CALCULATION OF SHIELDING FOR CT ROOMS FROM PATIENT DOSE DATA

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Scattered radiation levels are required for assessment of shielding for medical X-ray facilities. Scatter air kerma (K_s) around CT scanners can potentially be estimated from the patient dose parameter dose length product (DLP) using an equation of the form: $K_s = S_{CT} \times DLP$. Scatter air kerma levels have been measured to determine values of scatter factors (SCT) for head and body CT scans, and to allow shielding provided by the CT gantry to be taken into account.

METHODS

Scatter air kerma generated by scans of anatomical phantoms have been measured for four CT scanners (GE Lightspeed 16, Toshiba Aquilion 64, Philips MX8000 and Siemens Somatom 64). Measurements were made at 1 m from the isocentres using a Radcal 180 cc ionisation chamber with a 9010 dosemeter, as a function of angle (Figure 1). The angles were determined from distances to reference lines on the gantry and couch. Measurements were made of the decline in air kerma with distance to confirm that an inverse square law adjustment could be applied at greater distances.

RESULTS

Measurements of scatter air kerma per unit DLP are plotted against angle to the scan plane for 120 kV scans of the body in Figure 2. The 0° position corresponds to the scan plane through the isocentre and gantry, with negative angles for the front of the gantry and positive ones for the rear. Peak air kerma values were 0.30 - 0.36 μGy (mGy cm)$^{-1}$ towards the front and 0.22 - 0.28 μGy (mGy cm)$^{-1}$ to the rear. Scatter air kerma values for scans of the head peaked at 0.08 - 0.13 μGy (mGy cm)$^{-1}$. Isodose plots showing scatter distributions generated from the data for a body and a head scan are shown in Figure 3. Ratios of factors for 140 kV and 120 kV for individual scanners were 1.03±0.4, so factors independent of tube potential are recommended.

DISCUSSION

Values for S_{CT} giving the scatter air kerma per unit DLP at 1 m from the isocentre for different positions around the gantry were derived from the data collected and are summarised in Table 1. Three scatter factors are given for body scans, the largest for the front of the gantry (Figure 4), and the lowest for areas shielded by the gantry (Figure 5).

Table 1 Values of S_{CT} for scatter air kerma at 1 m from the isocentre for various angular positions.

Scan	Position with respect to gantry	Angular range (fig 1 and 2)	S_{CT} μGy (mGy cm)$^{-1}$
Trunk	front	-90° to -20°	0.36
Trunk	rear	+40° to +90°	0.3
Trunk	gantry	-20° to +40°	0.04
Head	front / rear	-90° to -20°, +40° to +90°	0.14
Head	gantry	-20° to +40°	0.014

The annual workload in terms of DLP for the body and head can be combined with the scatter factors to estimate scatter levels in different directions. Typical values of workload determined from surveys of 38 hospitals are given in Table 2. Shielding requirements can be derived by comparing the calculated scatter air kerma with an annual dose constraint (300 μSv for the UK) to determine the required transmission of the protection.

Table 2 Values of CT scanner workload from survey of 38 hospitals

	Mean DLP per exam (mGy cm)	Mean total DLP per annum (Gy cm)	3rd Quartile total DLP per annum (Gy cm)	Range of DLPs per annum (Gy cm)
Body	850	1,900	3,400	70 – 5,000
Head	870	1,300	2,500	50 – 3,600
Total	850	3,200	5,500	800 – 8,600

CONCLUSIONS

Factors S_{CT} linking scatter air kerma to DLP have been derived from detailed studies of CT scanners from four manufacturers. A methodology using several factors for different angular positions enables scatter levels around CT scanners to be predicted from workload data. The method allows gantry shielding to be taken into account.

Fig. 1 Experimental arrangement used for measurements

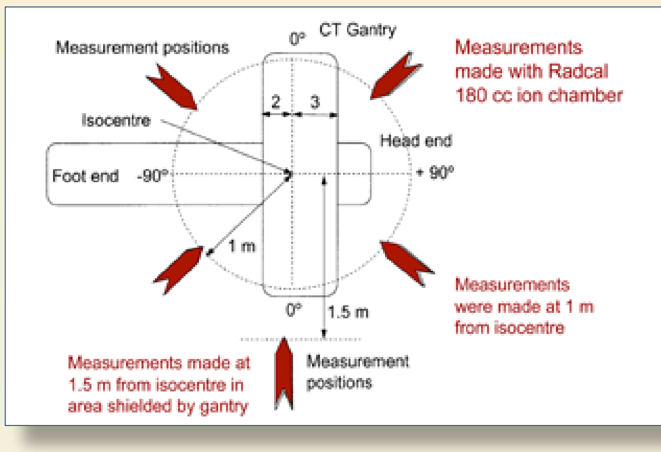


Fig. 2 Measurements of scatter air kerma as a function of angle for CT body scans

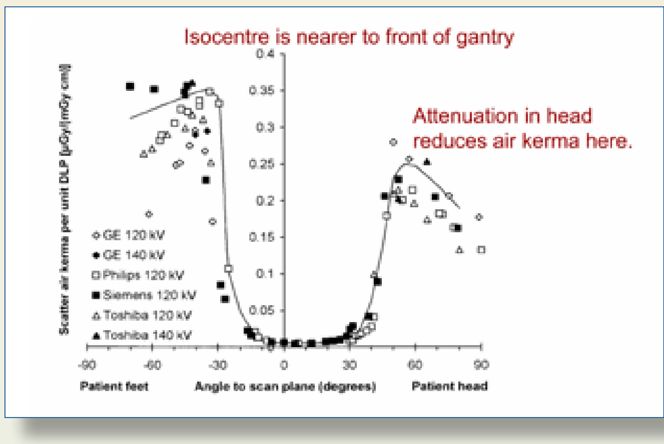


Fig. 3 Isodose plots of scatter air kerma derived from data

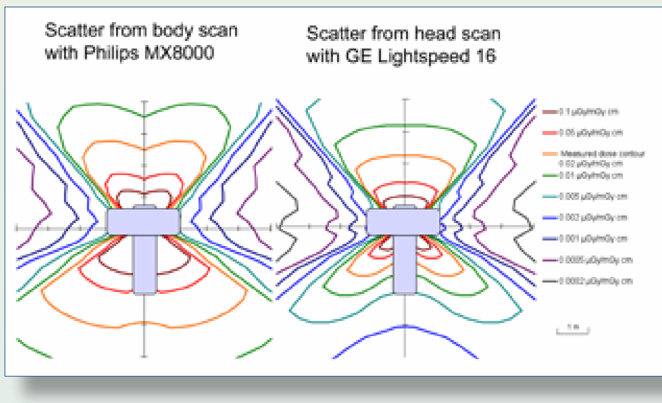


Fig. 4 Illustration of dependence of S_{CT} used for calculating scatter air kerma for body scans on angle

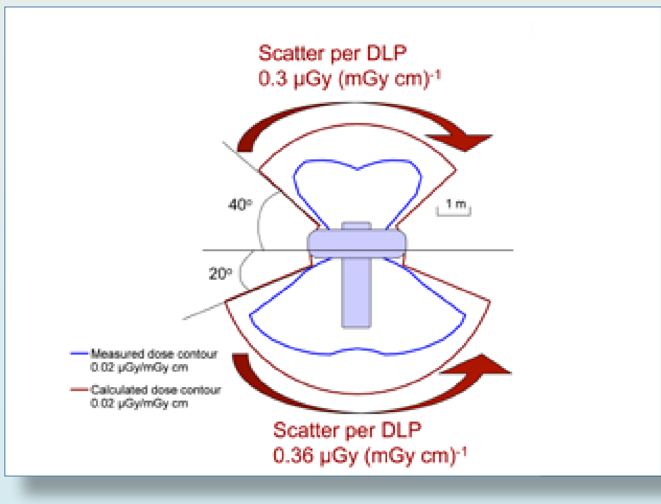
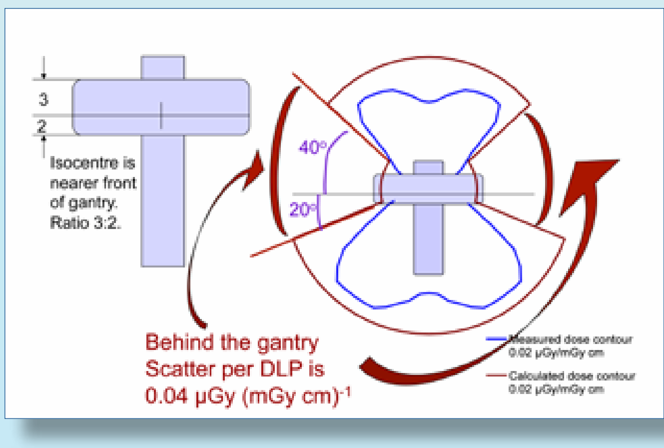


Fig. 5 Factors S_{CT} used to allow for shielding by CT gantry



References

Wallace H, Martin C J, Sutton D G, Peet D and Williams J R (2012) Establishment of scatter factors for use in shielding calculations and risk assessment for computed tomography facilities. J. Rad. Prot. 32(2).