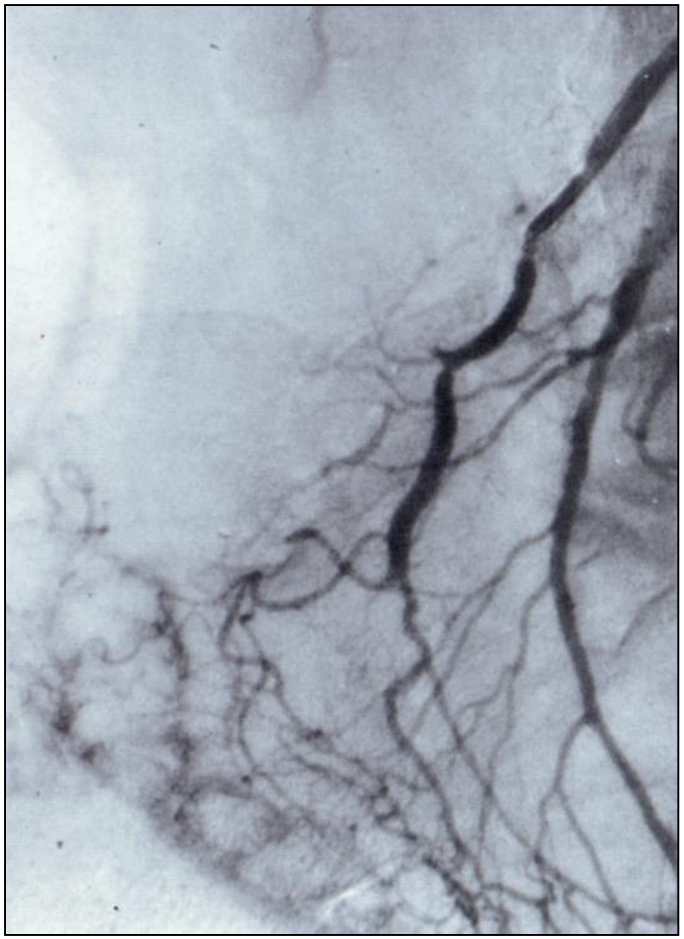
Chemoperfusion



Cancer vessels were demolished

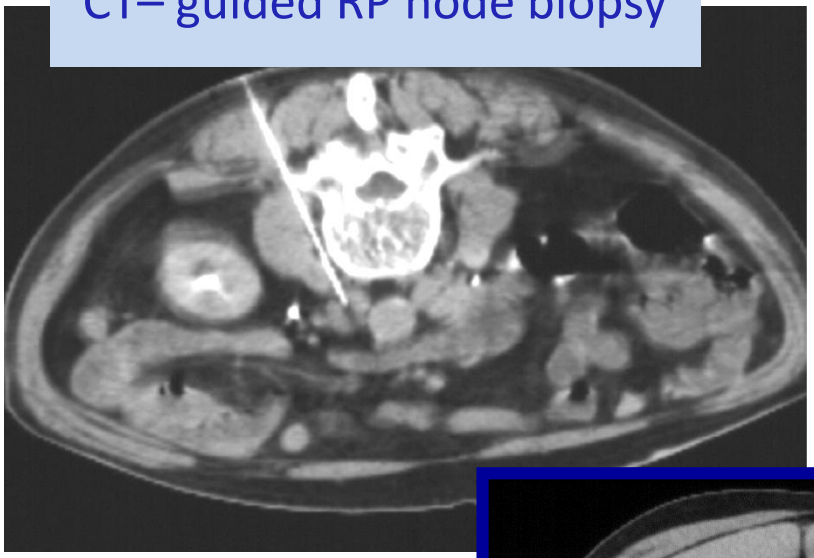
Embolisation of Coecum AV malformation
- because of bleeding-

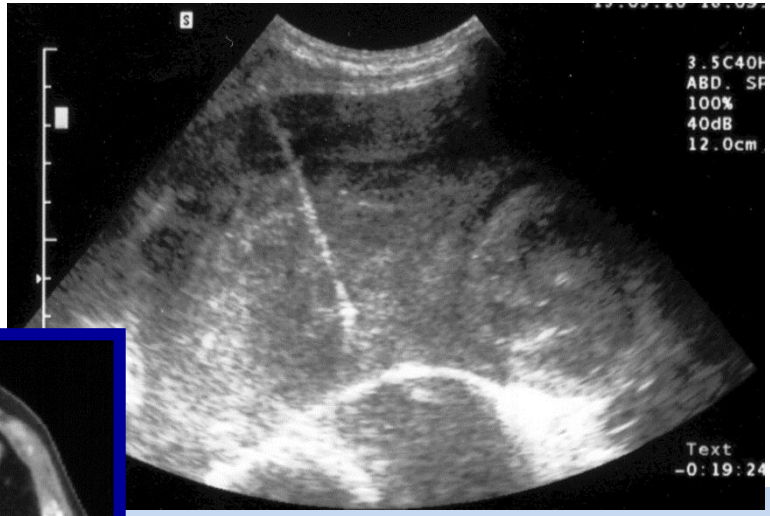




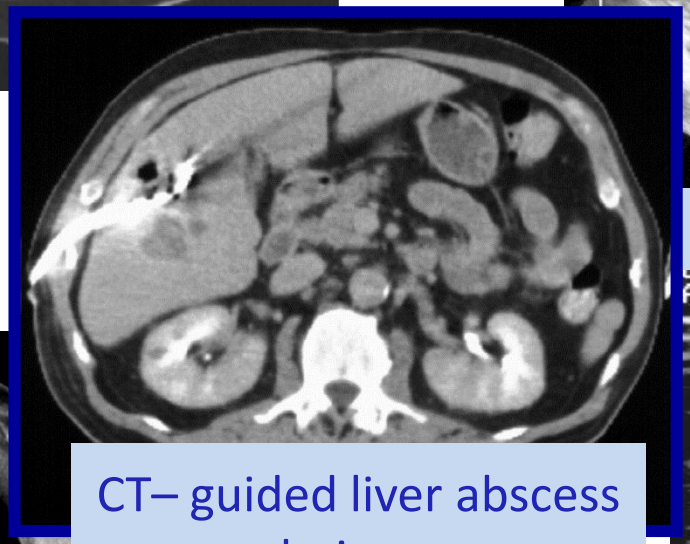
US, CT– guided biopsies, drainage

CT– guided RP node biopsy

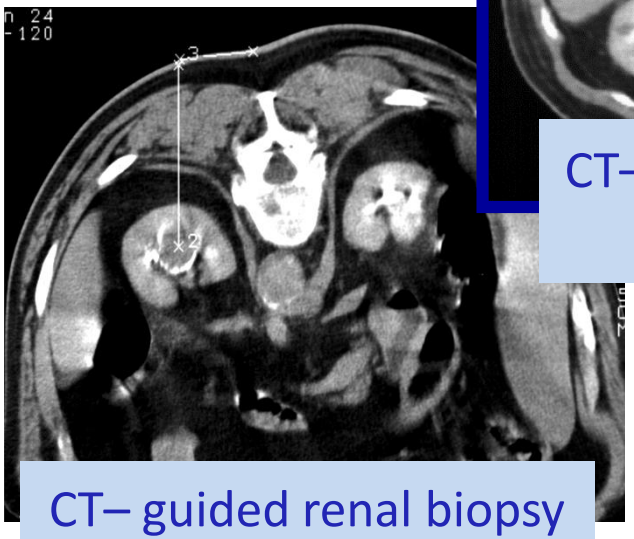




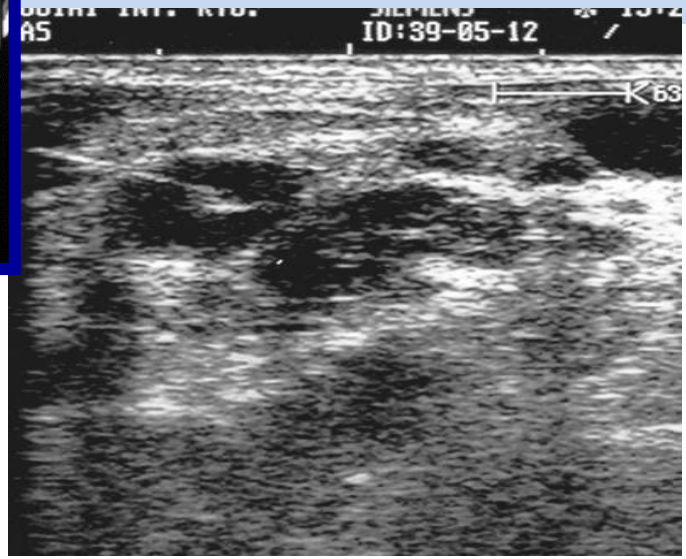
US – guided neck node biopsy



CT– guided liver abscess drainage



CT– guided renal biopsy



Tasks of imaging in different phases of clinical oncology

DETECTION
SCREENING

XR, US, CT, MRI
biopsy / guided

STAGING

CT, MRI, RN, PET, biopsy /US/CT guided

THERAPY
RESPONSE

CT,MR, RN, PET, US, XR

FOLLOW UP

US, CT, MRI, RN, XR.

RECURRENT TU
RESTAGING

CT, US, MRI, RN, PET

RATIONALITY OF SCREENING

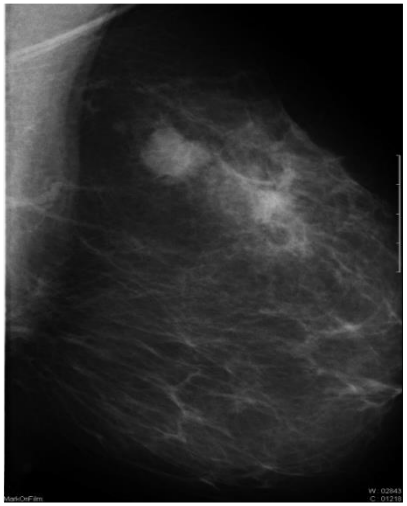
- Early diagnosis in preclinical stages
- **To find high risk asymptomatic individuals**
- To achieve higher cure rate

- *90% of all **breast cancer** cases could be cured if diagnosed early and treated accurately*

Sensitivity of mammography

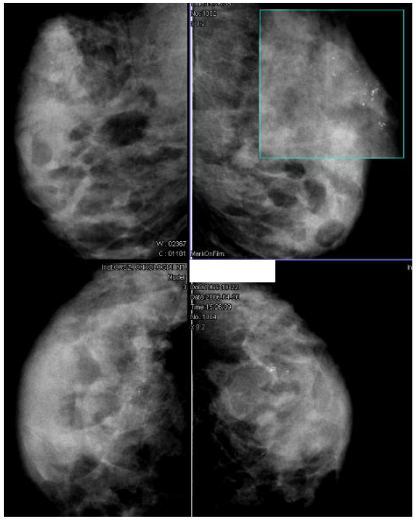
- Reported data: 80-85%
- In adipose breast: 99%

BASIC screening method
MAMMOGRAPHY



If breast density is increased, sensitivity will be decreased

For dens breast: US, MRI



Diagnostic procedures in **BREAST CANCER**

at symptomatic patients

a) **Mammography -** Analog / **Digital**
b) **US**
c) **Guided biopsy:** FNA – for citology
core-, vacuum assisted for histology
guided by US / mammography (stereotactic biopsy)

a) **MR-mammography** (MP-MRI, DCE-MRI, DW-MRI)

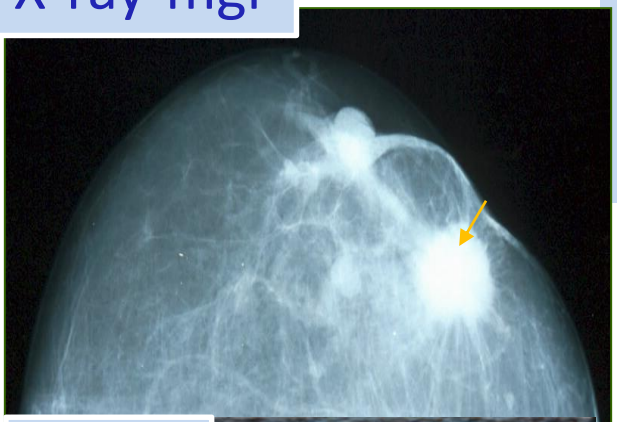
b) **Localization before op.:**
   a) Radioguided localisation(ROLL) for occult lesion, SLNB
   b) Hookwire-guided localization for non-palpable breast lesions

c) **Specimen** mammography /US

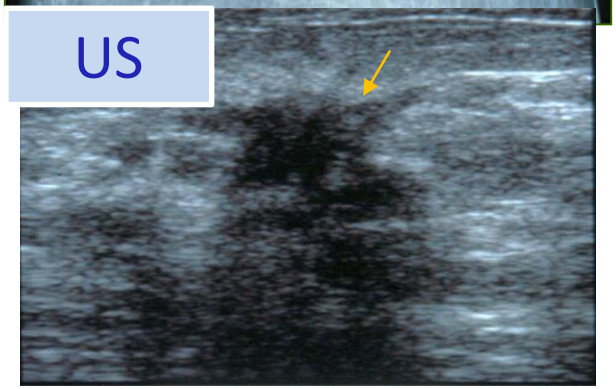
d) **CT / PET-CT – for staging**

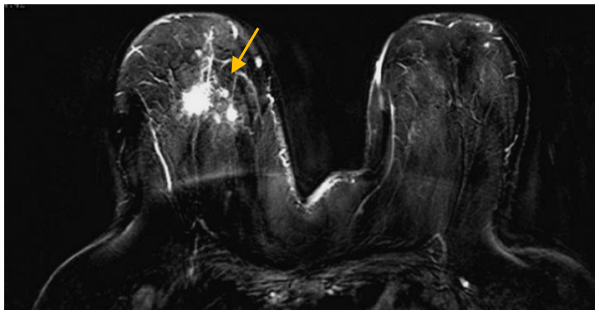
BREAST CANCER
MULTIMODAL evaluation

X-ray-mgr



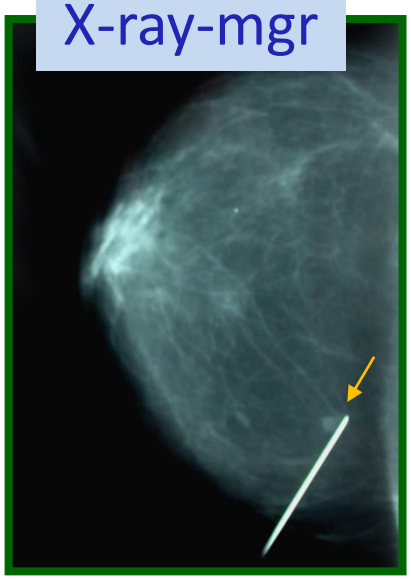
US





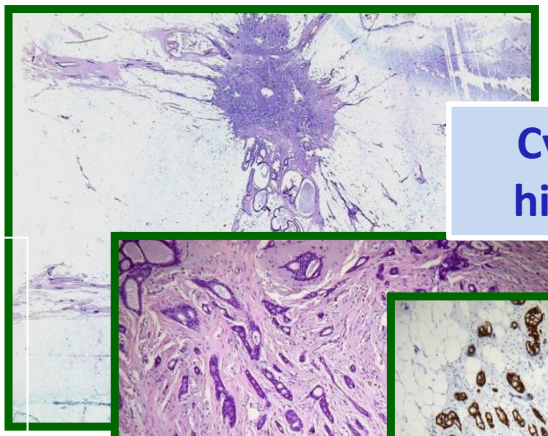
MR-mgr

X-ray-mgr

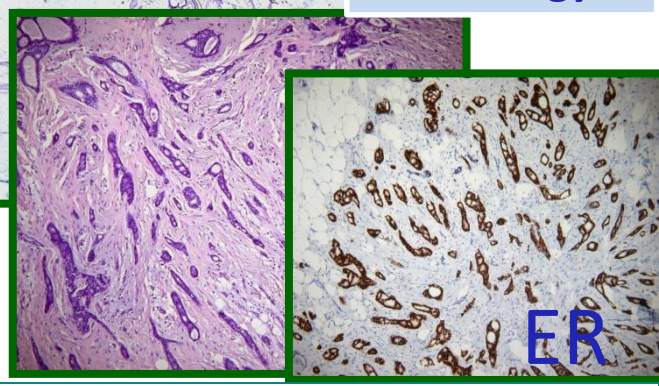


Mammography + US + biopsy
Sv 85%, **Sp 92-95%**
MR mammography:
Sv 95%, Sp 86%

Sentinel N
Lymphoscintigraphy +
+ (Blue dye)
+ hystology
(Sv94% NPV98%)



Cytology
histology



T/N: mammography / US / MRI /+sentinel N

LUNG CANCER

- **Leading cancer death**
  - 1.3 million deaths / year worldwide
  - Approximately 70% of cases are incurable at presentation, metastatic or locally advanced
  - **16% overall 5 year survival**

Theresa C. McLoud, MD
Massachusetts General Hospital, Harvard Medical School

LUNG CANCER mortality calls for screening

- **CT - highly sensitive for lung nodes <1cm**
- CT - detects more cancers than CXR
- **CT screening for lung cancer has mortality benefit**
  - NSCLC: in Stage IA - T<3cm, N0, M0 - survival > 65%
  - - T<1cm, N0, M0 – survival > 80%
- **High risk group** > 30 packs / years of smoking
  > 55 age
- **Annual controll low dose CT (LDCT** minus 20-25% of standard dose)
- **Follow up LDCT for growth**
  - **Volumetric measures - CAD (computer assisted diagnosis)**

Meaningful (36-53%) survival increasing in the low dose CT group

(Henschke study, 2011)

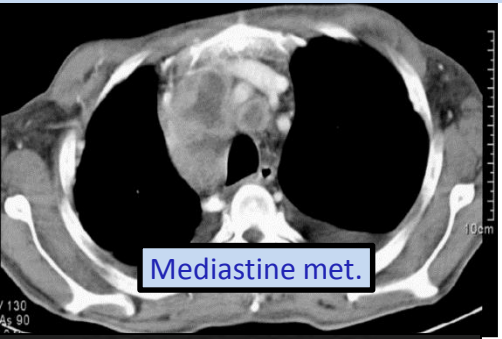
LUNG CANCER

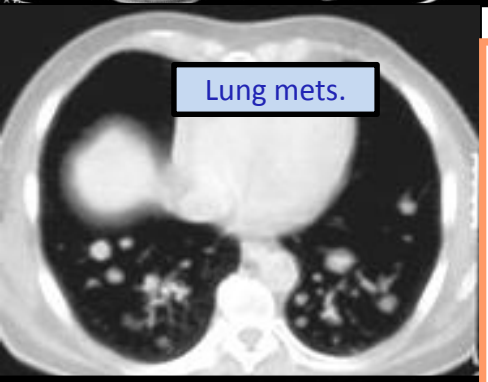
Multimodal imaging

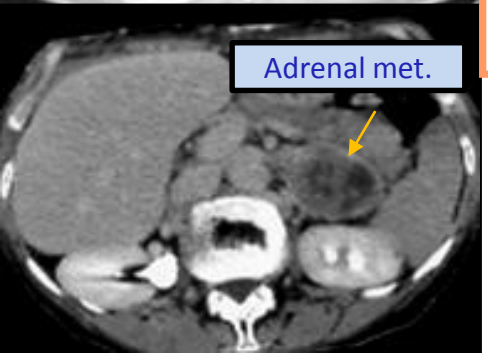
Clinical exam.: Bronchoscopy

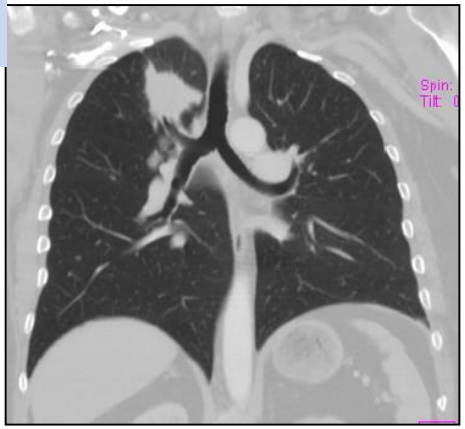
CT basic method

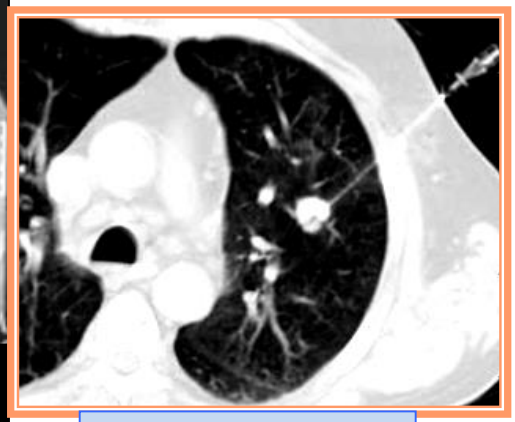
- Staging-
- **T-Acc 90%**











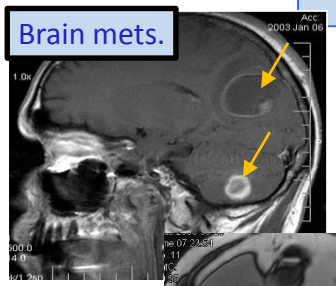
CT guided biopsy

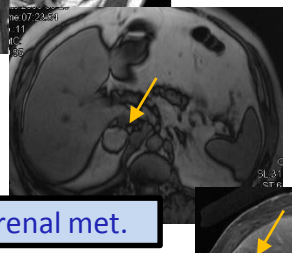
Role of MRI

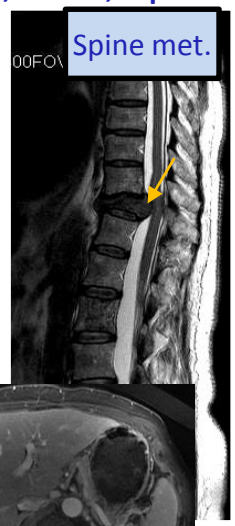
Complementary,

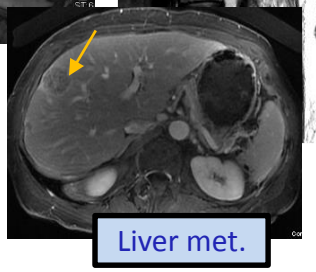
to evaluate the sites of mets,

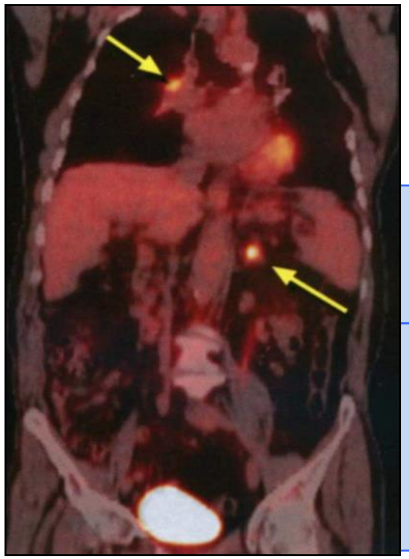
Brain, liver, spine











PET/CT staging

N met

Tu spread

Residual TU

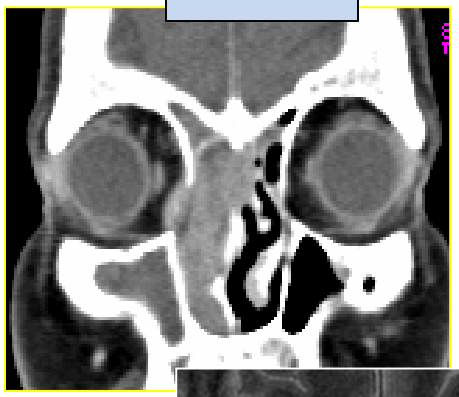
Recidiva

Imaging in **HEAD and NECK** tumors

- **US – for analysing neck masses**
  - Palpable neck mass: solid / cystic ?
  - Thyroid
  - Salivary glands
  - Color- Doppler US
  - Guided biopsy
- **CT- to evaluate the whole region** (from the skull base to the trachea bifurcation)
- **MP-MRI- best modality to evaluate the local staging**
- **PET/CT - for whole body information** – for distant TU spread, for residual /recurrant TU

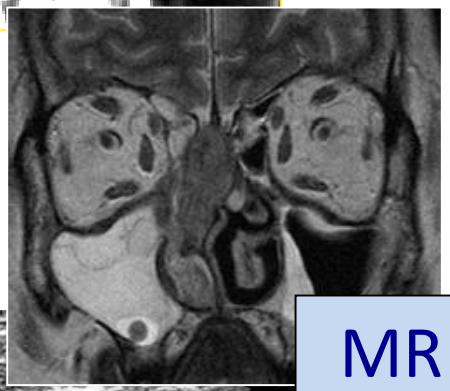
Head & Neck Ca: MR/CT/US

CT

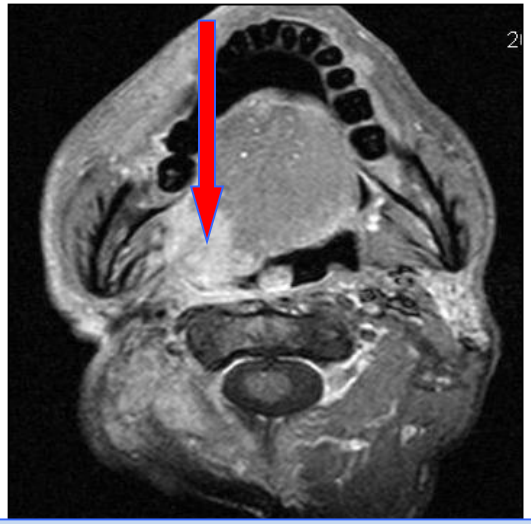


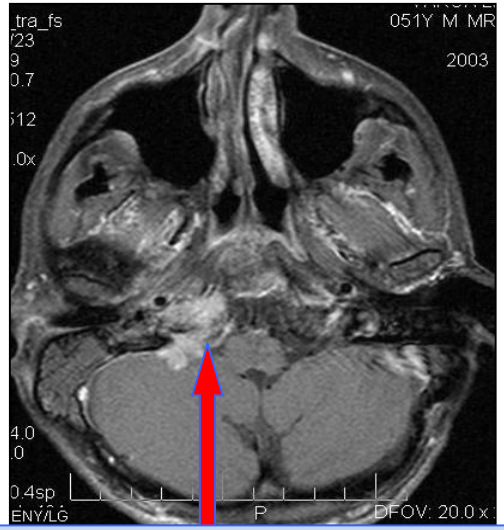
„T” - Accuracy: MR, CT >90%

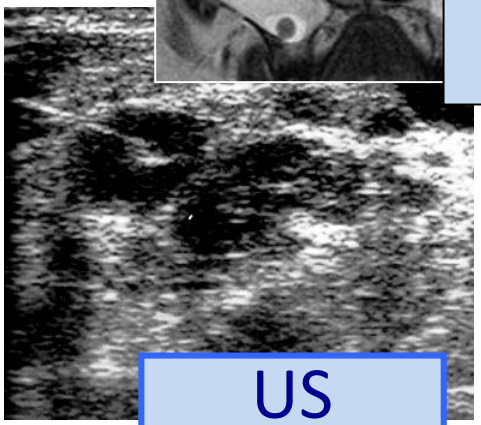
„N”- Accuracy: US 70%, CT80%, MR 80%



MR







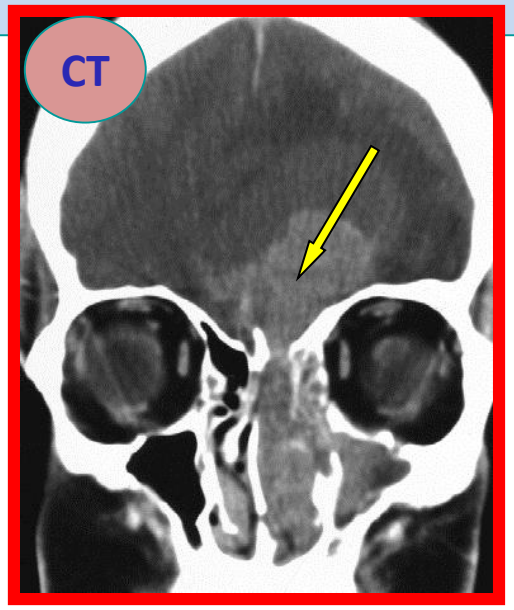
US
Guided
Asp. Cyt.
N - Acc >90%

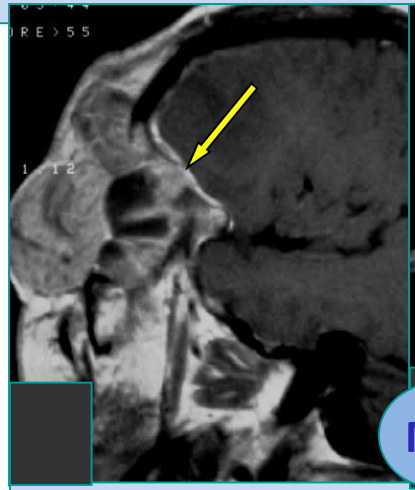
MR – „T” Acc: 95%

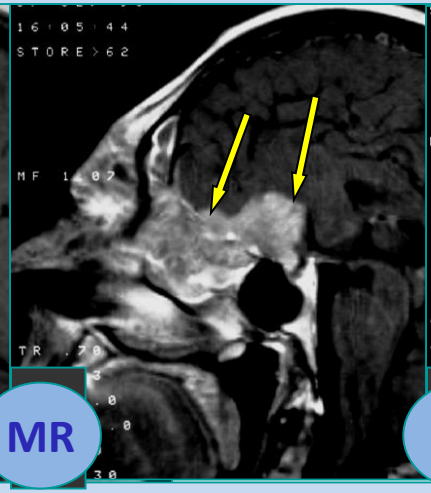
Clinically: mesopharynx ca T2 stage, operable

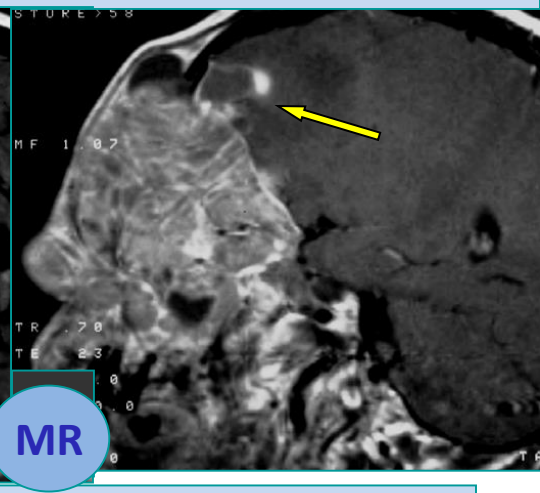
MRI: TU extension into posterior scala, T4b stage, inoperable

Intracranial TU extension - CT/ **MR**

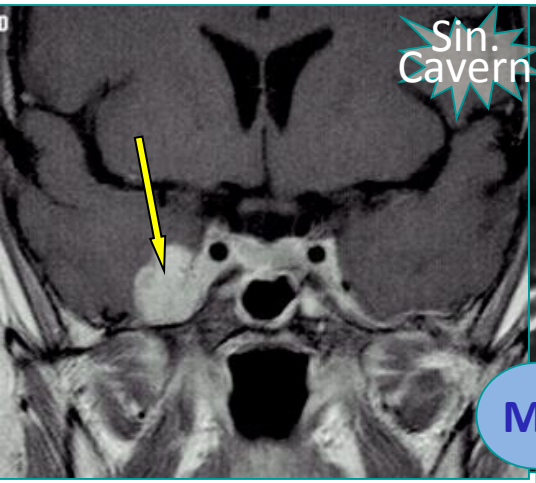


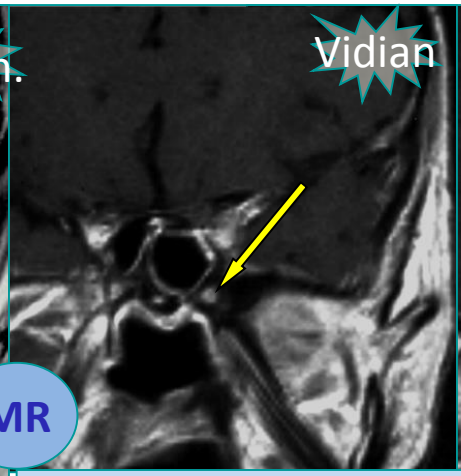


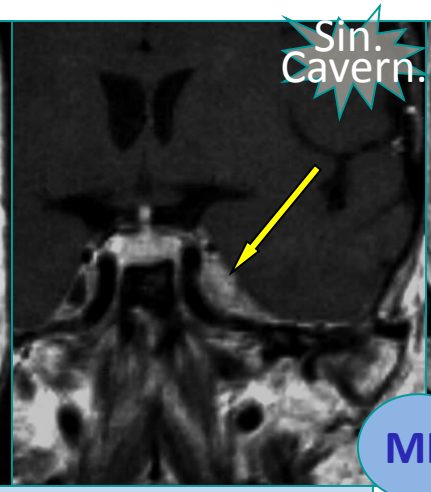


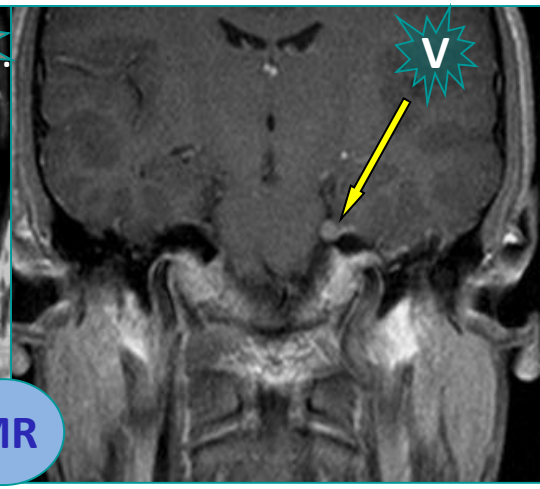


epidural dural intracerebral





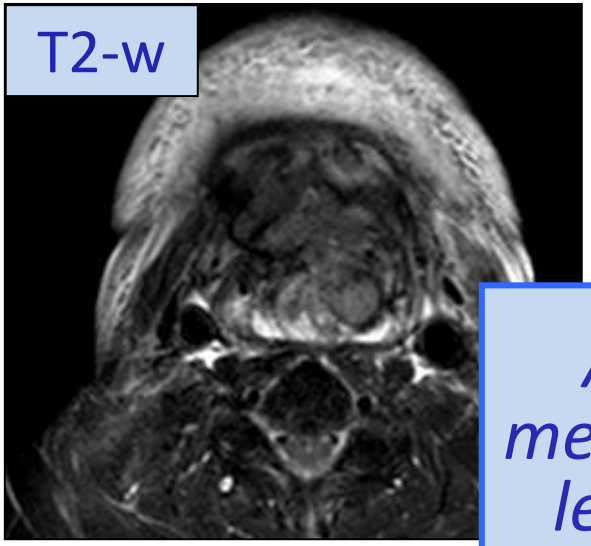


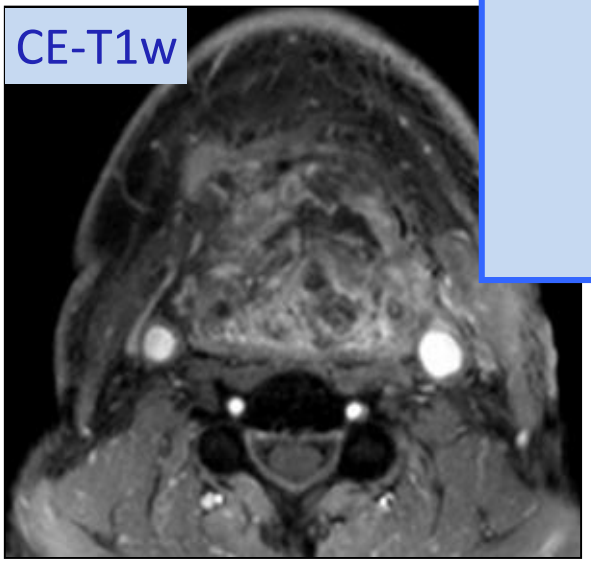


Perineural TU spread

Post RadioTherapeutic status in Head and Neck CA

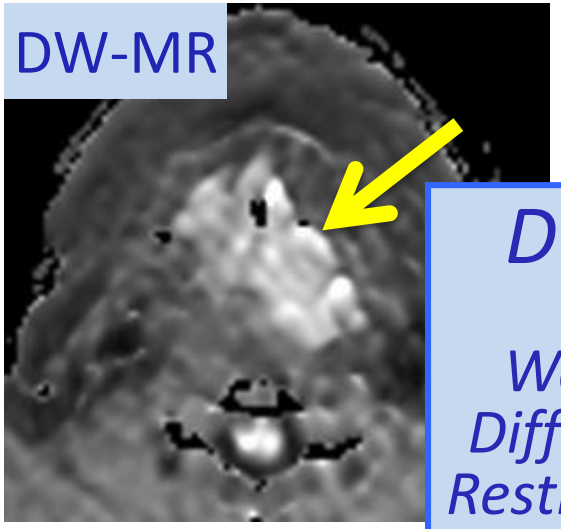
Question: residual CA ? Multiparametric - MRI !

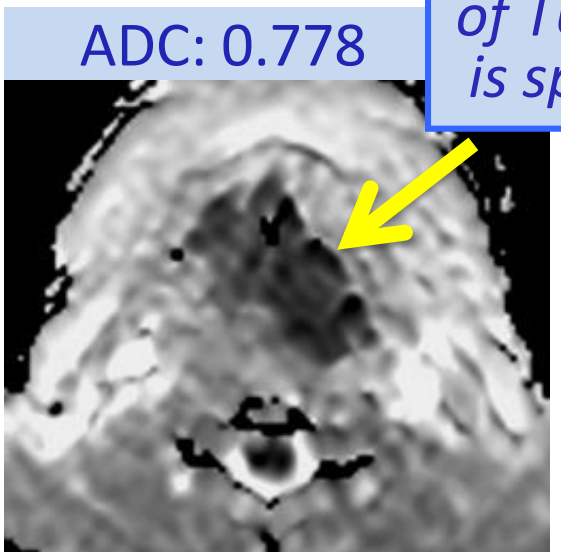




Anatomic measurements less specific

?





DWI:

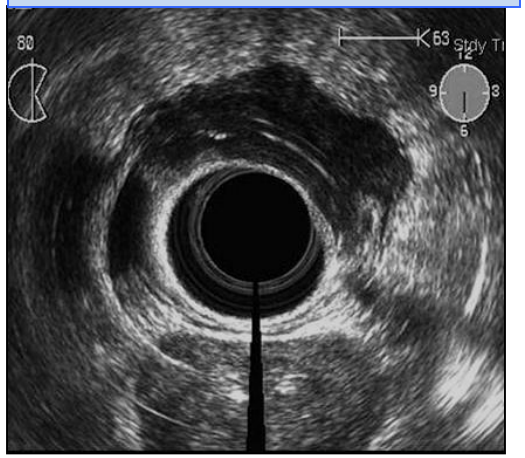
Water Diffusion Restriction of TUMOR is specific

RECTAL TUMOR
Multimodal Imaging

- **US** –Transabdominal US for general abdominal information
  - Endorectal US – intramural TU extension
- **MP-MRI**- **best evaluation for tumor extension beyond the wall,** to determine resection margin, **complex pelvic -, and best liver information**
- **CT**- to evaluate advanced TU extension
- **US/CT guided biopsy** (liver)
- **PET/CT** - for whole body information - distant TU extension, for recurrant TU

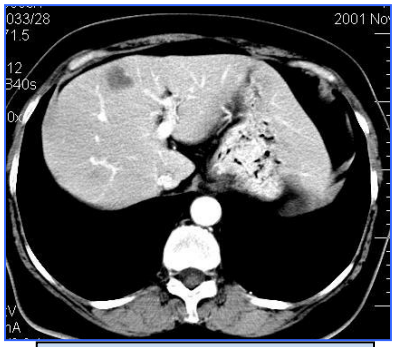
RECTAL Cancer
MULTIMODAL evaluation

EUS „T” Acc 90%

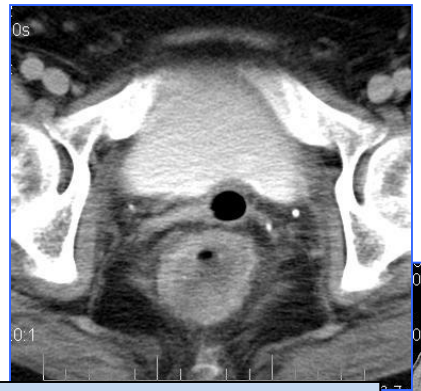


T1,T2,T2/3
Perirectal N

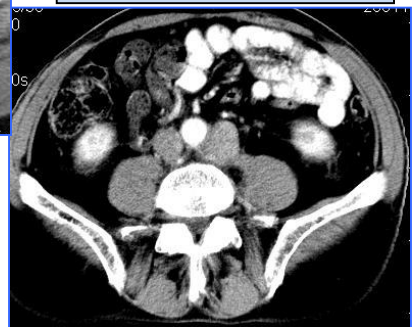
Liver nodes
Intraop. US
(Acc> 90%)

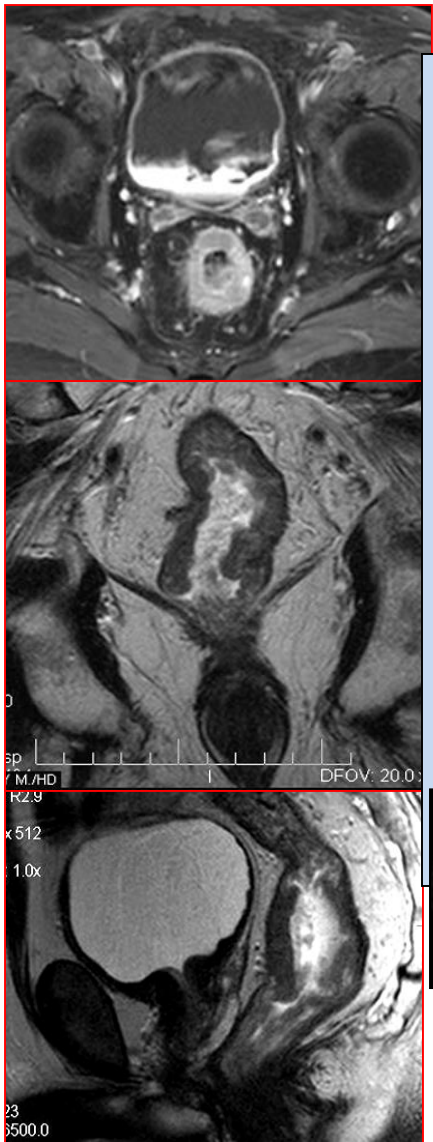


Liver (Acc 85%)



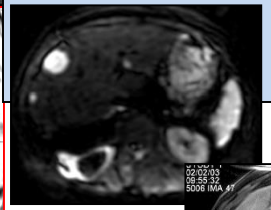
MDCT
„T”Acc 70-85%

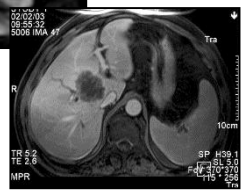




MRI
„T” infiltration
Beyond the wall
(Acc>90%)
Resection border
PPV 92%

Liver
Acc>90%

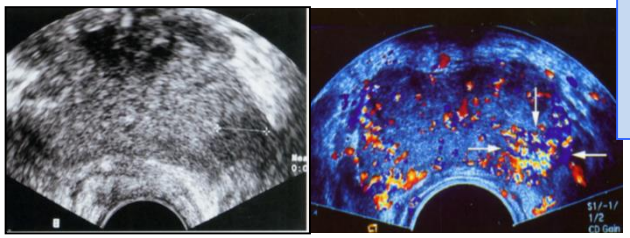




Imaging in **PROSTATE cancer (PC)**

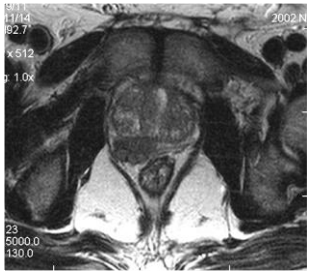
Screening *-* ***PSA*** *(prostate specific antigen) NOT reliable*

- **US** – for the first information and for guided biopsy
  - Transabdominal US – general
  - Endorectal US – prostate
    - Color- Doppler US



Color Doppler US may increase detection of PC

- **MP-MRI** - **for the accurate prostate and pelvic information, staging** *(for capsular penetration,for vesicula-, bladder-,other pelvic invasion, nodal status),* **recurrent ca, restaging**
- **Bone scan** – bone metastasis
- **CT**- to evaluate advanced TU extension
- **PET/CT** – for recidive cancer, for whole body information

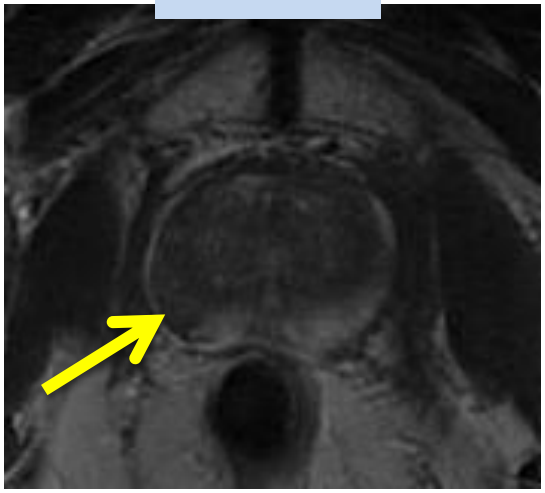


MR is the best for local staging of PC

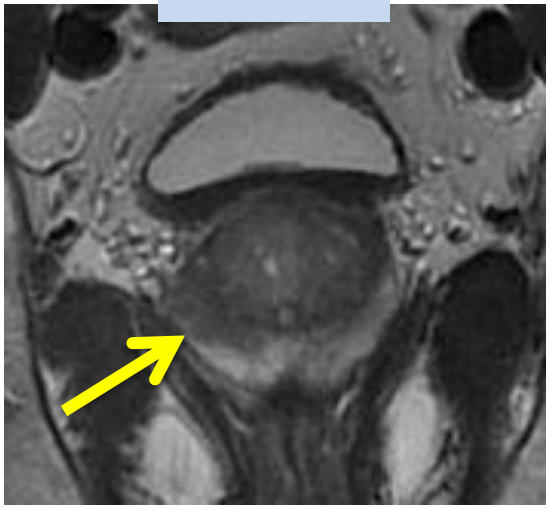
Prostate cancer

„T" Staging: MP-MRI (T2b)

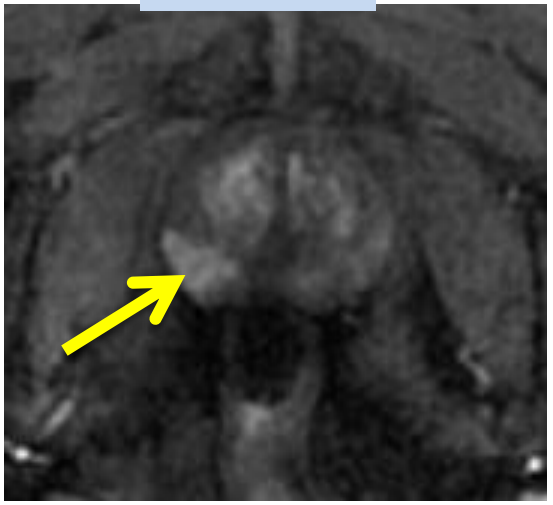
T2-w axi

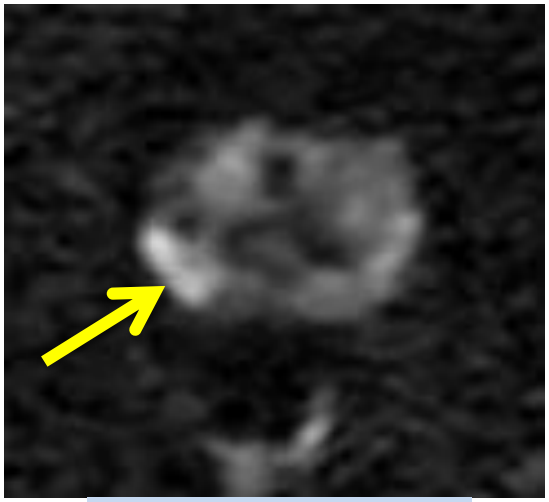


T2-w cor

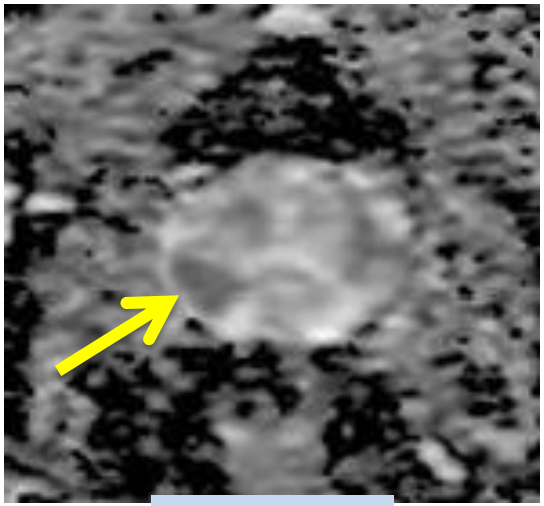


DCE-MRI

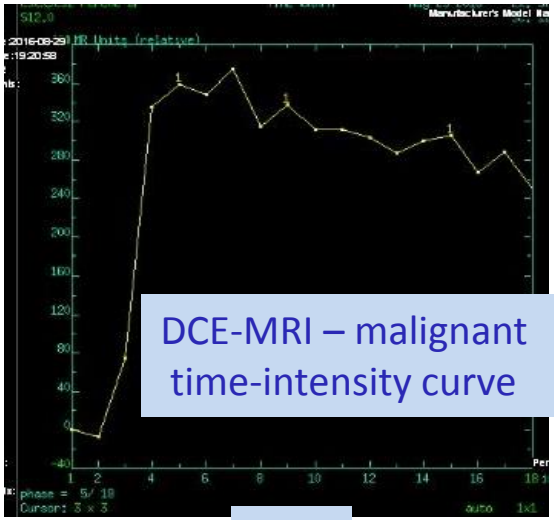




DW-MRI-b1000



ADC-MRI



DCE-MRI – malignant time-intensity curve

TIC

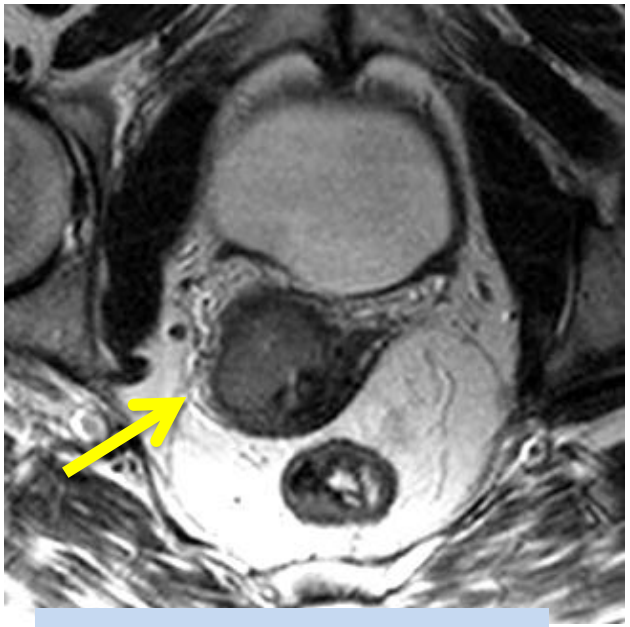
Imaging in **gynecological** tumors

- **US** – for the first information
  - Transabdominal US
  - Endovaginal US
- **MRI- for the accurate organ and pelvic information, staging**
- **CT**- to evaluate advanced TU extension- **OVARIAN!**
- **Guided /UH, CT/ biopsy**
- **PET/CT** - for whole body information - distant TU extension, for recurrant TU

Gynecologycal –TU

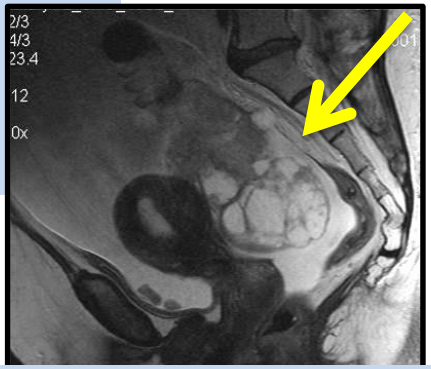
endovaginal **US**

MR, CT (ovarien)



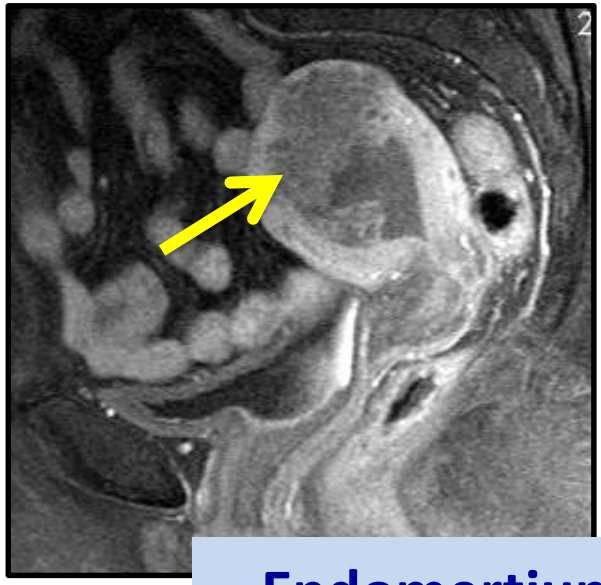
Cervix ca

MR-ACC:>95%



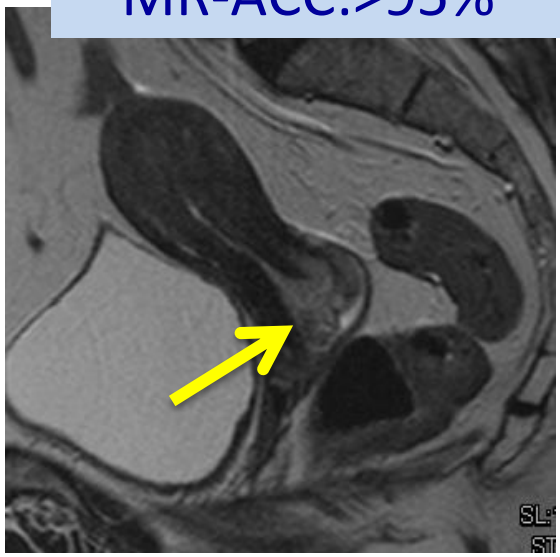
Ovarian

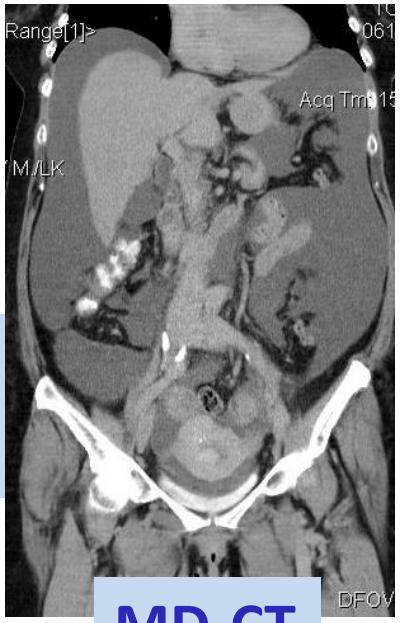
MR-ACC: 89-99%”



Endomertium ca

MR-ACC:> 90%





MD-CT

Conclusion 1.

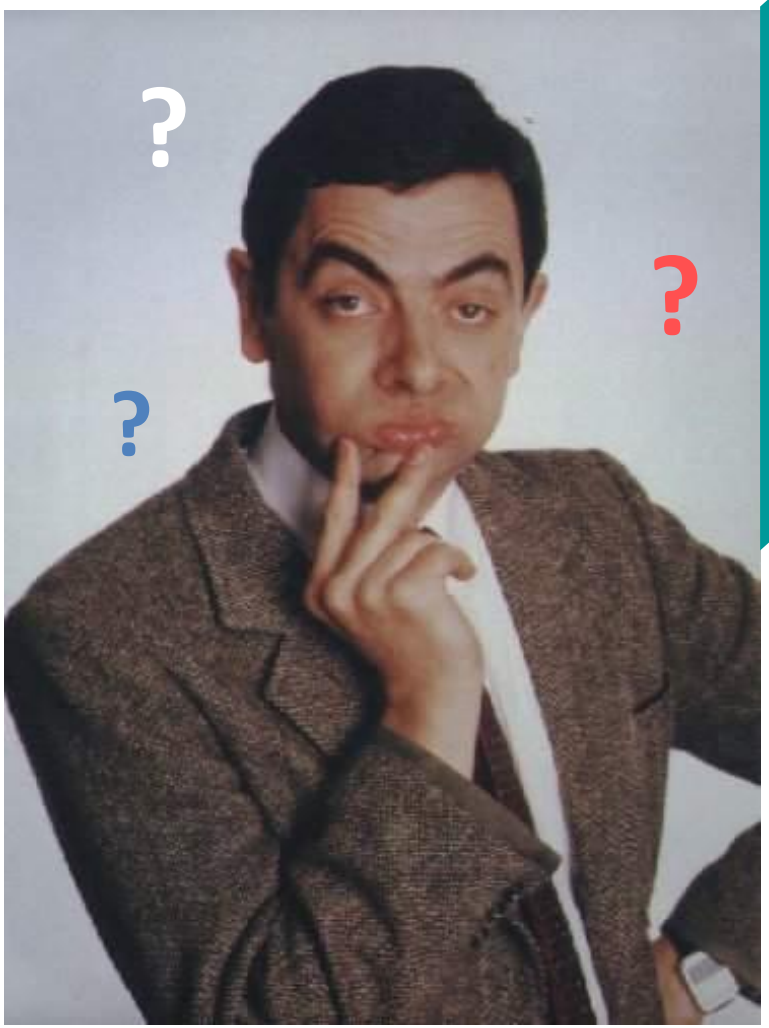
- The role of conventional radiography in the evalutaion of tumor is limited
- US is excellent modality for the evaluation of soft tissues, abdominal organs and excellent tool for tissue sampling, BUT not milestone!
- MRI/CT are basic modalities for cancer evaluation
- High - quality CT / MRI is required for the HR imaging
- CT and MRI are complementary imaging tools
- MRI has the advantage of superior visualization of soft tissues,
- MDCT has the advantage of quicker examination (less motion artifacts) and superior visualization of cortical bone
- PET/CT's main value is to detect distant metastases, recurrent diseases, to evaluate therapy response

Optimal treatment is based on multidisciplinary decision

Cancer care: Image-guided oncologic treatment

Conclusion 2.

- **Optimal treatment is based on multidisciplinary decision**
- **In the Oncologic Decision Process:**
  - **the diagnostic radiologists,**
  - **the surgical oncologists,**
  - **the clinical oncologists and**
  - **the radiotherapeutics need to strengthen the process from the diagnostic imaging to the therapeutic imaging, for the best patient care**
- **Image-guided oncologic treatment**



Radiologist has an important roll

and our responsibility is very high!

MD-CT

CE-US

3T-MR

DW-MR

Dyn-MR

PET/CT

PET/MR

Dyn-CT

MRSI

interventional radiology

Determination?
Evaluation?
Validation?