Abstract

Purpose: Computer based Treatment Planning Systems (TPS) are used worldwide to design and calculate treatment plans for treating radiation therapy patients. TPS are generally well designed and thoroughly tested by their developers and local physicists prior to clinical use. However, the wide-reaching impact of their accuracy warrants ongoing vigilance. This presentation reviews the findings of the Australian national audit system and provides recommendations for checks of TPS.

Methods: The Australian Clinical Dosimetry Service (ACDS) has designed and implemented a national system of audits, currently in a three year test phase. The Level II audits verify the accuracy of a beam model of a facility’s TPS through a comparison of measurements with calculation at selected points in an anthropomorphic phantom. The plans are prescribed by the ACDS and all measurement equipment is brought in for independent onsite measurements. In this first version of audits, plans are comparatively simple, involving asymmetric fields, wedges and homogenisers.

Results: The ACDS has performed 34 Level II audits to-date. Six audits returned at least one measurement at Action Level, indicating that the measured dose differed more than 3.3% (but less than 5%) from the planned dose. Two audits failed (difference >5%). One fail was caused by a TPS to Record and Verify system transmission error coupled with QA not being performed. The second fail was investigated and reduced to Action Level with the onsite audit team finding phantom setup at treatment a contributing factor. The Action Level result is attributed to small dose calculation deviations within the TPS, which are investigated and corrected by the facilities.

Conclusions: The ACDS has found a number of clinical cases which show up and can combine with output variations to result in unacceptable variations. Ongoing checks and independent audits are warranted.

Purpose

Radiation Therapy relies heavily on computer based Treatment Planning Systems (TPS) to design and calculate treatment plans for most patients treated. Clinical TPS are generally well designed and thoroughly tested by their developers and in the process of approval for general clinical use. Medical Physicists commission and verify the calculations of a TPS before the system is used to plan patient treatments at a Radiation Therapy facility. Medical Physicists also perform ongoing quality assurance (QA) of a TPS and additional checks when updates are installed. However, no check can cover all aspects of the system, and the wide-reaching impact of the accuracy of TPS calculations warrants ongoing vigilance.

The Australian Clinical Dosimetry Service (ACDS) has been created by the Australian Federal government as a joint initiative between the Department of Health and Ageing and the Australian Radiation Protection and Nuclear Safety Agency. The ACDS is nearing the end of a three year test period during which it was designed and implemented as a national level independent audit system. Audits are provided free of charge to Radiation Oncology Facilities throughout Australia (Williams et al 2012). This work reviews findings of the ACDS level III audit and provides recommendations for checks of TPS.

Methods

The ACDS Level III audit represents an end-to-end test that covers the entire chain of procedures a patient experiences at a Radiation Therapy facility from imaging through planning, checks, setup, delivery and record.

Radiation Therapists conduct each of the steps in keeping with routine clinical practice so that the audit assesses the actual patient process. The treatment plans are prescribed by the ACDS and all measurement equipment is brought in for independent onsite measurements by ACDS auditors. In this first version of audits, plans are comparatively simple, involving asymmetric fields, wedges and homogenisers. The audit uses an anthropomorphic thorax phantom (IMRT Phantom Model 3DTRC CRS) which contains material with radiological properties of skin, lung and bone as homogenisers (see figure 1).

Figure 1: CRS thorax phantom. CT image and phantom setup for measurement at linear accelerator

The phantom features ten cylindrical ports which, in the default configuration, are filled with solid plugs. For the audit measurements the plugs can be replaced with plugs that hold Farmer type ionisation chambers. The cases are planned with TPS. The audit is exclusively using 6 MV photon beams and a Farmer type ionisation chamber. The first case is a measurement near lateral reference conditions, which serves as a “sanity” check. A small field (1.8x1.8 cm2 field) is selected using a 100 cm SSD setup with the prescription being in point 1, at 8 m depth. A second measurement is performed at point 10, which is at 15 cm depth. The chamber is in a water equivalent plug, which is surrounded by a cylindrical shell of bone equivalent material.

Figure 2: Audit cases for first version of Level III audit. Case 1 is SSD setup. Cases 2 and 3 are isocentric (isocentre marked with cross). Measurements are indicated by arrows.

Cases 2 and 3 have been adopted from an international test case publication, the IAEA TECDOC 1583 [IAEA-TEDDOC-1583]. Small changes were made to the field size to allow for a sharper (superior – inferior direction) beam spread out in the phantom and a smaller area to transport. Also, in addition to the measurement points suggested in IAEA-TEDDOC-1583, additional measurement points were selected. Case 2, which is IAEA-TEDDOC-1583 Case 2, uses a lateral wedged field, isocentrically located around point 1, which is also the prescription point. Additional measurement points are in the build-up region behind the lung (material point) and at an off axis field location in the lung (point 7). Case 3 is based on IAEA-TEDDOC-1583 Case 7 with additional measurements taken at points 8 and 10. Measurement points are assessed for audit. The audit also measures the machine output to compare plan dose and measurement is “Variation from ACDS”, defined as: [facility planned dose – ACDS measured dose] / ACDS measured dose.

Figure 3: Case 2 results for points 1 and 4

Figure 4: The Level I audit verifies the accuracy of a beam model of a facility’s TPS through comparison of measurements with calculation at selected points in an anthropomorphic phantom. As the audit comprises of several steps, any deviations found could be attributed to several sources. Potentially, errors could also be carried over from one to the other. The treatment plan selected for the audit has been chosen to support both tracking of any deviations found. Additionally collected data, such as the complete 3D dose information and radiographic images taken to verify phantom setup at the treatment machine, is available to the audit team in this effort. If further verification is needed, the ACDS Level II audit can be deployed. The Level II audit uses a similar CT data set and a 2D array to verify phantom dose delivered to a rectilinear phantom made of water-equivalent material. The cases of the Level II audit represent commonly placed beams in the Level II audit, helping pinpoint the problem within the TPS or delivery system.

Figure 4: Case 3 results for point 5

Discussion and Conclusions

The Level III audit verifies the accuracy of a beam model of a facility’s TPS through comparison of measurements with calculation at selected points in an anthropomorphic phantom. As the audit comprises of several steps, any deviations found could be attributed to several sources. Potentially, errors could also be carried over from one to the other. The treatment plan selected for the audit has been chosen to support both tracking of any deviations found. Additionally collected data, such as the complete 3D dose information and radiographic images taken to verify phantom setup at the treatment machine, is available to the audit team in this effort. If further verification is needed, the ACDS Level II audit can be deployed. The Level II audit uses a similar CT data set and a 2D array to verify phantom dose delivered to a rectilinear phantom made of water-equivalent material. The cases of the Level II audit represent commonly placed beams in the Level II audit, helping pinpoint the problem within the TPS or delivery system.

The found Action Level and Fail results are attributed to:
1. Not following provided instructions
2. Failing to observe internal protocols and QA procedures
3. Setup errors
4. Dose calculation deviations in the TPS for wedges, in particular for off axis positions
5. Dose calculation deviations in the TPS for Reference conditions.

All of the above can be avoided or rectified. Tests should be implemented to check TPS and delivery system regularly. An independent audit program is warranted.

References


Acknowledgement

The Australian Clinical Dosimetry Service is a joint initiative between the Department of Health and Ageing and the Australian Radiation Protection and Nuclear Safety Agency.

Contact: Joerg Lehmann@arsn.org.au