Social drivers of audits

One of the main reasons for the ACDS' success has been the active awareness and interest of professional colleges, collaboration with government, and the engagement between the PSDL and clinical physicists. The colleges' engagement with dosimetric risk is exemplified by the collaboratively designed National Radiation Oncology Practice Standards which include a minimum dosimetric audit program commensurate with patient safety. Additional social drivers are considered below:

Peer influence: When auditing a facility, especially at the beginning of the pilot, auditees frequently asked whether the neighbouring facility has been audited.

Benchmarking: Auditees frequently asked how they performed relative to the local and national results.

Perceived quality: As the ACDS program progressed and collected more data for each of the audit types, the weight of evidence supporting the ACDS' scoring technique matured. Presenting data analysis publicly and privately impressed upon facilities the quality and reliability of the ACDS program.

Free pilot: When invited, every radiotherapy provider agreed to participate in the audit pilot which was provided at no financial cost to the provider.

Outcomes from ACDS audits

The encompassing justification for a dosimetric audit program is that it improves patient safety and/or the quality of patient treatment. The ACDS' evidence that it is justified in the Australian context is drawn from the recommendations which it has made to clinical providers which have been adopted. The recommendations have ranged from advising dosimeter replacement due to obsolescence or fault, all the way to reviewing dose calculation algorithms which led to changes in clinical practice [2, 3]. Over 200 recommendations have been issued to facilities.

Fig. 1. ACDS audit team (photo courtesy of J. Lehmann).

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BEL*d*ART: A Belgian dosimetry audit programme in radiotherapy based on alanine/EPR and radiochromic film dosimetry

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Introduction

The Nuclear Technology Centre (NuTeC) has been performing external dosimetry audits since 2009 [1] for Belgian radiotherapy departments. The Belgian Federal Agency for Nuclear Control (FANC) requested a national audit programme for reference and non-reference conditions that led to the creation of the BEL*d*ART project. All Belgian centres could participate in the trial free of charge. This was the first large-scale dosimetry audit programme using

alanine/EPR dosimetry. A team of experts in collaboration with the Belgian Hospital Physicists Association (BHPA) acted as the scientific advisory body to BEL*d*ART.

Subsequently, BEL*d*ART has developed audit programmes for advanced and dynamic radiotherapy (e.g. IMRT, Arc, tomotherapy, stereotaxy) based on alanine/EPR and radiochromic film dosimetry. A steering committee composed of five senior medical physicists functions as the advisory body to BEL*d*ART.

History and past activities

In 2009-2011, all Belgian radiotherapy departments were audited for at least one linac. Overall, 61 machines and 212 beams were audited. The audit encompassed an on-site visit by one BEL*d*ART employee who performed the mechanical tests and dosimetric verifications together with the local medical physicist. The output of photon and electron beams was verified in reference and non-reference conditions. The difference between the planned and measured doses was within 3 % for 96.7 % of the MV photon beams and 81.6 % of the electron beams. The positive feedback from the participating departments led the Belgian College of Radiation Oncology and the Federal Public Service

Healthcare to launch BEL*d*ART-2 within the framework of the national Cancer Plan.

BEL*d*ART-2 is a national postal audit programme involving complex radiotherapy techniques. The audit consists of basic tests using alanine detectors in water derived from the previous phase and an 'end-to-end' test to verify the delivery of dynamic radiotherapy for a prostate case using an anthropomorphic phantom loaded with alanine and radiochromic film detectors. All Belgian centres could participate free of charge to the trial during 2012-2016. Twenty-one centres participated with 34 beams. For the

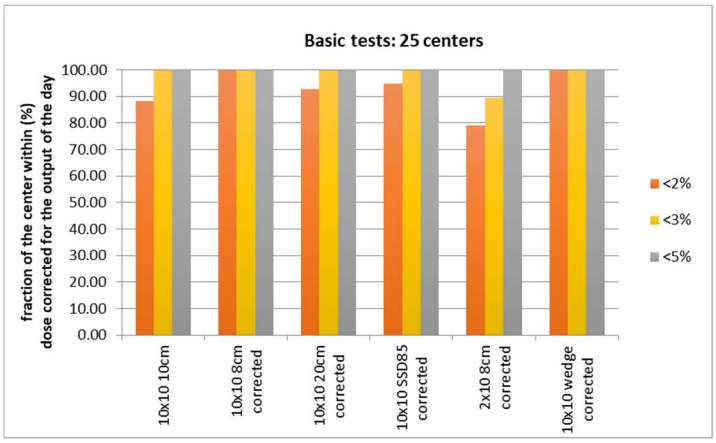

Fig. 1: Results from BLdART-2 (2012–2016).

basic tests, the difference between the measured and planned dose was within 3 % for all centres. For the end-to-end tests, the difference between the planned and the doses measured by EPR was within 3% for 84% of the centres. The film dosimetry results show that 97 % of the centres had a passing rate higher than 95% for the gamma evaluation [2, 3] with the criteria of 3%/3 mm, global gamma, with a threshold of 10%.

The choice of alanine-EPR dosimetry is justified by the low uncertainty that can be achieved, i.e. 1% or less with the technique we use [4, 5]. The measured doses are directly traceable to Physikalisch-Technische Bundesanstalt (PTB), the primary standard laboratory in Germany. The reading of alanine detectors is non-destructive with a very low fading which is invaluable for an audit service. Alanine detectors are also used for the film calibration. The films themselves are analysed using the triple channel dosimetry proposed in [6, 7].

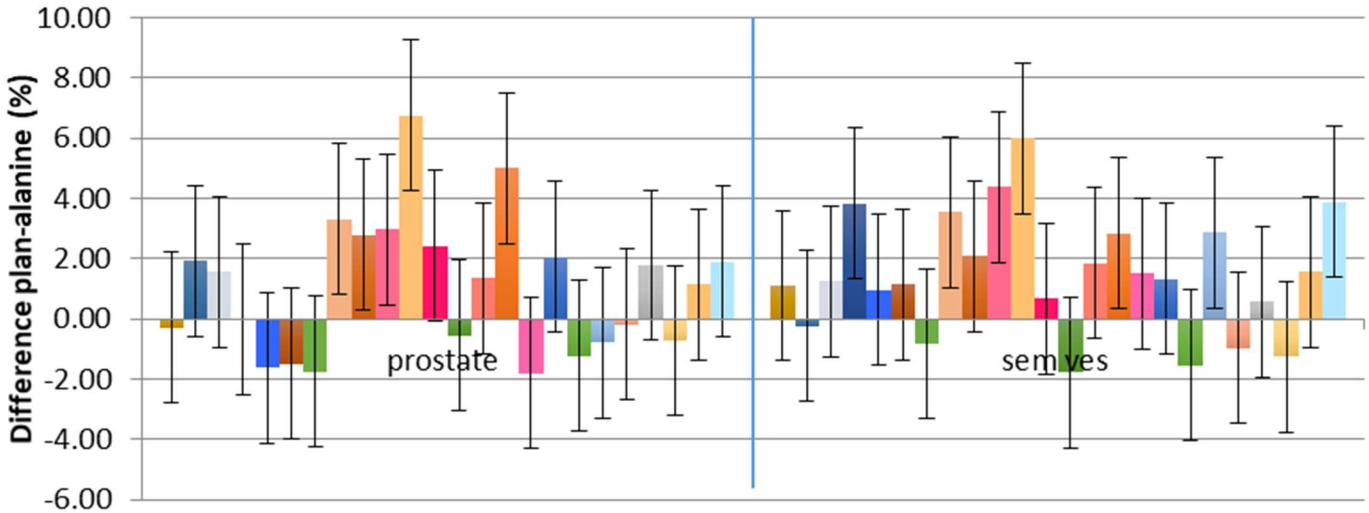

Figure 2: Alanine results from the anthropomorphic phantom in the high dose region. Left: pellets in the prostate, right: pellets in the seminal vesicles

Current activities

BEL*d*ART is supported by the Belgian College of Radiation Oncology to continuously develop new audit programmes. Currently BEL*d*ART focuses on stereotactic treatments. All Belgian centres can participate free of charge in the intracranial SRS trial. Meanwhile, BEL*d*ART is also developing an audit protocol for lung SBRT. Besides, BEL*d*ART is still offering postal BEL*d*ART-2 audits and basic tests in water based on EPR dosimetry.

Currently, the BEL*d*ART staff consists of one physicist, one engineer and one laboratory technician. The BEL*d*ART team performs dose measurements in their dosimetry lab in Diepenbeek, Belgium [3]

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TLD postal audits in radiotherapy in Brazil

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The National Cancer Institute (INCA) Quality Program in Radiotherapy (PQRT) started in 1999 as a three-year pilot postal audit program with only 33 radiotherapy services, using the IAEA system for reference conditions. Due to the positive results it has been integrated into the permanent INCA programs and its activities extended to all the radiotherapy services of the country, mainly those where patients from the National Health System (SUS) were treated. Therefore, since 2003 it became a national program, cost-free for all participants, to stimulate and to promote radiotherapy with quality, efficacy and efficiency.

In 2003 we created our own system (Fig. 1), able to measure photon beams in reference and non-reference conditions [1]. It evaluates the following parameters: reference beam output, depth dose at 10 cm and 20 cm, dose to rectangular field, beam quality (for linacs only), wedge and tray transmission factors, dynamic wedge factor and field flatness and symmetry. TLDs are irradiated in a standard water phantom at SSD according to our irradiation protocol. This system has been used in Brazil but also in some countries of Latin America and the Caribbean.

In Brazil, from 2003 till 2018 we evaluated 131 Co-60 machines where 862 tests were performed; and 708 linac beams, where 5445 tests were performed. The main problems that were identified were:

- Co-60 machines: field flatness (12.4%), depth dose at 10 cm (14.0%) and wedge filter factor (15.9%).
- linacs: depth dose at 10 cm and 20 cm (8.6%) and rectangular field dose (7.4%).

In Latin America and the Caribbean, from 2005 till 2018 we evaluated: 48 Co-60 machines where 270 tests were performed and 448 linac beams where 3358 tests were performed. Hospitals from the following countries participated in our audits: Argentina, Bolivia, Chile, Colombia, Costa Rica, Cuba, Ecuador, Guatemala, Honduras, Mexico, Panama, Paraguay, Peru, Dominican Republic, Uruguay and Venezuela. Until now our main partners have been Argentina and Chile. The main problems that were identified were:

- Co-60: depth dose at 10 cm (16.7%); wedge filter factor (15.6%) and field flatness (12.9%);
- linacs: rectangular field dose (9.1%); depth dose at 10 cm and 20 cm (7.3%) and wedge factor (5.7%).

Following our long experience and the improvement of the radiotherapy techniques, this postal photon beams system were updated and after January 2019 it evaluates only: off-axis dose, dose using multi-leaf collimator (MLC) fields, MLC transmission factor, depth dose using FFF and dose for