Dose to water vs. muscle: Rationale

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IMAGING AND RADIATION ONCOLOGY CORE
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Introduction

- **Clinical reference dosimetry (i.e., TG-51 calibration) is done in water**
- **Dose delivered in the patient is in tissue**
- **These are not the same!**

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Differences

	Water	Tissue	Muscle
• Density (g/cm^3)	1.00	1.025	1.050
• Relative e^- density	1.00	1.019	1.042
• Cost at steak house ($)	0	~40	
• Composition	O H	O C H N	Na,P,S,Cl,K
(% mass)	89 11	57/71 29/14 10 3	Trace

ICRU 46

Problem

- We want to know dose to tissue/muscle
  - This is what patients are made of
  - This is what clinical experience is based on (clinical trials)
  - This is where dose calculation algorithms are headed
- How do we manage this in terms of calibration
  - calibration (water) vs. calculation (muscle)?
- How do we move between these two media?

  - Not talking about Dm vs Dw, just talking about the specific issue of how do we move between these during calibration

Ideal solution

- **Calibration is done in water**
- **TPS recognizes that the patient is not water and inherently accounts for this difference**
- **Then moving between media is implicitly handled by the underlying physics (as it should be!)**

Historical management

- TPS (or hand calcs) didn't handle the non-water nature of the patient

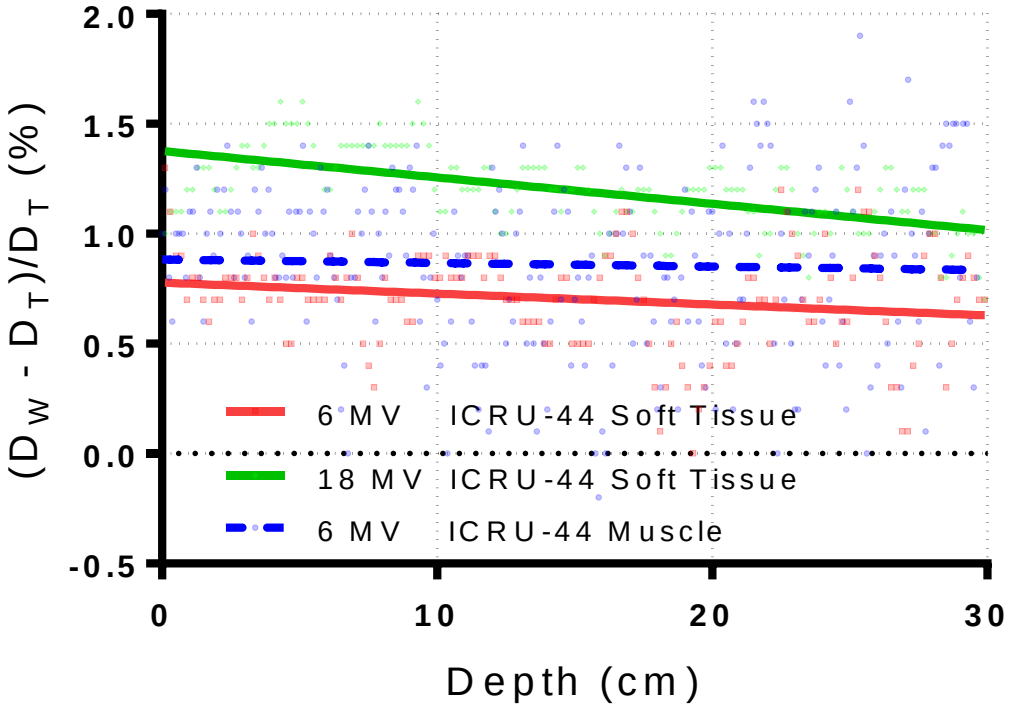
- Calibrate in water
- Apply a conversion 0.99 during the calibration
  - μ_{en}/ρ or S/ρ
  - Accounts for difference in chemical composition
- This yielded "dose-to-muscle"

Question 1:

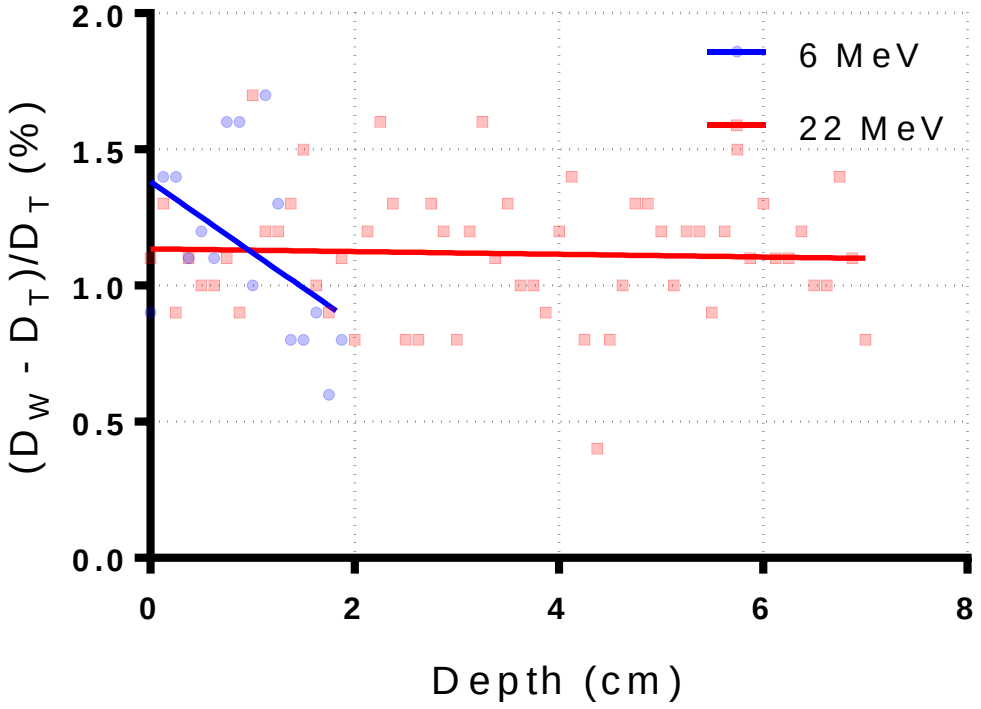
- **How well did this work?**

Dose deposition in water vs tissue

- **Dose difference between tissue/muscle and <u>water with the same electron density</u> (high density water)**
- **Photon Beams**



Electron Beams



Question 2:

- **Is this still appropriate?**

What is the current status?

- Mixed result
- From IROC reporting of output verification
  - 75%: Dose to water
  - 25%: Dose to muscle (via 0.99 correction)
- No consistency
- No dependence on planning system or algorithm

Why does the TPS matter?

- **Cleanest situation:**
  - **Calibrate dose to water, TPS inherently maps to the medium (i.e., muscle)**
  - **No error (dose calculated correctly)**
- **If TPS inherently maps from water (calibration) to muscle (patient calculation) and we apply a 0.99 correction**
  - **We have a 1% error (calculated dose too low)**
- **If TPS does not map from water to muscle and we don’t apply a 0.99 correction**
  - **We have a 1% error (calculated dose too high)**

Motivation

- **Provide clarity for the link between calibration (water) and dose to the patient (muscle)**
  - **For a given algorithm how do we manage water vs. muscle calibration so that results are as consistent as possible.**
- **Increase accuracy – everyone is getting the same answer under the same conditions**
- **Yes 1% is small**
  - **Half the uncertainty budget**
  - **Not small in calibration terms – larger than kQ, Pion, Ppol,….**

AAPM Group

AAPM report on clinical reference calibration: dose to water or dose to muscle?

- Stephen Kry (co-chair)
- Vladimir Feygelman (co-chair)
- Peter Balter
- Tommy Knoos
- CM Charlie Ma
- Michael Snyder
- Brian Tonner
- Oleg Vassiliev

Report is under review by the AAPM

Now on to part 2

- Hopefully this has provided a clear framework
- How do these results look
- How should one incorporate this into their clinical practice

End

Thank you