Simulation of I-131 Radiopharmaceuticals for the Treatment of Thyroid Cancer

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INTRODUCTION
# Cancer in Vietnam

**Viet Nam**  
Source: Globocan 2018

**Number of new cases in 2018, both sexes, all ages**

<table>
<thead>
<tr>
<th>Cancer</th>
<th>Number</th>
<th>Rank</th>
<th>(%)</th>
<th>Cum.risk</th>
<th>Number</th>
<th>Rank</th>
<th>(%)</th>
<th>Cum.risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liver</td>
<td>25,335</td>
<td>1</td>
<td>15.4</td>
<td>2.59</td>
<td>25,404</td>
<td>1</td>
<td>22.1</td>
<td>2.59</td>
</tr>
<tr>
<td>Lung</td>
<td>23,667</td>
<td>2</td>
<td>14.4</td>
<td>2.57</td>
<td>20,710</td>
<td>2</td>
<td>18.0</td>
<td>2.27</td>
</tr>
<tr>
<td>Stomach</td>
<td>17,527</td>
<td>3</td>
<td>10.6</td>
<td>1.86</td>
<td>15,065</td>
<td>3</td>
<td>13.1</td>
<td>1.52</td>
</tr>
<tr>
<td>Breast</td>
<td>15,229</td>
<td>4</td>
<td>9.2</td>
<td>2.93</td>
<td>6,103</td>
<td>4</td>
<td>5.3</td>
<td>1.24</td>
</tr>
<tr>
<td>Rectum</td>
<td>8,815</td>
<td>5</td>
<td>5.4</td>
<td>0.93</td>
<td>4,673</td>
<td>6</td>
<td>4.1</td>
<td>0.44</td>
</tr>
<tr>
<td>Nasopharynx</td>
<td>6,212</td>
<td>6</td>
<td>3.8</td>
<td>0.64</td>
<td>4,232</td>
<td>7</td>
<td>3.7</td>
<td>0.47</td>
</tr>
<tr>
<td>Leukaemia</td>
<td>6,144</td>
<td>7</td>
<td>3.7</td>
<td>0.52</td>
<td>4,923</td>
<td>5</td>
<td>4.3</td>
<td>0.43</td>
</tr>
<tr>
<td>Colon</td>
<td>5,457</td>
<td>8</td>
<td>3.3</td>
<td>0.60</td>
<td>3,183</td>
<td>8</td>
<td>2.8</td>
<td>0.31</td>
</tr>
<tr>
<td>Thyroid</td>
<td>5,418</td>
<td>9</td>
<td>3.3</td>
<td>0.45</td>
<td>528</td>
<td>22</td>
<td>0.46</td>
<td>0.05</td>
</tr>
<tr>
<td>Cervix uteri</td>
<td>4,177</td>
<td>10</td>
<td>2.5</td>
<td>0.77</td>
<td>2,420</td>
<td>10</td>
<td>2.1</td>
<td>0.47</td>
</tr>
</tbody>
</table>
I-131 therapy for thyroid

- Usually for the treatment of differentiated thyroid cancer after thyroidectomy.
- Activity of the I-131: \( \sim 30 \div 200 \text{mCi} \).

The affects on critical organs ??
Recent assessments

- Simulation using MIRD phantom.
- Measurement using physical phantom and thermo-luminescent dosimeter.
- Activity: 100, 150, and 175 mCi.
- Absorbed dose: for thyroid, sternum, and cervical vertebrae.

Recent assessments

- Simulation using MIRD phantom
- Activity: up to 200 mCi
- Absorbed dose: for thyroid, brain, lungs, and cervical vertebrae

Mesh-type ICRP reference phantoms

MRCPs
(Mesh-type Reference Computational Phantoms)

Objective of the study

Calculation of the dose values caused by I-131 source in critical organs to evaluate the risk of thyroid treatment by using the mesh-type ICRP reference phantoms.
MATERIALS AND METHODS
Organ mass deviation from the ICRP-89 Reference Values.

<table>
<thead>
<tr>
<th>Female MRCP</th>
<th>Male MRCP</th>
<th>Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>457 MB</td>
<td>436 MB</td>
<td>File size (ASCII)</td>
</tr>
<tr>
<td>6.89 mm³</td>
<td>8.64 mm³</td>
<td>Avg. volume of tetrahedron</td>
</tr>
<tr>
<td>8.596,890</td>
<td>8.232,811</td>
<td>Number of tetrahedrons</td>
</tr>
<tr>
<td>&gt; 0.1%</td>
<td>&gt; 0.1%</td>
<td>Deviation from ICRP 89 *</td>
</tr>
<tr>
<td>48</td>
<td>48</td>
<td>Number of organs</td>
</tr>
<tr>
<td>163 cm / 60 kg</td>
<td>176 cm / 73 kg</td>
<td>Height / Weight</td>
</tr>
</tbody>
</table>
Dose calculations with Geant4

- **Calculated values**
  - Organ/tissue specific absorbed fraction
  - Organ/tissue absorbed dose

- **MC simulation conditions**
  - Geant4 version: 10.4
  - Physics library: *G4EmLivermorePhysics*
  - Secondary range cut: 1 μm
  - Relative errors: less than 5%
  - Source organ: thyroid
  - Target organs: thyroid, brain, lungs, RBM, salivary glans, oesophagus
RESULTS
The SAF values

![Graph showing SAF values for different electron energy levels. The x-axis represents electron energy (MeV), ranging from 0.01 to 1. The y-axis represents SAF (1/kg), ranging from 1E-7 to 0.1. The graph includes data points for both male and female subjects, with male data indicated by black squares and female data by red circles. The graph is labeled 'Lungs.'
Absorbed doses for thyroid

Thyroid

Absorbed dose (mGy)

Activity of I-131 (mCi)

- Black squares: male phantom
- Red circles: female phantom
Absorbed doses for critical organs

RBM

Absorbed dose (mGy)

Activity of I-131 (mCi)

- male phantom
- female phantom
Absorbed doses for critical organs

Lungs

Absorbed dose (mGy)

Activity of I-131 (mCi)

- ■ male phantom
- ○ female phantom
Absorbed doses for critical organs

Brain

- male phantom
- female phantom

Absorbed dose (mGy)

Activity of I-131 (mCi)
Absorbed doses for critical organs

Oesophagus

Activity of I-131 (mCi)

Absorbed dose (mGy)

- male phantom
- female phantom
Absorbed doses for critical organs

Salivary gland

- male phantom
- female phantom

Absorbed dose (mGy) vs. Activity of I-131 (mCi)
CONCLUSIONS
The absorbed doses were calculated for critical organs using the mesh-type adult ICRP phantoms:

+ The absorbed doses in thyroid were calculated for the activity of I-131 from 25 – 200mCi.
+ The doses for critical organs are not higher than 0.1mGy, less than the deterministic levels for those organs.

In this study, the transported mechanism of I-131 in body was not considered, and the anatomical data of real patients may not be similar to reference data.

→ the absorbed doses in critical organs may be changed in realistic situation.

→ It’s necessary to study more in future.
Thank you very much for your kind attention!!