LQ-Model Workshop

Tim Craig, PhD, MCCPM
Director, Medical Physics
Walker Family Cancer Centre, Niagara Health

April 8, 2025

Disclosures

- **Licensing agreement with Modus Medical Devices**

Learning Objectives

- **To be able to compute EQD2 to compare radiation fractionation schemes**

Linear-Quadratic Equation

$$E = n(\alpha d + \beta d^2)$$

EQD2

- **EQuivalent Dose in 2 Gy fractions**

EQD2 Calculation

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

$$BED = EQD2\left(1 + \frac{2}{\alpha/\beta}\right)$$

$$EQD2 = \frac{BED}{\left(1 + \frac{2}{\alpha/\beta}\right)}$$

EQD2 Calculation

$$EQD2 = \frac{D\left(1 + \frac{d}{\alpha/\beta}\right)}{1 + \frac{2}{\alpha/\beta}}$$

$$EQD2 = \frac{D\left(\alpha/\beta + d\right)}{\alpha/\beta + 2}$$

$$EQD2 = \mathrm{D}\left(\frac{d + \alpha/\beta}{2 + \alpha/\beta}\right)$$

EQD2 and BED

$$EQD2 = \mathrm{D}\left(\frac{d + {}^{\alpha}/_{\beta}}{2 + {}^{\alpha}/_{\beta}}\right)$$

$$BED = EQD0 = \mathrm{D}\left(\frac{d + {}^{\alpha}/_{\beta}}{0 + {}^{\alpha}/_{\beta}}\right)$$

$$BED = \mathrm{D}\left(1 + \frac{d}{{}^{\alpha}/_{\beta}}\right)$$

Therefore, BED can be considered equivalent to dose given in fractions approaching the limit of 0 Gy per fraction

Example 1

- **Palliative treatment for spine**
- **20 Gy in 5 fractions**
- **Assume spinal cord α/β = 2 Gy**

$$EQD2 = \mathrm{D}\left(\frac{d + {}^{\alpha}/_{\beta}}{2 + {}^{\alpha}/_{\beta}}\right)$$

$$EQD2 = 20\left(\frac{4 + 2}{2 + 2}\right)$$

$$EQD2 = 30\ Gy$$

Example 1

- **Is that safe?**

RECOMMENDED DOSE–VOLUME LIMITS

With conventional fractionation of 2 Gy per day including the full cord cross-section, a total dose of 50 Gy, 60 Gy, and ~69 Gy are associated with a 0.2, 6, and 50% rate of myelopathy. For reirradiation of the full cord cross-section at 2 Gy

Kirkpatrick et al. Int R Radiat Oncol Biol Phys 2010; 76: S42-S49

Example 1

- **Can we escalate the dose?**

Fractionation	EQD2 (Gy)	QUANTEC Myelopathy Risk
25 Gy, 5 fractions		
30 Gy, 5 fractions		
35 Gy, 5 fractions		

Example 2

- **PROFIT**
- **Can we shorten prostate treatments from 39 fractions to 20 fractions?**

Example 2

- **Assume prostate cancer α/β is 1.5 Gy**
- **Compare 78 Gy in 39 fractions to 60 Gy in 20 fractions**
- **EQD2 is 78 Gy for 2 Gy/fraction arm (by definition)**

$$EQD2 = \mathrm{D}\left(\frac{d + {}^{\alpha}/_{\beta}}{2 + {}^{\alpha}/_{\beta}}\right) \qquad EQD2 = 60\left(\frac{3 + 1.5}{2 + 1.5}\right) \qquad EQD2 = 77.1\ Gy$$

Example 2

- Let's do for normal tissue too
- Assume rectum α/β is 3.0 Gy, no time factor
- EQD2 is 78 Gy for 2 Gy/fraction arm (by definition)

$$EQD2 = \mathrm{D}\left(\frac{d + {}^{\alpha}/_{\beta}}{2 + {}^{\alpha}/_{\beta}}\right) \qquad EQD2 = 60\left(\frac{3 + 3.0}{2 + 3.0}\right) \qquad EQD2 = 72.0\ Gy$$

Summary

- **EQD2 is easy to compute and allows comparisons of different fractionation schemes with familiar values**

Questions?

Thank you!

Tim Craig
tim.craig@niagarahealth.on.ca