Available online at www.sciencedirect.com

ScienceDirect

journal homepage: http://www.elsevier.com/locate/rpor

Review

Medical physics in radiotherapy: The importance of preserving clinical responsibilities and expanding the profession's role in research, education, and quality control

Julian Malicki [a,b,c,*]

[a] *University of Medical Sciences, Electroradiology Department, Garbary 15, 61-866 Poznan, Poland*
[b] *Greater Poland Cancer Centre, Medical Physics Department, Garbary 15, 61-866 Poznan, Poland*
[c] *Adam Mickiewicz University, Medical Physics Department, Umultowska 85, 61-614 Poznan, Poland*

ARTICLE INFO

Article history:
Received 10 February 2014
Received in revised form
12 November 2014
Accepted 8 January 2015

Keywords:
Medical physics
Profession
Education
Professional training

ABSTRACT

Medical physicists have long had an integral role in radiotherapy. In recent decades, medical physicists have slowly but surely stepped back from direct clinical responsibilities in planning radiotherapy treatments while medical dosimetrists have assumed more responsibility. In this article, I argue against this gradual withdrawal from routine therapy planning. It is essential that physicists be involved, at least to some extent, in treatment planning and clinical dosimetry for each and every patient; otherwise, physicists can no longer be considered clinical specialists. More importantly, this withdrawal could negatively impact treatment quality and patient safety. Medical physicists must have a sound understanding of human anatomy and physiology in order to be competent partners to radiation oncologists. In addition, they must possess a thorough knowledge of the physics of radiation as it interacts with body tissues, and also understand the limitations of the algorithms used in radiotherapy. Medical physicists should also take the lead in evaluating emerging challenges in quality and safety of radiotherapy. In this sense, the input of physicists in clinical audits and risk assessment is crucial. The way forward is to proactively take the necessary steps to maintain and advance our important role in clinical medicine.

1. Introduction

In recent decades, medical physicists have slowly become further removed from direct clinical responsibilities in planning radiotherapy treatments. This change has been more prominent in countries in Western and Northern Europe, somewhat less evident in Southern Europe, and only marginal in Eastern Europe.

Previously, physicists handled all aspects of the treatment planning from start to finish. Over time, however, this model has steadily given way to a new structure in which other

* *Correspondence to*: University of Medical Sciences, Electroradiology Department, Garbary 15, 61-866 Poznan, Poland. Tel.: +48 618850700.
E-mail address: julian.malicki@wco.pl

http://dx.doi.org/10.1016/j.rpor.2015.01.001
1507-1367/

specialists and technicians (primarily medical dosimetrists and technologists) have assumed many of these responsibilities. While the reasons for this transformation are many and varied, medical physicists themselves are undoubtedly at least partly responsible.

Not everyone agrees with the notion that medical physicists have become too distanced from clinical work. Bortfeld and Jeraj[1] argue that the real problem in medical physics is not insufficient clinical involvement, but rather that the research and academic aspects of the profession are weakening. Despite these arguments, I contend that there has indeed been a shift in the responsibilities of medical physicists.

One of the primary reasons that medical physics has become ever more distanced from its original, clinical role—in which the physicist was closely involved in treating patients—is the emergence of advanced technologies and the challenges that these technologies present. The work of medical physicists in the clinical setting has become increasingly less clinical. This is particularly evident in radiotherapy, where physicists were once responsible for developing treatment plans for all patients, but now have a more supervisory role in treatment planning. This change has altered how physicists are perceived by other members of the clinical staff, and it might even have a negative impact on the job positioning of physicists in the hospital, where the most important responsibilities are considered those that directly relate to patient care and treatment.

In the present article, I describe how and why this shift in responsibilities has occurred, and I explain how it has affected the profession of medical physics. I argue that it is essential that medical physicists maintain their clinical involvement because the specialized knowledge that physicists possess cannot be easily replaced by technicians or radiation oncologists, nor by specialized software run on advanced computers. In the long run, if medical physicists do not take steps now to alter current trends, we run the risk of irreparably harming the profession.

2. Historical background

The discipline of radiation oncology has changed tremendously since the discovery of the therapeutic value of X-rays around the turn of the 20th century. While contributions to the advance of radiotherapy have come from experts from a variety of fields—including clinicians and biologists—it seems safe to say that the innovations of physicists have been essential.[2,3]

From the very beginning, physics has had an important role in radiotherapy.[4] The early discoveries of the value of ionizing radiation in the treatment of cancer were made by eminent physicists such as Wilhelm Roentgen, and Marie and Pierre Curie. As a result, physicists were closely involved in developing radiotherapy treatments and protocols. The typical job titles of these early physicists—e.g., radiation physicist, clinical physicist, and medical physicist in radiotherapy—underscore their importance. The physicist was a key member of the treatment team and, more importantly, was involved in every case without exception.

Until the advent of computerized treatment planning and the sophisticated imaging methods made possible by computers, these early physicists performed most of their planning tasks manually. Consequently, developing an individualized treatment plan was not only time-consuming (early sources, such as kilo-voltage X-ray units, were not automated and required that the physicist perform frequent dosimetry and output dose checks), but also highly challenging. In order to create an effective treatment plan, it was necessary for the physicist to have an adequate understanding of both biology and anatomy, in addition to the ability to visualize patient anatomy in three dimensions. Moreover, technological limitations meant that physicists had to configure the beams and calculate the doses using only the topographic measurements of the outer contours of the patient's body and orthogonal X-ray images. In this pre-computer era, the dose calculation algorithms were quite simple, so much so that dose distributions could be calculated manually or with the aid of a calculator or calculating machine.

Despite the evident limitations of these now outdated methods, they had one very important advantage that has since been lost: because physicists were obliged to perform dose calculations manually, they developed a strong understanding of the limitations of the algorithms and formulas used to calculate the dose. Through experience, medical physicists knew instinctively that any type of body slope or inhomogeneity had to be corrected for. Of course, this is not to say that we should lament the passing of the old methods, nor that we should return to using them; rather, this example shows that we need to think about whether and what kinds of hands-on computational approaches should be included in training physicists, as such methods still have educational value.

The interaction between ionizing radiation and the human body is complex, in large part because a variety of different phenomena can affect the dose. In the past, it was widely understood that the person who performed the dose calculations and beam configurations needed to possess extensive knowledge of the physical interaction between radiation and matter. Moreover, these early physicists had to be able to measure the delivered doses to calibrate the therapeutic sources and to assure that the correct dose was delivered in vivo. Given the complexities involved, this work could only be performed by highly-trained individuals who had studied physics at the master's or Ph.D. level.[3,5] This means that, in radiotherapy hospitals, the role and position of the medical physicists was closely associated with the daily clinical activity of treatment planning, although the profession of medical physics in radiotherapy was not formally recognized in some countries. However, as we shall see, that scenario has changed.

3. Medical physics in the 21st century

As technological developments continue to revolutionize radiation oncology, the role of medical physicists has also evolved.[1,3] However, some believe that some of these changes are not entirely positive, and we may need to steer a modified course. For instance, in many countries, the focus of medical physicists has become extremely narrow, with an emphasis on improving specific skills at the expense of a broader role for medical physicists. In other words, it seems that greater