Appendix 1: Calculation of Radiation Dose

Abdomen and Chest X-Ray doses

A download was made of all children (0 to <18 years) who underwent a single plain film (abdomen or chest X-ray) examination between April 2015 and May 2016 at our centre. The dose indices recorded by radiographers on Computerised Radiology Information System (CRIS) is dose area product (DAP). This result was collected. Outliers were removed by calculating the interquartile range (IQR) and excluding any data that fell less than 1.5x the IQR below the first quartile, or greater than 1.5x the IQR above the third quartile. Consequently the mean DAP value for an abdomen and chest X-ray was calculated as per the specified age range.

Reference was made to NRPB-R279.[1] This report provides conversion coefficients for the deviation of effective dose from DAP values taken during commonly performed paediatric radiographs. The coefficients have been calculated using *Monte Carlo* mathematical simulations on a series of mathematical phantoms that represent 0, 1, 5, 10 and 15 year old children. As a result the coefficients take account of the patient size and the increased proximity of organs just outside the primary X-ray relative to that of an adult.

For example for an abdominal x-ray in a 15-18 year old patient the mean DAP for a plain film was 50cGy.cm^{2}. Based on the performance of the X-ray sets currently in use in the Trust and the AP technique routinely used, the conversion coefficient is 0.225mSv.Gy^{-1}.cm^{-2}. Therefore the estimated effective dose is (50/100)x0.225=0.11mSv.

Computerised Tomography (CT) Scan Dose

A download was made from CRIS for all children (0 to <18 years) who underwent either (or combinations of) CT Chest, CT abdomen, CT Pelvis and CT sinus examinations between April 2012 and May 2016**.** The dose indices recorded by the radiographers on CRIS is the Dose Length Product (DLP) measured in mGy.cm. This takes into account the dose per slice and the length of the scan and stochastic risk for an exam type that covers the same anatomical region. This was recorded.

During the period of data collection our unit has had four scanners; three Siemens Somatom Definition AS+ and one Siemens Somatom Definition Flash. These scanners are near identical (the flash having two X-ray tubes and 2 detector arrays) and as a result have been set up so that the same scan protocols for any anatomical programme. The scanners have the facility for iterative reconstruction, adaptive collimation, modulated tube current and kV.

The Dose Length Product (DLP) data was then subdivided into appropriate age ranges at the time of the examination and the mean value was calculated. To convert the mean DLP into an effective dose, it is standard to use a conversion factor. The conversion factor needs to takes account of the dose, anatomical region scanned and the radiosensitivity of the organs exposed. In order to calculate this, the ImPACT Dosimetry software[2] was utilised and values established specific to the anatomy exposed for each specified exam protocol (i.e. Chest, Abdomen & Pelvis). The units of the correction factor are ($mSv.mGy^{-1}.cm^{-1}$). ImPACT utilises the National Radiological Protection Board (NRPB) Monte Carlo simulation data sets. It also takes account of the most recent tissue weighting factors published in by the International Commission of Radiological Protection Report 103.[3]

Multiplying the DLP by the calculated conversion factor would give an estimated effective dose for an adult. However additional correction needs to be introduced for paediatrics to account for different habitus size for different age ranges. The ImPACT software[2] provides corrections to account for this for Head & Neck, Chest and Abdomen & Pelvis scans.

Example: For a 5-10 year old undergoing an Abdomen & Pelvis CT scan the mean DLP was estimated to equal 120mGy.cm. The conversion factor for this region of the body was $0.015 mSv.mGy^{-1}cm^{-1}$. *The correction for patient size for an Abdomen and Pelvis scan was 1.6 (worst case scenario based on a possible range from 1.2-1.6). Therefore the estimated effective dose =* $120 \times 0.015 \times 1.6 \approx 2.9 mSv$

Fluoroscopy (port-a-cath insertion)

Radiology Physics were provided with the details of 21 paediatric patients with cystic fibrosis and who underwent port-a-cath insertions using fluoroscopy at our centre. Using the patients ID numbers it was possible using both RIS and PACS to determine the patients age at the time of the examination, the total DAP (Dose Area Product) for the procedure and the X-ray equipment used.

Using NRPB-R279[1] conversion factors can be derived that are based on anatomy (chest) and patient age. This value can be then multiplied by the DAP value to produce an effective dose. This is very similar to the method used in assessing abdomen and chest x-ray doses.

References

[1] D. Hart, D. G. Jones, B. F. Wall. Coefficients for Estimating Effective Doses from paediatric X-ray examinations. National Radiological Protection Board 1996.

[2] CTDosimetry_1.0.4.xls, Impact CT Patient Dosimetry Calculator Version 1.0.4, IMPACT 2011

[3] The 2007 Recommendations of the International Commission on Radiological Protection (IRCP). Annals of the IRCP – Publication 103. Editor: J Valentin.