Preventing accidental exposures from new external beam radiation therapy technologies

ICRP Publication 112

Task Group:
Key questions:

1. Are lessons from conventional techniques applicable to newer technologies?
2. Are there new lessons from new technologies?
3. Can we anticipate “what else can go wrong?”
1st question

Are lessons from conventional techniques applicable to newer technologies?
Overall lesson from conventional techniques

- “...purchasing new equipment without a concomitant effort on education and training and on a programme of quality assurance is dangerous”.

Valid for new technologies? Yes, indeed
Lessons from conventional techniques valid for new technologies?

- Beam calibration: independent verification of absorbed dose at the reference point

Accidental Overexposure of Radiotherapy Patients in San José, Costa Rica

115 patients affected
Lessons from conventional techniques valid for new technologies?

- Need for commissioning of treatment planning systems (TPS)
- Validation of procedures and of their modifications, particularly TPS
- For individual patients: check of the dose to a point, independently from TPS calculations

28 patients severely overdosed in Panama
1045 patients underdosed in the UK
Lessons from conventional techniques valid for new technologies?

- Clear notification of maintenance and repairs to the person responsible for radiotherapy physics, before resuming patient treatments

27 patients affected
All these lessons from conventional techniques are valid for new technologies. They should be incorporated into training programmes, and into procedures in radiotherapy departments.
2nd question
Are there new lessons from new technologies?

Yes, the following
New lessons: Computer “crash” or “frozen”
Computer “frozen”

- When saving data of treatment plan, the computer got “frozen”. After restarting, data on collimator setting was “lost”
- As a result, open fields instead of small fields were applied
- Consequences: one patient received 39 Gy in the first three sessions
- Need for procedures for checkin data integrity after computer “crashes”
Wrong calibration files for an applicator were supplied by the manufacturer.
Intraoperative radiotherapy

- Supply of wrong calibration file for a given applicator
- Measurements revealed a discrepancy, the physicist asked the installation engineer and received an erroneous advice
- Radiotherapy department accepted the advice, assuming that the maintenance engineer was right and the measurements by the physicists may be wrong

Avoid “believes or assumptions” and base the treatment on proper understanding and verification!
Errors from imaging:
Wrong site treatment (right-left)
Image distortion
Multiple imaging modalities: problems of inconsistencies

- Left-right error
- Image distortion when transferring from TPS to “record and verify” system
- Potential problems of image artefacts from contrast media and wrong tissue density
- With increased use of different imaging modalities, consistency becomes more critical
Significant radiation dose from daily imaging for verification
Several events due to poor understanding of new techniques and poor communication and recording
Calibration of very small beams (micro multileaf collimators)

- Partial volume irradiation of the chamber. Wrong absorbed dose determination
- **Need for deeper knowledge (training) and awareness**
Reference markers in virtual simulation

- The tattoo for the initial plane of virtual simulation (A) was taken as the isocenter plane (B).
Dynamic wedges

- Erroneous selection of the type of wedges with the result of excessive monitor units
- Monitor units selected for physical wedges, but treatment performed with dynamic wedge
- Misunderstanding of the acronym (enhanced wedges, EW)
- 23 patients overdosed, four of them died in the first year
Small fields in stereotactic treatment with applicator
Confusion 40 mm - 40 cm
Patient died from the treatment
Avoid poor understanding of new techniques and poor communication and recording

Lesson No “quick” training...

... but solid training
All these new lessons are useful in preventing reported types of risks, but
3rd question: Can we anticipate what else can go wrong?
The unknown or unreported

- What about possible unreported events?
- What about other types of potential events, which have not happened yet?
- Do we need to wait until they occur, to learn the lesson?
- ¿What should be done about increasing equipment complexity and thus ever larger lists of double checks and verifications?
There are proactive methods of safety assessment

- Failure mode and effect analysis (FMEA)
- Probabilistic Safety Assessment (PSA)
- Risk Matrix Approach

Examples: work done by the Ibero American FORO of Nuclear and Radiation Safety Regulatory Agencies and by the American Association of Physicists in Medicine, briefly described in ICRP 112
Example No. 1 of major finding from probabilistic safety assessment

• Much attention has been focused on major catastrophic, multiple-patient events with very low probability, but

• Attention to other types of events with much higher probability, involving single patients, can be also severe, and may go unreported
Major finding 2 from probabilistic safety assessment

• Increased control by software (control of linear accelerator functions, treatment planning, virtual simulation, image guided radiotherapy, record and verify control, radiotherapy information systems, electronic charts) confers software safety a paramount importance

• Software deserves higher attention in standards by regulators, manufacturers and professional bodies;
Major finding 3 from probabilistic safety assessment

• Safety aspects related to treatment plan by the radiation oncologist
• In vivo dosimetry or equivalent,
• Daily observation of the patient and periodic medical control, important in mitigation for patients being treated and prevention for other patients
Recap

- Most lessons from conventional techniques are applicable to new technologies.
- Additional lessons for new technologies have become available (ICRP 112).
- Anticipative approaches provide a risk-informed and rational choice of safety provisions.
Thank you

• You are invited to use these lessons for training and to apply them to real practice

• More details in ICRP publication 112