PET/CT for Tumor Response Evaluation

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FDG PET/CT for Cancer Imaging
• Staging and restaging
• Early treatment response evaluation
• Guiding biopsy

• NOT for: cancer diagnosis or screening - very low (3%) positive predict value

PET/CT scanner

PET/CT scanner
Anatomic Tumor Response Assessment in CT or MRI

• Imaging as surrogate for
  – Survival, response, time to tumor progression
• RECIST criteria based on longest diameter
  – Complete response (CR): disappear
  – Partial response (PR): ≥ 50% decrease
  – Stable disease (SD): others
  – Progressive disease (PD): ≥ 25% increase or new tumor

Metabolic Tumor Response Assessment in FDG-PET

• Strong correlation between FDG uptake and cancer cell number

• Metabolic (functional) change may occur earlier and more markedly than tumor size (anatomic) change

Qualitative (Visual) PET Response Evaluation

• Distribution and intensity of FDG uptake in tumor are visually compared with uptake in normal tissues

• Requires clinical experience, knowledge of disease patterns
**Visual PET Response Evaluation in Lymphoma**

- Deauville 5 point scale
  - Score 1, no uptake
  - Score 2, uptake ≤ mediastinum (blood)
  - Score 3, uptake > mediastinum (blood) but ≤ liver
  - Score 4, uptake moderately higher than liver
  - Score 5, uptake markedly higher than liver, and/or new lesions


**Example 5 Point Scale**

**Semi-Quantitative PET Response Assessment**

- Clinic: SUVmax
- PERCIST criteria (SULpeak hottest tumor)
  - CMR: normalize to background level
  - PMR: ≥ 30% decrease and ≥ 0.8 unit in SUL
  - SMR: others
  - PMD: ≥ 30% increase and ≥ 0.8 unit in SUL or visible increase in extent of uptake, or new FDG-avid lesion
Esophageal Cancer – A Responder

Esophageal Cancer – A Non-Responder

PET/CT for Tumor Response: An Example in Pancreatic Tumor

Large decline in SUL (-41%) despite stable pancreatic mass anatomically
(arrows) → Partial metabolic response.

Early Therapy Response Evaluation

1 cycle

whole cycle

whole cycle

Early PET-Guided Chemotherapy: MUNICON Phase II Trial

- 110 PTs w/ esophagogastric junction tumor
- PET response defined as >35% reduction of SUV at 2 weeks of induction chemo
- 58% of PET responders achieved pathological response vs. none of PET non-responders


Mid-RT (40-50 Gy) PET-Guided ART

- PET tumor volume decreased in 6 of 14 PTs
- Allowed dose escalation of 58 Gy or reduction in NTCP of 2%

Differentiate Tumor Recurrence from Fibrosis after SABR for Lung Cancer

• Mass-like consolidation 19 m after SABR
• Hard to differentiate from tumor recurrence in CT
• Completely resolved in FDG PET ➔ fibrosis
• Follow-up CT confirmed radiation-induced fibrosis


Limitation of Metabolic Tumor Response Assessment in PET

• Poor resolution: smallest tumors PET can detect: 4-10 mm diameter, 10^8 cells
• Depends on time to normalization (positive to negative) of the PET scan


Normal Tissue Inflammation due to RT

• Lung inflammation in RT field hindered tumor delineation
• Hard to differentiate inflammation uptake from viable residual tumor uptake

Image reconstruction with time-of-flight and point-spread function

- TOF more accurately locates annihilation point
- PSF compensates for geometric distortion
- Improves image quality and SNR


Esophageal Cancer

Three texture features post-CRT – Inertia, Correlation, and Cluster Prominence
- Top: responder, homogeneous FDG uptake post-CRT
- Bottom: non-responder, heterogeneous FDG uptake post-CRT

SUV skewness pre-CRT
- Top: responder, more skewed (fewer higher SUVs)
- Bottom: non-responder, less skewed (more higher SUVs)


Texture: Spatial Variation in FDG Uptake is Important Prognostic Factor


Belhassen and Zaidi 2010. Med Phys
Accuracy of Individual Spatial-Temporal FDG-PET Features

<table>
<thead>
<tr>
<th>Variable</th>
<th>FDG-Uptake</th>
<th>FDG-Heterogeneity</th>
<th>FLUORINE</th>
<th>FDOPA</th>
<th>PET/MR</th>
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Beyond FDG PET, and beyond traditional sites

- FMISO PET for imaging hypoxia
- FLT PET for imaging cell proliferation
- Prostate cancer (PSMA)
- Brain cancer (amino acid: 11C-methionine, 18F-FDOPA, PET/MR)

Summary

- FDG PET/CT shows advantages over CT for tumor response evaluation in many cancers
  - More accurate
  - Earlier evaluation
- Radiomics, particularly FDG uptake heterogeneity, is likely prognostic
- Non-FDG tracers, PET/MRI are useful in certain diseases/applications
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