Role of Imaging in oncology

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Important Basic Information in Oncology

• Imaging is of great importance in cancer management
  – Detection of tumor
  – Evaluation of therapeutic-, and post-therapeutic changes
  – Complications of treatments
  – Follow up for finding the early detection of recurrence

• Tumor staging is one of the most important prognostic factors, it determines therapy (operability, radio-, chemotherapy planning)

• Precise evaluation is only possible with strict technical criteria, standard protocols and correct image interpretation
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 patient.**
- **To give information about the „nature” of the disease (biopsy)**

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

- **Anatomic imaging modalities**
  - Conventional X-ray – mammography
  - Angiography
  - US
  - CT – MD-CT
  - MRI – 1.5T-3T

- **Functional, molecular, metabolic imaging modalities**
  - RN
    - SPECT-CT
    - PET/CT
  - MRSI, DCE-MRI, DW-MRI, perfusion CT, tissue specific CE-MRI, CE-US
Functional imaging produces biomarkers in oncology

NEW measurements

Molecular / functional data

CE-US (based on tumor neo-vascularisation)
Perfusion CT (perfusion alteration because of tumor vascularisation)
DCE-MRI qualitative, semiquantitative (time-enhancement curve),
   quantitative ($K_{trans}$) (vascularisation, permeability)
DW-MRI (water diffusion restriction because of cell density, -integrity)
Tissue specific CE (hepatocyt-, RES specific)
MRSI (biochemical status of molecular products)
SPECT-CT, PET-CT (are based on metabolic processes)
CXR
The role of conventional radiography in the evaluation of tumor cases is limited

(Analog) – Digital
  Easy access, cheap
Tomosynthesis – renewed, digital tomography,

Question: enough information??
  • Bone
  • Thorax
  • Abdomen
  • Breast
  • Gastro-intestinal
Question: information will be enough?
Ultrasonography

**Advantages:**
- Easy access, cheap
- Excellent soft tissue resolution
- Non invasive, non ionising, good tolerable
- Real-time information
- Flow information

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

**Clinical applications**
- Transcutan – abdominal, pelvic, neck, breast, extremities
- Endo 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

Complex information of the tumor & tumor spread

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

Disadvantage

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

Guided biopsy

- Head
- Skull base, neck
- Lung
- Pelvis
- Liver
- Whole body
- Bone, spine
- Mediastinum
- Guided drainage
MDCT - Volumetric measurement – Multiplanar-, 3D information
Virtual endoscopy

CT- Angiography

Are based on volumetric measurements
Advantages of MRI
Complex information of the tumor & tumor spread 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. hepatocyta-, RES-specific contrast agents
- **Functional information**: dynamic contrast enhanced MRI (DCE-MRI), diffusion-weighted MRI (DW-MRI), MR-spectroscopy (MRSI)
- **Flow sensitivity**
  - MR angiography

Lepto-meningeal T spread  Perineural (V.) T spread
Advantages of MRI

• Brain tu– CT+MRI= 80% improvement in assessment of Tu volume
  • KHOO VS, British J. of Rad, 2006
• H&N (tu spread, perineural, lgl)
  – Nasopharyngeal ca – CT+MR=50% better staging
    » MANAVIS J, Clin. Imaging, 2005
• Pelvis
  – Prostate ca–CT+MR=52% improvement in staging
  – Gynecological tu’s– MR Acc > 90%
  – Rectal ca – MR Acc : 80 - 90% J.Husband, R. Reznek, 2004
MEDULLOBLASTOMA in the IV. ventricle
MRI- CE-T1-w images

Best evaluation in intracranial tumors
To day: MRI- Basic method

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

*Two malignant primary tumors*

Colon ca / ocular malignant melanoma

MRI: High T1-w foci in the liver - because of melanin content

US – unspecific density
It might be metastasis

DG: MM mets
Tissue specific information

MR spectroscopy (MRSI) - biochemical analysis

*Recidive tu- could be detect earlier*

post chemo-radiation

Tumor side (R) Normal side (L)

Cholin pick

NAA ↓

N-acetylaspartate

Cholin NAA
• **PET/CT** – *hardware fusion of PET and CT*
  - Whole body- complex information of the
  - **PET**: metabolic activity-
  - **CT**: basic anatomic information
• **Clinical applications:**
  - Staging – distant metastasis
  - Therapy response
  - Posttherapeutic evaluation
  - To detect recurrent tumor
  - Restaging
  - To seek unknown primary

• **PET/MR** – under investigation, promising data
FDG-PET/CT

Two primaries

1. Radix linguae + N met

2. Non-Hodgkin-Lymphoma in the abdomen
Interventional onco-radiology

**Diagnostic**
- angiography - DSA
  vascular morphology, neovascularisation, cancer vessels
- Guided biopsy
  (US-, CT-, MR-, fluoroscopy)
  - FNAB – fine needle aspiration biopsy for cytology
  - core biopsy for histology

**Therapeutic**
- Tumor demolition
  - Tumor ablation (with radiofrequency-, (RFA)
    Laser wave, percutan ethanol injection (PEI), focused US)
- Intravascular therapy - DSA
  - Dilatation, stanting
  - Embolisation,
  - Chemoperfusion
- Extravascular therapy
  - Percutan drainage
Chemotherapy

Cancer vessels have been closed

DSA
Localized cancer
TH

Chemoperfusion

Cancer vessels were demolished
Embolisation of Coecum AV malformation - because of bleeding-
CT– guided biopsy

US, CT– guided biopsies, drainage

CT– guided liver abscess drainage

US – guided biopsies

CT– guided biopsy
Tasks of imaging in different phases of clinical oncology

DETECTION SCREENING: XR, US, CT, MRI
biopsie / guided

STAGING: CT, MRI, RN, PET,
biopsie /US/CT guided

THERAPY RESPONSE: CT, MR, RN, PET, US, XR

FOLLOW UP: US, CT, MRI, RN, XR.

RECURRANT 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: 85%
- In adipose breast: 99%

If breast density is increased, sensitivity will be decreased
Diagnostic procedures in **BREAST CANCER**

a) **Mammography** - Analog / Digital

b) **US**

c) **Guided biopsy** (FNA, core, vacuum assisted) guided by US / mammography (stereotactic biopsy)

d) **Multiparametric MRI** (MP-MRI, DCE-MRI, DW-MRI)

e) Localization before op.(ROLL+SLNB, Hookwire)

f) specimen mammography /US

g) **PET-CT**
BREAST CANCER
MULTIMODAL evaluation

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

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

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

Cytology
histology

X-ray-mgr
US
MR-mgr
Significance of breast MRI in locally advanced BREAST CANCER

- Evaluation of the effectiveness of the therapy
  - 22.01.2009.

MRM is the best method to determine the pathological size

- 01.04.2009.

To determine TH response
LUNG CANCER

- Leading cause of death from malignancy
  - 1.3 million deaths / year worldwide
  - U.S. >/60,000 deaths – 2010
  - Approximately 70% of cases have incurable disease at presentation, metastatic or locally advanced
  - 14% overall 5 year survival

Theresa C. McLoud, MD
Massachusetts General Hospital, Harvard Medical School
LUNG CANCER mortality calls for screening

- CT highly sensitive for nodules
- CT detects more cancers than CXR
- CT screening for lung cancer has meaningful mortality benefit
  - NSCLC Stage IA > 65% survival
  - Small < 1 cm Stage IA > 80% survival
- Low dose CT minus 20-25% of standard dose

**Annual control low dose CT**
- Noninvasive management-follow up for growth
  - CAD
  - Volumetric measures
- **High risk group** > 30 pack years of smoking
  > 45 age
  
  36-53% survival increasing in the low dose CT group
  *(Henschke study, 2011)*
LUNG CANCER staging
Multimodal imaging
Clinical exam.: Bronchoscopy

CT basic method
- Staging- 
- T-Acc 90%

Role of MRI
Complementary, to evaluate the sites of mets, Brain, liver, spine

PET/CT
N met
Residual TU
Recidiva

CT guided biopsy
Lung cancer metastases

Distant metastases

- Liver
- Brain
- Adrenal
- Bone/spine

CT

MRI
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 soft tissue information, best modality to evaluate the local staging

- **PET/CT** – for whole body information - distant TU extension, for residual /recurrant TU
Head & Neck Ca: MR/CT/US

„T” - Accuracy: MR, CT > 90%

„N”- Accuracy: US 70%, CT 80%, MR 80%

MR – „T” Acc: 95%
Clinical: 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
Supraglottic residual ca – *multiparametric-MRI*

*Water Diffusion restriction of tumor*
Multimodal Imaging in RECTAL TUMOR

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

- **UH/CT guided biopsy** (liver)

- **PET/CT** - for whole body information - distant TU extension, for recurrent TU
RECTAL Cancer
MULTIMODAL evaluation

T1, T2, T2/3 Perirectal N

Liver
Intraop. US (Acc > 90%)

Liver (Acc 85%)

MDCT „T” Acc 70-85%

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

Liver
Acc > 90%

EUS-T Acc 90%

MR
Liver
Acc > 90%
Imaging in PROSTATE cancer

• **US** — for the first information
  – Transabdominal US – general
  – Endorectal US – prostate
    • Color- Doppler US

• **MP-MRI** - for the accurate prostate and pelvic information, staging, recurrant ca, restaging

• **Bone scan** — bone metastasis

• **CT**- for evaluated advanced TU extension

• **PET/CT** — for recidive cancer, for whole body information
PROSTATE cancer

- **Screening - PSA** (prostate specific antigen) NOT reliable
- **Diagnosis:** Transrectal EUS - colour Doppler - TRUS-guided biopsies

- **Staging, MRI:** for capsular penetration, for vesicula-, bladder-, other pelvic invasion, nodal status
PROSTATE cancer recurrant TU

Adenocarcinoma, Postop, Preirrad. **Multiparametric MRI**

With functional measurements, DW-MRI, DCE-MRI
Imaging in gynecological tumors

- **US** – for the first information
  - Transabdominal US
  - Endovaginal US
  - Color- Doppler US
- **MRI**- for the accurate organ and pelvic information, staging
- **CT**- for evaluated advanced TU extension
- **Guided /UH, CT/ biopsy**
- **PET/CT** - for whole body information - distant TU extension, for recurrent TU
Gynecological – TU

endovaginal US

MR

Cervix ca
MR-ACC: >95%

Endometrium ca
MR-ACC: > 90%

Ovarian
MR-ACC: 89-99%
Conclusion

- The role of conventional radiography in the evaluation of tumor cases is limited
- US is excellent modality for the evaluation of superficial soft tissues, abdominal organs and excellent tool for tissue sampling
- 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
Conclusion

- 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, in success of
- Image-guided oncologic treatment
Radiologist has an important roll and our responsibility is very high!

Determination? Evaluation? Validation?

interventional radiology

MD-CT

3T-MR

CE-US

DW-MR

Dyn-MR

PET/CT

PET/MR

Dyn-CT

MRSI