Radiation-induced neurotoxicity assessed by spatio-temporal modelling combined with artificial Intelligence after brain radiotherapy: the RADIO-AIDE project

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Radiation-induced neurotoxicity assessed by spatio-temporal modelling combined with artificial intelligence after brain radiotherapy: the RADIO-AIDE project

Context

- **High-grade glioma**: the most frequent high-grade brain tumor in adults
- **Radiotherapy (RT)**: one of the most important treatments, generally combined with surgery and/or chemotherapy
  - increased patient survival;
  - but increase of side effects like cognitive impairments (ex: attentional, executive and memory disorders) ↔ Altered quality of life for patients.
- **Potential toxicity of RT on the central nervous system?**
  - Which neurotoxic mechanisms are potentially associated with the initiation and progression of post-RT brain lesions? Are there spatio-temporal (ST) signatures of these post-RT brain lesions?
  - Could these post-RT brain lesions be associated with the initiation and temporal progression of cognitive impairments?
  - What about the radio sensitivity of the brain structures implied in cognitive processes?

Objectives

The RADIO-AIDE project is a multidisciplinary project of 4 years, that started in April 2022.

- **Clinical objective**: To generate new knowledge about the neurotoxic mechanisms implied in the initiation and temporal progression of cognitive impairments following brain RT
- **Methodological objectives**:
  - To provide to clinicians a usable academic software to perform an automated longitudinal extraction of clinically relevant image-based biomarkers from brain magnetic resonance images (MRI) acquired in clinical routine;
  - To develop artificial intelligence (AI) tools to predict individual cognitive impairments at early stage after brain RT

Methods

- **Data**: The prospective EpiBrainRad cohort including patients treated by RT for a high-grade glioma
  - For each patient: brain MRIs, computed tomography (CT) images used in brain RT treatment planning, clinical features, cognitive scores following neuropsychological exams

EpiBrainRad cohort

<table>
<thead>
<tr>
<th>EpiBrainRad cohort</th>
<th>AP-HP Pitié Salpêtrière</th>
<th>ICANS</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of patients included</td>
<td>172</td>
<td>71</td>
<td>243</td>
</tr>
<tr>
<td>Deceased patients</td>
<td>154</td>
<td>44</td>
<td>198</td>
</tr>
<tr>
<td>Lost (%)</td>
<td>0</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Total number of MRIs (Average per individual; Max)</td>
<td>1779 (10; 29)</td>
<td>310 (5; 13)</td>
<td>2089 (7.5; 29)</td>
</tr>
<tr>
<td>Number of patients with at least 3 MRIs</td>
<td>160</td>
<td>43</td>
<td>203</td>
</tr>
<tr>
<td>Number of MRIs per patient with at least 3 MRIs scan (Average per individual; Max)</td>
<td>1761 (11; 29)</td>
<td>277 (6; 13)</td>
<td>2038 (8.5; 29)</td>
</tr>
<tr>
<td>Number of patients with neuropsychological exams at baseline (BL) and at 12 months</td>
<td>64</td>
<td>30</td>
<td>94</td>
</tr>
<tr>
<td>— at BL, 12 and 24 months</td>
<td>22</td>
<td>15</td>
<td>37</td>
</tr>
<tr>
<td>— at BL, 12, 24 and 36 months</td>
<td>10</td>
<td>8</td>
<td>18</td>
</tr>
</tbody>
</table>

Results and perspectives

- **An extension of the EpiBrainRad cohort is in progress. New patients will be included from 2023.**
- **An annotated dataset including ground truth labels for post-RT WMH, vascular lesions and tumoral lesions as well as many brain regions of interest implied in cognitive functions is being produced from the brain MRIs of the EpiBrainRad cohort.** This large and well curated learning data set will feed the ST models and AI tools subsequently developed.

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