Workshop 3: Practical Application of Radiobiology

Hanbo Chen Irene Karam

April 11, 2025

Learning Objectives:

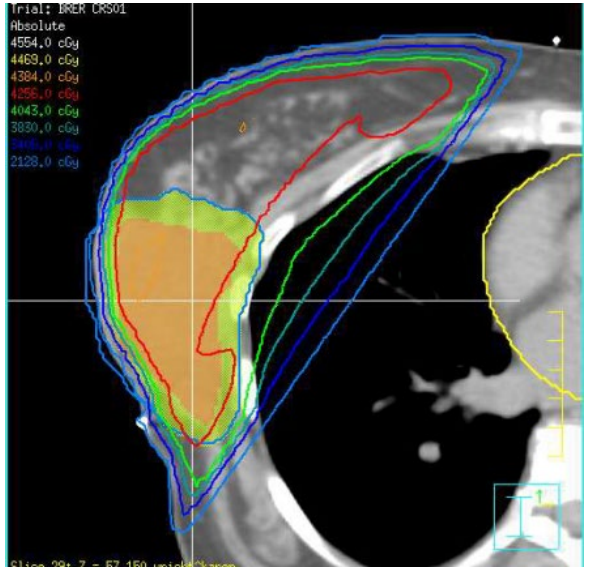
- Apply the LQ model in evaluating reirradiation schedules
- Review tolerances doses to organs-at-risk in cases of reirradiation
- Highlight clinical example(s) of reirradiation and the quantitative and qualitative application of radiobiological principles

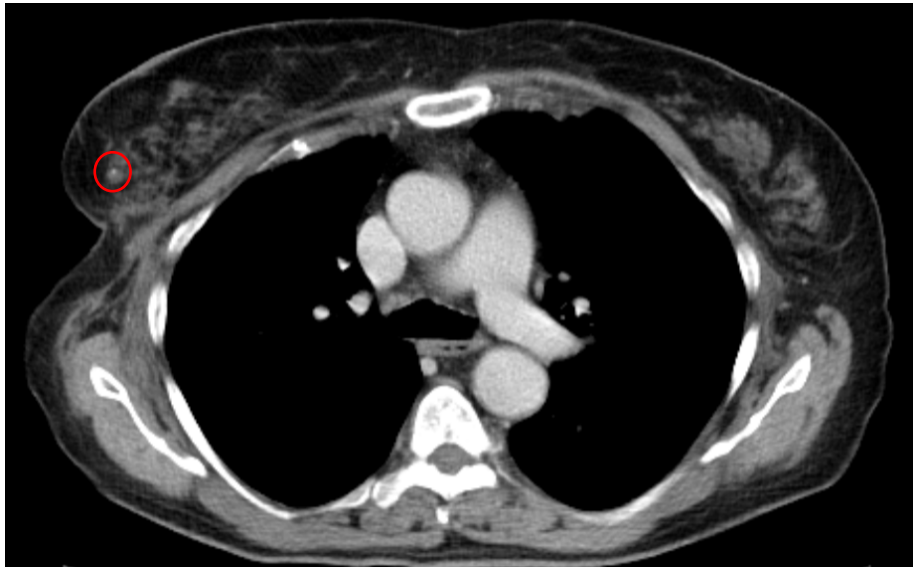
$$BED = \frac{E}{\alpha} = D \cdot (1 + \frac{d}{(\alpha / \beta)})$$

$$EQD_2 = D \cdot \frac{d + (\alpha / \beta)}{2Gy + (\alpha / \beta)}$$

Scenario 1

- 56 y/o patient treated with lumpectomy and adjuvant whole breast radiotherapy 42.6 Gy in 16 fractions with a 12.5 Gy in 5 fraction boost to the surgical bed for a left-sided pT1c N0 IDC in 2015. She had persistent mild fibrosis in the breast.
- In 2023 she had a biopsy-proven ipsilateral breast recurrence. The surgeon performed another lumpectomy that showed pT1c (1.9 cm) N0 ER+/Her2- disease and referred her back for radiation.





Scenario 1 Questions

- Briefly discuss the clinical and radiobiologic factors that you would consider for re-irradiation, as was discussed in class

- What is the cumulative EQD2 of 42.6 Gy in 16 fractions and 12.5 Gy in 5 fractions? What method/model will you use to add these different fractionations? Assuming that we are mainly interested in the effect of this dose on the breast as a late-responding normal tissue. What α/β ratio did you use?

- Apart from the breast itself, what other normal organs would you consider to be most at risk for re-irradiation to the breast?

Scenario 1 Questions

- We will focus on the breast as the main OAR. Assuming that the recovery potential of the breast for late effects is approximately 70% from 2015 to now (i.e. only 30% of the initial dose is still ‘remembered’ by the tissue), and the cumulative late-effect tolerance of the breast is 70 Gy EQD2 (using the same α/β you used previously), what dose EQD2 could you safely deliver with your re-irradiation? Can you suggest 2 different dose/fractionation schedules that can deliver this safe reirradiation EQD2?

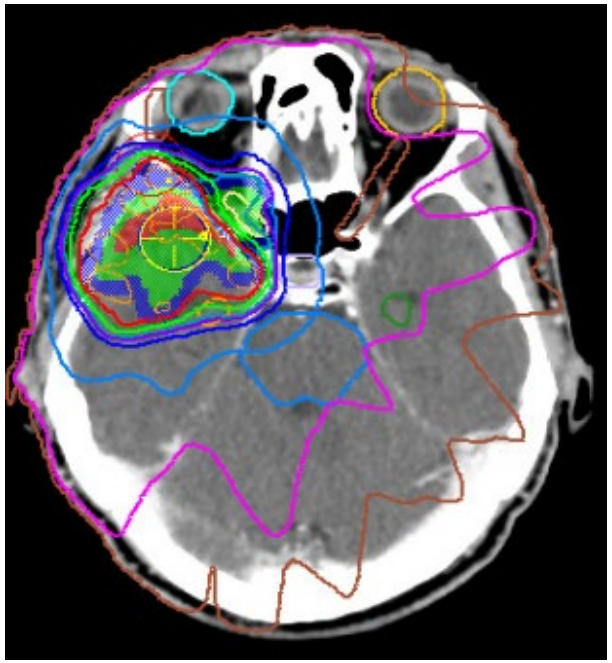
- What is the maximal safe reirradiation EQD2 dose if the recovery potential of the breast for late effects from 2015 to now was 30%? What if it was 90%?

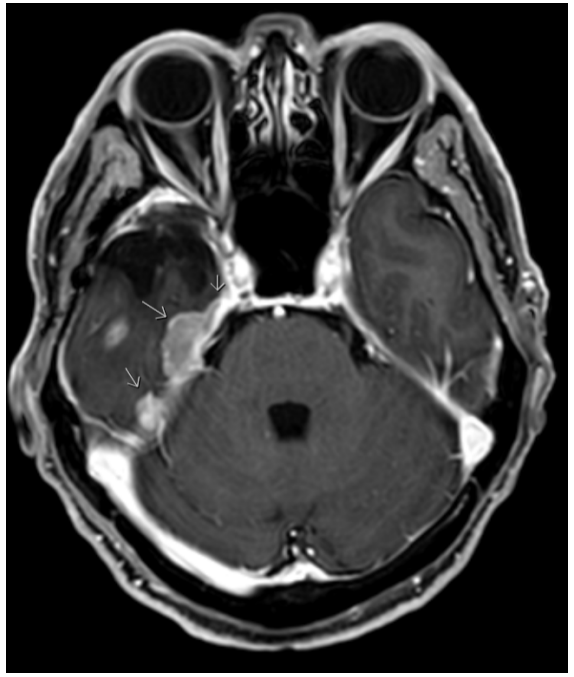
Scenario 1 Questions

- Thinking of the potential mitigation strategies that were discussed in class. What ways can you think of to further minimize the risk of re-irradiation using these general strategies?
  - Dose reduction
  - Treatment volume reduction
  - Delay/avoid re-irradiation

Scenario 2

- 60 y/o patient with meningiomatosis, initial presented with a grade 2 meningioma treated with surgery and adjuvant 70 Gy/35 in Feb 2022 (Left figure).
- Developed multiple further meningiomas in various locations. In 2024 he developed new large meningioma plaques in close proximity to the region previously treated to 70 Gy/35 (Right figure, arrows)
- Patient is otherwise a triathlete and wishes for a curative treatment





Scenario 2 Questions

- Briefly discuss the clinical and radiobiologic factors that you would consider for re-irradiation, as was discussed in class.

Scenario 2 Questions

- The following total doses were received by critical OARs from the initial course:
  - Brainstem: 46.0 Gy (Dmax)
  - Optic chiasm: 49.3 Gy (Dmax)
  - Right optic nerve: 55.6 Gy (Dmax)
  - Left optic nerve: 28.5 Gy (Dmax)
  - Brain: 69.5 Gy (Dmax)

Please convert these point maximum doses to EQD2. What α/β ratio did you use for each of these OARs?

Scenario 2 Questions

- What are the standard dose tolerances of the previously indicated OARs (feel free to look online)? Focus on the point maximum dose tolerances and also the clinical toxicities associated with each tolerance. Assuming a 20% recovery (i.e. the OARs ‘remember’ 80% of the previously delivered dose), and assuming that all standard tolerances are in EQD2, what ‘room’ is left for each OAR for re-irradiation?

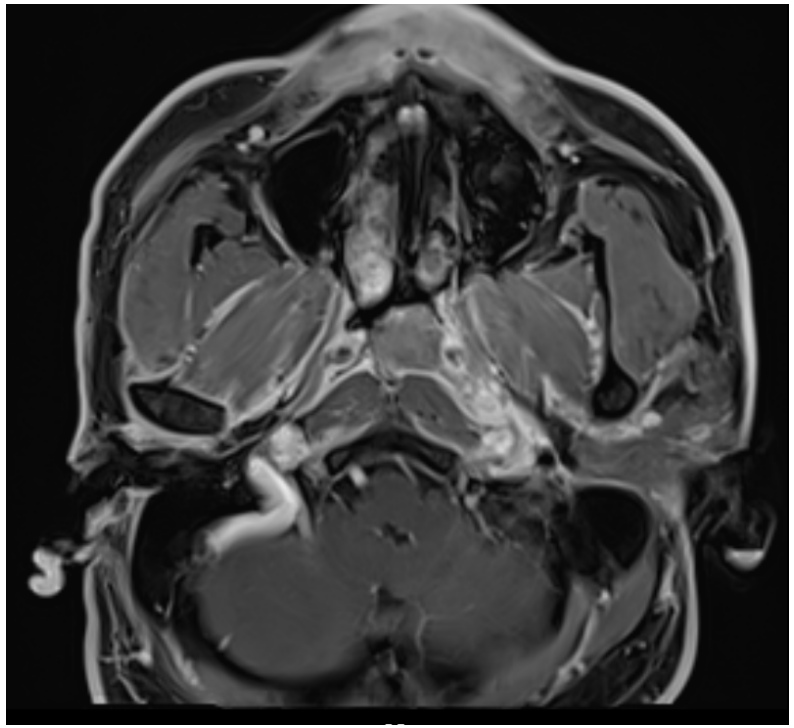
- Why might using the initial radiotherapy course’s OAR Dmax’s in the calculation for the room left for re-irradiation tend to underestimate the amount of room still available for re-irradiation for this patient? (Hint: this is a marginal recurrence)

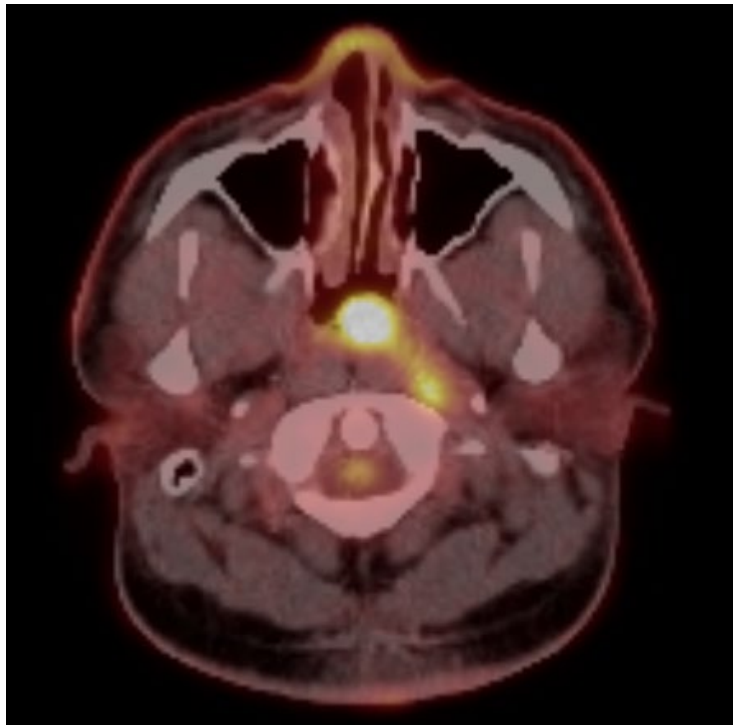
Scenario 2 Questions

- The patient ended up having 50.4 Gy in 28 fractions of re-irradiation to the recurrence volume on the Gamma Knife using a very small margin beyond the gross tumour (1mm). He was treated when further growth in the recurrent nodule showed that it was encroaching on the right optic canal. Only 90% of the planning target volume (PTV) was only covered by the prescription dose, with the remaining 10% receiving below the prescription dose. Please identify the re-irradiation toxicity mitigation strategies used in this patient from the description of his treatment.

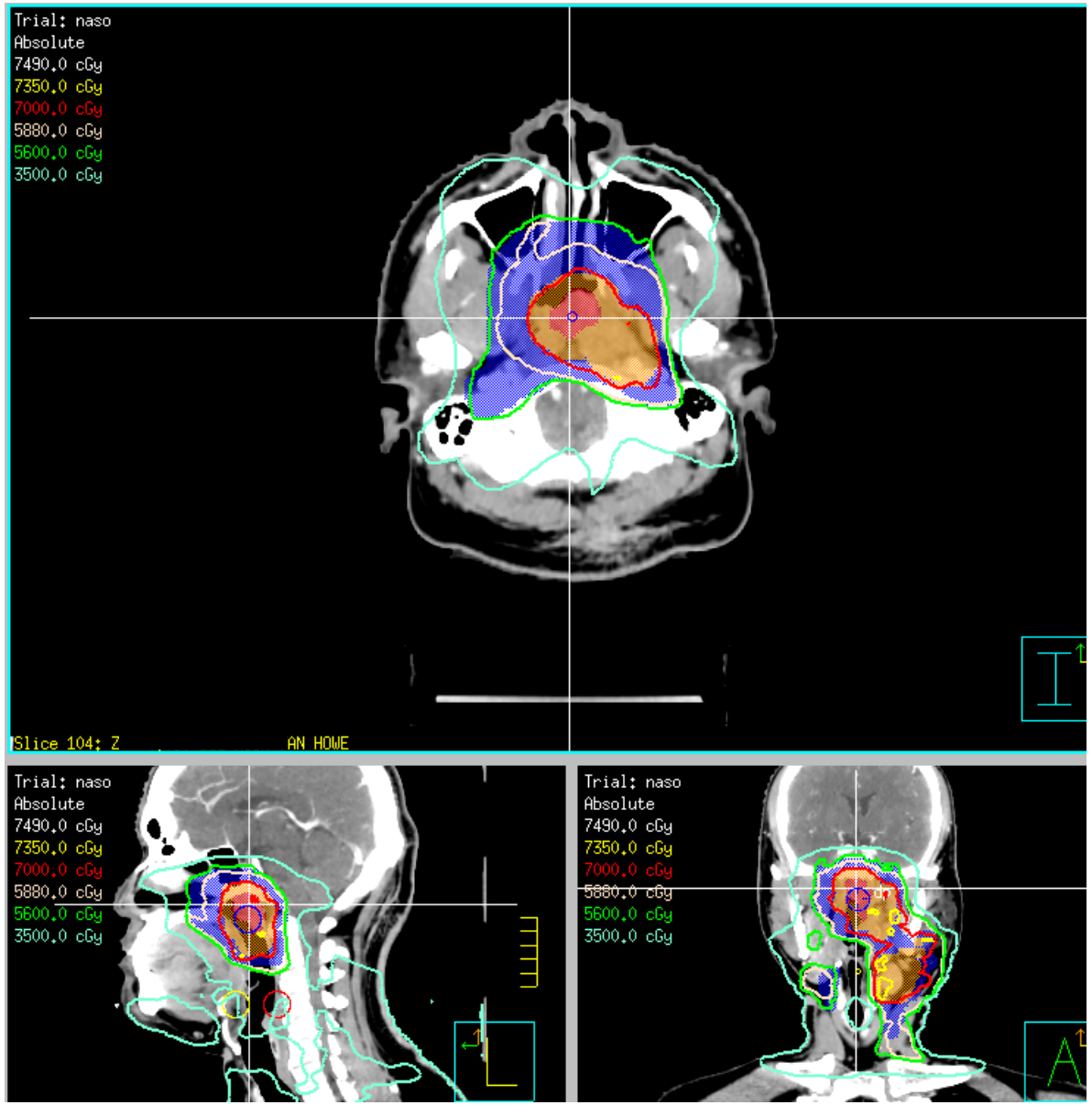
Scenario 3

- Apr 2021: 43yo M with previous nasopharyngeal cancer (cT1N3), treated with CRT to 70 Gy/35 followed by adjuvant chemotherapy





Scenario 3: Initial Radiotherapy

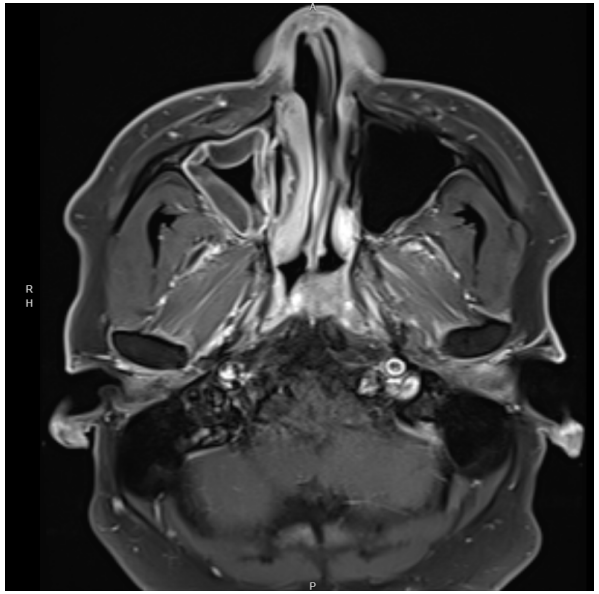


Scenario 3: Initial Radiotherapy

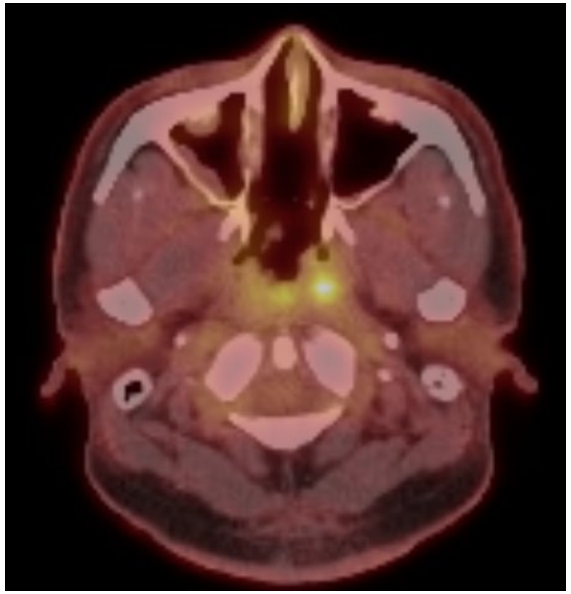
- Brainstem: 57.6 Gy (Dmax)
- Spinal cord: 39.5 Gy (Dmax)
- Right parotid: 24.6 Gy (mean dose)
- Left parotid: 36.5 Gy (mean dose)
- Right cochlea: 40.0 Gy (mean dose)
- Left cochlea: 42.1 Gy (mean dose)

Scenario 3: Recurrence

- Jan 2024 – Local recurrence in nasopharynx (time to recurrence from previous RT ~3yrs)
  - Underwent endoscopic transnasal transsphenoidal nasopharyngeal resection
  - Path – SCC, non-keratinizing with positive margins and possible residual disease, EBV positive



MRI pre - op



PET/CT post-op

Scenario 3: Recurrence

- Discussed at HN MCC – recommendation was for re-treatment with concurrent chemotherapy

Scenario 3 Questions

- **What are the clinical considerations relevant to this case?**

- **What are the radiobiologic considerations relevant to this case?**

Scenario 3 questions

- Consider the OARs with doses from initial radiotherapy course listed in the stem of the case. Please convert these point maximum doses to EQD2. What α/β ratio did you use for each of these OARs?

- What are the standard dose tolerances of the previously indicated OARs (feel free to look online)? Assuming a 30% recovery (i.e. the OARs 'remember' 70% of the previously delivered dose) over 3 years, and assuming that all standard tolerances are in EQD2, what 'room' is left for each OAR for re-irradiation?

- Considering that the initial dose was 70 Gy and a dose close to this range would be needed for re-irradiation to be effective, what mitigation strategies might you consider to reduce the risks of re-irradiation?