Dosimetry of Brachytherapy Sources: Review of The AAPM TG-43 Formalism

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ABSTRACT

In 1995, the American Association of Physicists in Medicine (AAPM) Task Group 43 published a report dealing with the dosimetry of interstitial brachytherapy sources, generally known as the TG-43 report. Compared to previously adopted formalisms, a formalism proposed in this report provides a more accurate and systematic brachytherapy dose calculation method, especially for Ir-192 and other low energy gamma sources such as I-125 and Pd-103. In this lecture, an overview of the TG-43 formalism will be presented, along with the lecturer's experience in determining the TG-43 parameters by the Monte Carlo method and experimental methods such as TLD and radiochromic film.

Keywords: dosimetry, brachytherapy, gamma sources.

1. INTRODUCTION

Over the last several decades, the dosimetry of brachytherapy sources has evolved from a simple point source approximation to more sophisticated methods which take actual source geometry into account. Since its release in 1995, the AAPM TG-43 formalism[1] has gained a wide acceptance as a new standard way to describe the dosimetry of brachytherapy sources. Accordingly, many researchers have devoted significant effort on the determination of the TG-43 parameters by a number of approaches including the Monte Carlo method and various experimental methods. In this review, an overview of the TG-43 formalism will be presented by discussing the meaning and physical implication of each TG-43 parameter. A brief description for the Monte Carlo method, TLD, and radiochromic film will also be provided, in terms of their usage for the determination of the TG-43 parameters.

2. MATERIALS AND METHODS

2.1 The TG-43 formalism

According to the TG-43 report,[1] for cylindrically symmetric sources (Figure 1), the dose rate at point (r, θ) can be computed as:

$$\dot{D}(r,\theta) = S_k \, \Lambda \frac{G(r,\theta)}{G(r_0,\theta_0)} g(r) F(r,\theta) \qquad (1)$$

where S_k = air kerma strength of the source; Λ = dose rate constant; $G(r, \theta)$ =geometry factor; $g(r)$ = radial dose function; $F(r, \theta)$ = anisotropy function. Note (r_0, θ_0) refers to the reference point (i.e., r_0 = 1 cm and $\theta_0 = 90°$). Each parameter in Eq. (1) can be further defined as described in the TG-43 report[1] and will be discussed in depth during the lecture.

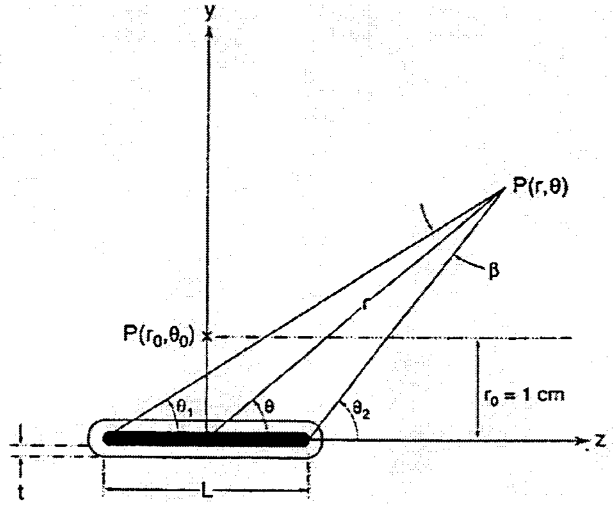

Fig. 1. Illustration of geometry for the TG-43 formalism (Ref. 1)

2.2 Determination of the TG-43 parameters by the Monte Carlo method

Each parameter appeared in Eq. (1) may be determined by the Monte Carlo method. The Monte Carlo method could provide a way to determine the TG-43 parameters more accurately than experimental measurements, because one can avoid errors involved in experimental measurements (e.g., positioning error). Over the years, various Monte Carlo codes have been used for the determination of the TG-43 parameters. One of the popular codes is the MCNP code,[2] a general purpose Monte Carlo code for performing the transport of neutrons, photons, and/or electrons in various geometry. The use of the MCNP code will be discussed in detail during the lecture by presenting some examples.

2.3 Determination of the TG-43 parameters by TLD measurements

Thermoluminescent dosimeters (TLD) have frequently been used for the determination of the TG-43 parameters,[3,4] due to some of their advantages. In general, TLD may serve well for measurements with brachytherapy sources at the radial distances beyond 1 cm. Some details about TLD measurements will be presented during the lecture.

2.4 Determination of the TG-43 parameters by radiochromic film

Accurate measurements with brachytherpy sources are very difficult when a high dose gradient is presented over dosimeters with finite sizes. In general, conventional dosimeters such as TLD or ionization chambers may not provide an enough spatial resolution over a high dose gradient region (e.g., proximate radial distances from the source). On the other hand, radiochromic film may provide a desired spatial resolution, even under the presence of a high dose gradient.[5] Moreover, radiochromic film could be used to easily obtain the two-dimensional dose distribution around the sources. Therefore, radiochromic film has often been chosen by many researchers as a possible alternative or complement to conventional experimental techniques. More details about radiochromic film measurements will be presented during the lecture.

3. SUMMARY

The AAPM TG-43 formalism may provide a more accurate and systematic brachytherapy dose calculation method, compared to previously adopted formalisms. However, the dosimetry parameters suggested in this formalism (i.e., TG-43 parameters) should be determined precisely to ensure the maximum accuracy in brachytherapy dose calculations using the TG-43 formalism. Over the years, therefore, researchers have used the Monte Carlo method and experimental methods such as TLD and radiochromic film, in order to accurately determine the TG-43 parameters.

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