


Role of Imaging in Oncology

Dr. Ujlaki Mátyás MD
Prof. Mária Gődény MD, PhD, DSc
National Institute of Oncology

Basic information in Oncology

- **Tumor staging is one of the most important prognostic factors, it determines therapy** (operability, radio-, chemotherapy planning)
- **Imaging has great importance in cancer management**
  - DETECTION and EVALUATION of tumor
  - Evaluation of POST-THERAPEUTIC changes
  - Detection of the ADVERSE EFFECTs of therapy
  - FOLLOW-UP; early detection of RECURRENT TUMOR
- **Precise evaluation** is only possible with strict technical criteria, **standard protocols** and **correct image interpretation** – **our responsibility is high**

Role of imaging at the modern oncological care

Participating in the oncotherapeutic algorythm:

- TUMOR sreening
- TUMOR detecting
- Staging – T, N, M
- Therapy monitoring
- Post-therapy staging
  - –Differentiation between residual tumor and scar
- Follow up
- Recurrent tumor detection - staging

–Technical expectations:

- Early diagnosis
- Precise evaluation
- Tumor extension
- Tumor size, volumen definition
- Tissue specific data collection

Imaging plays an important role also in planning radiotherapy

Imaging modalities

- **Anatomic imaging modalities** *(static/dynamic information)*
  - Conventional X-ray – mammography (digital)
  - Angiography – Digital Subtraction Angiography (DSA) – Th.
  - US
  - **CT – MD-CT** (≥16 detector rows in oncology)
  - **MRI –** (high magnetic field strength, 1.5T-3T)

- **Functional, molecular, metabolic imaging modalities**
  - Radioisotope diagnostic methods (bone, thyroid gl.)
  - 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*

DynCE-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*

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

CXR

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

Today: Digital

Advantages: *Easy access, cheap*

- **Bone**
- **Lung**
- **Breast**
- Abdomen
- Gastro-intestinal tract

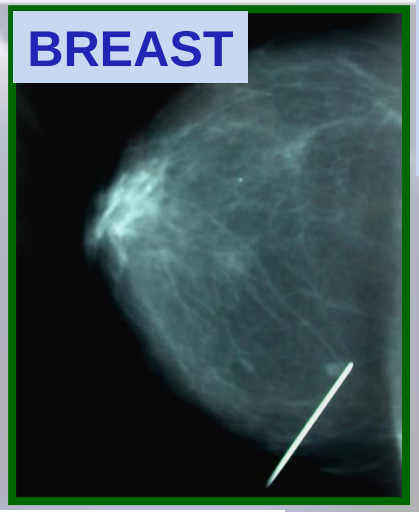
Tomosynthesis: *renewed, digital tomography for the lung and breast*

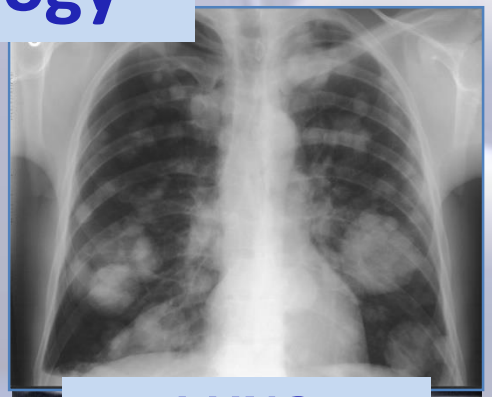
Main QUESTION: is the information enough??

CXR in oncology

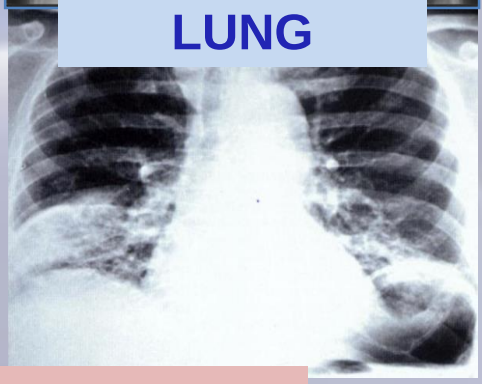
BONE

BREAST



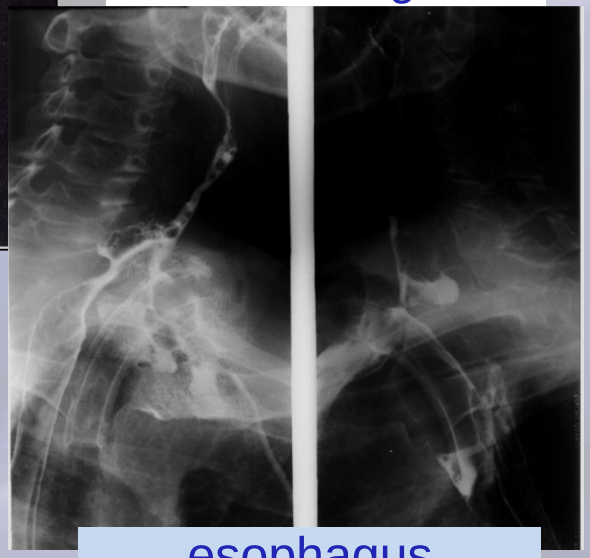


LUNG

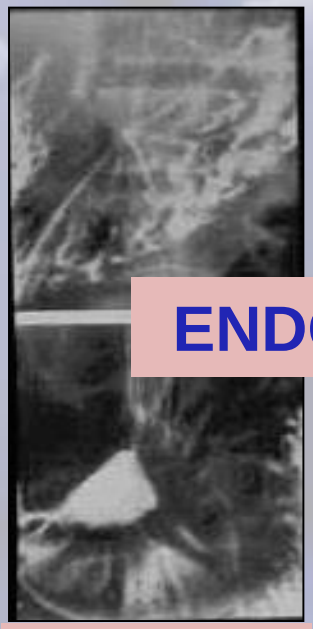


abdomen
Ileus? perforation?

Question:
information
will be enough ??

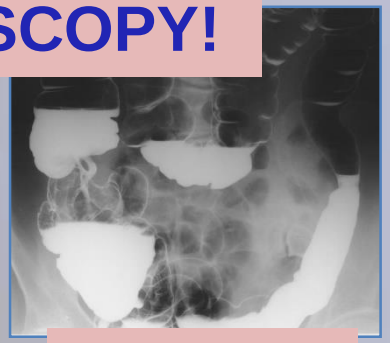


esophagus
swallowing function



stomach

ENDOSCOPY!



colon

Ultrasonography

excellent for the soft tissue

Advantages:

- Easy access, cheap
- Non invasive, non ionising
- Tolerable
- Real-time information

Clinical applications

- Transcutan – abdominal, pelvic, neck, breast, extremities
- Vessels
- 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
- Subjective
- Hard to standardize

Methods

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

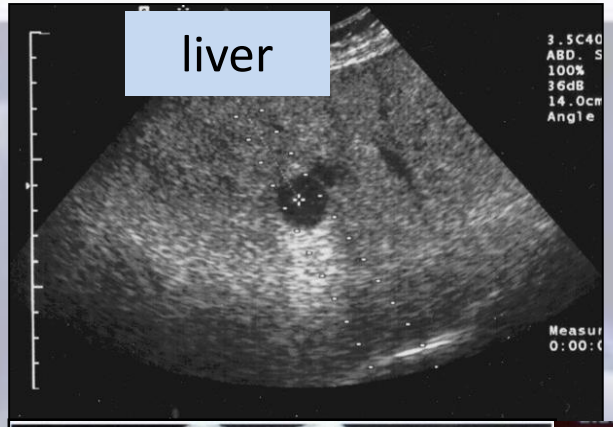
CE-US - HCC

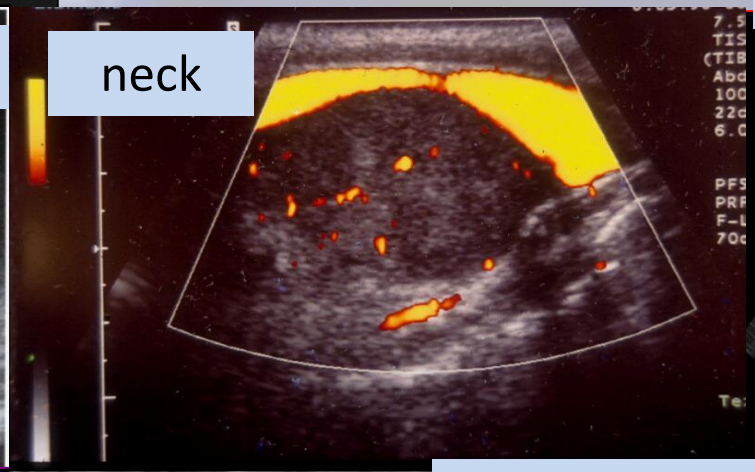
arterial, portal, venous, parenchymal phases

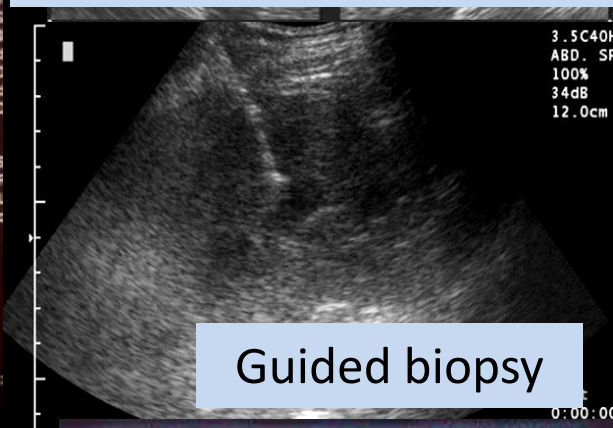
US is not the standard tool for tumor evaluation

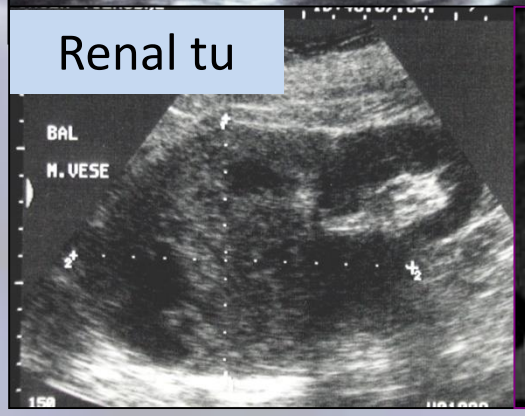
US
excellent soft tissue resolution

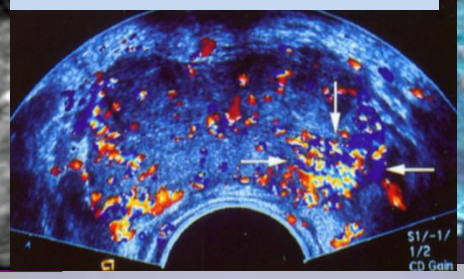
BUT
lack of complex information

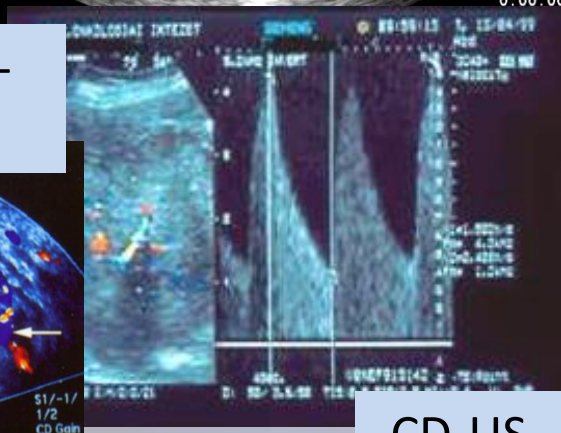












Ovarian ca

Advantages of MD-CT

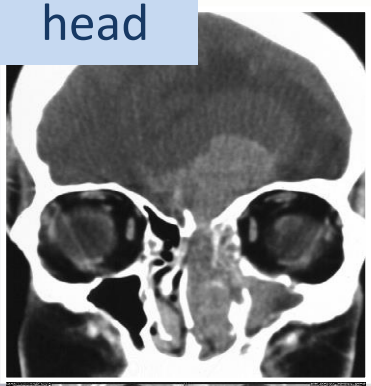
- Quick, tolerable, informative, standardized
- Whole body information
- Optimal vascular phase settings
- Dynamic / Perfusion information
- Excellent multiplanar reconstructions and 3D images
  - CTA & virtual endoscopy
  - We can see better, more and detect smaller changes
  - More structural details

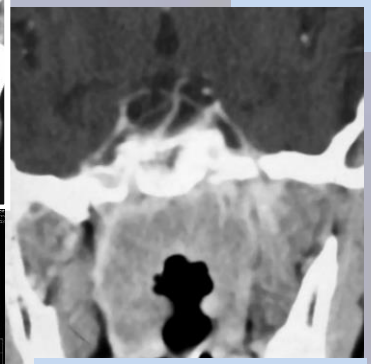
Disadvantage: ionising radiation

CT

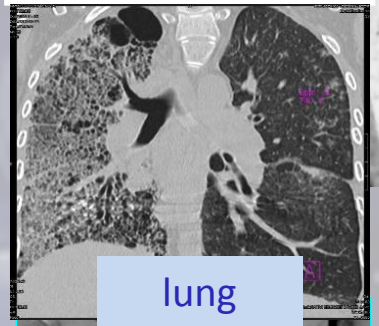
Quick, informative, standard method

head





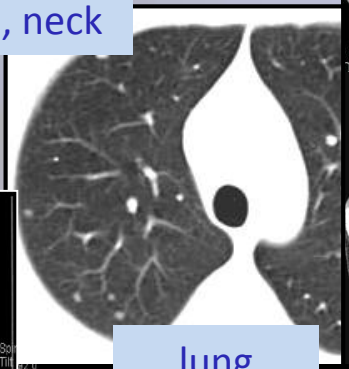
Skull base, neck



lung

Whole body

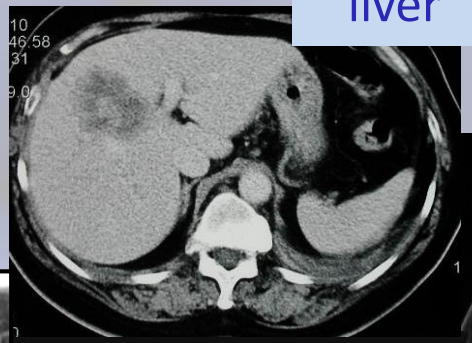
Bone, spine



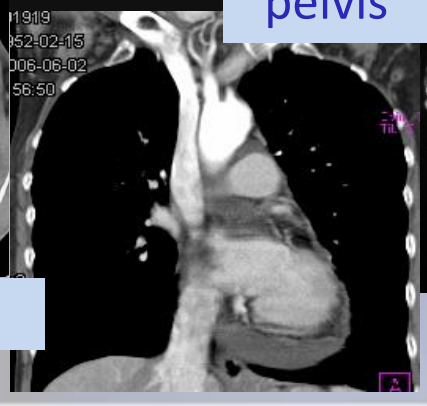
lung

mediastinum

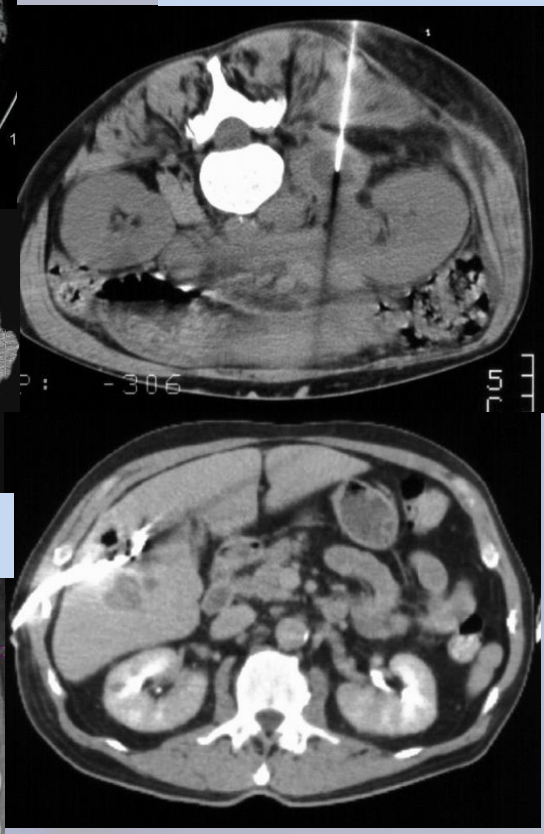
liver



pelvis



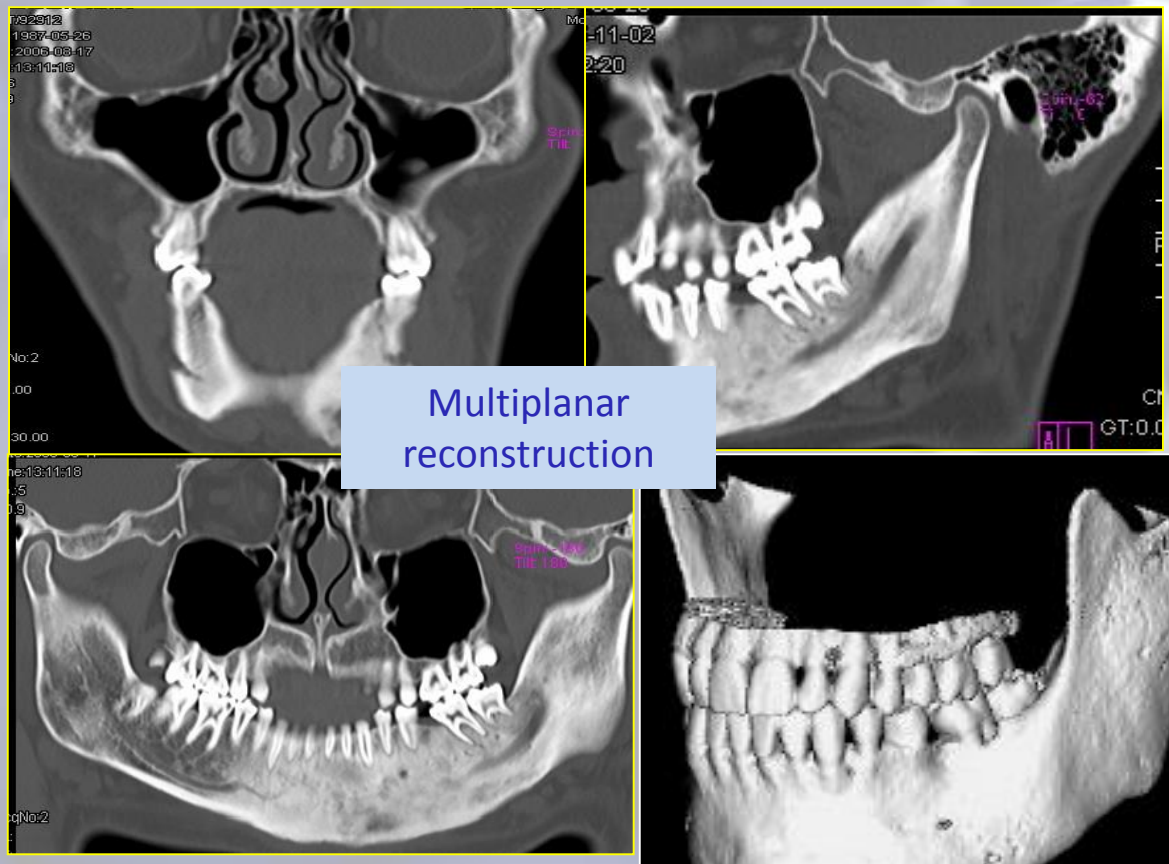
Guided biopsy



Guided drainage

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

Volumetric measurement

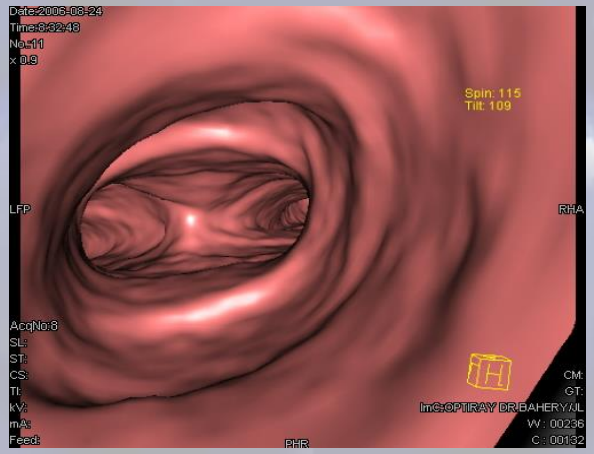


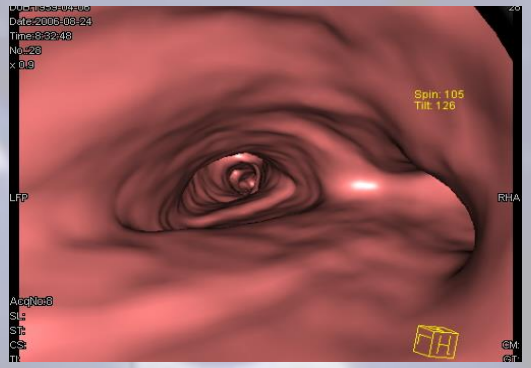
Multiplanar reconstruction

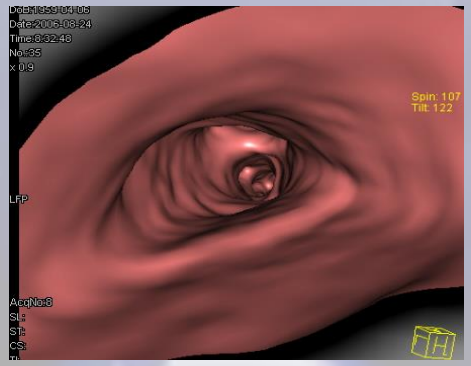
3D information

MDCT

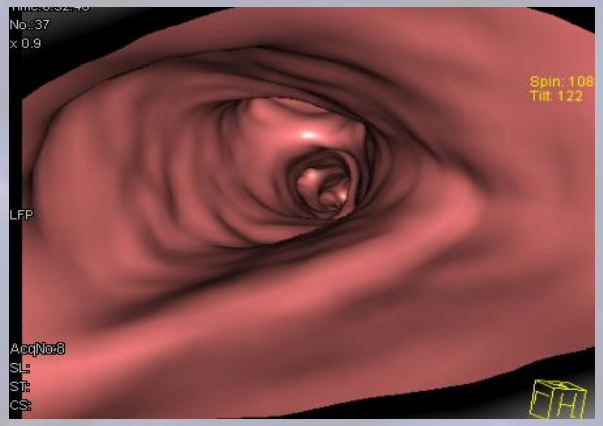
Virtual endoscopy







based on volumetric data collection



CT- Angiography

Magnetic Resonance Imaging- MRI (≥1.5T)

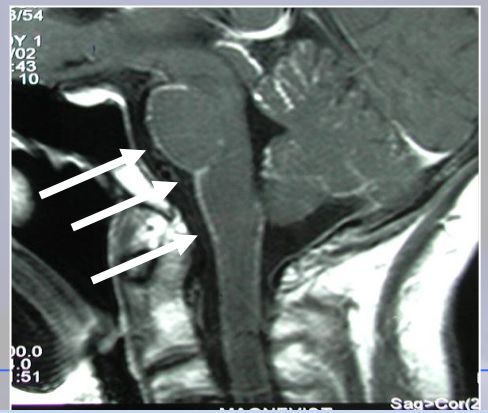
excellent multiparametric modality

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

ATTENTION!
Methal within the body!



Lepto-meningeal TU spread

Perineural (N.V.) TU spread

MRI „gold standard”

Problem solving method!

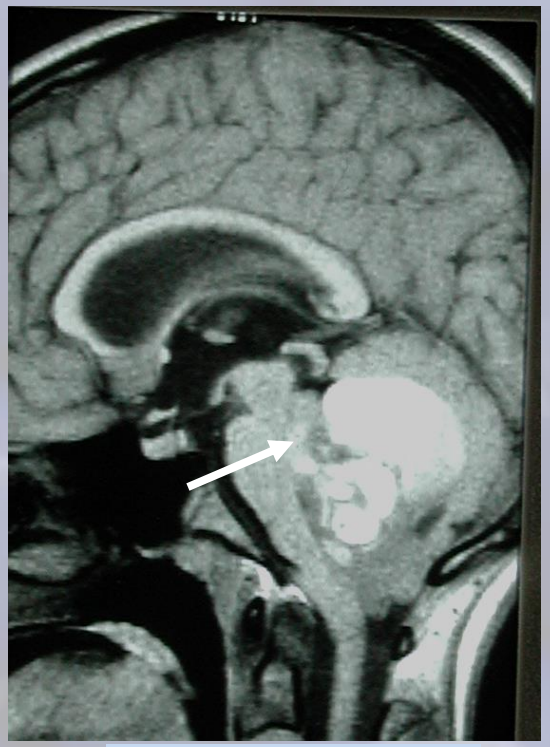
BETTER than CT at:

- **Brain tu: assessment of Tu volume/localisation/function**
- **H&N staging: intracranial / perineural tu spread; lgl evaluation**
- **Abdomen** *(fast sequences):* **LIVER;** *pancreas, kidney, adrenal gland, GI*
- **Pelvis**
  - **Prostate ca / Gynecological tu / Rectal ca**
- **Bone (marrow) – metastasis**
- **Soft tissue tumors**

MRI ACC: >80-90%

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

Best multiplanar evaluation of intracranial tumors

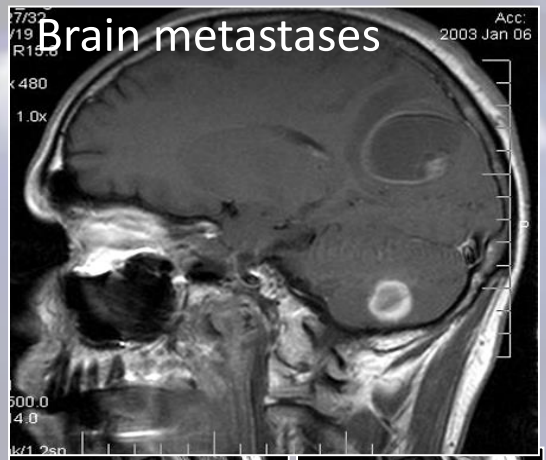


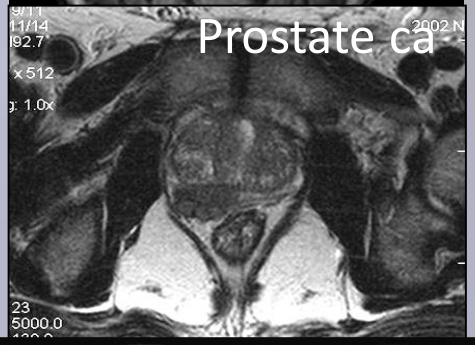
Sagital

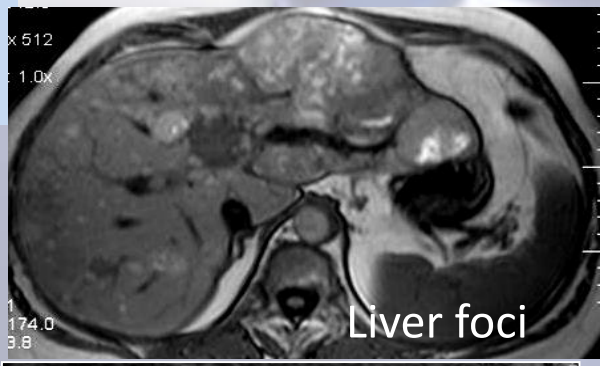
Coronal

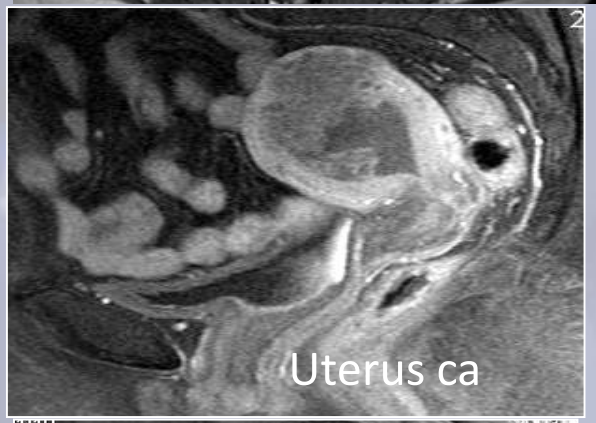
Axial

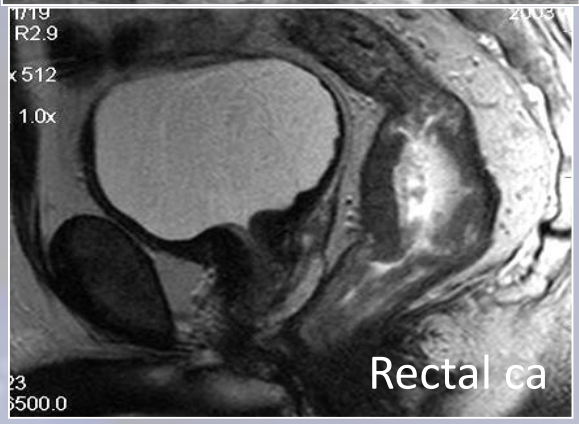
Today: MRI - Basic method







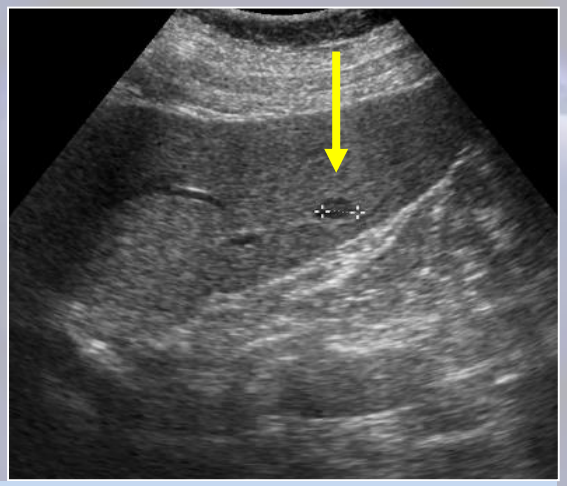




Tissue specific information

Two malignant primary tumors

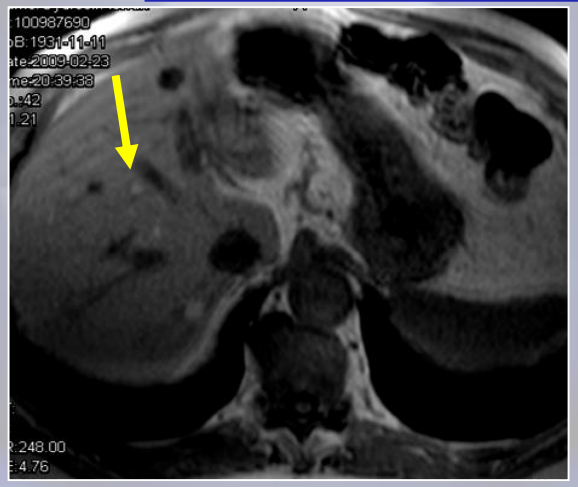
Colon ca / ocular malignant melanoma

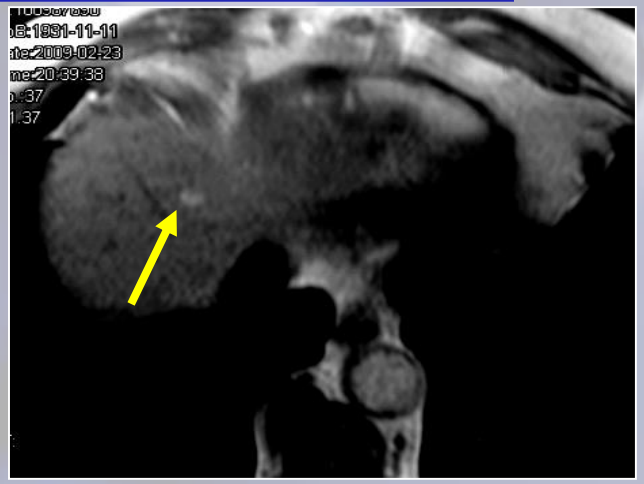


US – unspecific density
It might be metastasis

MRI: specific for MM metastasis

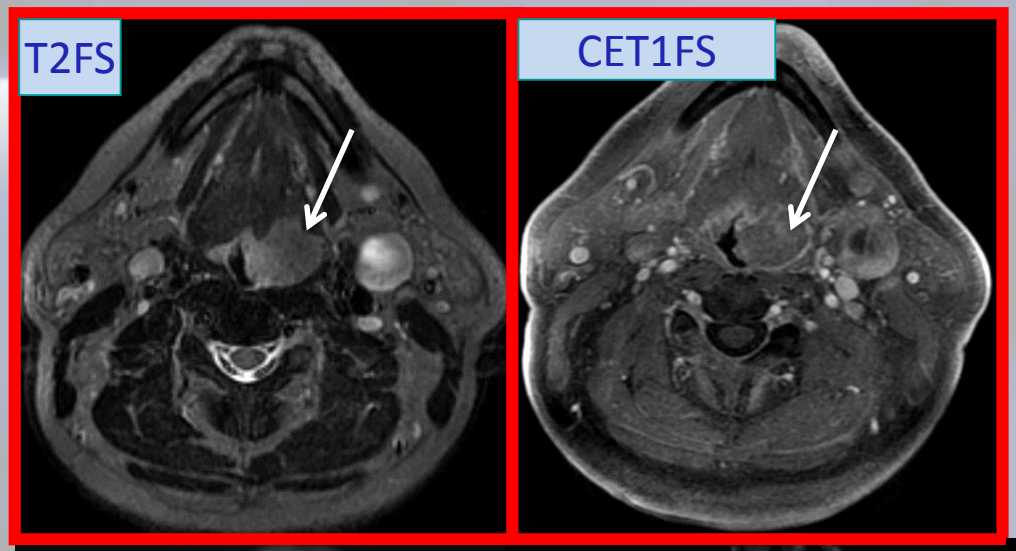
High signal intensity T1-w foci in the liver - because of melanin content

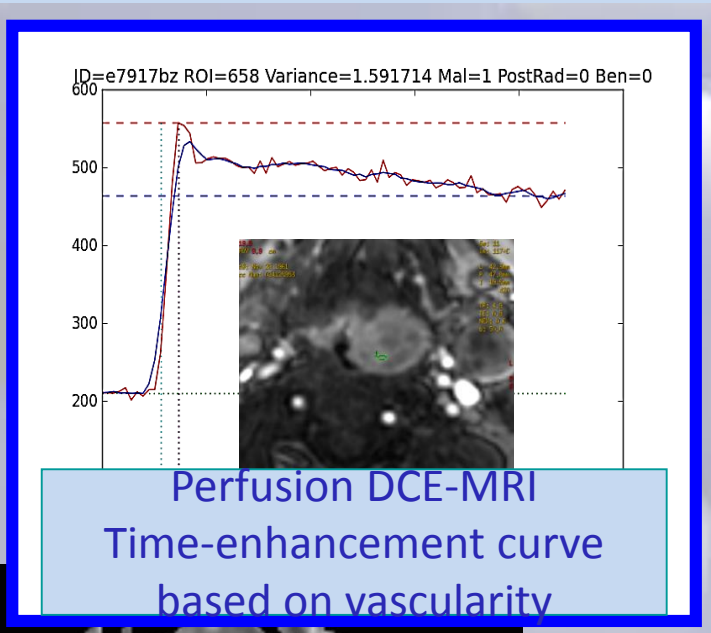




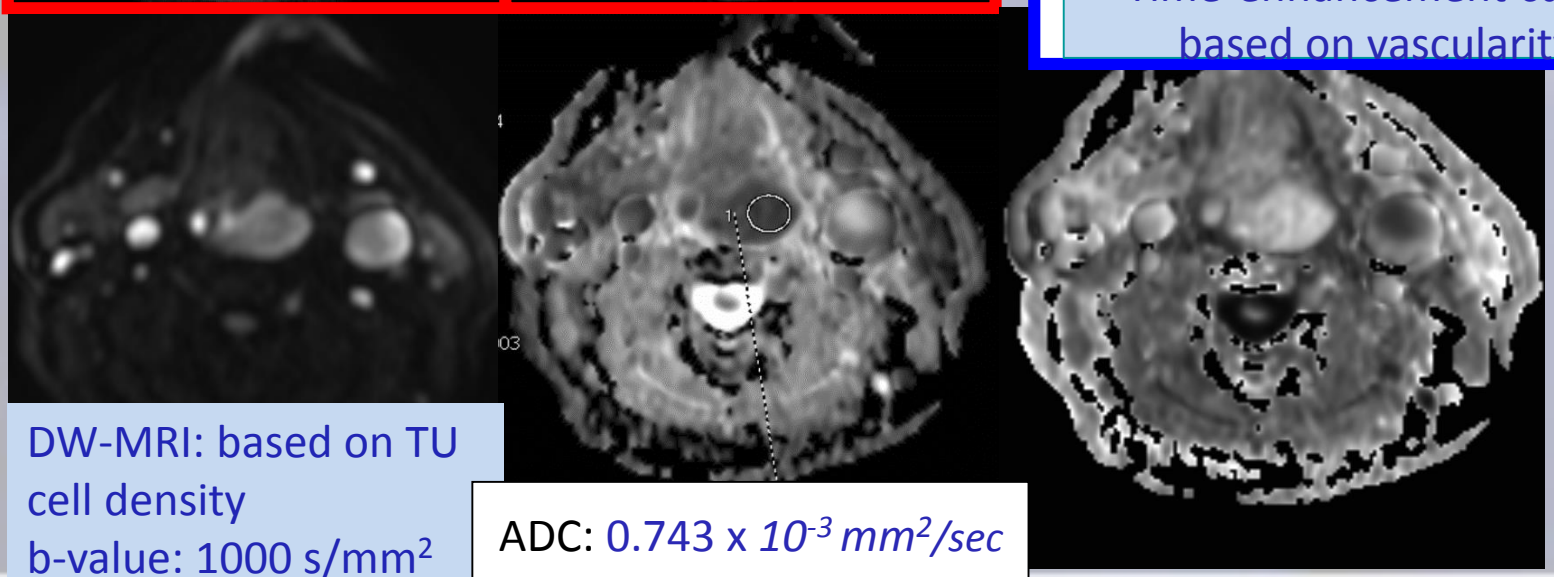
DG: MM mets

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

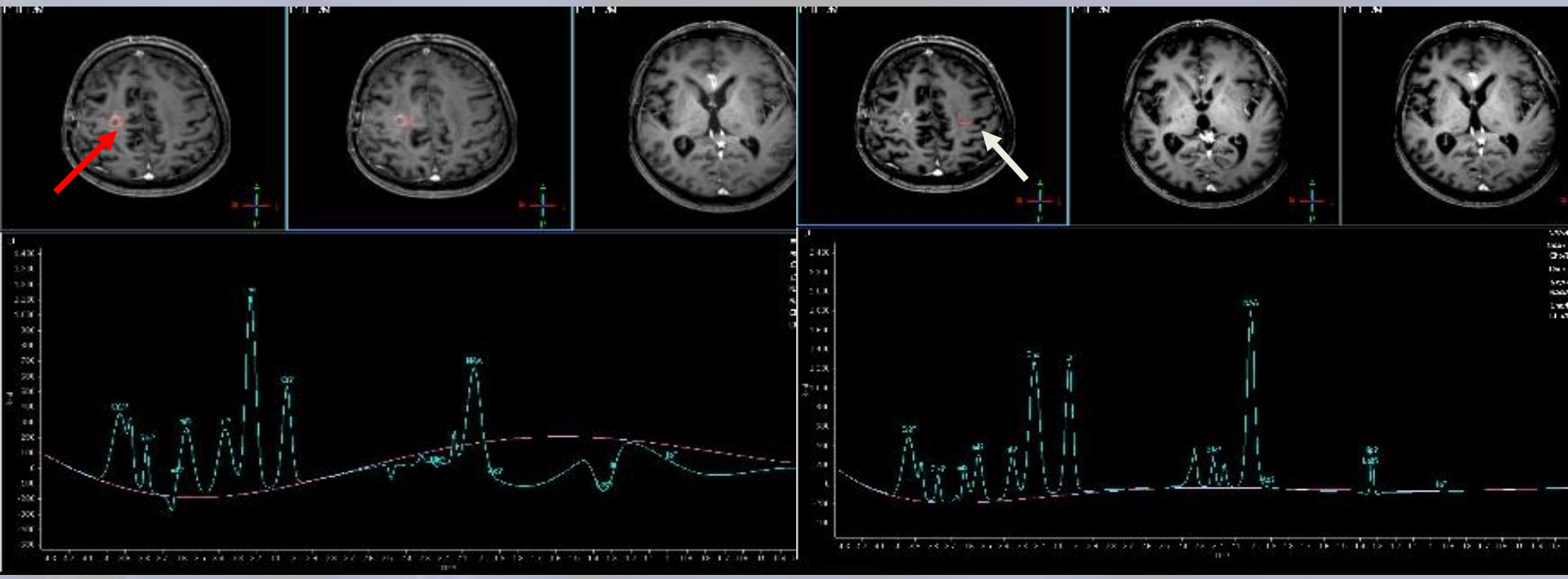
MR spectroscopy (MRSI) –

*(*biochemical analysis *of molecular products)*

Recurrent brain tu- could be detected earlier

Tumor side (R)

Normal side (L)



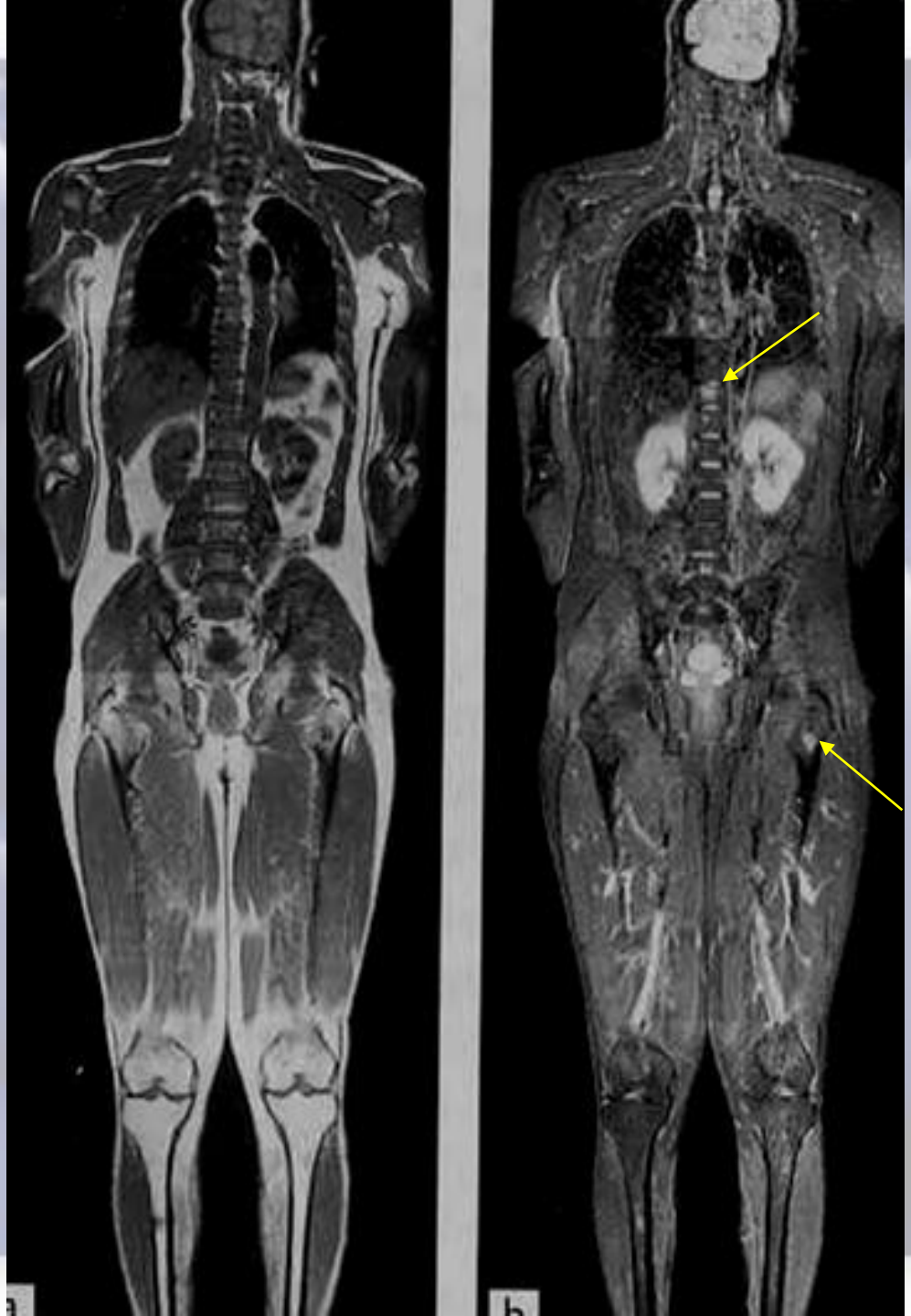
Cholin peak ↑

NAA ↓

N-acetylaspartate

Cholin ↓

NAA ↑



Whole body MRI

Sensitive and specific for bone marrow metastasis

Right: T1-w sequence

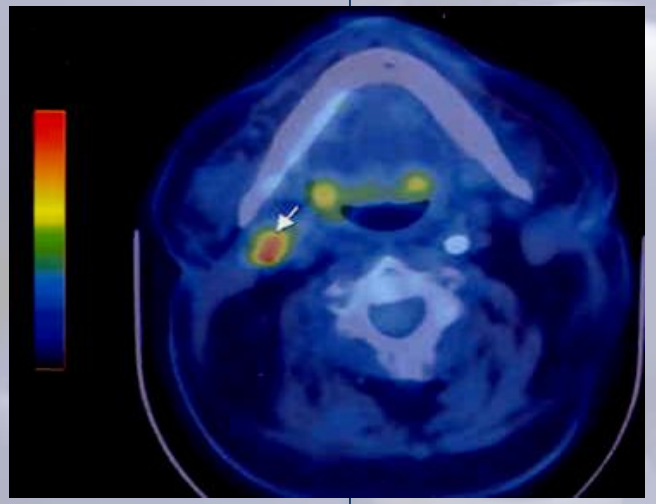
Left: STIR sequence

PET/CT

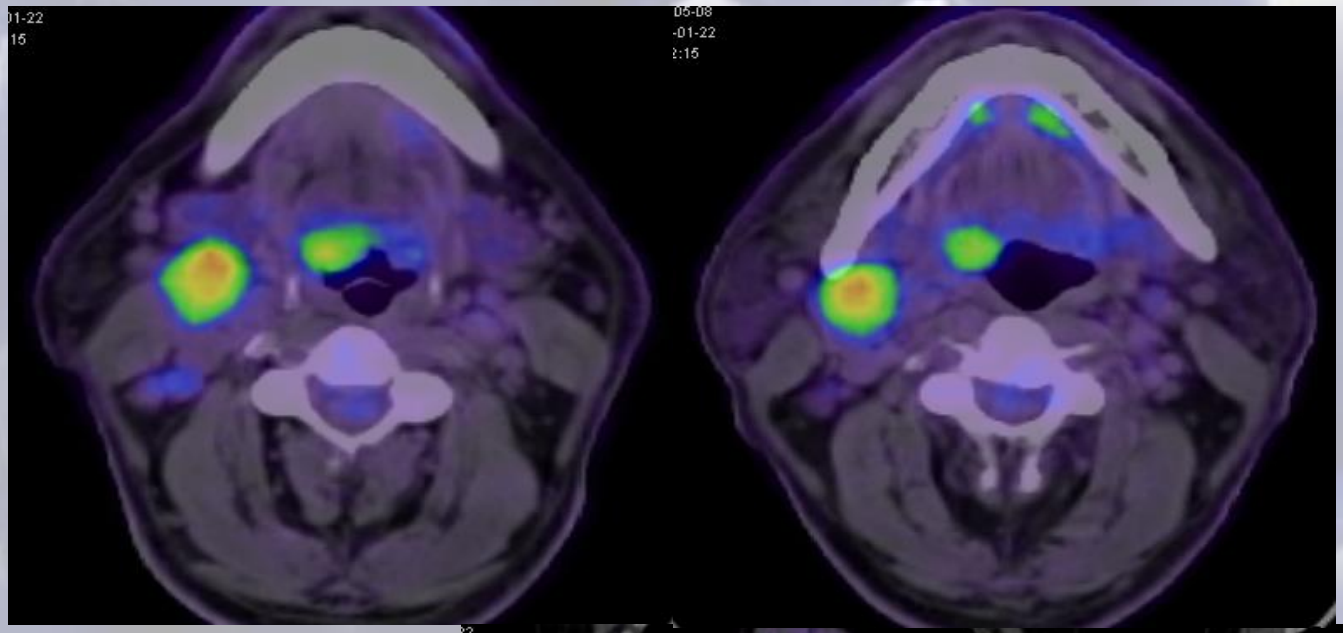
- **PET/CT** – ***better imaging of molecular processes***
- Whole body information
- **PET: sensitive for metabolic activity – Tracer: FDG** (F18FluoroDeoxyGlucose) **– glucose alternative**
- **CT: anatomic backround and structural analysis**
- **Together: improved sensitivity/specificity/accuracy**

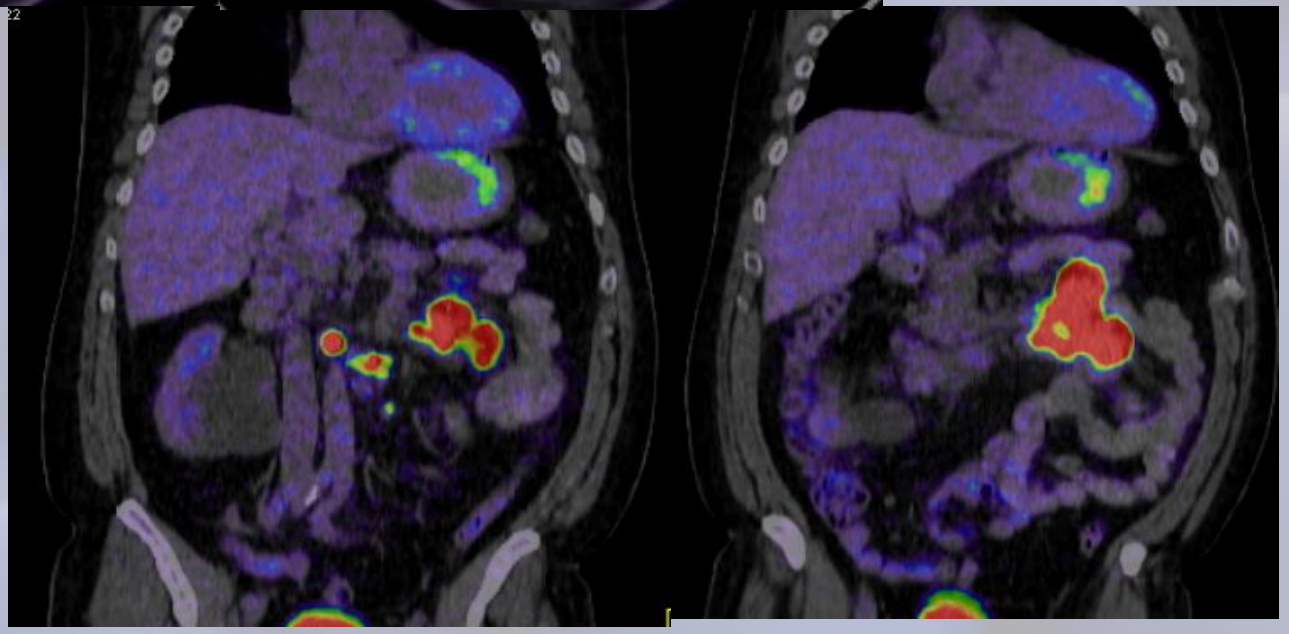
PET/CT
general indications

- Clinically suspected distant metastases
- Therapy monitoring
- Assessment of residual / recurrent tumor
- Re-staging in case of recurrent disease
- Unknown primary (cervical metastatic lymph node – detected primary tumor in 30-40%)



False NEGATIVE & POSITIVE cases!
Ionising radiation!
High costs!



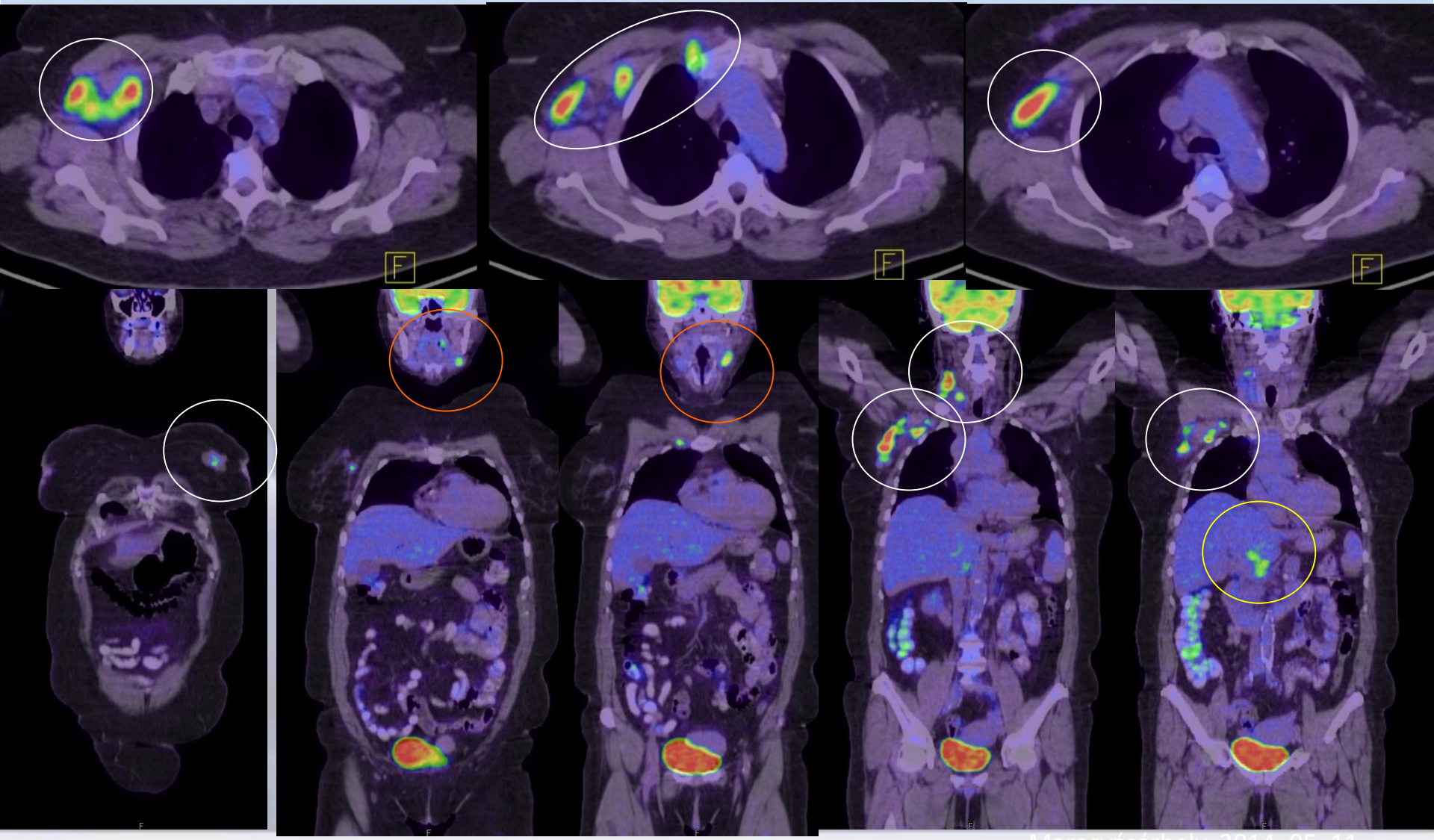


FDG-PET/CT

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)



BONE

Spine metastasis

RN-

osteoscan

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

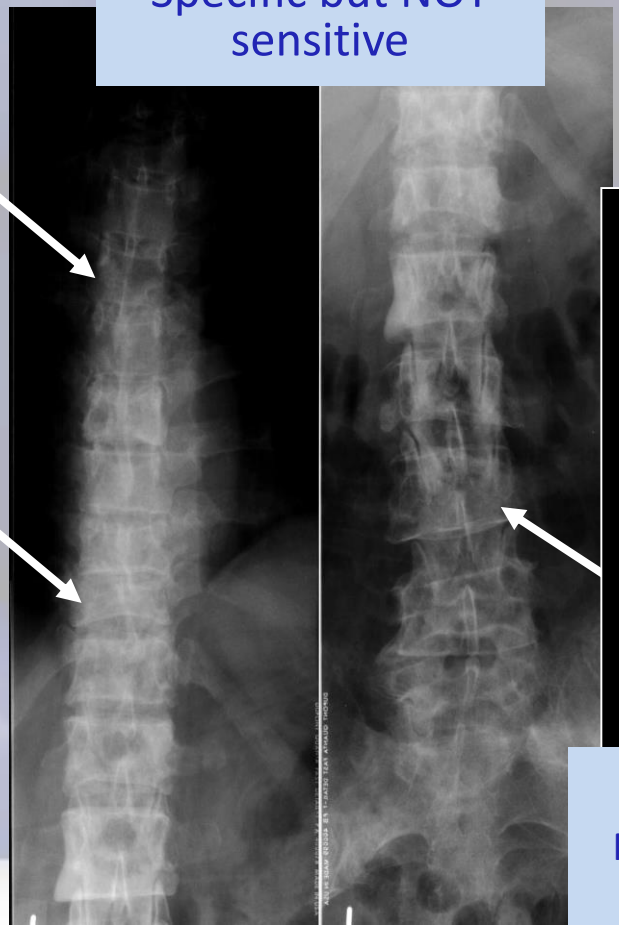
based on: osteoblast activity

MR

Sensitive and specific

CXR

Specific but NOT sensitive



PET/CT

sensitive and specific

CT

Medium specific and sensitive

Interventional radiology in oncology

Diagnostic

- **Diagnostic angiography - DSA**

  vascular morphology, neovascularisation, cancer vessels

- **Guided biopsy**

  (Fluoroscopy-, Mgr-, US-,CT-,MR-)

  - 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 wave, percutan ethanol injection (PEI), focused US)
- **Drainage** *(abscess)*

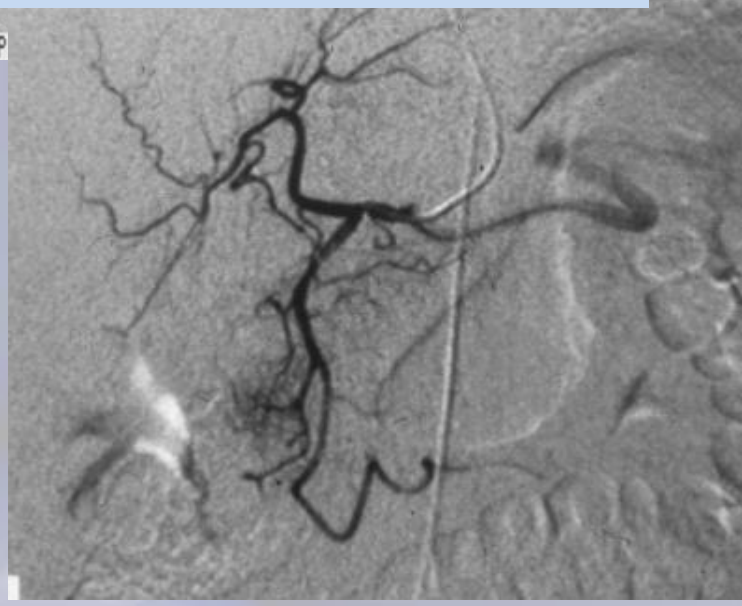
DSA -TH

Localized cancer

Chemoperfusion

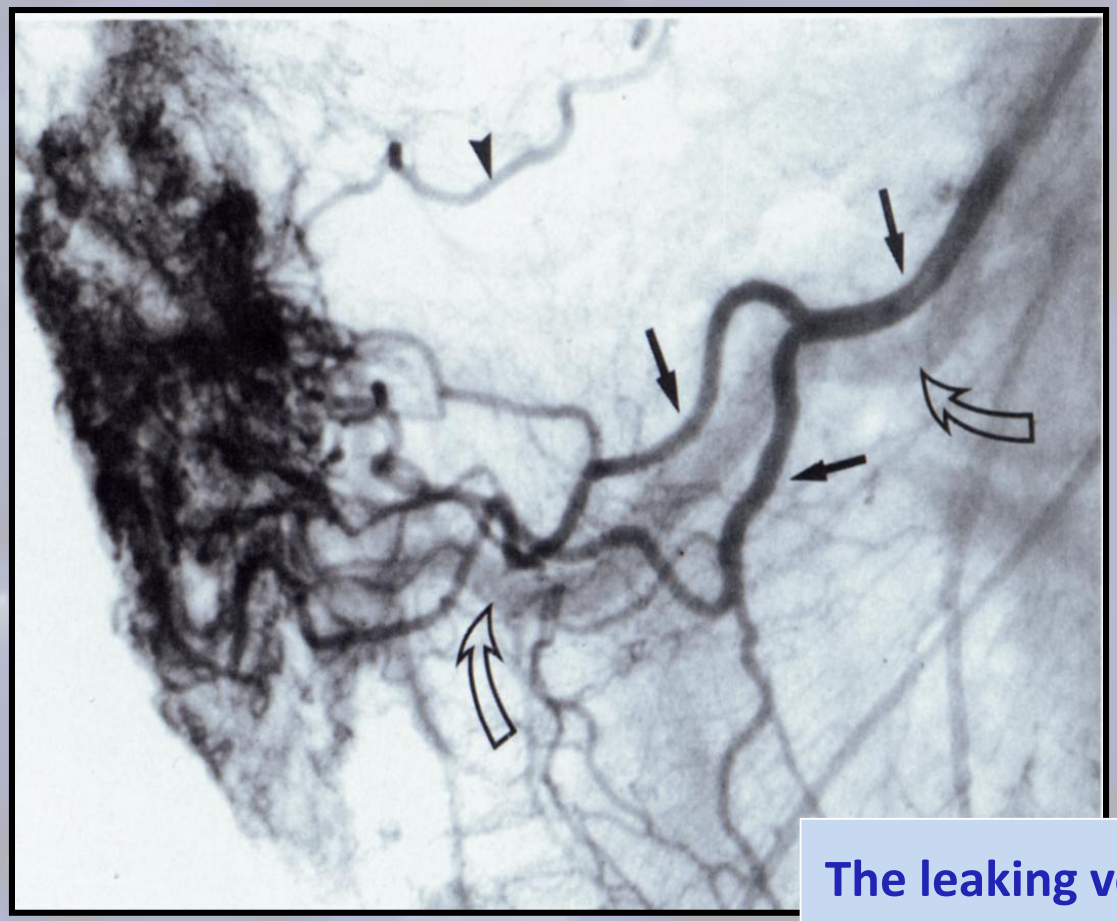
Chemoembolisation

Cancer vessels have been closed



Cancer vessels were demolished

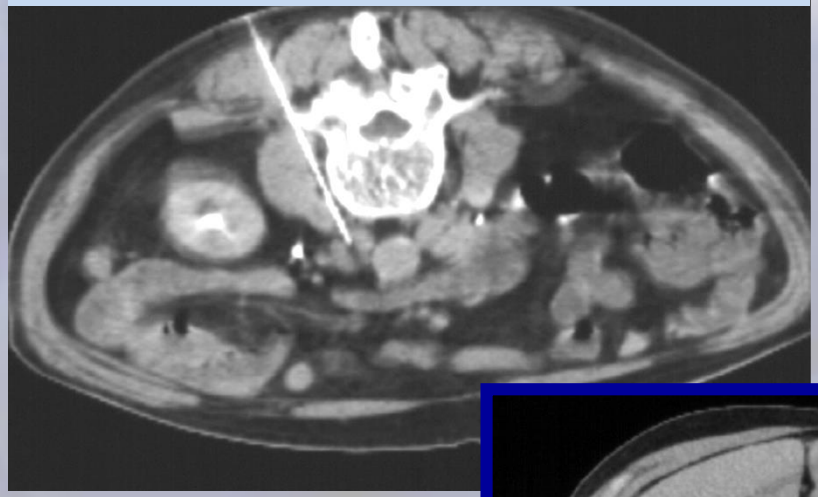
Embolisation of coecal AV malformation
- because of bleeding -

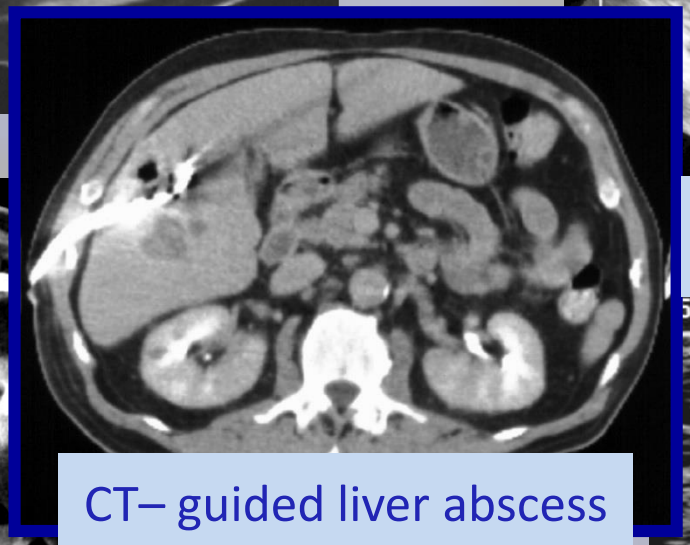


The leaking vessels were obstructed

US, CT– guided biopsies, drainage

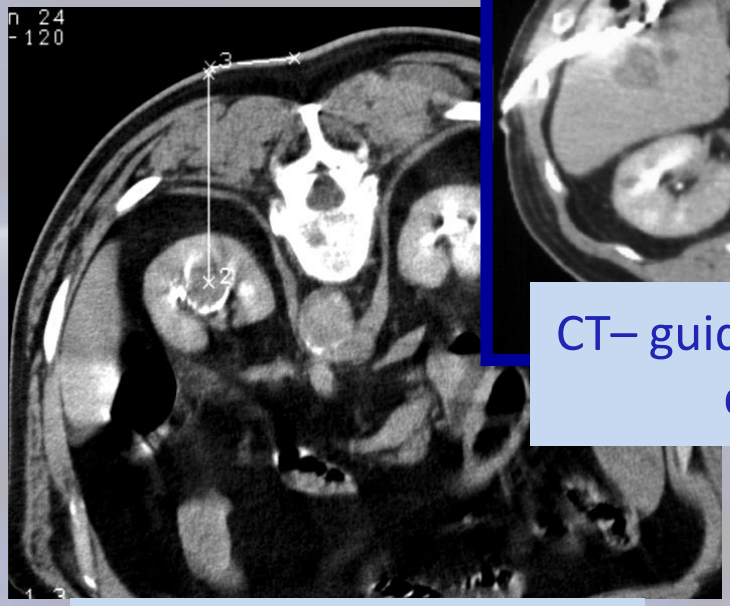
CT– guided lymph node biopsy



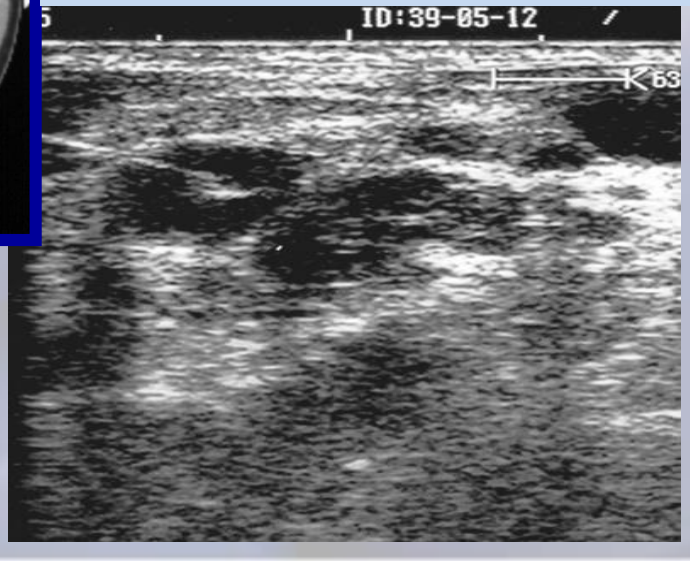


CT– guided liver abscess drainage

US – guided neck node biopsy



CT– guided renal biopsy



Oncological diagnostic algorythm

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

Reqirements of SCREENING

Rational chance for:

- Early diagnosis in preclinical stages
- To find high risk asymptomatic individuals
- To achieve lower mortality rate

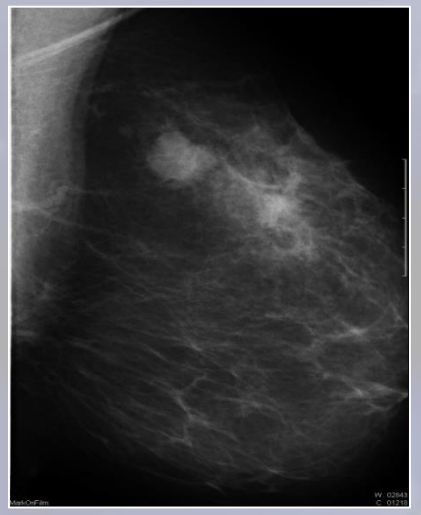
*For example: 90% of all **breast cancer** can be cured with early diagnosis and appropriate therapy!*

Mammography

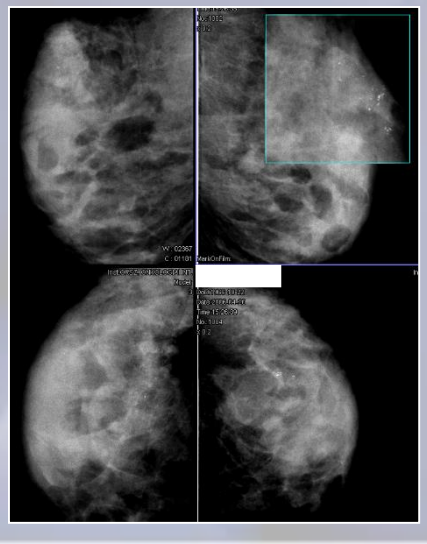
- basic screening method for breast cancer -

SENSITIVITY

- Average in literature: 80-85%
- In adipose breast: 99%



As breast density increases sensitivity decreases!



For dens breast: additional US, MRI

BREAST CANCER

Stage determining imaging methods

- **Mammography -** Analog / **Digital**
  - **Tomosynthesis**
  - **CAD (Computer Assisted Diagnosis)**
- **US**
- **Guided biopsy:** FNAB / core-, vacuum assisted biopsy
  by US / mammography (stereotactic biopsy)

- **Multiparametric MRI** (Anatomical and functional assessment)
- **CT / PET-CT – for staging (metastases?)**

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

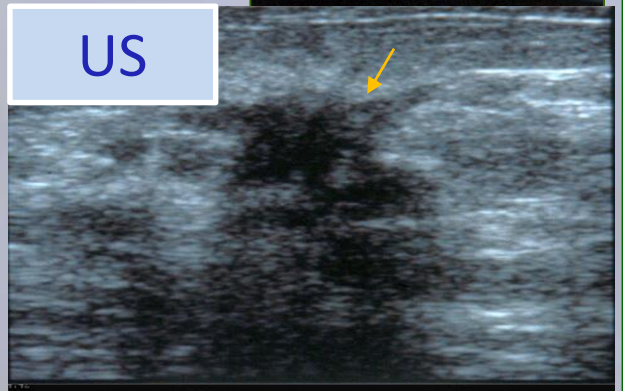
- **Specimen** mammography /US

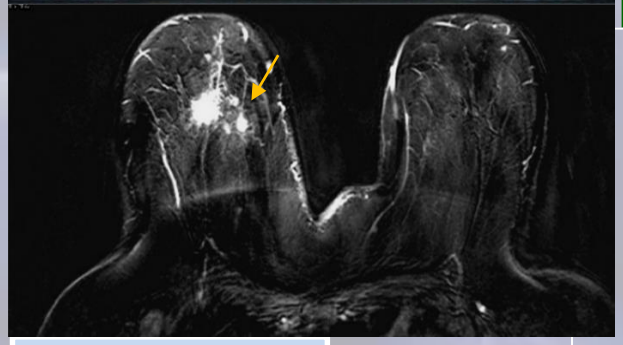
BREAST CANCER

Multimodality - Multidisciplinary

X-ray-mgr

US





Breast MRI

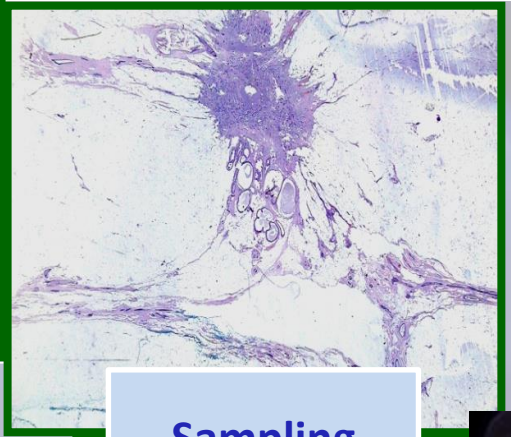
marking

Mammography + US + biopsy

Sv 85%, **Sp 92-95%**

Breast MRI:

Sv 95%, Sp 86%



Sentinel N

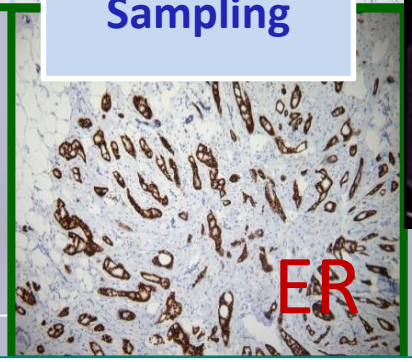
Lymphoscintigraphy +

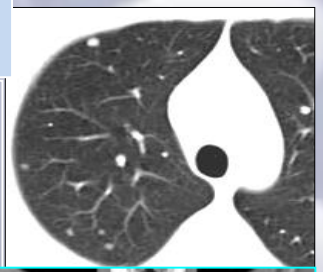
+ (Blue dye)

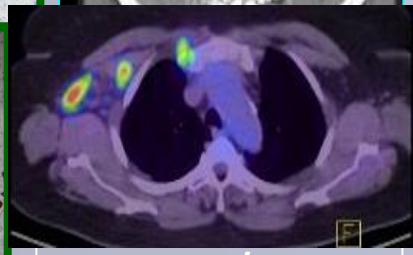
+ Histology

(Accuracy >90%)

Sampling







CT, PET/CT staging

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

LUNG CANCER

- **Leading cancer death**
  - 1.3 million deaths / year worldwide
  - >60.000 deaths in 2010 in USA
  - Approximately 70% of cases are incurable at presentation, metastatic or locally advanced
  - **14% overall 5 year survival**

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

LUNG CANCER SCREENING

- **CT - highly sensitive for small lung nodes**

  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%

  (Henschke study)
- **Low dose CT (**minus 20-25% of standard dose)
  - **Follow up LDCT for grow**
  - **Volumetric measures - CAD (computer assisted diagnosis)**
- **Risk:** currently no determined risk limit at CT screening for lung cancer
- **High risk group:** smokers >1 pack/day; >55 years old

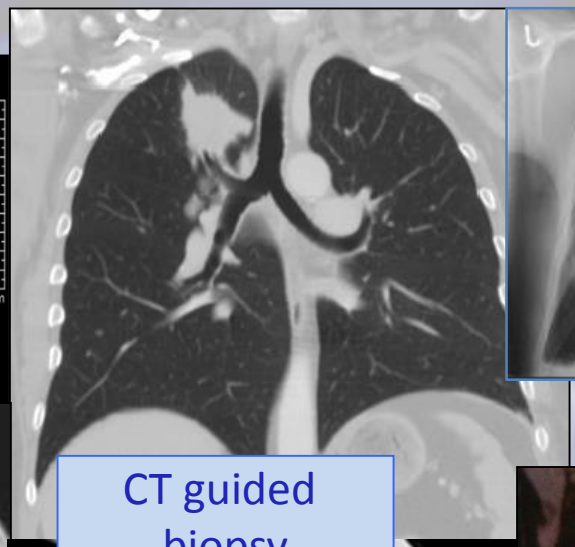
(Dr. Lecia V. Sequist, Massachusetts General Hospital, Boston)

LUNG CANCER

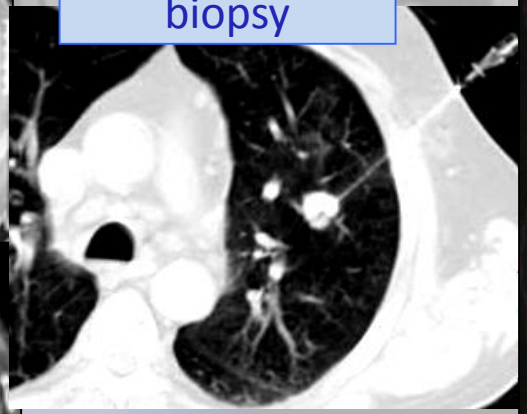
Clinical exam.: Bronchoscopy

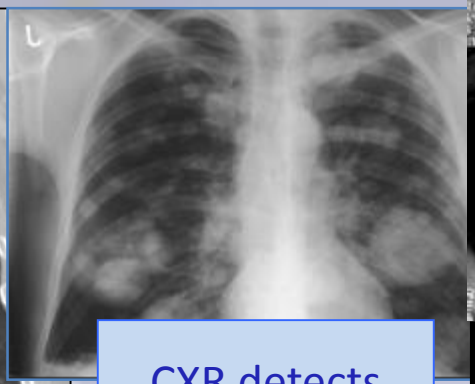
CT basic method

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



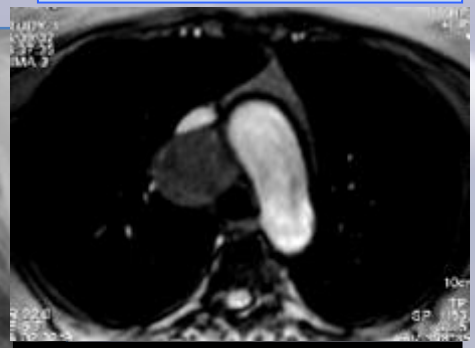
CT guided biopsy

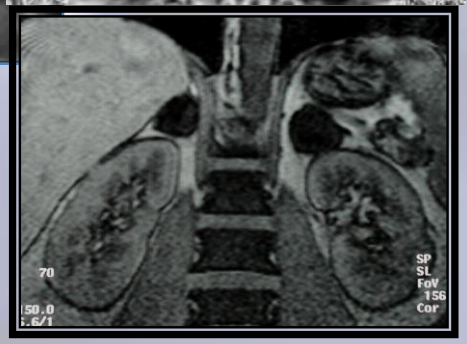




CXR detects

Complementary MRI



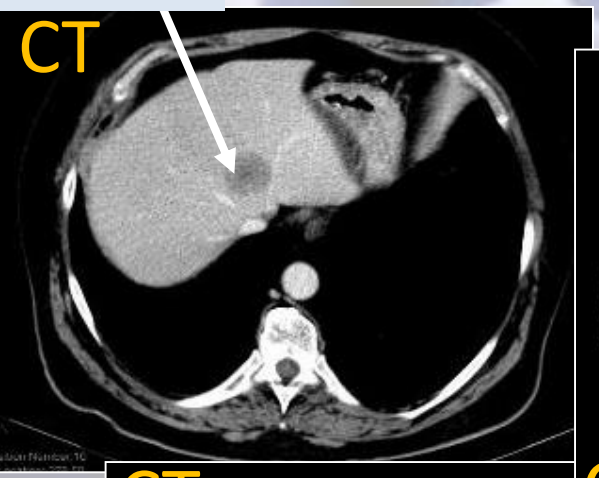


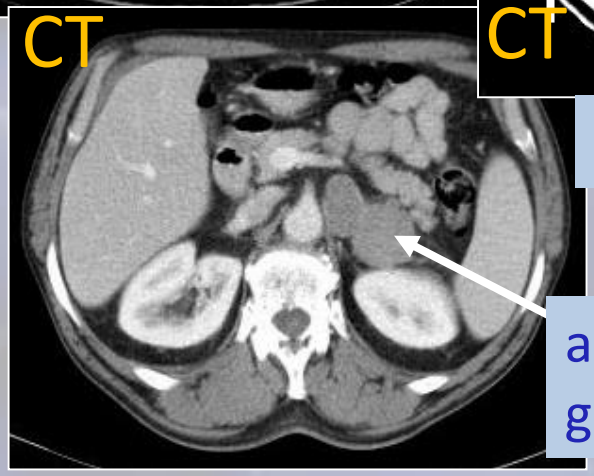
PET/CT staging

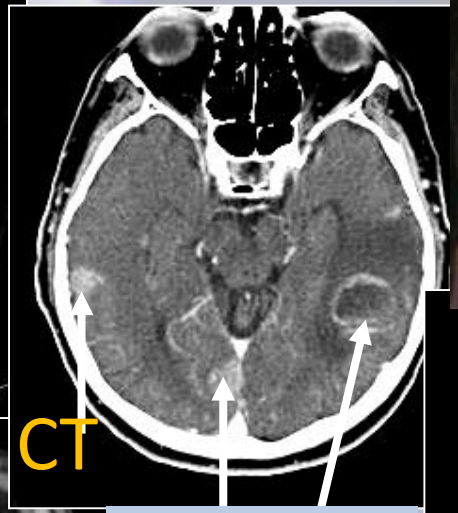
Lymph node & adrenal gl. met

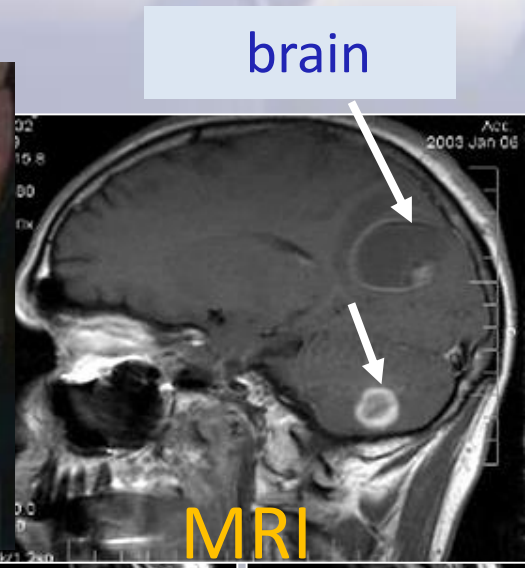
LUNG CANCER METASTASES

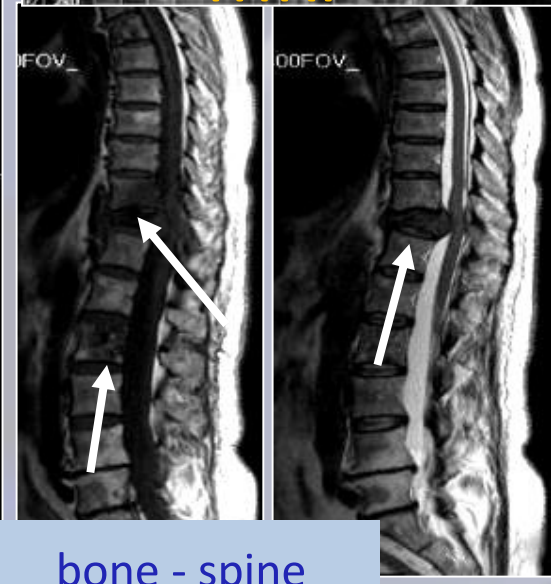
(CT / MRI / PET-CT)











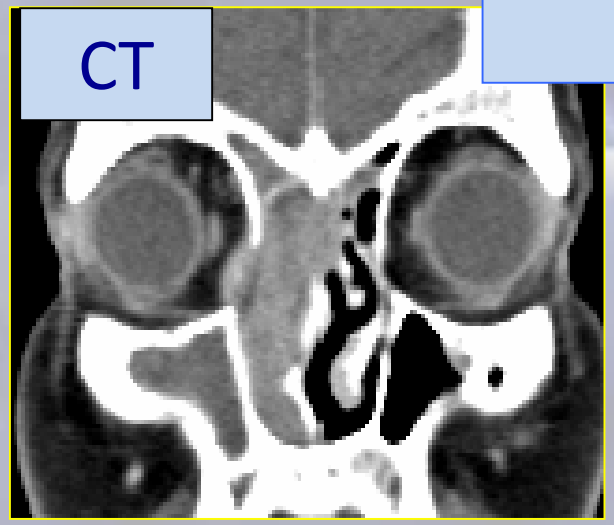
Imaging in **HEAD and NECK** tumors

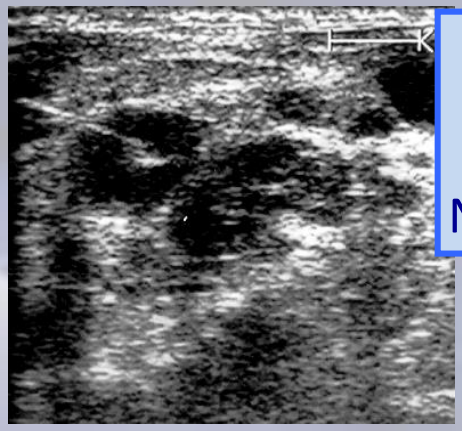
- **US – for analysing palpable neck masses**
  - solid / cystic? , lymph node, thyroid gl., salivary gl., vessels
  - Guided biopsy
- **CT** *(complete imaging of neck from the skull base to the trachea bifurcation) + facial bones*
- **MP-MRI: best modality to evaluate the local staging**
- **PET/CT - for whole body information** – for distant TU spread, for residual /recurrant TU

Head & Neck Ca: MR/CT/US

Clinical examination: endoscopy

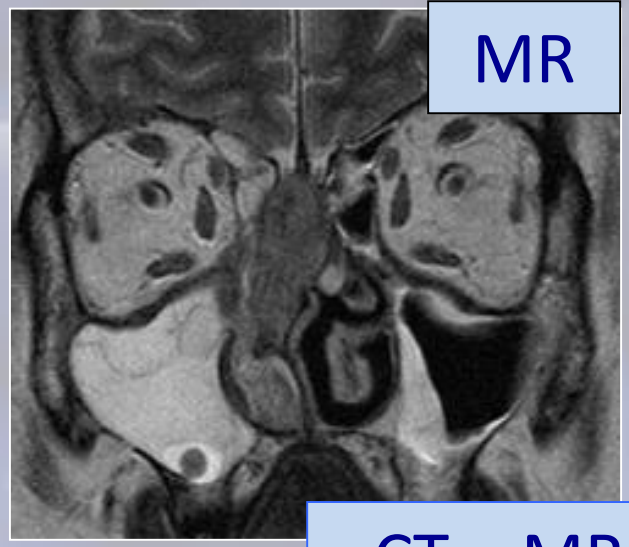
CT

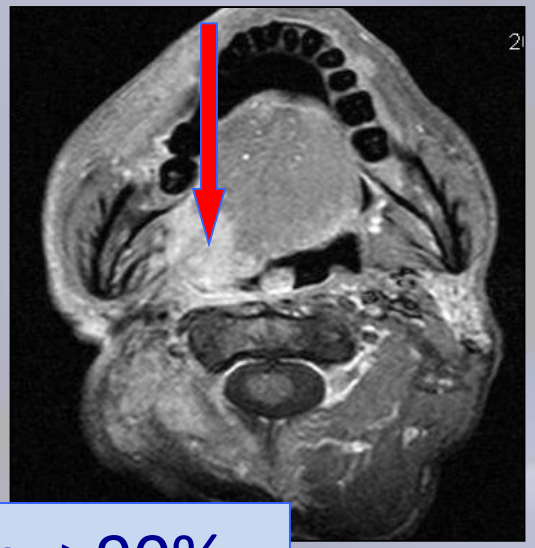


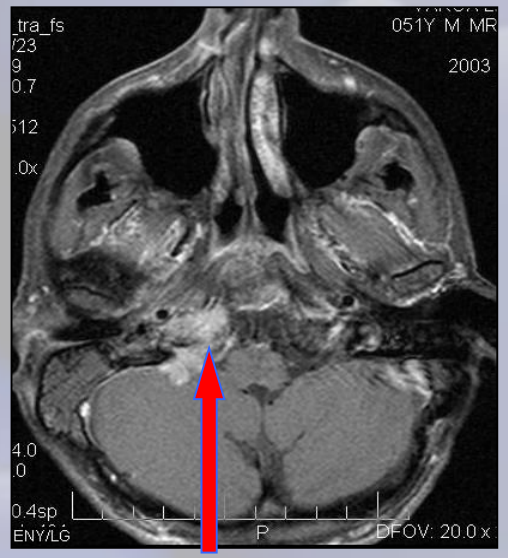


US
Guided
Asp. Cyt.
N - Acc >90%

MR

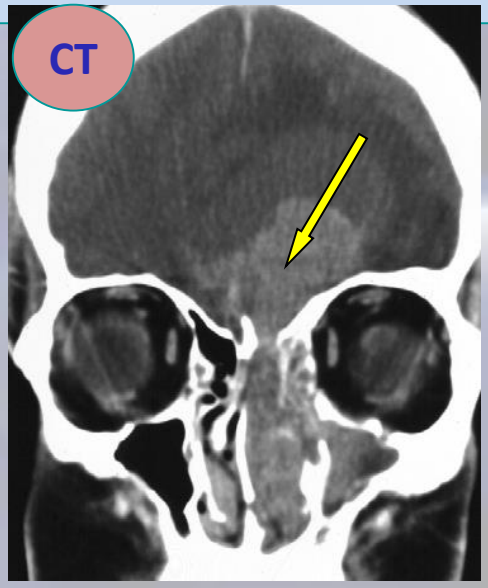


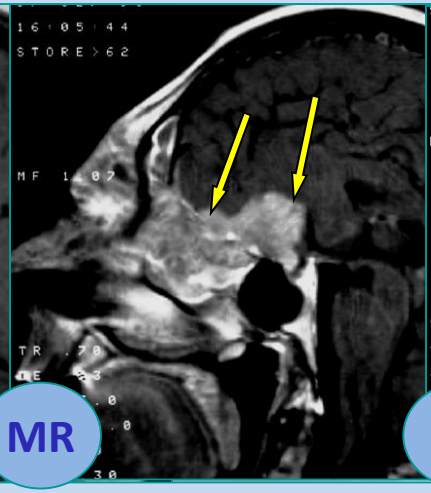


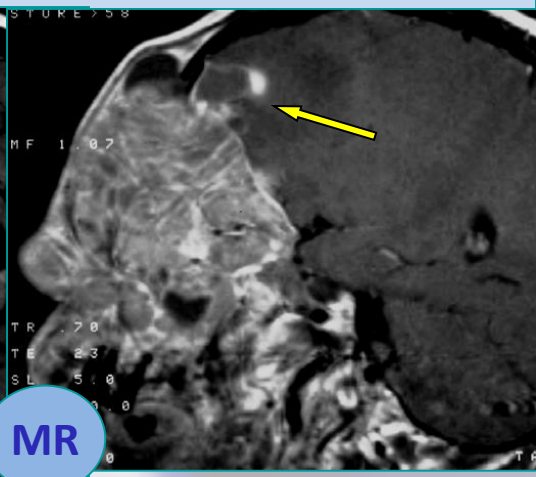


CT – MR Acc: >90%

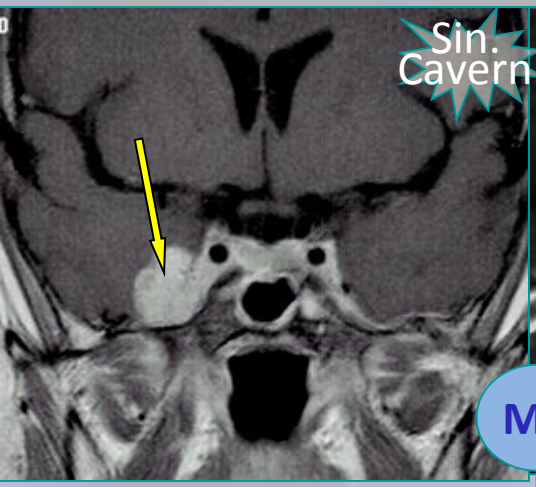
Intracranial TU extension - CT/ **MR**

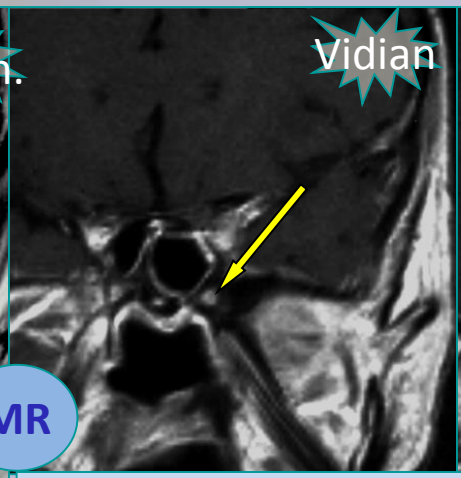


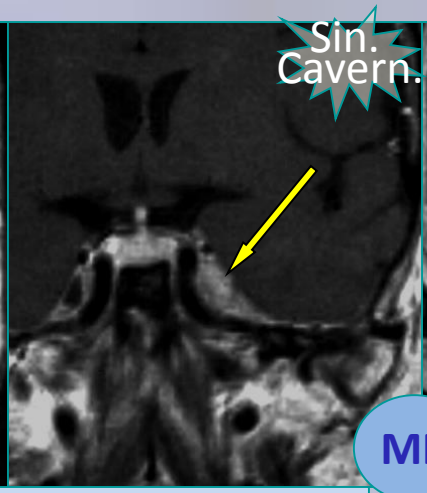


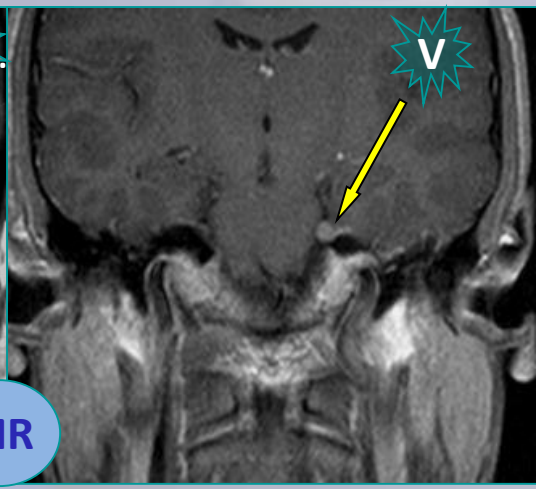


epidural dural intracerebral





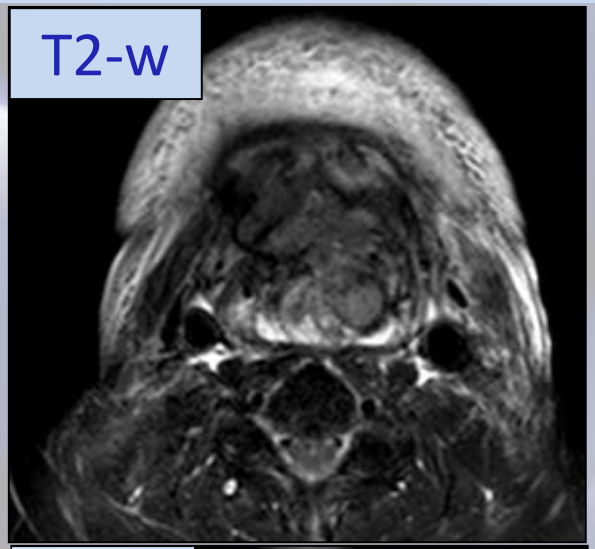


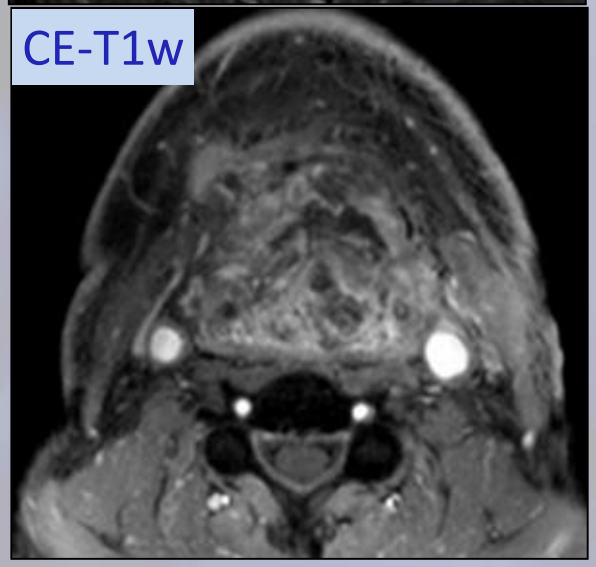


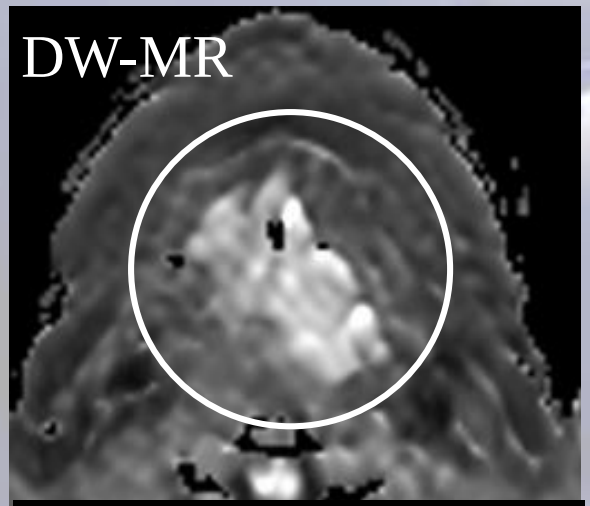
Perineural TU spread

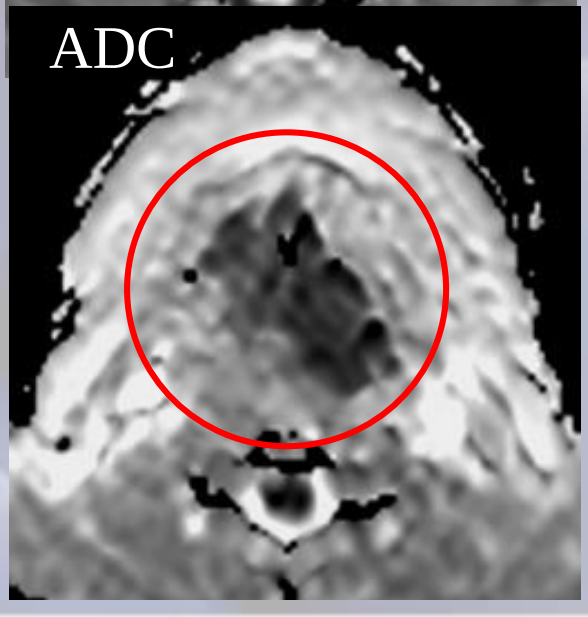
Supraglottic residual carcinoma – MP-MRI

Restricted diffusion within the residual tumor tissue









RECTAL TUMOR
Multimodal Imaging

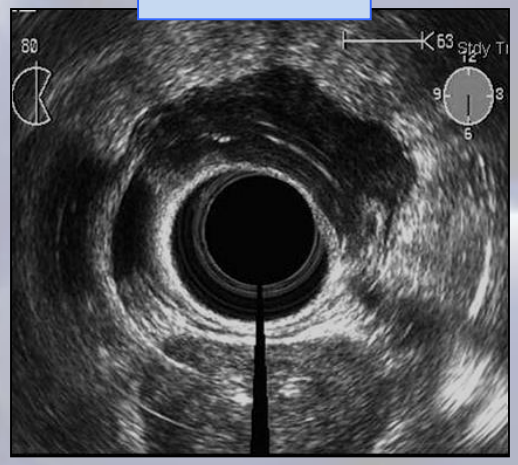
- **US** Transabdominal US for general abdominal information

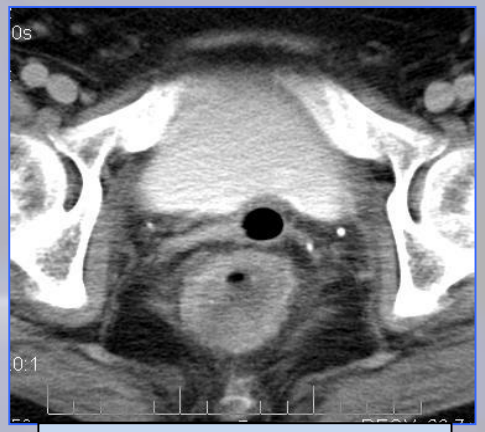
  Endorectal US – intramural TU extension
- **MP-MRI** best evaluation for tumor extension beyond the wall, relation to the adjacent organs, lymph nodes, liver
- **CT** to evaluate advanced TU extension (thoraco-abdominal-pelvic)
- **US/CT guided biopsy** (liver)
- **PET/CT** whole body information – distant / recurrent Tu

RECTAL Cancer

Clinical examination: rectoscopy

EUS

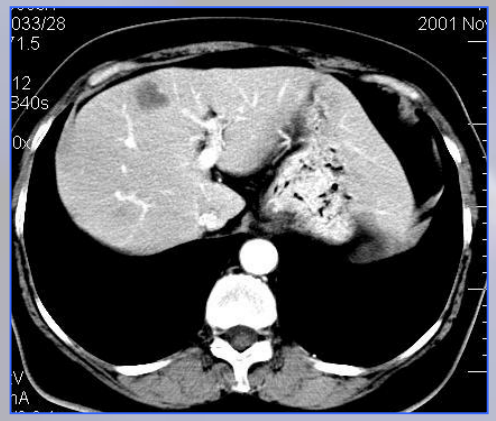


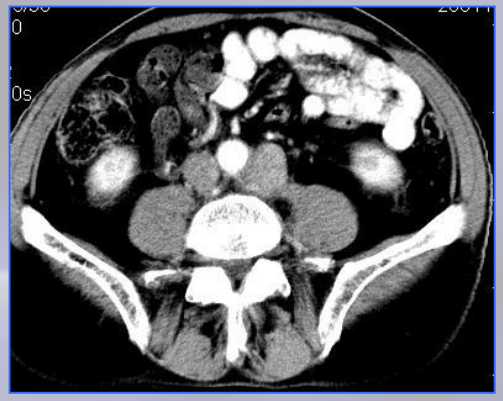


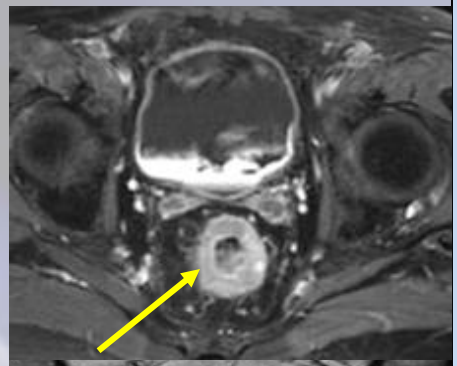
CT

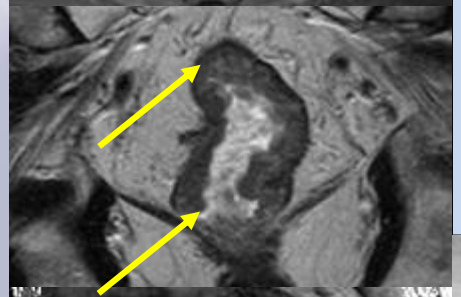
Rectal ca

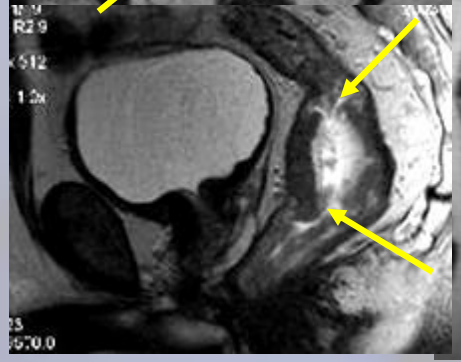
Acc 70-85%









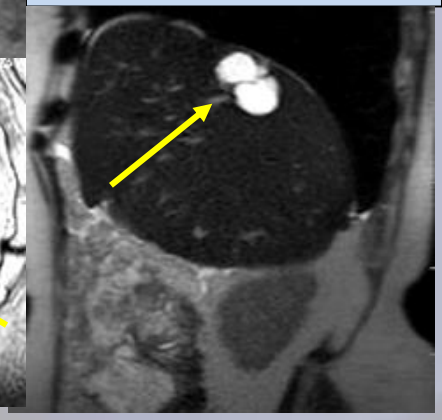


MRI

Acc>90%

Liver met

Acc>90%



Imaging in **PROSTATE cancer**

- **US** – general abdominal and pelvic informations
  - Transabdominal US
  - Endorectal US
    - Color- Doppler US
- **MP-MRI (T2-w, DW-, Dyn-MRI)**
  - Reliable pelvic status, T/N staging for prostate, recurrent tu?
- **Bone scan** – bone metastasis
- **CT**- to evaluate advanced Tu and dissemination
- **PET/CT** – for recurrent tumor or metastases

Prostate cancer

- **Clinical Dg:**
  - **PSA – not reliable for Dg. and staging**
    - Organ specific *(not tumor specific!)*
    - norm: >3-4-6 ng/ml (age dependent)
    - **Good for follow-up**
  - **PCA – better, but not sure**
  - **DRE (digital rectal exam)**– suspected tumor, usual underestimation
- **Sextant / TUR** (transurethral) **biopsy** (core)

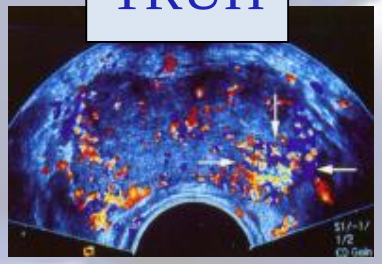
Imaging Dg:

- **TRUH** – orientation about the structure

  guided biopsy with MRI image fusion
- **MP-MRI** – Dg, staging, therapy monitoring, recurrent tu?
- **Bone scan – bone metastases**
- **CT** – advanced Tu stages, TU **dissemination**

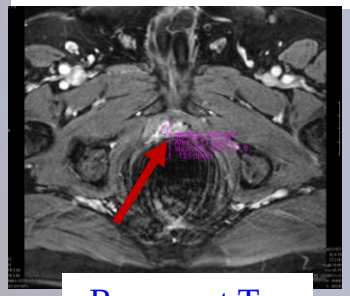
  guidance for radiotherapy
- **PET-CT:** recurrent tumor, therapy monitoring, recurrent Tu?

TRUH



MR

Tu broke through the capsule - T3a

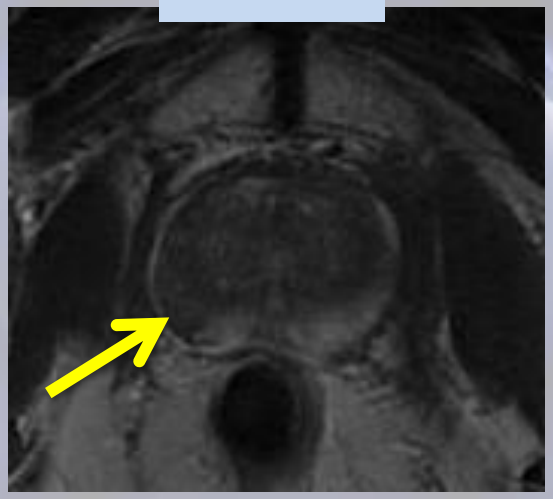


Recurrent Tu.

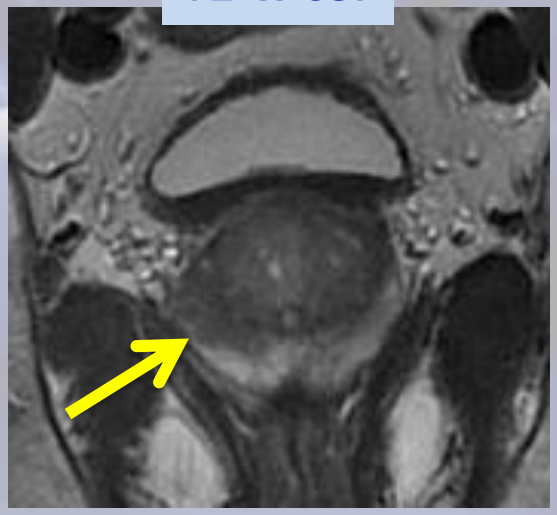
Prostate cancer

„T" Staging: MP-MRI (T2b)

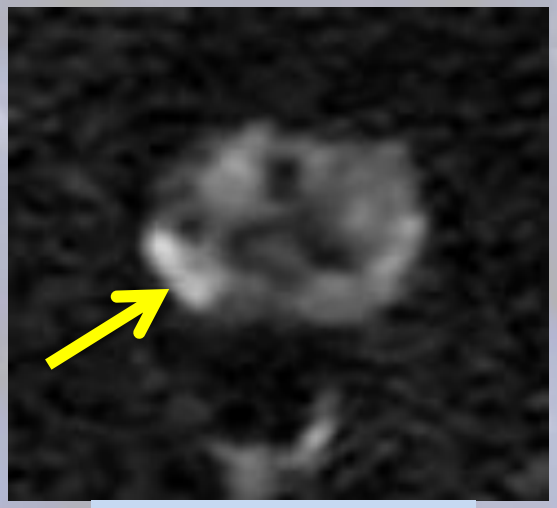
T2-w axi



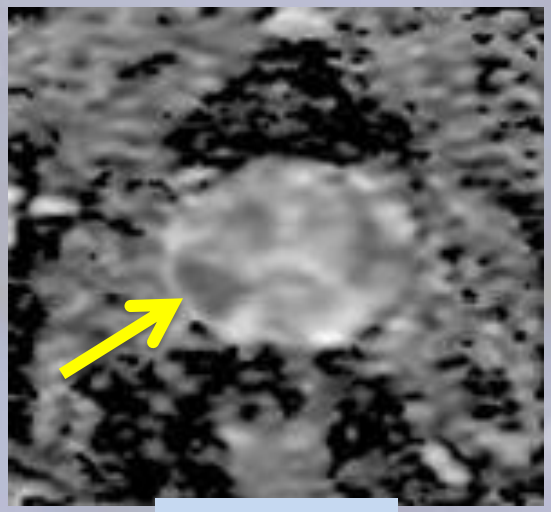
T2-w cor



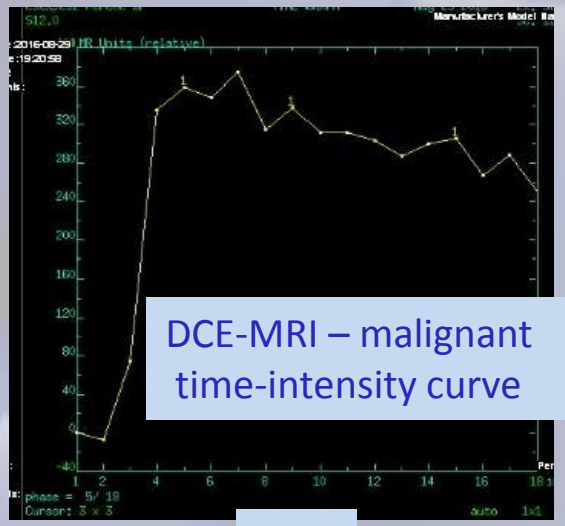
DCE-MRI



DW-MRI-b1000



ADC-MRI



DCE-MRI – malignant time-intensity curve

TIC

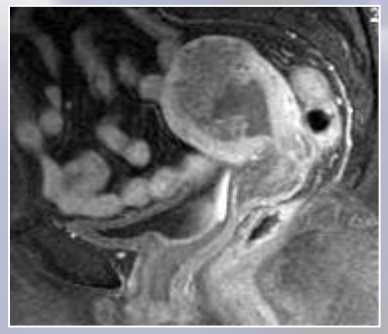
Imaging in **gynecological** tumors

- **US** – orientation
  - Transabdominal US (+Doppler)
  - Endovaginal US (+Doppler)
- **MRI – STAGING!**
- **CT** – advanced TU extension
  OVARIAN!

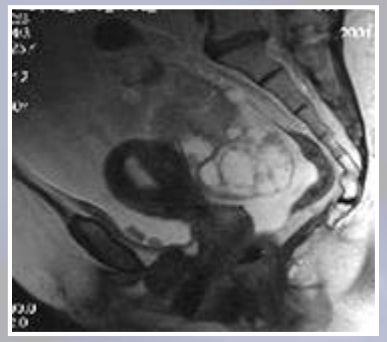
- **Guided /UH, CT/ biopsy**
- **PET/CT** – metastases, recurrant TU

Cervix ca.
MR-ACC:>95%

Lymph node: 70-80%



Corpus tu.
MR-ACC:> 90%



Ovarian ca.
MR-ACC: 89-99%

Conclusion

- **CXR:** the evalutaion of tumor is limited
- **US:** excellent for the evaluation of soft tissues, abdominal organs and excellent tool for tissue sampling, BUT don't forget the limitations!
- **MRI/CT** are basic modalities for cancer evaluation
  - CT & MR: complementing each other
  - Advantages of MR: better soft tissue resolution, multiplanar imaging, functional measurements
  - Advantages of CT: faster, less motion artifacts, whole body information, better assessment of cortical bone.
- **PET-CT:** detection of distant metastases, recurrent diseases, to evaluate therapy response

Optimal treatment is based on multidisciplinary decision

High quality imaging guides oncological treatment

Dyn-MR

CE-US

MD-CT

MD-CT

PET-CT

Interventions

DW-MR

Thank you for your attention!

…welcome in Blue Ball Street; Budapest

ORSZÁGOS ONKOLÓGIAI INTÉZET - NATIONAL INSTITUTE OF ONCOLOGY