Radiation Protection for Fluoroscopically-Guided Interventional Procedures: Patient Dose and Radiobiology

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Session Objectives

• Briefly review basic fluoroscopic radiation dose metrics and how they relate to skin absorbed dose

• Using clinical fluoro procedure examples to discuss:
  • single procedure high doses
  • multiple procedure high doses
  • multi-discipline multiple procedures

• Review basic radiobiological principles

• Discuss potential applications of Radiation Oncology fundamentals
Dosimetric and Radiobiologic Challenges

Case Reports of Fluoroscopically-Guided Interventions (FGIs)

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From $K_{a,r}$ and $P_{k,a}$ to Tissue Dose
From $K_{a,r}$ and $P_{ka}$ to Tissue Dose

- **Global corrections**
  - Accuracy of the displayed air kerma (AAPM TG 190)
  - Table and pad attenuation for posteroanterior projections (~30% attenuation)

- **Radiation event corrections (DICOM RDSR [structured report])**
  - Patient location – table height, lateral and longitudinal table positioning
  - Gantry orientation – Primary (RAO, LAO) & secondary (CRA, CAU)
  - Image acquisition – FOV, Beam spectrum (kV, filtration)
Additional Resources for Review

• NCRP 168 – Radiation Dose Management for Fluoroscopically-Guided Interventional Procedures (FGIs)
  • Background information and general overview relating to FGIs

• JACMP – 2011, 2012 – Jones & Pasciak – Calculating the peak skin dose resulting from FGIs Parts 1 and 2
  • Review of dose calculation approaches and mechanics
Current Status of Radiobiology for FGIs
Clinical Case Type 1 – High Dose Single Procedure
(Mostly Known Knowns)

• Patient Information:
  • 66 y/o female patient
  • BMI 34.5 kg/m²
  • Abdominal arterial / venous fistula embolization

• DICOM RDSR Summary Information:
  • $K_{a,r} = 9.4$ Gy
  • $P_{ka} = 2,158.4$ Gycm²
Calculated peak skin dose: **9.113 Gy**
Phantom dimensions: 62x42x24 (HxWxD)
Extracted patient height: 1.57 m
Extracted patient mass: 94.8 kg
Extracted patient orientation: HFS

OpenREM / OpenSkin – PSD includes BSFs and table / pad transmission (not displayed $K_{a,r}$ accuracy)
What about the RBE, is it affected by the spectral shift due to Cu filtration?
Does it matter that this dose delivery was protracted? Typical halftime for double strand DNA break repair is ~ 1-2 hours
Instantaneous rates vary from ~ 20 mGy/min (Gy/hr) to 1200 mGy/min (Gy/hr). Does this affect outcomes?
Figure barrowed from “Essential Physics of Medical Imaging” by Bushberg et al.
Clinical Case Type 2 – Multiple Procedures
(Known Unknowns)

• Patient Information:
  • 41 y/o male
  • BMI 36.2 kg/m²
  • Pelvic ArterioVenous Malformation

• Estimated maximum skin dose to a given area of skin:
  • 1\textsuperscript{st} procedure – 8/20 – 5.1 Gy
  • 2\textsuperscript{nd} procedure – 10/29 – 4.9 Gy
  • 3\textsuperscript{rd} procedure – 12/19 – 12.6 Gy

• Total PSD = 22.6 Gy (JC Sentinel Event)
Case Type 2 – Cont’d

Image taken ~6 weeks after the last procedure
Case Type 2 – Cont’d

- 4th procedure needed 4 months later
- Clinical team contacted physics and asked “is it safe”?
- Still within the 6 month JC “quasi window"
- Pre-procedure reaction image:
Radiobiological Questions

• How can we better predict early and late effects?

• How can we use that information to assist our clinical colleagues in guiding patient care?
To Be Continued….