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Evaluation of Patient Dose in Interventional Cardiology.

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ABSTRACT

In diagnosis and treatment of coronary artery diseases performed with x-ray, numerous images have to be taken from this area of the body which causes an increase in patient's radiation dose. The objectives of this study are the measurement of Dose Area Product (DAP) and fluoroscopy time. Furthermore it evaluates the correlation between DAP and fluoroscopy time, DAP and Body Mass Index (BMI), and fluoroscopy time and BMI. In this study, 119 patients were investigated and among these patients, 43 patients underwent Percutaneous Transluminal Coronary Angioplasty (PTCA) and 76 patients underwent Coronary Angiography (CA). The mean values of DAP for CA and PTCA were respectively 17.99 and 55.49 Gy.cm2 in women and 18.87 and 51.74 Gy.cm2 in men. Strong correlation for CA ($p < 0.001$) and PTCA ($p < 0.02$) between DAP and fluoroscopy time was observed. By comparing the mean values of DAP and the fluoroscopy time obtained in this study with other studies carried out in the field, it is revealed that these values are lower than the outcomes of previous studies. This difference was due to the high knowledge and experience of the cardiologist and the suitable pulse rate (15 frame per second) which was used in this study.

Keywords: Patient Dose, Coronary Angiography, Dose Area Product, Fluoroscopy Time.

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INTRODUCTION

Cardiovascular diseases (CVDs) have been recognized as one of the main causes of death in the world. According to the World Health Organization (WHO) in 2008, 17.3 million people die annually from these diseases. Among these, the coronary artery disease with 7.3 million deaths each year has the largest population. This value is predicted to reach 23.3 million by 2030 [1]. In Iran, CVDs are a leading cause of death and disability and comprises 50 percent of deaths each year [2]. This issue indicates the necessity of diagnosis and effective treatment in people who are suffering from these diseases. Today, the development of X-ray diagnostic applications has led the angiography of the coronary arteries to be one of the most accurate diagnostic methods by the cardiologists [3, 4].

The coronary arteries changes are being imaged using X-ray and guiding catheter and injecting contrastive materials into the vessels; In other words the patient is being angiographed. When the coronary arteries are troubled or blocked, percutaneous transluminal coronary angioplasty (PTCA) method can be applied to solve this problem. To this end, first of all a balloon-tipped catheter is placed in the congested place, and after inflation of the balloon, the blood flow re-establishes. In order to keep the coronary artery open, a stent is placed in the desired location. This method is common throughout the world [5, 6]. During CA and PTCA procedures many images have to be taken from the area which causes an increase in patient's radiation dose. With increasing the rate of radiation dose, the contingency of stochastic effects of radiation (cancer) increases correspondingly. Accordingly if the radiation dose exceeds 2 Gy, there will be deterministic effects [7, 8]. The Patient's radiation dose changes under various circumstances such as the structure of angiographic system, method of protecting x ray tube, fluoroscopy time and BMI [9, 10].

The physical quantity of DAP is an indirect technique for measuring the patient's dose, which can be attained by interference of effective factors in dose such as distance of x-ray tube from skin and collimator settings using the factors that are effective on radiation dose. If the size of irradiated surface area is known, the skin dose can be obtained by DAP value; Furthermore the DAP is also an acceptable method to compare the patients' dose [11, 12].

Controlling the patient's exposure is the main task of the cardiologists and radiology technologists which occurs with reducing the exposure time. Having knowledge about the level of patient's exposure in the interventional radiology can help significantly to optimize the application of radiation. Therefore, in this study the measurement of DAP was the preferred choice for patients dosimetry because of rapidness and availability. Considering the fact that the reduction of patient's dose and awareness of radiation rate is of great importance, the objective of this study was the measurement of DAP and evaluating its correlation with BMI and fluoroscopy time in patients undergoing coronary angiography.

EXPERIMENTAL

In this study, 119 patients were investigated during a six-month period (November 2014 – April 2015). These patients attended the Urmia Seyyed-Al-Shohada Heart Hospital. Among these patients, 43 patients underwent PTCA and 76 patients underwent CA and on all of them heart angiography system of Siemens (Artis Zee floor model) which was made in Germany was used. In this system both the flat panel detector and the collimator are synchronized and are always in line with the table.

The rate of radiation exposure was considered constant during all scans and was equal to 15 images per second and images were eventually stored on a compact disc. The patients' dosimetry information, including DAP and fluoroscopy time were recorded from the control room monitor in each procedure. Moreover to calculate the BMI of the patients, their weight and height were noted from patients' files.

All statistical evaluations were performed using the SPSS science software version 16 at a significance level of p=0.05. Since the distribution data was normal, the Pearson correlation test was used for the evaluation of relationships. The results of this study were compared with other studies in the field.

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RESULTS

Table 1 shows the mean values of DAP (Gy.cm^2) and fluoroscopy time (min) for CA and PTCA procedures in men and women.

Table 1: The mean value of DAP during CA and PTCA in men and women

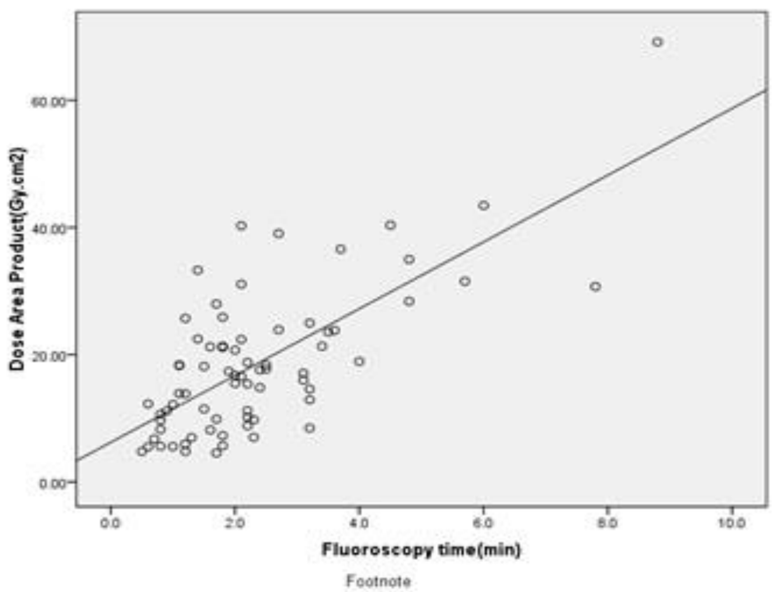
	Sex	No.	DAP (Gy.cm^2)	fluoroscopy time (min)
CA	Men	40	18.87	2.124
	Women	36	17.99	2.344
PTCA	Men	25	51.74	7.392
	Women	18	55.49	7.511

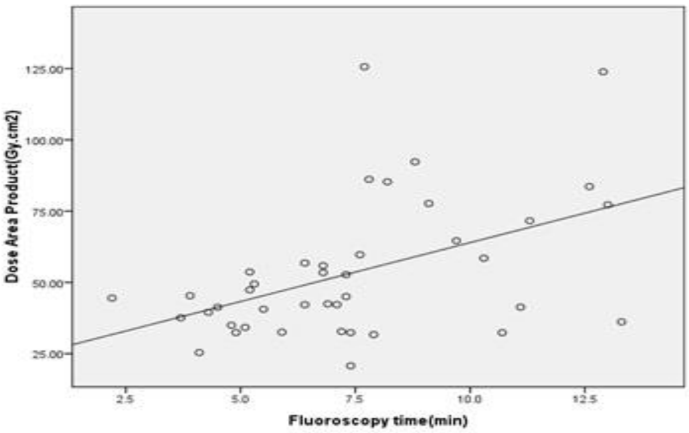
By statistical analysis of DAP and fluoroscopy time values, it is obvious that the normal distribution is not very good. Therefore, for better illustration of the distribution, in addition to the mean values and standard deviation, the values of median, 25th percentiles, 75th percentile, maximum and minimum are also shown in Table 2.

Table 2: Statistical parameters of DAP and fluoroscopy time distribution for CA and PTCA

		Min	Max	Mean	SD	Median	25 Percentile	75 Percentile
CA	DAP	4.54	69.15	18.46	11.51	16.92	9.79	23.76
	fluoroscopy time	0.5	7.8	2.224	1.330	2.0	1.3	2.7
PTCA	DAP	20.73	125.63	53.44	25.95	45.17	35.85	62.23
	fluoroscopy time	2.2	13.3	7.442	2.707	7.3	5.2	8.8

Likewise the correlation between the DAP and fluoroscopy time, DAP and BMI, and fluoroscopy time and BMI are evaluated. As can be observed in Figure 1 and 2, there are a strong correlation between DAP and fluoroscopy time for CA ($p < 0.001$) and PTCA ($p < 0.02$) with Pearson correlation coefficient of 0.710 and 0.472 repectively. Furthermore the Relationship between DAP and fluoroscopy time with BMI was investigated; however no significant relationship was found between them.





DISCUSSION

Recently Interventional cardiology(IC) has developed rapidly in both the techniques of access to different parts of the human body and also the use of various devices including: catheters, drugs, stents and angiographic system [4]. Among the radiological X-ray procedures, cardiac catheterization imposes the highest dose to the patient which the possibility of reaching the threshold dose (2Gy) is not unexpected. This level of exposure causes deterministic effects such as erythema and multiple cases of this disease have been reported following the PTCA. Therefore the use of ionizing radiation and increase of patients' absorbed dose must be justified.

IC is related to high patient's entrance doses, depending on the degree of difficulty in gaining access to the point of interest (vessel tortuosity, number of treated vessels) and accordingly the fluoroscopy time, the patient's size and weight, the use of radiological equipment that does not meet the radiation protection rules, and the interventional cardiologist's lack of knowledge or inexperience to access and cure the disease (e.g. initial positioning of the patient close to the X-ray tube, practice of a high-dose fluoroscopic mode with a high pulse rate for a long time, maladroit maneuvers, exposure of the same skin region during the procedure, use of a large radiation field, etc.).

The current study examined the data from the 119 patients, 63 males and 56 females, which generally indicated that the absorbed dose in women in PTCA was slightly more than men. According to Table 1, the mean DAP value for men and women in CA were 18.87 and 17.99 Gy.cm^2 and in PTCA were 51.74 and 55.49 Gy.cm^2 respectively.

Figure 1 and 2 shows the strong correlation between the DAP and fluoroscopy time that the previous studies also found the same correlation. In this study, a significant correlation was not found between BMI with DAP and fluoroscopy time. This is in conflict with the study of Bouzarjomehri and Tsapaki [3], who found a significant relationship between BMI and DAP.

Table 3: Comparison of the results obtained from this study with other studies for CA

Study	No.	DAP (Gy.cm^2)				fluoroscopy time (min)
		Mean	SD	Median	75 Percentile	Mean
This study	76	18.46	11.51	16.92	23.76	2.7
Vano [13]	288	66.5		45.7	96.3	
Toosi [7]	116	32.47				3.4
Padovani[14]	13	39.3	18			3.6
Bozarjomehri [3]	103	29.14	16.9			2.71
A.I. Stratis [4]	108	23.52	16.9	19.96	30.00	11.9
Tsapaki [6]	195	47.3	27.9	39.1	60.4	6.5
Zorzeetto [15]	79	55.9		52.5	65.6	4.9
A.Sulieman [16]	53	22.32				3.4

A comparison of the mean values of DAP and fluoroscopy time obtained in this study with the results of previous studies carried out in the field, as shown in tables 3 and 4, reveals that the mean values in CA are lower than the outcomes of other studies in table 3. As displayed in table 4, the mean DAP in PTCA found in this study was substantially lower than the other studies [3, 4, 6, 13-16] except the results of Bahreyni et al. [7]. The reason for this result is that 15 frame per second pulse rate used in the procedures of these studies was a suitable pulse rate and also interventional cardiologist had sufficient knowledge and experience.

A European survey was carried out by SENTINEL consortium to examine doses in designated interventional cardiac procedures, and to establish updated reference levels (RLs). The survey involved nine European partners and near 2000 procedures were examined [17]. RLs for fluoroscopy time and DAP in CA were 6.5 min and 45 Gy.cm^2, respectively. Corresponding RLs in PTCA were 15.5 min and 85 Gy.cm^2. Our results show that mean DAP (17.92 Gy.cm^2), fluoroscopy time (2.58 min) in CA procedure are lower than SENTINEL RLs. In PTCA, our values of DAP (53.59 Gy.cm^2) and fluoroscopy time (7.4 min) are lower than SENTINEL RLs. These results indicate that the health center used in this study, i.e. Urmia Seyyd-Al-Shohada Heart Hospital, appears to have acceptable procedures regarding radiation protection principals.

Table 4: Comparison of the results obtained from this study with other studies for PTCA

Study	No.	DAP (Gy.cm^2)				fluoroscopy time (min)
		Mean	SD	Median	75 Percentile	Mean
This study	43	53.44	25.95	44.17	62.23	8.8
Vano [13]	45	87.5		66.7	122.3	
Toosi [7]	31	44.49				7.8
Padovani [14]	54	101.9	84.9			18.5
A.I. Stratis [4]	101	53.82	46.71	40.17	59.99	28.7
Tsapaki [6]	97	68	48.7	58.3	80.7	12.2
Zorzeetto [15]	31	91.8		82.6	104.6	12.2
A.Sulieman [16]	35	58.62				9.9

In a study carried out by Dragusin and et al. [18] the obtained reference values for DAP in CA and PTCA methods are respectively 40 and 47 Gy.cm^2. The comparison of these values with the results of this study reveals that the values obtained from CA in this study is lower than 40 Gy.cm^2 (almost half), but in PTCA the value is higher than 47 Gy.cm^2.

CONCLUSIONS

The results of this study illustrated patient radiation exposure doses, in terms of DAP values, for interventional cardiology in Seyyed-Al-Shohada Heart Hospital in Urmia. The entrance skin dose delivered to the patient was lower than that of other studies [4, 6, 13-16] and the mean fluoroscopy time was low per patient. Patient dose reduction is of prime importance and practitioners should optimize the radiation dose.

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