Errors During Acceptance of Treatment Planning System

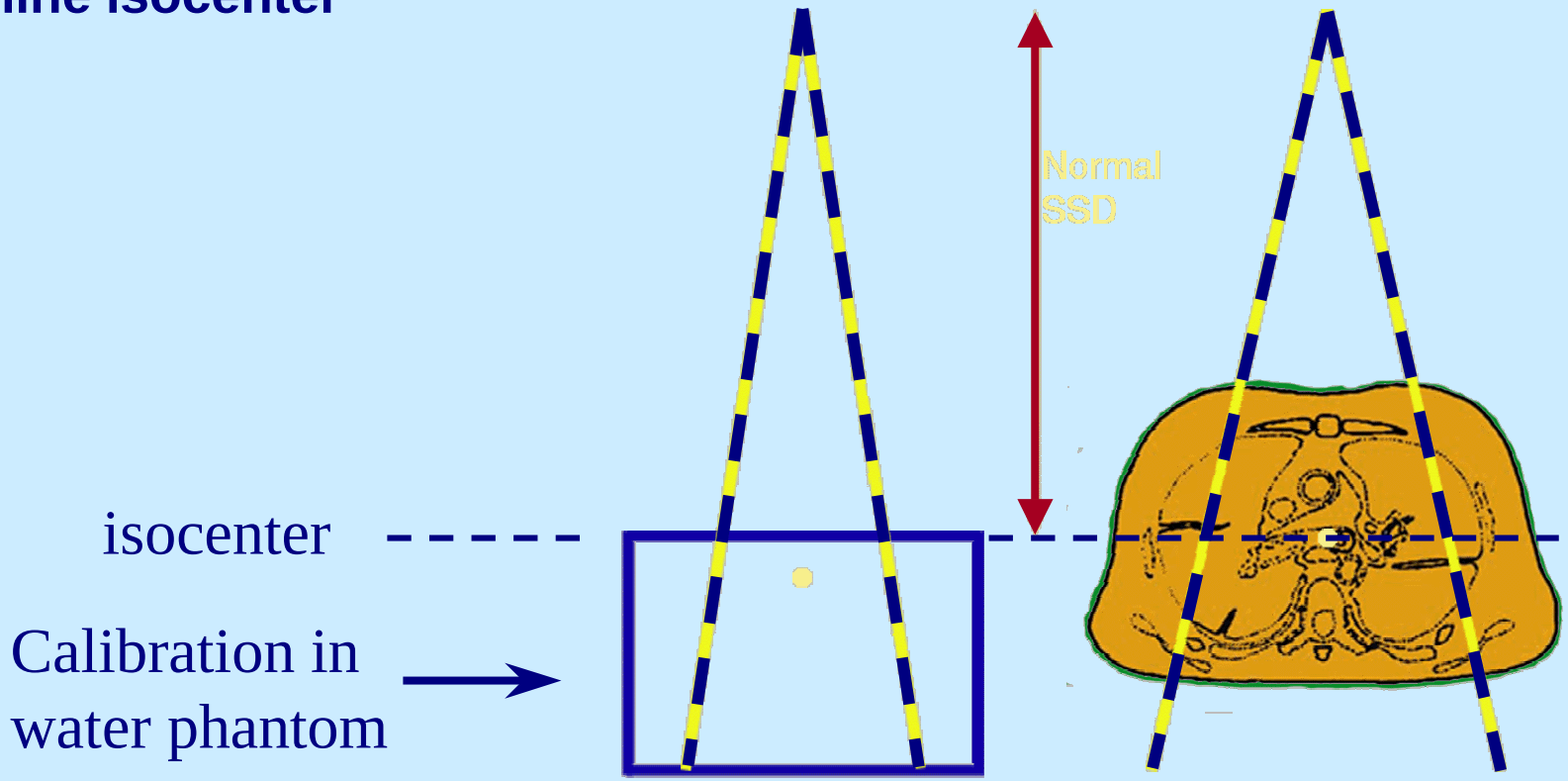
Actual accidental medical exposures

History

- Until 1982, hospital used only manual calculations
- Treatments were generally at standard SSD
- Correction factors were used for unusual SSD, so that conventional %DD calculations could be used at non-conventional SSD
- A computerized treatment planning system was acquired in autumn of 1982
- At same time, and because TPS had the capability, hospital began treating with isocentric techniques more frequently

Isocentric Radiotherapy

- **Machine used principally for SSD treatments was probably calibrated at 100 cm SSD + d_{max}**
- **For isocentric treatment, patients generally positioned with center of PTV at machine isocenter**



Implementation of TPS

- For first isocentric treatment, technologists applied previously-determined correction factors for non-standard SSD
- Hospital physicists approved this procedure
- It was not recognized that TPS correctly applied inverse-square correction for isocentric treatments

Calculations for Isocentric Treatments

- **TPS either used tissue-phantom ratios, or applied inverse-square correction to %DD calculation**
  - ***For example, MU to deliver 1 Gy at 10 cm depth, 10 cm x 10 cm field, 100 cm SAD (if 6 MV accelerator calibrated to deliver 1cGy/MU at 100 cm SSD+d_{max}):***

$$\text{MU} = 100\ \text{cGy}/[(0.77)(1.03)]$$
$$\text{MU} = 126$$

where TPR = 0.77, and inverse-square correction from 100 cm SSD + d_{max} to isocenter is 1.03

Incorrect Application of Distance Correction

- However, technologists continued to apply distance correction factor to all subsequent calculations
- Consequently, distance correction factor was applied twice for all patients treated isocentrically, or at non-standard SSD
- This error caused patients to receive doses lower than prescribed
- The incorrect procedures were in place until 1991, or for approximately nine years
- Evaluation by Ash and Bates showed that of 1 045 patients whose calculations were affected by the incorrect procedures, 492 developed local recurrences that could be attributed to the error

Example of Typical Error

- **The hospital applied an inverse-square correction, assuming an SSD-type calculation, which might have been**

$$(101.5/91.5)^2 = 1.23$$

  - ***From previous example, MU to deliver 1 Gy at 10 cm depth, 10 cm x 10 cm field, 100 cm SAD (if 6 MV accelerator calibrated to deliver 1 cGy/MU at 100 cm SSD+d_{max}) and with additional inverse-square correction:***

$$MU = 100\ cGy/[(0.77)(1.03)(1.23)]$$
$$MU = 103$$

- **Application of additional inverse-square correction leads to treatment time (monitor unit setting) that is too low by approximately 20%**
- **Patients receive doses ~20% too low**

Lessons: manufacturers

- Instruction manuals must explain clearly how calculations are performed
- Customers should be advised to perform comprehensive commissioning, and to assure that their staff understand the operation of the equipment

Lessons: Radiotherapy Department

- Assure adequate staffing of Physics group
- Assure that staff are properly trained in the operation of the equipment
- Include in the Quality Assurance Programme:
  - Procedures to perform complete commissioning of treatment planning equipment before first use
  - Procedures for independent checking of patient treatment time calculations