Estimating partial body ionizing radiation exposure by automated cytogenetic biodosimetry

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Purpose: Inhomogeneous exposures to ionizing radiation can be detected and quantified with the Dicentric Chromosome Assay (DCA) of metaphase cells. Complete automation of interpretation of the DCA for whole body irradiation has significantly improved throughput without compromising accuracy, however low levels of residual false positive dicentric chromosomes (DCs) have confounded its application for partial body exposure determination.
Materials and Methods: We describe a method of estimating and correcting for false positive DCs in digitally processed images of metaphase cells. Nearly all DCs detected in unirradiated calibration samples are introduced by digital image processing. DC frequencies of irradiated calibration samples and those exposed to unknown radiation levels are corrected subtracting this false positive fraction from each. In partial body exposures, the fraction of cells exposed, and radiation dose can be quantified after applying this modification of the contaminated Poisson method.
Results: The u test correctly discriminates whole from partially irradiated samples in all synthetic samples, and 75% of exercise samples with whole body dose ≥ 1 Gy and was the best discriminator of the three methods tested. Dose estimates of three partially irradiated samples diverged 0.2 to 2.5 Gy from physical doses and irradiated cell fractions deviated by 2.3-15.8% from the known levels. Synthetic partial body samples comprised of unirradiated and 3 Gy samples from 4 laboratories were correctly discriminated as inhomogeneous by multiple criteria. Root mean squared errors of these dose estimates ranged from 0.52 to 1.14 Gy^2 and from 8.1 to 33.3%^{2} for the fraction of cells irradiated. Partial body dose estimation has been incorporated into ADCI software (https://adciwiki.cytognomix.com/doku.php?id=main:partialbodyestimatedose).
Conclusions: Automated DCA can differentiate whole- from partial-body radiation exposures and provides timely quantification of estimated whole-body equivalent dose. Complete, integrated automation of the DCA that includes partial body dose estimation will be more expeditious and portable when compared with traditional approaches

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