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 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 screening
- 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, volume 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
**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** (hepatocytta-, 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 conventional 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??*
BONE

BREAST

CXR in oncology

LUNG

Question: information will be enough ??

abdomen
Ileus? perforation?

esophagus
swallowing function

stomach

colon

ENDOSCOPY!
Ultrasonography
excellent for the soft tissue

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

**Disadvantages :**
- Lack of complex information
- Difficulties in the evaluation of
  - Deep structures
  - Big lesions
- Subjective
- Hard to standardize

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

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

**US is not the standard tool for tumor evaluation**
US excellent soft tissue resolution

BUT lack of complex information

- liver
- Bile duct
- neck
- Renal tu
- Ovarian ca
- Guided biopsy
- Endorectal US-in rectal ca
- Endorectal US-in prostate ca
- CD-US
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

- liver
- Guided biopsy
- Skull base, neck
- lung
- Guided drainage
- mediastinum
- Bone, spine
- lung
- pelvis
- Whole body
- head
MD-CT - Volumetric measurement – Multiplanar-, 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

**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
Today: MRI - Basic method

- Brain metastases
- Spine bone metastases
- Liver foci
- Pharynx ca
- Prostate ca
- Breast ca
- Uterus ca
- Rectal ca
Tissue specific information

**Two malignant primary tumors**

Colon ca / ocular malignant melanoma

**MRI:** specific for MM metastasis

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

**US – unspecific density**

It might be metastasis

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

- T2FS
- CET1FS

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

- ADC: $0.743 \times 10^{-3}$ mm$^2$/sec

- Perfusion DCE-MRI
  - Time-enhancement curve based on vascularity
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** – *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)
CXR
Specific but NOT sensitive

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

based on: osteoblast activity

BONE
Spine metastasis

PET/CT
Sensitive and specific

MR
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)*
Chemoembolisation

Cancer vessels have been closed

Chemoperfusion

Cancer vessels were demolished

Localized cancer
Embolisation of coecal AV malformation - because of bleeding -

The leaking vessels were obstructed
CT– guided lymph node biopsy

US, CT– guided biopsies, drainage

US – guided neck node biopsy

CT– guided liver abscess drainage

CT– guided renal biopsy
Oncological diagnostic algorithm

- 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
Requirements 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 (stereotactactic 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

Sentinel N Lymphoscintigraphy + (Blue dye) + Histology (Accuracy >90%)

Mammography + US + biopsy Sv 85%, Sp 92-95%
Breast MRI: Sv 95%, Sp 86%

Sampling

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%

Complementary MRI

CT guided biopsy

CXR detects

PET/CT staging

Lymph node & adrenal gl. met
LUNG CANCER METASTASES
(CT / MRI / PET-CT)

- liver
- brain
- adrenal gland
- bone - spine
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 – 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

MRI
Acc > 90%
Liver met
Acc > 90%

CT
Rectal ca
Acc 70-85%

EUS
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)

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**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?
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
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, recurrent TU

**Cervix ca.**
MR-ACC: >95%
Lymph node: 70-80%

**Corpus tu.**
MR-ACC: >90%

**Ovarian ca.**
MR-ACC: 89-99%
Conclusion

- **CXR**: the evaluation 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
Thank you for your attention!

...welcome in Blue Ball Street; Budapest