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Staff dose assessment from coronary angiography

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► ***Original article***

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ABSTRACT

Background: Interventional cardiology procedures such as coronary angiography (CA) and percutaneous transluminal coronary angiography (PTCA) has been increased recent years. The purpose of this study was to measurement of effective dose to cardiology staffs who operate near the patient and are exposed to non-uniform radiation field due to patient scattered radiation. ***Materials and Methods***: This study was performed in angiography department of Fatemeh Zahra Hospital as specialized hospital of heart in Sari, the Northern city of Iran for two months and 687 interventional cardiology procedures were studied. Doses were recorded with thermoluminescence dosimeter (TLD) for 10 cardiologists, 10 nurses and 1 radiology technologist and the effective dose were estimate using the Niklason algorithm. ***Results***: Mean annual effective dose (µSv) to cardiologist and nurses and radiology technologist from interventional cardiology procedures were 535.57 (68.6 – 1984.8) µSv and 153.7 (59.5 – 277.2) µSv respectively. Mean effective dose (µSv) per interventional cardiology procedure for cardiologist and nurses and radiology technologist were 2.123 and 0.274 µSv respectively. ***Conclusion***: The results indicate large variation in radiation exposure between staffs. No correlation was found between the number of procedures and effective dose. None of the annual effective dose appear to exceed the annual effective dose limit of 20 mSv.

Keywords: *Thermoluminescent dosimeter, Staff dose, coronary angiography* .

INTRODUCTION

In recent years the number of cardiac and interventional X-ray exams has been increased. The staff operates near the patient and is exposed to non-uniform radiation field due to patient scattered radiation. Interventional cardiology procedures are the typical operations in special heart ward. Fluoroscopy systems are used in coronary angiography procedures and exposure time in this procedure is high thus personnel doses in coronary angiography department are a topic of major concern in occupational radiation protection. Staffs are divided into three groups in angiography departments as cardiologists, nurses and radiology technologists. Since outputs of X-ray generators in the coronary angiography departments vary and cardiologists have individual skills therefore examination times and operation techniques by department teams are different and every interventional cardiology departments must be detected individually. Angiography workers may receive over a period relatively high radiation dose [1-3]. Effective dose is a quantity that is related to the stochastic radiation risk and radiation dose to workers usually is expressed by this quantity [4]. There are two method in Interventional cardiology

procedures: coronary angiography (CA) for diagnosis of coronary branch blocking and percutaneous transluminal coronary angiography (PTCA) for treatment of involved coronary vessels. Many articles have measured the effective dose to staff in coronary angiography and reported variety of values. Methods of measures are different as well. Corresponding to SENTINEL European consortium report [5], staff dose in coronary angiography department ranges from 0.5 to 6 mSv with 1.3 mSv median effective dose, and another study in Norway on cardiologist showed it to be 5 mSv (range about 1 to 11 mSv) [6]. Coronary angiography examinations are widely performed in Iranian hospitals but unfortunately staff dose assessment has rarely performed. Fatemeh Zahra hospital in Sari-Iran is one of the important therapeutic centers in which cardiology department accepts many patients for cardiac study for diagnostic and therapeutic. Therefore we decided to estimate effective dose levels in workers in angiography ward because we hypothesized these groups received high dose levels. We measured the effective dose of cardiologists, nurses and technologist.

MATERIALS AND METHODS

This study was performed in angiography department of Fatemeh Zahra hospital which is an specialized hospital of heart in Sari the Northern city of Iran. This center has 10 cardiologists and 10 nurses and 1 radiology technician. In this center, two angiography rooms are active. In room 1 a Simence C-arm fluoroscope system 1617450G2175 model is set and in room 2 is geared with Simence C-arm fluoroscope system 10092591 models. In most research to measure the effective dose, thermoluminescent dosimeter (TLD) has been used [7,8]. We used TLD (LiF-MCP) to estimate dose. The TLDs used were chips (3×3×1 mm^3). The dosimeters were sealed in small plastic envelope. Before irradiation, TLDs were annealed at temperature of 240 ºC for 10 minutes. The dosimeters were read by a Harshaw 3500 TLD reader. For any of the staffs one measurement has been done in thyroid level, over collar and the other was in waist level, under the apron. This study was performed in two months [6]. In this study for calculation of effective dose, Niklason algorithm [9] was used. According to this algorithm, effective dose was determined by the relationship1 or 2:

$$(1)\ E= 0.06\ (H_O - H_U) + H_U$$

$$(2)\ E= 0.02\ (H_O - H_U) + H_U$$

In these equations Ho and Hu are over collar and under apron doses respectively. Relationship 1 stands for cases where staffs do not use the collar and 2 for cases that collars are used. For elimination of background radiation and calculation of net dose to staff from scatter radiation of each examination, one measurement was performed in interventional cardiology department [6]. For measurement of annual effective dose, doses to staffs per examination were multiplied by number of annual examination.

RESULTS

Mean annual number of patient in Ftemeh Zahra hospital is 4388. Approximately 10% of this number is related to PTCA examination. Range of cardiologists, nurses and radiology technologist annual effective dose are shown in table 4.

Table 2 and 3 show effective dose to the cardiologist and nurses and technologists versus number of procedure, respectively.

This study was performed in two months and 687 cardiac angiography examinations were studied. There were 10 cardiologists, 10 nurses and 1 radiology technologist in interventional cardiology department of Fatemh Zahra hospital. Cumulative dose in thyroid (over collar) and abdomen (under apron) areas were measured and effective dose per examination were calculated according to Nikleson algorithm. Effective dose per examination to target groups are shown in table 1.

Table 1. Effective dose(μSv)per angiography examination to angiography staffs in Fatemeh Zahra Hospital.

Target groups	Mean	Median	Range
Cardiologist	2.123	0.700	0.093-12.722
Nurses and tech.	0.274	0.26	0.113- 0.443

Tables 2 and 3 show effective dose to the cardiologist and nurses and technologists versus number of procedure, respectively.

Mean annual number of patient in Ftemeh Zahra hospital is 4388. Approximately 10% of this number is related to PTCA examination. Range of cardiologists, nurses and radiology technologist annual effective dose are shown in table 4.

DISCUSSION

The results indicate large variation in radiation exposure between staffs. This is probably due to different factors such as complexity of the procedures performed, work technique, equipment, shielding, and perhaps the most important, the experience and skills of the operator [10-15]. Effective doses to nurses and technologist are directly depended to the cardiologists' skills because examination time as an important factor is related to experience and skill of cardiologists. Effective doses to cardiologists are more than three times nurses and technologist effective dose. Nearer positions of cardiologist to X-ray source than nurses and technologist is one of the most important factors for higher cardiologist effective dose.

No correlation was found between the number of procedures and effective dose.

Higher effective dose to the cardiologist (330.8 μSv) is related to numbers lower angiography procedure (26 procedures) (table 2). Nurse with 13μSv effective dose (N1) has 29 procedures; whereas nurse with 11.4 μSv effective dose (N6) has 101 procedures (table 3). The mean annual effective dose of cardiologists are 0.5 mSv (range: 0.07 – 2) and for nurses and technologist are 0.2 mSv (range: 0.06 – 0.3) . Study of Nicol [16] shows that the dose to cardiologist is 2mSv (range: 0.4 to 10 mSv) which is comparable with the results of our project (range:0.7 to 2 mSv). Padovani study shows that cardiologists dose per examination is between 0.5 to 18.8 μSv While in our project this quantity is between 0.1 to 13 μSv [17]. Cumulative professional radiological exposure is associated with a non-negligible Lifetime attributable risk of cancer for the most exposed contemporary cardiac catheterization laboratory staff [18]. The potential risk of malignancy was calculated for each procedure using the value 0.05 Sv^{-1}, i.e. a risk of inducing fatal cancer following a 1 mSv

Table2. Effective dose (μSv) to cardiologists versus number of procedures.

	Cardiologist									
	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Number of procedure	26	27	30	48	50	68	82	103	123	157
Effective dose	330.8	107.1	68.6	32.9	14.5	19.1	61.6	143.3	11.4	103.8

Table 3. Effective dose (μSv) to nurses and technologist versus number of procedures.

	Nurses and technologist										
	N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	Tech.
Number of procedure	29	80	97	99	101	101	102	109	110	133	129
Effective dose	12.9	20.8	14.3	38.5	21.7	11.4	42.7	13.8	46.3	39.8	24.3

Table 4. Annual effective dose (μSv) to cardiologists and nurses in Fatemeh Zahra Hospital.

Staffs	Mean	Median	Range
Cardiologist	535.57	780.8	68.6 – 1984.8
Nurses and technologist	153.7	130.7	59.5 – 277.2

whole body exposure of one in 20,000 for apopulation of all ages [16].

Our project shows that none of the annual effective dose appears to exceed the annual effective dose limit of 20 mSv [6]. Permissible annual number of angiography procedure of cardiologist is calculated with take the limit of annual effective dose (20 mSv) and effective dose per procedure (table 1).

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