A STUDY ON THE ANNUAL EQUIVALENT DOSES RECEIVED BY CARDIOLOGISTS IN A UK HOSPITAL

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Abstract

A dose assessment study was carried out to determine the likely annual equivalent doses received by various parts of a cardiologist's body. High sensitivity GR-200 thermoluminescent dosemeters were attached to cardiologists' foreheads, little fingers, wrists, elbows, knees and ankles. Three common cardiology procedures were investigated, namely, percutaneous transluminal coronary angioplasty (PTCA), permanent pacemaker insertion (PPM) and left heart catheterisation (LHC). Dose monitoring was done on a case-by-case basis. Data on ten cases of each procedure were gathered. The projected annual equivalent doses were computed by averaging the ten doses measured at each site for each examination type and finding out from the cardiologists how many cases of PTCA, PPM and LHC they do in a year. Results in this study show that for the lens of the eye, the projected annual equivalent dose is below 10 mSv and for the other body parts, it is below 100 mSv per year. The study demonstrated that the methodology used can help to optimise radiation protection in diagnostic radiology.

1. Introduction

For workers who are occupationally exposed to ionising radiations, article 9 of Council Directive 96/29 Euratom [1] states an annual equivalent dose limit of 150 mSv for the lens of the eye and 500 mSv for hands, forearms, feet and ankles. United Kingdom has adopted these values in the Ionising Radiations Regulations 1999 [2]. Paragraph 1(c) of Schedule 4 of Ionising Radiations Regulations 1999 states, "the limit on equivalent dose for the hands, forearms, feet and ankles shall be 500 mSv in a calendar year". For the first time in UK legislation, specific parts of the limbs are subject to a dose limit, hence there is a need to make some dose assessment to these body parts. In diagnostic radiology, the group of workers that is most likely to receive the highest doses are people who are involved in interventional work. Cardiologists are one example.

A study was carried out to (i) assess scattered doses received by different parts of a cardiologist's body, (ii) estimate the likely annual equivalent doses that the various body parts would receive and (iii) establish if additional protective measures are needed.

The dose received by different parts of the cardiologist's body depends on many factors, such as the examination procedure, the patient and complexity of the case, the skill of the cardiologist, the x-ray image intensifier system, the protective equipment used and the position of the cardiologist in relation to the x-ray tube and patient. Due to this interplay of contributing factors and for practical reasons, dose assessment was made per individual case using small, high sensitivity thermoluminescent dosemeters (TLD) that can be attached on or close to the body parts under study. Previous researchers [3] have studied exposure to operating staff in cardiology using thermoluminescence dosimetry but only five cases of cardiac catheterization were investigated. The current study investigated three common cardiology procedures and data from many more cases were collected.

2. Materials and methods

The study was conducted in a well-established cardiology department of a large teaching hospital. Seven cardiologists were involved, comprising one consultant and six specialist registrars in various years of their training. Three common cardiological procedures were

selected for this study: percutaneous transluminal coronary angioplasty (PTCA), permanent pacemaker insertion (PPM) and left heart catheterisation (LHC). Data on ten cases of each of these examinations were collected. Dose monitoring was done on a case-by-case basis. The examinations were carried out in three cardiac laboratories equipped with C-arm x-ray image intensifier units that are less than 5 years old (table 1). Each unit has Diamentor transmission ionisation chamber (Diamentor, PTW, Freiburg, Germany) attached to the head of the x-ray tube.

Table 1. Specification of the x-ray equipment in the three cardiac laboratories

	Laboratory 1	Laboratory 2	Laboratory 3
Manufacturer/ Model	Philips Integris V3000	Siemens Coroskop Classic	Philips Integris H3000
Generator	Optimus CP	Polydoros IS/C	Optimus M2000
Field sizes (cm)	38, 31, 25, 20, 17	23, 17, 13	23, 18, 13
Copper pre-filtration	None	Fluoroscopy and Acquisition*	Fluoroscopy

*No copper filter in acquisition mode if patient size is greater than 25 cm.

Individually calibrated LiF: Cu, Mg, P dosemeters were used to monitor doses at various sites of the cardiologist's body. They were GR-200 chip dosemeters, also called TLD-100H chips (3mm x 3mm x 1mm) from Harshaw Bicron/NE-Technology (BICRON-NE, Solon, OH, USA). These TLDs have high sensitivity and are able to detect doses down to 1μSv above background. They are commonly known as Chinese TLDs. The TLDs were sealed in small black plastic sachets and attached to the forehead, the fifth digit of each hand and the left and right wrists, elbows, knees and ankles. The TLD sachets were taped to the body part using micropore tape except for the forehead where a headband was used and the wrists where wrist bands were used. The TLD at the forehead was aimed at monitoring dose to the eye. The finger TLDs were taped at the distal end of the finger but not at the fingertip so that the dexterity and comfort of the cardiologist were not affected. Two unexposed TLDs were used as control dosemeters. At the end of each examination, all TLDs were removed and read out in a Toledo 654 reader (D. A. Pitman Ltd.). They were annealed in an oven at 240° for 15 minutes followed by rapid cooling to room temperature before re-use.

In addition to the GR-200 dosemeters worn for the purpose of this study, the cardiologists also wore their monthly dosemeters comprising a body film badge, a collar film badge, a headband containing a TLD-100 dosemeter and a wrist band containing a TLD-100 dosemeter. They all wore lead aprons which had 0.5mm lead (Pb) at the front and 0.35mm Pb at the back, a 0.5 mm Pb thyroid shield and no Pb glasses. During PTCA and LH catheterisation procedures, they used a Brompton screen for protection. The screen has a cut-out in the Pb glass and has Pb drapes at the bottom. No protective screen was used for pacemaker insertion procedures. The projected annual equivalent doses were computed by averaging the ten doses measured at each site for each examination type and finding out from the cardiologists how many cases of PTCA, PPM and LHC they do in a year. These three examinations together comprise the majority of their workload. In order to be conservative, data from a cardiologist who had the highest caseload were used.

3. Results and Discussion

The results are presented in figures 1 and 2.

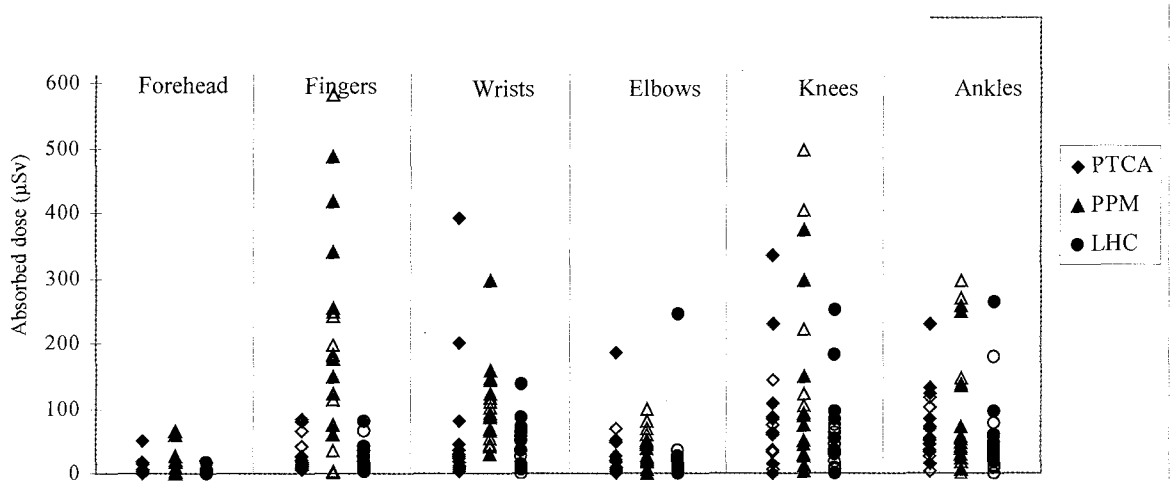

Figure 1. Distribution of individual doses measured in the study. Solid markers are doses measured on the left body part and open markers are doses measured on the right body part

Figure 1 shows all the individual doses measured in the study. For PTCA which is marked by diamond markers, the highest doses are found in the wrists and knees. The left wrist and left knee get a higher dose than the right side. The left is marked by solid diamonds. During PTCA, the cardiologist stands on the right side of the patient and it is the left side of the cardiologist that is closer to the x-ray tube, hence the higher dose. For PPM, the fingers and knees get the highest doses. Many of these doses are also much higher than those received during PTCA and LHC. This is because the cardiologists do not use any protective screen during PPM. In PPM, it is the right side of the cardiologist that gets the higher dose, marked by open triangles. This is because during PPM, the cardiologist stands on the left side of the patient and it is the right side of the cardiologist that is closer to the tube, hence the right side tends to get the higher doses. For LHC, the knees and ankles get the highest doses. Like PTCA, the left side gets a higher dose than the right side. The cardiologist stands on the right side of the patient and it is the left side of the cardiologist that is closer to the tube, hence the higher doses marked by the solid circles. In general, doses received during LHC are lower than those received during PTCA which is a more complicated procedure.

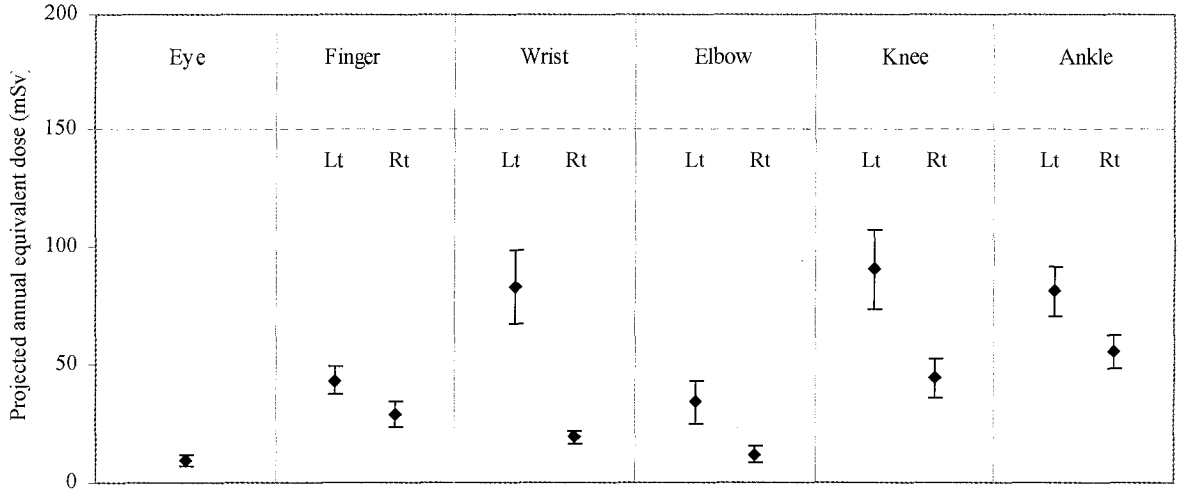

Figure 2. Projected annual equivalent doses for a senior cardiology specialist registrar

Figure 2 shows the projected annual doses and standard error. It also marks the 150 mSv level which is the three-tenths UK annual equivalent dose limit for the various body parts and the full annual dose limit for the lens of the eye. All doses are well below the 150 mSv line. Projected annual equivalent dose to the lens of the eye is below 10mSv and the spread is small. For the other body parts, the projected annual equivalent dose is less than 100 mSv, even taking the spread in dose into account. In each case, the left hand side gets more dose than the right hand side because except for PPMs, it is the left side of the cardiologist's body that is closer to the tube. Left wrist, left knee and left ankle get the highest doses.

4. Conclusions

The use of high sensitivity GR-200 thermoluminescent dosemeters had enabled individual doses at various sites of a cardiologist's body to be measured on a case-by-case basis. Three common cardiology procedures were investigated, namely, PTCA, PPM and LHC. Three conclusions can be drawn from this study.

(1) Overall, doses on the left side of a cardiologist's body are higher than doses on the right. This is due to the fact that for PTCA and LHC procedures, the cardiologist stands on the right side of the patient and it is the left side of the cardiologist's body that is nearer to the x-ray tube.
(2) Results from this study show that the projected annual equivalent doses are well within three-tenths of any UK annual dose limit. Therefore there is no justification for designating cardiologists in the establishment concerned as classified workers on the basis of their equivalent doses. Routine personal monitoring shows that cardiologists' body doses are also well below the three-tenths limit.
(3) Dose monitoring at the additional sites is not routinely required under current circumstances.
(4) From this study, two recommendations are proposed. Firstly from the point of view of radiation protection, routine monitoring of wrist doses should be done on the left wrist. Secondly, the addition of lead curtains to beds in angiography laboratories should be considered. This will greatly reduce doses to knees and ankles. On-going training in radiation protection is necessary in helping radiation workers to keep their doses as low as reasonably achievable.

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