Predicting the short-term response to chemoradiotherapy using IVIM-DWI and DCE-MRI in advanced nasopharyngeal carcinoma (NPC)

Yu Xiao-Ping
Department of diagnostic radiology
Hunan Cancer Hospital, Changsha, China
NPC: Southern China / Asia

Chemoradiotherapy (CRT): the primary treatment for advanced NPC, local residual and relapse (treatment failure).

MRI: diagnosis, staging, treatment assessment

Identifying poor-responders: schemes to be modified

DCE-MRI and IVIM-DWI in predicting early response to IC or CRT

Predicting longer (short- or long-term) response: more valuable, but not been well investigated
AIM

to investigate the utility of IVIM DWI and DCE-MRI in predicting the short-term response to CRT in patients with advanced NPC.
METHODS:

- Single-center prospective study
- Finally enrolled 43 NPC patients
  (1) had NPC confirmed by pathology;
  (2) above 18 years old;
  (3) scheduled for CRT (IC+RT);
  (4) without prior anti-tumor treatment for NPC;
  (5) without contraindications for MRI or CRT;
  (6) signed the informed consent form;
METHODS: MRI and Response Evaluation

- **Pretreatment**
  - Conventional MRI
  - IVIM-DWI
  - DCE-MRI

- **IC (cycle 1)**
  - Conventional MRI
  - IVIM-DWI
  - DCE-MRI

- **IC (cycle 2) + RT**
  - Conventional MRI
  - Pharyngorhinoscopy

- **Followup (6 months)**

- **Followup**

- **Course**

- **CRT scheme:** two cycles of IC (Taxol plus nedaplatin, 21 day/cycle) + radiotherapy (total dose: 71.3-75.9 Gy; 31-33 fractions).
- **MRI scanner:** 1.5 Tesla
- **IVIM-DWI:** Ten b values (0~1000 s/mm²)
- **DCE-MRI:** quantitative pharmacokinetics analysis
- **Tofts and Kermode model**
  - Gadodiamide

**Short-term response evaluation**
Intravoxel Incoherent Motion MRI (IVIM-DWI)

- $D$: true diffusion coefficient
- $D^*$: pseudo-diffusion coefficient
- $f$: microvascular volume fraction
- ADC: apparent diffusion coefficient

METHODS: MRI data analyses
METHODS: MRI data analyses (DCE-MRI):

- Dynamic Contrast-enhanced MRI
- $K_{\text{trans}}$: influx transfer constant
- $K_{\text{ep}}$: efflux rate constant
- $V_e$: volume fraction of EES

$$V_e = \frac{K_{\text{trans}}}{K_{\text{ep}}}$$
METHODS: Treatment Assessment and Statistical Analysis

- Treatment Assessment:
  Six months after the end of CRT
  - good-responder group: no residual and relapse on MRI + pharyngorhi noscopy
  - poor-responder group: with residual or relapse

- Compared between the two groups:
  IVIM-DWI and DCE-MRI parameter values for NPC at baseline (pre-), after the first cycle of IC (post-), together with their percentage changes ($\Delta\%$)

  eg: $\Delta\%k_{trans} = (postk_{trans} - prek_{trans}) / prek_{trans}$
<table>
<thead>
<tr>
<th>parameters</th>
<th>Poor-responder(n = 8)</th>
<th>Good-responder(n = 35)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>preADC ( \times 10^{-3} \text{ mm}^2/\text{s} )</td>
<td>1.113 ± 0.256</td>
<td>0.946 ± 0.219</td>
<td><strong>0.034</strong>*</td>
</tr>
<tr>
<td>postADC ( \times 10^{-3}\text{mm}^2/\text{s} )</td>
<td>1.549 ± 0.352</td>
<td>1.356 ± 0.351</td>
<td>0.160</td>
</tr>
<tr>
<td>△%ADC (%)</td>
<td>41.863 ± 33.198</td>
<td>46.433 ± 36.816</td>
<td>0.851</td>
</tr>
<tr>
<td>preD ( \times 10^{-3} \text{ mm}^2/\text{s} )</td>
<td>0.878 ± 0.174</td>
<td>0.688 ± 0.144</td>
<td><strong>0.002</strong>*</td>
</tr>
<tr>
<td>postD ( \times 10^{-3} \text{ mm}^2/\text{s} )</td>
<td>1.270 ± 0.332</td>
<td>0.950 ± 0.277</td>
<td><strong>0.013</strong>*</td>
</tr>
<tr>
<td>△%D (%)</td>
<td>37.125 ± 33.879</td>
<td>42.883 ± 52.407</td>
<td>0.876</td>
</tr>
<tr>
<td>preD* ( \times 10^{-3} \text{ mm}^2/\text{s} )</td>
<td>21.263 ± 21.920</td>
<td>17.966 ± 12.562</td>
<td>0.662</td>
</tr>
<tr>
<td>postD* ( \times 10^{-3} \text{ mm}^2/\text{s} )</td>
<td>12.962 ± 6.576</td>
<td>11.352 ± 6.499</td>
<td>0.585</td>
</tr>
<tr>
<td>△%D* (%)</td>
<td>-52.887 ± 81.143</td>
<td>-17.165 ± 65.766</td>
<td>0.417</td>
</tr>
<tr>
<td>pre f</td>
<td>0.241 ± 0.073</td>
<td>0.268 ± 0.117</td>
<td>0.564</td>
</tr>
<tr>
<td>post f</td>
<td>0.285 ± 0.087</td>
<td>0.349 ± 0.106</td>
<td>0.142</td>
</tr>
<tr>
<td>△%f (%)</td>
<td>23.427 ± 36.282</td>
<td>49.638 ± 63.401</td>
<td>0.275</td>
</tr>
<tr>
<td>prektrans ( \text{min}^{-1} )</td>
<td>0.419 ± 0.108</td>
<td>0.393 ± 0.157</td>
<td>0.532</td>
</tr>
<tr>
<td>postktrans ( \text{min}^{-1} )</td>
<td>0.524 ± 0.194</td>
<td>0.520 ± 0.301</td>
<td>0.848</td>
</tr>
<tr>
<td>△%ktrans</td>
<td>32.465 ± 60.811</td>
<td>33.570 ± 86.638</td>
<td>0.717</td>
</tr>
<tr>
<td>prekep ( \text{min}^{-1} )</td>
<td>0.726 ± 0.367</td>
<td>0.714 ± 0.491</td>
<td>0.698</td>
</tr>
<tr>
<td>postkep ( \text{min}^{-1} )</td>
<td>0.647 ± 0.317</td>
<td>0.790 ± 0.544</td>
<td>0.509</td>
</tr>
<tr>
<td>△%kep</td>
<td>14.949 ± 48.661</td>
<td>8.581 ± 89.132</td>
<td>0.949</td>
</tr>
<tr>
<td>preVe</td>
<td>0.657 ± 0.395</td>
<td>0.924 ± 0.648</td>
<td>0.231</td>
</tr>
<tr>
<td>postVe</td>
<td>0.914 ± 0.373</td>
<td>0.913 ± 0.612</td>
<td>0.624</td>
</tr>
<tr>
<td>△%Ve</td>
<td>58.868 ± 58.846</td>
<td>14.904 ± 48.661</td>
<td>0.101</td>
</tr>
</tbody>
</table>
Diagnostic efficacy of IVIM-DWI parameters in predicting the short-term response to CRT in NPC

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Cutoff Values</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>AUC (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>preADC</td>
<td>$0.893 \times 10^{-3} \text{mm}^2/\text{s}$</td>
<td>100%</td>
<td>57.14%</td>
<td>0.743(0.587 - 0.864)</td>
</tr>
<tr>
<td>preD</td>
<td>$0.711 \times 10^{-3} \text{mm}^2/\text{s}$</td>
<td>100%</td>
<td>65.71%</td>
<td>0.854(0.712 - 0.943)</td>
</tr>
<tr>
<td>postD</td>
<td>$0.912 \times 10^{-3} \text{mm}^2/\text{s}$</td>
<td>100%</td>
<td>48.57%</td>
<td>0.786(0.631 - 0.941)</td>
</tr>
</tbody>
</table>

The ROC curve of IVIM-DWI parameters in predicting the short-term response to CRT in NPC

area under the curve
preADC=0.743
preD=0.854
postD=0.786
Discussion

- DCE-MRI and IVIM-DWI can provide micro-environmental information related to microcirculation perfusion.
- \( D^* \): blood velocity and capillary segment length
- \( f \): intravascular blood volume.
- \( K^{\text{trans}} \): microvascular blood flow, capillary permeability and surface area.
- \( K_{\text{ep}} \): capillary permeability and surface area.
- \( V_e \): blood volume in the extravascular extracellular space.
Discussion

- Blood perfusion has little impact on short-term response to CRT and perfusion-related IVIM-DWI ($D^*$ and $f$)
- DCE-MRI parameters benefit little to the prediction of short-term effects for NPC.
Discussion

- IVIM-DWI provide parameters related to water molecular diffusion.
- $D$: pure diffusion-related parameter
- ADC: hybrid IVIM-DWI parameter. $D + D$
Discussion

- Water molecular diffusion in tumor tissue is associated with the response to CRT.
- IVIM-DWI is helpful in discriminating the good- from poor-responder NPC groups received CRT.
Conclusion

- The diffusion-related micro-environmental features have more impact on the treatment sensitivity to CRT for NPC than the perfusion-related micro-environmental features.
- The diffusion-related IVIM-DWI parameters may be more powerful than the perfusion-related IVIM-DWI and DCE-MRI parameters in predicting the short-term response to CRT in advanced NPC patients.
Our Recent Publications on NPC


Thank you for your attention