

KUSUMOTO-1: Application of a novel concept DABBLE to biological effectiveness

Tamon Kusumoto¹, Ryo Ogawara^{2,3}, Kazuyo Igawa⁴

¹National Institutes for Quantum and Radiological Science and Technology

²Advanced Research Center for Beam Science, Institute for Chemical Research, Kyoto University

³RIKEN Nishina Center for Accelerator-Based Science

⁴Neutron Therapy Research Center, Okayama University

Email: kusumoto.tamon@qst.go.jp

Currently, accelerator-based neutron source (ABNS) is used for boron neutron capture therapy (BNCT) in hospitals, rather than reactor-based neutron source. One of the concerns about ABNS is large amount of “contamination radiations” (i.e., fast neutrons and gamma rays) in the thermal neutron field compared to reactor-based neutron source. To accurately elucidate biological effectiveness of BNCT using ABNS, the influence not only of thermal neutrons but also of contamination radiations should be investigated. Generally, relative biological effectiveness (RBE) has been used to evaluate the effectiveness of BNCT relative to conventional X-ray therapy and heavy ion therapy. RBE is derived from the survival curve expressed as a function of absorbed dose. However, difference in radiation quality can not be properly considered when the survival curve is described using absorbed dose. In other words, the survival fraction must be expressed using a universal parameter, instead of absorbed dose.

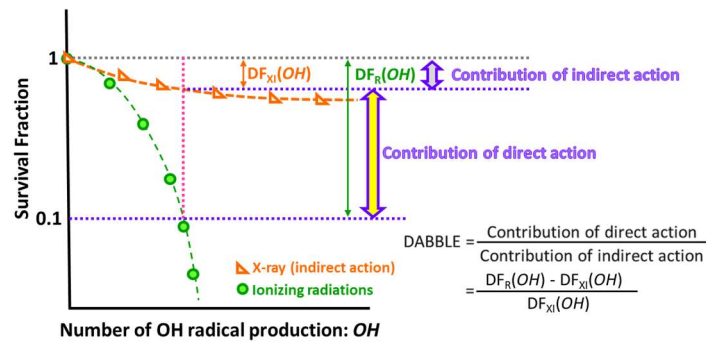


Fig. 1. Schematic view of the derivation process of DABBLE.

To do so, we apply the number of OH radicals produced for describing the survival curves. Figure 1 shows a schematic of the survival curve of ionizing radiations (circles) and that of indirect action induced by X-rays (triangles) [1]. We note that the survival curve approaches a certain value, because the contribution of direct action is ignored. Generally, the number of OH radicals produced is measured using radical scavenger. This would imply that the number of OH radicals is equivalent to that attacking DNA. In other words, the contribution of indirect action is equal at the same abscissa point. From survival curves described by the number of OH radicals produced, a novel concept **D**irect **A**ction-**B**ased **B**iological **E**ffectiveness (DABBLE) is proposed to discuss the contribution ratio of direct action. To derive DABBLE, we first pay attention to the number of OH radicals produced when the survival fraction is 0.1, namely death fraction of cells irradiated with ionizing radiations (e.g., heavy ions) $DF_R(OH)$ is 0.9 (green arrow). At the same abscissa point, the death fraction of cells due to indirect action by X-rays $DF_{XI}(OH)$ (orange arrow) is derived [1]. Therefore, $DF_R(OH) - DF_{XI}(OH)$ (thick yellow arrow) indicates the contribution of direct action induced by C ions. From this view point, we propose DABBLE as,

$$DABBLE = \frac{DF_R(OH) - DF_{XI}(OH)}{DF_{XI}(OH)}. \quad (1)$$

The denominator expresses the death fraction due to indirect action by X-rays and the numerator indicates the death fraction due to direct action by C ions. Namely, DABBLE indicates the ratio of direct action to indirect action. In the presentation, we will discriminate the biological effectiveness induced by the $^{10}\text{B}(n,\alpha)^7\text{Li}$ reactions from that by contamination radiations and discuss about the biological effectiveness of BNCT compared to the other radiation cancer treatments based on DABBLE.

References

[1] Hirayama et al., *Radiat. Res.* **171** (2009) 212-218.