Organ Dose Reconstruction for Wilms Tumor Patients Treated with Radiation Therapy

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Outlines

• The Purpose
• Wilms Tumor, Symptoms, Early and late effects
• Treatment Plan for Wilms Tumor
• Introduction to Monte Carlo Simulation, Interactions, Beam Modeling
• Methods
• Results
• Conclusions
The Purpose

The goal of this research is to reconstruct the organ dose for Wilms tumor patients for the assessment of health risk including cancer and infertility for adults who had received radiation during childhood for Wilms tumor.
What is Wilms Tumor?

- Wilms tumor is a type of cancer that starts in the kidneys in children.

- **Symptoms of Wilms tumor:** Swelling or a hard mass in the abdomen (belly), fever, nausea, loss of appetite, shortness of breath, constipation, blood in the urine.

- Wilms Tumor is detected based on physical exam imaging tests, they can’t be certain until a sample of the tumor is looked at under a microscope.

- Two types: **Favorable histology** and **Unfavorable histology**.
Early and Late effect of Radiation Therapy

Possible short-term effects:
Erythema, hair loss, nausea, and diarrhea.

Possible long-term effects:
• Slow growth of normal body tissues (such as bones), kidneys, heart, lungs, ovaries as second cancer effects.
Treatment Plan for Wilms Tumor

- Radiation therapy is delivered by AP and PA technique.
- The beam fields is in the abdomen cavity, may extent to the diaphragm, if needed.
- For whole-abdomen fields are treated, dose should be kept below 15Gy to the uninvolved kidney.
- Typical dose fraction is between 1.5 to 2.0 Gy.
- The dose to the field is limited (10 to 30 Gy) depending on age, stage of tumor, and histology.

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Monte Carlo transport of radiation photon

Fundamental Interactions types:

- Compton scattering
- Photo-electric effect
- Pair production Interaction
Monte Carlo transport of radiation Electron

Electron interactions types are:

• Collisions
• Elastic scattering
• Radiative processes (bremsstrahlung)

What Is Monte Carlo Methods?
Monte Carlo codes

• Modeling Radiotherapy beams: \textit{BEAMnrc}

• Optimized for Patient dose calculation: \textit{VMC/XVMC}
Medical linear accelerator beam modeling

Methods

DICOM-RT
(CT Images, Anatomy Structure, Treatment Plan)

Monte Carlo code input conversion
(DICOM-RT, .vmc, .hed, .dmx)

Dose Calculations
(.d3d)
Methods

• Then, Computational Environment for Radiotherapy Research (CERR) is used to analysis of treatment plans and Monte Carlo Calculations for each plan set.

• CERR is used to calculate the dose volume histogram (DVH) and organ mean dose.
Results

Coronal View of 49-Months Female Phantom treated with Wilms Tumor in the whole abdomen area.
## 49-Months Female Phantom

<table>
<thead>
<tr>
<th>Organ</th>
<th>TPS Mean Dose (Gy)</th>
<th>MC Mean Dose (Gy)</th>
<th>% Diff</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thyroid</td>
<td>0.22</td>
<td>0.25</td>
<td>-15.2</td>
</tr>
<tr>
<td>R Kidney:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medulla</td>
<td>20.5</td>
<td>20.9</td>
<td>-1.80</td>
</tr>
<tr>
<td>Pelvis</td>
<td>20.5</td>
<td>20.9</td>
<td>-1.95</td>
</tr>
<tr>
<td>Cortex</td>
<td>20.6</td>
<td>20.9</td>
<td>-1.75</td>
</tr>
<tr>
<td>L Kidney:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medulla</td>
<td>20.3</td>
<td>20.7</td>
<td>-1.97</td>
</tr>
<tr>
<td>Pelvis</td>
<td>20.3</td>
<td>20.7</td>
<td>-2.96</td>
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<tr>
<td>Cortex</td>
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<tr>
<td>R Lung</td>
<td>2.90</td>
<td>3.21</td>
<td>-10.7</td>
</tr>
<tr>
<td>L Lung</td>
<td>2.80</td>
<td>2.94</td>
<td>-5.00</td>
</tr>
<tr>
<td>Ovaries</td>
<td>20.3</td>
<td>20.4</td>
<td>-0.39</td>
</tr>
<tr>
<td>Liver</td>
<td>20.1</td>
<td>20.4</td>
<td>-1.44</td>
</tr>
</tbody>
</table>
Result

DVH Comparison between TPS and MC (49-Months Female Phantom)
Conclusions

• This method is useful for organ dose reconstruction for pediatric study.

• Radiotherapy is well established in curative treatment of Wilms Tumor but radiation has the potential to induce second cancer risk.

• It is important to keep the health tissue exposures to a minimum for young patient.

• Women who receive abdomen radiation therapy as part of their treatment are at increased risk of low birthweight, premature birth, and the occurrence of inherited abnormalities. These risks must be considered for female survivors of Wilms tumor.
Thank You