Comparison of Effective Doses for Chest Examinations between Different Sites in Europe

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Introduction

- The quantity of radiation dose to the patient can vary between different sites.[1]
- One of the reasons for this is due to differences in image processing techniques.[2]
- In the UK The Ionising Radiation (Medical Exposure) Regulations (IRMER) based upon EC Directive 97/43 EURATOM states that doses to patients should be kept as low as reasonably acheivable[3] and that clinical audits should occur.[3]
- Effective dose can be of value for comparing the relative doses from different diagnostic procedures and for comparing the use of similar technologies and procedures in different hospitals and countries as well as the use of different technologies for the same medical examination.[4]

Purpose

- Dose data has been collected from 5 different departments with 1 site supplying data from 2 different rooms. Air Entrance Kerma has been determined using various methods for each site.

- A previous study on this data set assessed skin entrance doses using Entrance Surface Dose (ESD) calculations and Dose Area Product (DAP) results.[5]

- The aim of the current study on this data set is to explore the possibility of calculating effective dose and how this quantity can be applied to comparing the risk to patients from different hospitals.

Effective Dose Calculation

- Effective dose was defined as a quantity to relate the probability of health detriment due to stochastic effects from exposure to low doses of ionising radiation.

- Effective dose has been determined as sex and age averaged values and therefore the effective dose 'cannot be used for the assessment of individual risk'[4]

- For this study effective dose has been calculated using CALDose_X , which uses conversion coefficients to calculate the absorbed dose to organs and tissues calculated using the FAX06 and MAX06 phantoms.[6]

- These provide separately calculated weighted male and weighted whole body doses which represent the sex-specific contributions to the effective dose. [6]

- Entrance surface dose has been used as the normalisation quantity.

Materials and Methods

- 527 records have been collected from radiology departments across Europe (Fulda, Liverpool, Nicosia, Passau and Sofia). The number of records recorded from each site ranges from 39 to 185.

- Methods for measuring air kerma include using an air kerma meter, calculation from exposure factors, dividing the DAP by the field size and by using TLD badges. Also DAP, Patient gender, age, height and weight, field size and exposure factors have been recorded.

- Entrance Surface Dose has been calculated by using a backscatter factor.[7] Results have been compared to UK and Europe reference levels.

- Calculation of gender specific weighted whole body dose using either the air entrance kerma or DAP as a normalisation factor has been performed by CALX_Dose [http://www.grupodoin.com]. As it is time consuming to process all records only those with the most common exposure factors for each site have been calculated using the average air kerma for selected records as the normalisation factor. CaLX_Dose does not calculate dose for kVs above 120 therefore it has been necessary to process records with high kV's as120. As filtration is unknown 2.5mmAl has been used for calculations.

Results

Comparing calculated ESD to UK NDRL 5 out of 6 rooms were within the UK NDRL. (Table 1) and there was an overall increase in ESD with respect to patient body mass index. (Figure 1)

Site	N	Mean ESD (mGy)	Mean kV	Mean mAs
A	46	0.20	125.00	3.78
B	185	0.06	125.00	1.44
C (Digital)	62	0.08	125.00	1.49
C (Film Screen)	76	0.46	69.89	18.83
D	39	0.18	110.26	3.02
E	119	0.20	150.00	2.29
All	527	0.17	121.61	4.47

Table 1. Calculated mean Entrance Surface Dose (ESD),mAs and kV values for sites A to E

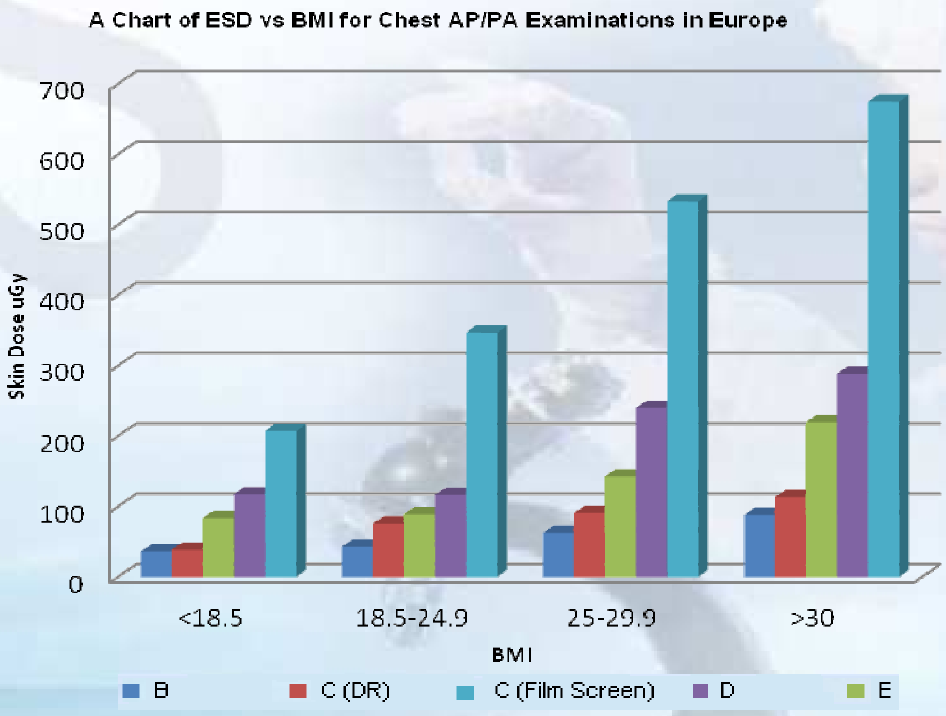

Figure 1. A chart of BMI against Entrance Surface Dose for sites B to E. Site A did not record BMI

Male

Site	kV	mAs	N	ESD (mGy)	Mode Whole body weighted dose	Minimum Whole Body Weighted Dose	Maximum Whole Body Weighted Dose
A	125	3	10	0.18	0.02	0.02	0.02
B	125	1	51	0.06	0.01	0.01	0.04
C (Digital)	125	1	20	0.08	0.01	0.01	0.03
C (Film Screen)	75	30	5	0.87	0.06	0.01	0.10
D	110	2	9	0.17	0.02	0.01	0.08
E	150	2	43	0.2	0.03	0.01	0.11

Table 2. Calculated male whole body weighted dose calculated from the mode factors for sites A to E. Also whole body dose using the minimum and maximum factors has been calculated. kV and mAs are modal values.

Female

Site	kV	mAs	N	ESD (mGy)	Mode Whole body weighted dose	Minimum Whole Body Weighted Dose	Maximum Whole Body Weighted Dose
A	125	3	9	0.17	0.03	0.02	0.08
B	125	1	67	0.05	0.01	0.01	0.02
C (Digital)	125	2	15	0.11	0.02	0.00	0.02
C (Film Screen)	75	15	6*	0.41	0.05	0.01	0.09
D	110	2	6*	0.13	0.02	0.02	0.1
E	150	2	26	0.18	0.03	0.02	0.13

Table 3. Calculated female whole body weighted dose calculated from the mode factors for sites A to E. Also whole body dose using the minimum and maximum factors has been calculated. kV and mAs are modal values.

Conclusions

- The highest calculated mode whole body weighted dose for both males and females was from the site employing a film screen technique and also a low kV method.

- This site was also the only site where the mean calculated entrance surface dose exceeded the UK NDRL.

- Apart from the site using the film screen technique the weighted whole body dose ranges from 0.01 to 0.03mGy. Results for males and females are similar.

- The data set contains good patient information for analysis of dose against size and gender. As the majority of sites have doses collected by at least 2 methods a further comparison of 2 methods would be beneficial and additional time to process more records through Cal Dose would be useful to the study.

Uncertainties

- The MAX06 and FAX06 phantoms are based on a standard male and female adult patient. It does not take into account the BMI or age of the patient. The next version of CALDose_X will be updated with Conversion Coefficients for derived male and female phantoms.[6]

- Calculations performed by CALDose_X assume a standard field size of 35x40cm for chest examinations. Average field sizes for the data included in this study are 38x38cm

- Calculations use a FSD of 160cm and the average FSD for data that is part of this study is 145cm. Differences of up to 10% cause changes in the cc's of less than 10%, however organs near the edge of the beam may fall be found inside or outside the beam after a change in FSD.[6]

- The position of the field on the body is the quantity which has the strongest effect on the absorbed dose of an organ or tissue. There are inevitable variations that occur in practise from hospital to hospital and patient to patient.[8]

- CALDose_X can perform calculations for kV's up to 120. Where examinations have used higher than this whole body dose has been calculated using 120.

- Results are displayed to two decimal places. For chest exams where results are typically in the region of 0.01-0.03 mGy, being able to say the results displayed to a higher number of decimal places would be beneficial for comparison.

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