Cervical lymph nodes: Techniques for evaluation

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Objectives

Compare and contrast Imaging techniques in Cervical lymph node evaluation

Goals of imaging cervical LN

- Determine benign versus malignant
  - Size
  - Morphologic assessment
    - Shape
  - Necrosis / cystic changes
  - Extracapsular spread
  - Functional abnormality
- Before Rx and after Rx

Recurrence or not?

Ultrasound

YESSSSS!!!!

NO IDEA!
ULTRASOUND

- Easily available, No ionizing radiation
- Good look at internal architecture

Contrast Enhanced Ultrasound

- Intravenous contrast agents containing microbubbles of perfluorocarbon or nitrogen gas
- Bubbles affect backscatter and increase vascular contrast akin to contrast enhanced CT and MRI
- Allows for dynamic & repeat exams

Contrast Enhanced Ultrasound

- 17 patients with known head and neck malignancy
- Sonographic signal intensity as a function of time, time to peak, time to arrival and time to wash-out quantified
- Contrast-enhanced ultrasound - 100% sensitivity and 85.7% specificity for lymph node involvement
- Contrast peaks significantly earlier in the malignant nodes at $24.14 \pm 2.7$ s compared with $29.33 \pm 3.4$ s

Contrast Enhanced Ultrasound

- Randomly divided into metastasis group (12 rabbits) and reactive hyperplastic group (12 rabbits)
- Enhancement
  - All 12 hyperplastic nodes - Centripetal homogeneous
  - 8 metastatic nodes - Diffuse heterogeneous
  - 3 metastatic nodes - Centrifugal heterogeneous
  - 1 metastatic node - Centripetal homogeneous

Hyperplastic

Metastatic


ULTRASOUND

- Easily available, No ionizing radiation
- Good look at internal architecture
- Functional information about flow
- Faster wash-in
- Homogeneous
- Operator dependent
- Deeper nodes not accessible
- Difficult to assess post treatment neck

CT

Ultrasound

Faster Wash-in

Homogeneous
CT
- Widely available, less operator dependence
- Assess deeper nodes
- Conspicuity problem
- Distortion of anatomy post-Rx neck

Dual energy CT
- Scanning an object with 80 kVp results in a different attenuation than with 140 kVp
- Iodine - maximum attenuation at low energy, while its CT-value is only about half in high-energy scans
- Muscle - changes much less when exposed to low-energy scans compared to high KeV examinations

Dual energy CT
- Spectral HU curve
- Iodine content

Papillary thyroid cancer
- Slope of the spectral HU curve (HU), normalized iodine concentration, and normalized effective atomic number significantly higher in metastatic than in benign lymph nodes
- Single best parameter - Venous phase HU

<table>
<thead>
<tr>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Accuracy</th>
<th>PPV</th>
<th>NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>62%</td>
<td>81%</td>
<td>81%</td>
<td>80%</td>
<td>81%</td>
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</tbody>
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Larynx and Hypopharynx SCC
- N= 47 patients, 79 lymph nodes (31 metastatic, 48 benign)
- Slope of the curve in the target lymph node and the lesion calculated and ratios studied
- The ratios were 1.20 ± 0.09 and 0.82 ± 0.12 in metastatic and benign lymph nodes, respectively

Normal, Inflammatory and Metastatic LN
- 16 normal LN, 20 Inflammatory and 23 Metastatic LN
- Iodine content was significantly lower for metastatic lymph nodes (2.34 ± 0.45) than for normal (2.86 ± 0.37) and inflammatory (3.53 ± 0.56) lymph nodes
- Iodine overlay (HU) was also significantly lower for metastatic nodes than normal and inflammatory nodes

Liu X et al. Radiology 2015;275:167-76
**Dual energy CT**

- No additional radiation or contrast load
- Better lesion conspicuity at lower virtual monochromatic keV values

70 keV

40 keV

('Single energy CT equivalent')

**CT perfusion**

- Requires dynamic imaging after contrast administration
- Perfusion maps - Blood volume, blood flow, mean transit time, permeability surface area product

**CT perfusion - Larynx and Hypopharynx CA**

- N = 293 nodes (125 malignant and 83 benign)
- Compared to non-malignant nodes, malignant ones showed significantly higher BF, BV and PS values
- CTP - ? Additional functional information regarding possible malignancy

**PET/CT-Perfusion**

- All CTP data statistically different between tumors, inflammatory lesions, healthy tissue and metastatic lymph nodes
- PET/CT data were in part significantly different, and CTP and PET parameters were not significantly correlated
- ? CTP may provide additional insights into tumor behavior

54 y/o male

Larynx SCC

Left level III LN

One cycle chemorad

Radiation dose ++

Motion degradation during dynamic imaging

No standardized measurements
Ultrasound

CT

MRI

MRI

• No ionizing radiation
• Better contrast resolution
• Internal architecture +++

Diffusion weighted MRI

?Surrogate marker for cellularity

Less cellularity (Benign)  
\[ \text{Higher ADC} \]

More cellularity (Malignant)  
\[ \text{Lower ADC} \]

The diffusion dilemma

Oral SCC – 3T MRI with DWI

• Mean ADC: Malignant - 1.143 vs. Benign - 0.987
  Using an ADC value of 0.994 as threshold:
  • Sensitivity - 80%, specificity - 65%, PPV - 31%, NPV - 93%
  • Preoperative determination of the extent of neck dissection on the basis of ADC measurements is not meaningful

ADC histograms - Lymphoma vs SCC mets

• \( N = 67 \) (lymphoma = 20; SCC = 47), SCC group divided into nasopharyngeal and non-nasopharyngeal groups
  • Lymphoma showed significantly lower \( \text{ADC}_{90} \), \( \text{ADC}_{75} \), \( \text{ADC}_{50} \), and \( \text{ADC}_{0} \) than SCC, specifically non-nasopharyngeal
  • Subgroup analyses showed no significant difference between lymphoma and NPC

**DWI compared to CT perfusion**

- **DWI with ADC value measurements may be more accurate than CTP for the preoperative diagnosis of cervical LN metastases**

<table>
<thead>
<tr>
<th>Metastatic nodes</th>
<th>Benign nodes</th>
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<tbody>
<tr>
<td>Lower ADC</td>
<td>Higher ADC</td>
</tr>
<tr>
<td>Higher Blood volume</td>
<td>Lower Blood volume</td>
</tr>
<tr>
<td>Higher Blood Flow</td>
<td>Lower Blood Flow</td>
</tr>
<tr>
<td>Lower Mean transit time</td>
<td>Higher Mean transit time</td>
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</table>

- Sensitivity: DWI 43/48 (89.58%), CTP 33/48 (68.75%)
- Specificity: DWI 13/17 (76.47%), CTP 9/17 (52.94%)
- PPV: DWI 43/47 (91.49%), CTP 33/41 (80.48%)
- NPV: DWI 13/18 (72.22%), CTP 9/24 (37.50%)
- Accuracy: DWI 56/65 (86.15%), CTP 42/65 (64.61%)
- AUC: DWI 0.830, CTP 0.605

**Perfusion MRI**

- Can be performed with or without gadolinium
- Dynamic information similar to CT perfusion but without radiation
- Potential correlation with neoangiogenesis (new blood vessels)

**T2⁺ DSC MRI perfusion**

- N = 45 lymph nodes
- Mean DSC% compared
- **MALIGNANT - 44.8% versus BENIGN - 28.8%**
- Metastatic nodes - 48.72% versus Lymphoma 37.09%
- DSC% threshold for differentiating malignant from benign nodes and metastatic from lymphomatous nodes were 34.3% and 43.5%, with areas under the curve of 0.95 and 0.97, respectively

**MRI**

- No ionizing radiation
- Internal architecture
- Functional information
- Longer acquisition with more artifacts
- Techniques not standardized

**FDG-PET**

- Relies on abnormal glucose metabolism
- Correlation with CT and MRI images possible
- Overlap of SUV values with inflammation
PET MRI in head and neck cancer

- 20 patients - Conventional PET scan and subsequent PET/MRI
- Tumor detected by PET/MRI: 17/20 patients, PET: 16 and MRI: 14
- PET/MRI examination - significantly higher SUV_{max} than the conventional PET
- Number of lymph nodes with increased FDG uptake (PET-MRI) >> Number detected by the stand-alone PET system


Ultrasound, FDG PET-CT, FDG PET-MRI

<table>
<thead>
<tr>
<th></th>
<th>US</th>
<th>PET-CT</th>
<th>PET-MRI</th>
<th>PET-MRI / DWI</th>
</tr>
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<tbody>
<tr>
<td>SENSITIVITY</td>
<td>63</td>
<td>30</td>
<td>52</td>
<td>53</td>
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<tr>
<td>SPECIFICITY</td>
<td>99</td>
<td>97</td>
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<td>97</td>
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<td>PPV</td>
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<tr>
<td>NPV</td>
<td>96</td>
<td>92</td>
<td>94</td>
<td>95</td>
</tr>
<tr>
<td>ACCURACY</td>
<td>95</td>
<td>92</td>
<td>95</td>
<td>95</td>
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</tbody>
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Software-based fusion of (18)F-FDG-PET-MRI and (18)F-FDG-PET-MRI plus DWI may not increase nodal detection and N-staging performance in patients with oral malignancies compared to US and (18)F-FDG-PET/CT

N = 18


Others

- USPIO MRI
- Photoacoustic tomography + PET-CT
- Sentinel node mapping with SPECT-CT

Pre-Rx staging of Laryngeal cancer

DECT

70 keV (Single energy CT equivalent)

Improve detection and better characterization

Metastatic B/L level II lymph nodes

71 y/o F with recurrent mass in left palate

DECT

Improved detection of abnormal lymph nodes

Metastatic right RP lymph node
Intra therapy tumor response assessment

Is this recurrent tumor?

Pathology proven lymph nodal recurrence

So, which one is better?

- Depends on the individual scenario

SUMMARY

- Identification of metastatic lymph nodes in head and neck cancer significantly affects prognosis
- Many choices for lymph node evaluation
- CT & PET-CT → Remain workhorse clinically
- Future → ? Dual energy CT+ DWI + PET