Bundesamt
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Dose variations using an X-ray cabinet to establish *in vitro* dose-response curves for biological dosimetry assays

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Background and Aim

In biological dosimetry, dose-response curves are essential for reliable dose estimations in the event of a radiation accident. For this purpose, blood samples are irradiated *ex vivo* and evaluated according to the used methods. Irradiation is a critical part of the experimental procedure and is susceptible to experimental influences, especially when X-ray cabinets are used due to their different physical properties. Nowadays, X-ray cabinets are replacing $^{137}Cs/^{60}Co$ sources in radiation facilities and many laboratories due to advantages in size, handling and radiation protection requirements. The aim of this study was to investigate the variations and pitfalls associated with the experimental setups used to establish dose-response (calibration) curves in biological dosimetry with X-ray cabinets.

Materials and Methods

The blood collection tubes were X-ray irradiated in horizontal or vertical position in the center of the beam with or without the use of an additional fan heater to ensure irradiation at 37°C (Fig. 1). Irradiation was performed with an X-ray high-protection device: 195kV, 10mA, 0.5mm thick copper filter, 2.09mm thick aluminum flattening filter, at a dose rate of 0.52Gy/min and a distance of 50cm from the focal point of the tube.

To evaluate the influence of this experimental setup, physical dose measurements using an ionization chamber, thermoluminescence (TL) dosimeters and alanine (dosimeter) pellets and investigations on biological effects by quantification of dicentric chromosomes (DIC) were compared.

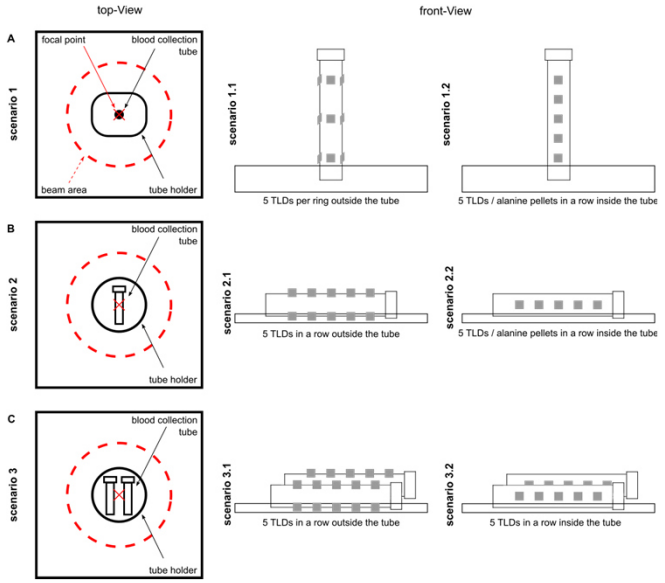

Figure 1. Schemata of the experimental setup. The irradiations were performed in three different scenarios. In all scenarios, the blood collection tubes were filled with water for physical dose measurements or with whole blood for biological dosimetry studies. **A**: One blood collection tube was positioned upright in the central position of the irradiation field (scenario 1) and TLDs were placed in three rings outside the tube (scenario 1.1) or TLDs or alanine pellets were placed in a row inside the tube (scenario 1.2). **B**: One blood collection tube was placed lying in the center of the irradiation field (scenario 2) and TLDs were placed in two rows above and below outside the tube (scenario 2.1) or TLDs or alanine pellets were placed in one row inside the tube (scenario 2.2). **C**: Two blood collection tubes were irradiated lying at the same distance from the central position of the irradiation field (scenario 3) and the TLDs were placed in two rows above and below outside the tube (scenario 3.1) or the TLDs were placed in one row inside the tube (scenario 3.2).

Results

Influence of the experimental setup on radiation doses

In standing tubes, a dose gradient of approximately 600mGy from the cap to the bottom was observed using TLD measurements outside and inside (Fig. 2). Measurements with the ionization chamber confirmed a dose gradient of about 250mGy. For horizontal tubes, the dose gradient is limited to approximately 150mGy (Fig. 3). The presence of an additional fan heater below the irradiation level did not affect the dose. The evaluation of alanine pellets is still ongoing.

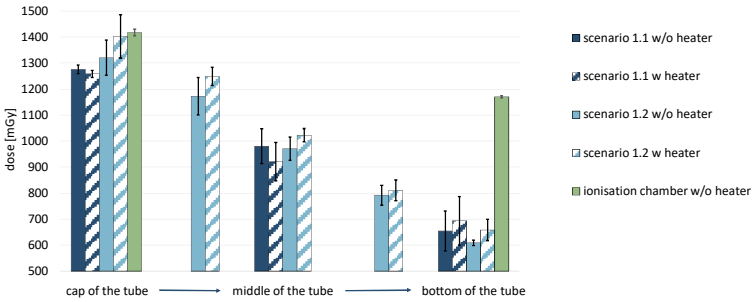

Figure 2. The irradiation dose was measured from the cap to the bottom of standing tubes, and in the presence (striped) or absence (uniform filled) of a heater, by using TLDs outside or (blue) inside the tube (light blue), or with an ionization chamber (green).

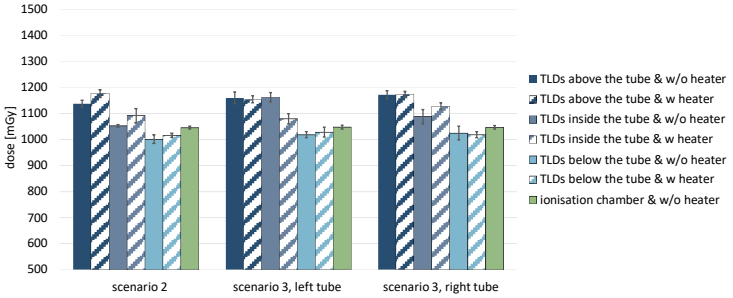

Figure 3. Irradiation dose was measured with TLDs above (blue), inside (blue-gray) or below the tube (light blue), or with an ionization chamber (green) and in the presence (striped) or absence (uniformly filled) of a heater.

Influence of the experimental setup on biological effects

Manual scoring of dicentric chromosomes revealed that the number of dicentric chromosomes per cell was lower for irradiation of the standing tubes compared to the lying tubes (scenario 1 vs. 2; 0.11 vs. 0.17 dics/cell). This result was confirmed in the semi-automatic analysis. In addition, no difference between scenario 2 and 3 was detected (Fig. 4). The presence of an additional fan heater below the irradiation level did not affect the dose. The manual scoring of the different scenarios is still ongoing.

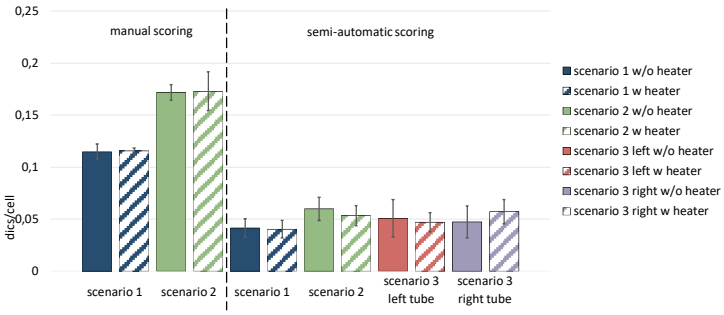

Figure 4. Manual and semi-automatic analysis of dicentric chromosomes in the presence (striped) or absence (uniformly filled) of a heater.

Conclusion

The obtained results show an clear influence of the experimental setup (position of the tubes) on the results of the biological effect (chromosomal aberrations) in the blood samples. Therefore, strict dosimetric monitoring is mandatory for the establishment of dose-response curves in biological dosimetry. Careful consideration of the experimental setup in close collaboration with physicists is required to ensure traceability and reproducibility of irradiation conditions, to correlate the radiation dose and the number of micronuclei and dicentric chromosomes correctly and to avoid systematical bias influencing the dose estimation in the frame of biological dosimetry.