RENEB inter-laboratory comparison: Biological dosimetry based on dicentric chromosomes

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Background and Aim

Inter-laboratory comparisons (ILCs) are regularly performed in the frame of the European RENEB e.V. (Running the European Network of Biological and Physical retrospective Dosimetry) network to validate and improve the procedures for various physical and biological assays. The dicentric chromosome assay (DCA) is considered as the "gold standard" for radiation biodosimetry and is an important tool for radiation dose assessment in small and large-scale radiation accidents. For a large-scale accident, where many individuals are potentially exposed to ionizing radiation, the scoring procedure has to be adjusted to handle the large amount of data in a reasonable time frame and it is crucial to test the performance of the laboratories under conditions simulating a real accident situation.

Materials and Methods

33 biodosimetry laboratories from 15 European and 7 non-European countries participated in the RENEB ILC 2021 for the DCA. The study design included the irradiation of blood samples, shipment, sample processing, analysis of chromosome aberrations and dose assessment. Blood from one healthy donor was irradiated in vitro with X-rays (240 kV, 1 Gy/min). Three blind coded blood samples (#1: 0 Gy, #2: 1.2 Gy and #3: 3.5 Gy) were sent to the participants. The task was to culture and prepare slides and to assess radiation doses based on triage scoring (manual scoring: 50 cells or 30 dicentric chromosomes per sample and semi-automated scoring: 150 cells per sample) using an appropriate calibration curve. The main aim was to determine whether the estimated doses were in good agreement with the reference doses, to identify potential needs for further training and harmonisation. The participation of laboratories from countries around the world gave the opportunity to compare the results on an international level.

Figure 1: Distribution of participating laboratories around the world. In total 24 laboratories from Europe, 2 laboratories from North America and 7 laboratories from Asia participated in the ILC for the DCA.

Acknowledgment

Thanks to the Bundeswehr Institute of Radiobiology for organizing this ILC and thanks to all participants around the world. The names of the participants could not be shown due to the limited amount of space.

Results

Calibration curves used by the participants

- Most labs performed manual scoring (N=31); 5 labs performed semi-automatic scoring.
- Most labs used Cs-137 or Co-60 gamma-ray curves (N=22)
- Some labs (N=8) used X-ray curves with variable energies
- Calibration curves show considerable variation (see Figure 2) which can not only be attributed to radiation quality

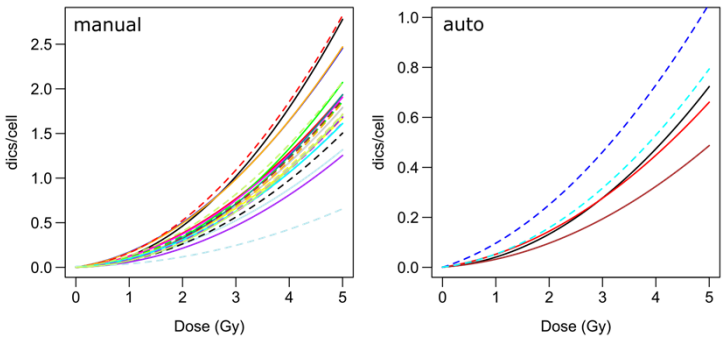

Figure 2: Calibration curves for manual (left) and semi-automatic (right) scoring used by the participating laboratories.

Dose estimates vs reference doses

- The control sample #1 (0 Gy) was detected by 97% of the labs
- Sample #2 (1.2 Gy) was estimated within [0.5-2] Gy by 81% of the labs
- Sample #3 (3.5 Gy) was estimated as > 3 Gy by 100% of the labs
- All labs found the correct dose effect relationship of the blind samples
- Samples #2 and #3 were systematically overestimated by ~0.5 Gy and ~1 Gy, respectively

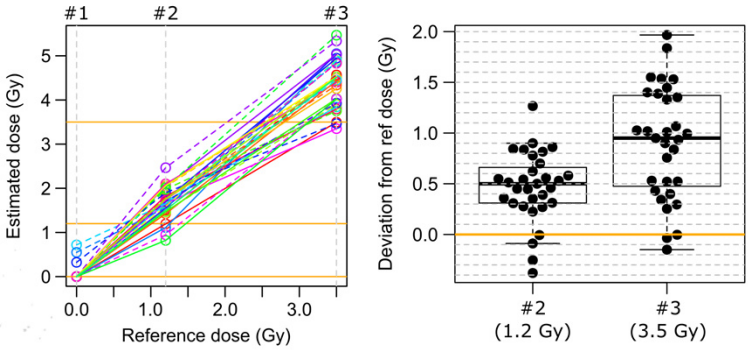

Figure 3: DCA dose estimates vs reference doses (left) and deviation from the reference doses (right).

Summary and Conclusions

- Dose estimates relatively homogeneous between participants
- Good classification of control, low and high dose samples
- Systematic overestimation was observed for samples #2 and #3
- Potential factors causing overestimation: differences in radiation quality between curves and blind samples, donor effects, inhomogeneities of the radiation field, combination of factors