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Overview

Lessons Learnt from Past Incidents and Accidents in Radiation Oncology

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Abstract

The purpose of this report is to review and compile what have been and can be learnt from incidents and accidents in radiation oncology, especially in external beam and brachytherapy. Some major accidents from the last 20 years will be discussed. The relationship between major events and minor or so-called near misses is mentioned, leading to the next topic of exploring the knowledge hidden among them. The main lessons learnt from the discussion here and elsewhere are that a well-functioning and safe radiotherapy department should help staff to work with awareness and alertness and that documentation and procedures should be in place and known by everyone. It also requires that trained and educated staff with the required competences are in place and, finally, functions and responsibilities are defined and well known.
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Key words: Accidents; incidents; lessons; radiation oncology; radiotherapy; safety

Introduction

Radiotherapy is a high-tech treatment modality for a large proportion of all cancer patients. It is known that for about 50% of all patients, radiotherapy would be beneficial, either as a primary treatment or palliative (see for example [1]). In 2012, there were about 14 million new cancer cases in the world [2] and if radiotherapy were available for all patients requiring it, we would have treated around seven million patients. Unfortunately, radiotherapy is not available for everybody in the world. Today, radiotherapy is given at around 13 000 treatment units (1900 of these are ^{60}Co units) with a total capacity of 115 million fractions annually [3]. Even if this number is not reached in reality, one may summarise that a large number of radiotherapy fractions are administrated every day, with many opportunities for the complex process to go wrong. Many near misses are present and corrected online by competent staff, but, as can be seen in this review, sometimes the holes in Reason's cheese model align and severe events happens [4].

Review of Some Accidents

Calibration

Exeter, UK

After replacing a ^{60}Co source, the determination of output (dose rate in Gy/min) is among several things that has to be carried out to assure future clinical usage of the treatment machine. In 1998, at Royal Devon and Exeter Hospital, UK, a new source was installed and the dose rate determination was carried out by a medical physicist who unfortunately entered the wrong measurement time in his calculations, resulting in a dose rate 25% higher than planned being used and leading to patient overdose. During the months until this deviation was detected, 153 patients were treated [5].

Due to local circumstances, this was not clinically detected, but instead during a national dosimetry audit (organised by the Institute of Physical Sciences in Medicine), this deviation was detected [6–8]. Notable is that

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there is no mention of any independent or secondary check of the dose rate. Everything depends on a single physicist's actions.

Ottawa, Canada

In 2004, after re-localisation, an orthovoltage machine went through a new commissioning process and a medical physicist carried out the measurements and prepared the data needed for clinical use of the machine. The results for the reference field (i.e. for the cone of 10×10 cm^2) were accurate for all beam qualities available, but when preparing the data for all other cones, a mistake was made and the so-called backscatter factor was left out. This meant that all treatments apart from those with the reference cone were erroneous (in principle by the ratios of backscatter factors between the used cone and the reference).

This error was detected in 2007, when another physicist carried out the annual review and noted some discrepancies in the data. This was followed by extensive measurements and it was revealed that the management of the previous measurements for creating the data for treatment was incorrect. During these 3 years, 620 patients were treated (1019 treatments); 326 were considered to have received a potentially clinically significant underdosage (up to 17%) [9]. Also in this case, there was no documentation regarding any secondary check before the machine was used clinically.

Summary

When errors involving equipment are present in the radiotherapy process, e.g. calibration of the beam, as discussed above, it will involve all patients treated with that unit in a systematic way. In the first case, there was an offset in dose resulting in a 25% overdose to all patients; in the other case, depending on the prescribed field size, the deviation was not equal for all.

Many contributing factors can be identified and discussed in both accidents. However, one lesson to learn is that a new or re-commissioned treatment unit must be checked and rechecked. Unfortunately, this problem is not isolated to only these two events. This has happened on many other occasions [10–12] and will continue to happen. Thus, having an in-house or preferably an external audit of dosimetry before clinical use may catch these problems and consequently improve safety substantially [13]. Having an *in vivo* dosimetry system that is independently calibrated may also catch a systematic deviation [14].

Procedures, Knowledge and Training

Glasgow, UK

In 2005, a new or updated version of the record and verify system and the treatment planning system (TPS) was introduced and taken into clinical use. The update resulted in the two software systems sharing the same database and omitting manual data transfer as previously carried out. This new environment required the prescription dose to be entered at the start of the planning process and is then followed through the whole process until the patient is brought up on the treatment console. This was new at the hospital, as previously all treatment plans had been created with a prescription dose per fraction of 1 Gy and consequently the settings for treatment were the number of monitor units (MU) to give 1 Gy to the target volume. This was before the upgrade adjusted the treatment console by scaling (multiplying) the 'MU per 1 Gy' with the prescribed dose to receive the correct number of MUs for the prescribed dose.

All procedures were updated such that the correct prescription dose had to be entered when planning started and the scaling of MUs at the treatment unit was no longer necessary. However, one protocol was overlooked – for cranio-spinal treatments. A form remained in use that contained a part where the number of MUs/Gy had to be entered and then rescaled by the prescription dose to receive the final number.

A patient (Lisa Norris) was planned at the end of 2005 and the prescription dose was entered into the TPS as the new routine. At the end, after the plan was approved, the form for cranio-spinal treatments was completed and the final MU to be given to the patient was scaled by the prescription dose of 1.67 Gy, resulting in an overdose of 67%, as it was applied twice.

This patient was only the third patient of this group (out of about 9000 patients annually) since the upgrade of the system. The first had been handled correctly; the second had a prescription dose of 1 Gy/fraction. Another case was planned in January 2006 and was entered and managed correctly. In February a fifth case was planned and it happened to be the same planner as for this case, who then realised the mistake she/he had made filling out the form. At this moment, the patient had just received her 19th fraction and the treatment was interrupted. This description is based on the full report by the Scottish Minister [15].

This case is a consequence of many contributing factors; for example, an inexperienced planner working under supervision, the plan being checked by the planner's supervisor (rather than an independent person), an under-staffed department, written procedures not updated, etc. [16].

Many aspect of what went wrong and what quality controls (or barriers) failed can be discussed, but changing the process requires special attention to all processes and also that all staff are updated and made aware of the changes introduced. For example, why did no-one question the scaling of MU for this particular patient as that procedure was no longer in use?

New York, NY, USA

A patient with head and neck cancer started treatment (intensity-modulated radiotherapy; IMRT) at St Vincent's Hospital in New York City in early 2005 (8 March). The treatment plan had been reviewed and passed the quality controls according to the procedures at the hospital. After the fourth treatment (all four sessions had been delivered without any problem), the responsible radiation oncologist wanted to modify the treatment to reduce the dose to the teeth in the anterior part of the mouth. This was on Friday 11 March. On the following Monday, the physics/dosimetry room was informed about this and started to re-plan the case after the changes initiated by the radiation oncologist.

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