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RESEARCH ARTICLE - MEDICAL TECHNIQUES

Measurement of the Radiation Level Dose to Patient from Fluoroscopy Device during Cardiac Catheterization

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Abstract

Fluoroscopy is a type of medical imaging that shows a continuous X-ray image on a screen, it is used in a wide range of examination and procedures for diagnosis such as in cardiac catheterization. Fluoroscopy can result in relatively high radiation doses, especially for complex interventional procedures that it needed to monitor radiation to reduce exposure. The purpose of this study is to determine the radiation doses for patients during cardiac catheterization exam and compare it with the permissible dose limits. The main parameters which are studied in this work are the time of exposure dose rate, x-ray techniques (milliamper. second), tube voltage (kilovolt) and Dose Area Product (DAP). Twenty-seven patients were included and absorbed doses were measured and distributed according to Fluoroscopy (Fluo) time, mAs and Dose Area Product (DPA). It was found that the absorbed dose received by the patients has a linear relationship with the Fluoroscopy time, mAs and DAP. Exposure dose rates were measured and compared with the maximum permissible dose (100 mGy/min), the estimated patient dose rate varied from (12-81.6) mGy/min) for 24 patients as a permissible dose in the safe side, and 3 patients exposed to higher values of the exposure dose rates (over permissible dose) range (107.4-108) mGy/min.

Keywords: Fluoroscopy, Cardiac Catheterization, exposure dose, estimated patient dose.

1. Introduction

Ionizing radiation was used in medicine, while showing to patient's great benefit, also contributes safely to radiation exposure of individuals and populations. Interventions for the radiology and cardiology (IC) contributes a significant proportion of the collective dose of the population from medical exposure [1]. The fluoroscopy device is an imaging technique that uses x-rays to obtain real-time moving images of the interior of an object .In its simplest form , a fluoroscope consist of an x-ray source and fluorescent screen , between which a patient is placed .After passing through the patient ,the remnant beam impinged upon the fluorescent screen and produces a visible glow , which is directly observed by the practitioner .However, in modern systems, the fluorescent screen is coupled to an electronic device that amplifies and transforms the glowing light into a video signal suitable for presentation on an electronic display. The skin is a major tissue and is important for use in fluoroscopy. The increasing use of high-level fluoroscopy in the cardiology practice and in interventional radiology has resulted in many serious skin injuries. Entrance skin exposure in fluoroscopy is much more difficult to estimate than that for radiography because the x-ray field moves and sometimes varies in size [2]. Cardiac catheterization is an invasive imaging procedure using fluoroscopy by allowing the doctor to see how well the heart is functioning by insertion into the heart fine-bore tubes (catheters) through cannula slot into a vein or peripheral artery. Procedures are usually implemented via the femoral vessels. However, the best safety record is radial artery approach which is becoming increasingly popular. Now rarely used is Brachial access because of its potentially higher complication rates and complexity [5, 6]. This therapeutic procedure and diagnostics require radiation exposure to the operator and patient. Below the inguinal ligament in the groin is locate the pulse, which passes between the anterior superior iliac spine and the symphysis pubis [7]. After the catheter is in place, the guidewire allows the radiologist to place the catheter within the vascular network. Guidewires are fabricated of unspotted steel and contain an inner core wire that is tapered at the end to a soft, elastic tip. This core wire stops loss of sections of the wire if it breaks. The guidewire has trailing end which is stiff and allows the guidewire to be pushed and twisted so the catheter can be positioned in the chosen vessel [2, 8]. The Purpose of this work was to determine the radiation doses to patients during cardiac catheterization exam using Philips fluoroscopy device and compare them with the permissible dose limits.

2. Patients and methods

From December 2017 to April 2018, a total of 27 patients were studied. The study included 10 females and 17 males, and the age group range was (40-90) years. The study was conducted in compliance to the medical ethics rules and all participants have given their consent. The study was performed in Al-Shahed Ghazy Al-hariry hospital\Iraqi center for catheterization. Philips fluoroscopy examination was performed by the use of device (Netherlands-2012).

2.1. Preparation of the patient before cardiac catheterization

The patient were told not to drink or eat anything for six to eight hours before the test. If the patient has diabetes, adjustment may need to be made to patient treatment. The patients were asked if they had taken any medication and to stop taking some medication before the test, especially if the patients are taking a Coumadin (warfarin) or anti-platelet medicines such as Aspirin (Plavix). Patients were asked to wear a hospital gown and empty the bladder before the procedure. The patients were asked to take off any Metal objects.

2.2. Performance of the procedure

During the procedure, the patient lies face up on a table, and the cardiac monitor is connected to a patient. A local anesthetic in the site of insertion, and by using a needle the vein or artery were accessed, the facilitate insertion of catheters and infusion of drugs by a hard plastic tube, is put in the site of the puncture. Under fluoroscopic guidance, a guide-wire (a thin wire that guides the catheter insertion) is passed through a femoral artery or brachial artery to the heart. The catheter, an elastic or reshaped tube approximately (80–110 cm) long, then inserted over the wire and to the arterial side of the heart. The patient may suffer from pressure as the catheter is threaded into the heart. The contrast agent, or dye, used for imaging is then surrounding vessels. Following injection of the contrast medium the patient may experience a hot, flushed feeling or slight nausea. Depending on the area being imaged and type of catheterization (left or right part of the heart), diverse catheters with various ends and shapes are used. Fluoroscopy was used to observe the procedure composed from an x-ray subsystem and video system with showing monitors as well as taking still x-rays for documentation purposes. The digital angiography system that allows images to be recorded is used as a modern systems. During the exam we are measuring radiation dose for the patient by dosimeter type (Gamma scout) which is equipped with Geiger – muller to detect not only gamma radiation but all ionizing radiation, the dosimeter was placed beside the patient to record the radiation dose received and when the exam ends, the radiation dose was taken from the dosimeter using a special software.

Fig. (1) Dosimeter type (Gamma scout).

3. Results and discussion

All patients were randomly selected and analyzed by catheterization fluoroscopy. The result showed that 88.8% of patients received radiation doses within the permissible limits. Exposure dose for catheterization fluoroscopy varied from (189- 1151) mGy, specific fluoroscopy protocols (72 to 114) Kv, and (51 to 97) mAs. Table (1) presents the 27 patients with different parameters from fluoroscopy. While Table (2) presents the distribution of Exposure Dose rate by weight.

Table (1): Distribution of age groups according to gender.

Age groups (year)		Gender		Total
		Male	Female	
(40-49)	No.	4	2	6
	%	14.8%	7.4%	22.2%
(50-59)	No.	5	5	10
	%	18.5%	18.5%	37%
(60-69)	No.	7	3	10
	%	25.9%	11.1%	37.0%
(70-79)	No.	0	0	0
	%	0	0	0
(80-90)	No.	1	0	1
	%	3.7%	0	3.7%
	%	63.0%	37.0%	100.0%

Table (2): Distribution of Exposure Dose rate by weight.

Weight (kg)		Dose rate		Total
		(<100)	(≥100)	
(70-79)	No.	8	0	8
	%	29.6%	0.0%	29.6%
(80-89)	No.	10	2	12
	%	37.0%	7.4%	44.4%
(90-100)	No.	6	1	7
	%	22.2%	3.7%	25.9%
Total	No.	24	3	27
	%	88.9%	11.1%	100.0%

Table (3): Relationship between exposure dose rate level and other parameters (mAs-DAP-time-Kv-SID).

	Exposure dose rate level	N	Mean± SD	p-value
mAs	(<100)	24	82.45±12.55	>0.05
	(≥100)	3	82.79 ±16.92	
DAP	(<100)	24	35290.46±24611.48	>0.05
	(≥100)	3	33257.33±7632.54	
Time	(<100)	24	3.53±4.81	>0.05
	(≥100)	3	1.34±0.24	
kV	(<100)	24	88.58±13.03	>0.05
	(≥100)	3	78.33±5.69	
SID	(<100)	24	117.29±4.95	>0.05
	(≥100)	3	112.33±7.51	

The results show that the exposure dose rate compared with mAs, DAP, Time, Kv, and SID (<100) for 24 patients, and with mAs, DAP, Time, Kv, and SID (≥100) for 3 patients, which was insignificant, p value > 0.05 as presented in Table (5).

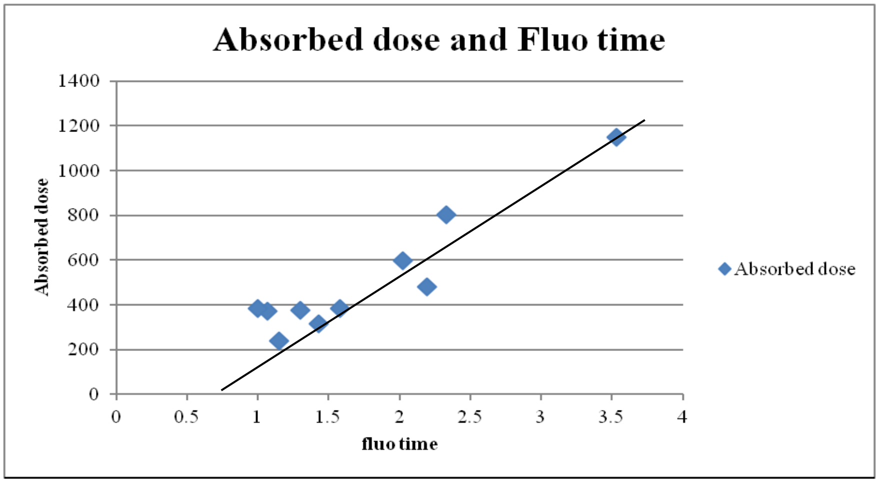

Figure (2): The relationship between Fluo time and absorbed dose.

Fig. (2) show the relationship between Fluo time and absorbed dose that explain the absorbed dose was increased with increasing the Fluo time.

Table (4): Distribution of Absorbed dose with mAs.

	mAs/S.	absorbed dose (mGy)
1	65	189
2	67	315
3	72	261
4	74	462
5	84	599
6	87	805
7	88	757
8	89	705
9	92	740
10	97	1151

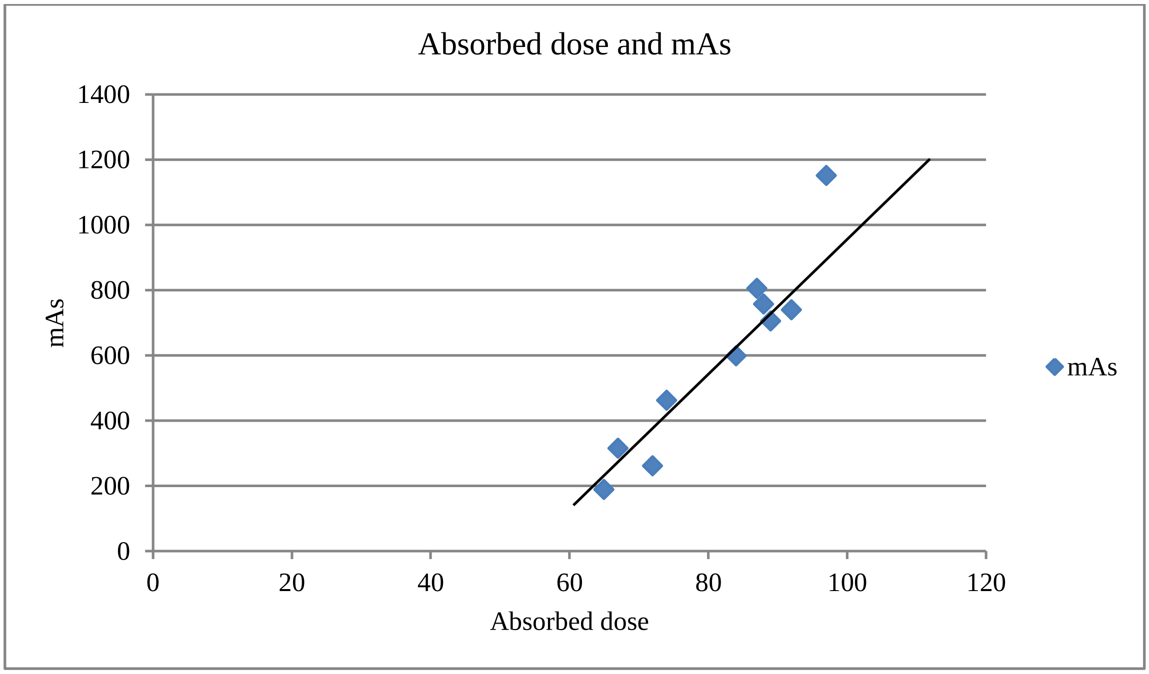

Fig. (3): The relationship between mAs and absorbed dose.

Table (5): Distribution of Absorbed dose with Dose Area Product (DAP).

	DAP (mGy.⟦cm⟧^2)	absorbed dose (mGy)
1	15197	189
2	17580	245
3	19566	273
4	28215	375
5	34157	479
6	42396	599
7	46418	705
8	51141	757
9	53023	805
10	89509	1151

Absorbed dose rang (189-1151) mGy and DAP rang (15197-89509) mGy.cm^2, the distribution show that Absorbed dose increased with increasing DAP.

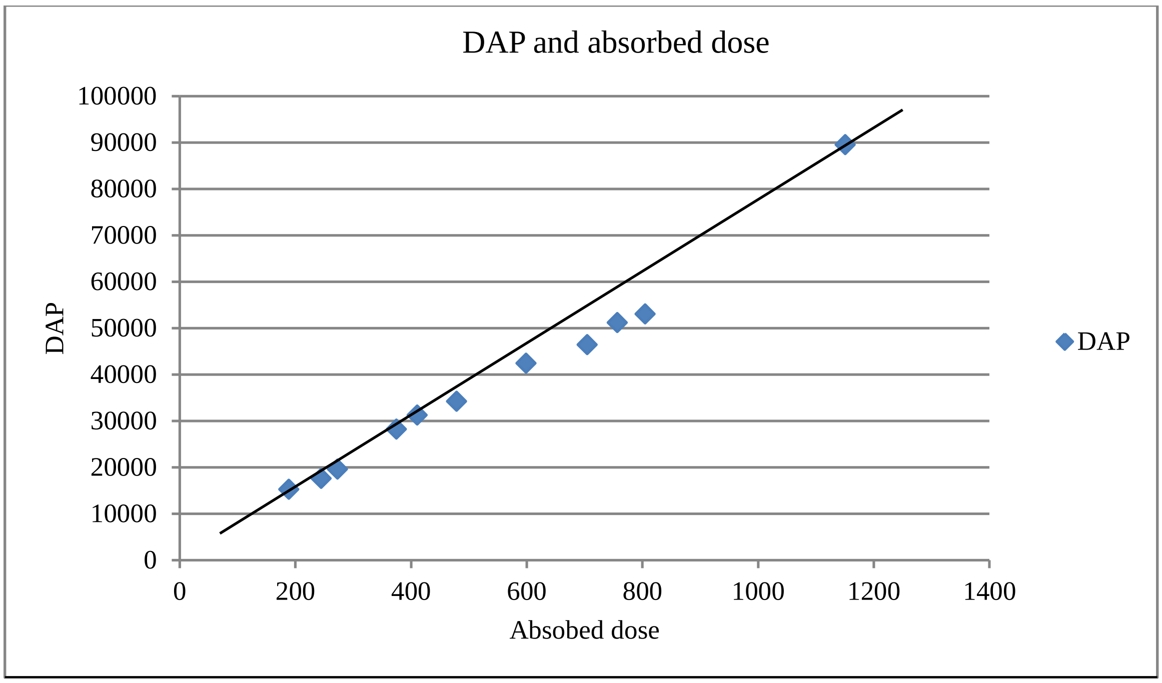

Figure (4): The relationship between Dose Area Product (DAP) and Absorbed dose.

Table (6): The fluoroscopy radiation dose compared to the normal level.

Patient No.	Dose rate (mGy/min)	Typical value of dose rate(mGy\min)
1	107	100
2	35	100
3	57	100
4	81	100
5	81	100
6	75	100
7	29	100
8	75	100
9	61	100
10	38	100
11	79	100
12	25	100
13	22	100
14	55	100
15	62	100
16	37	100
17	48	100
18	64	100
19	32	100
20	61	100
21	55	100
22	58	100
23	57	100
24	108	100
25	107	100
26	12	100
27	34	100

Comparison of exposure dose rates mGy\min with the recommended dose rate level ICRP 60(100 mGy\min) [9-11] .Twenty-four of cases are within the permissible dose limits and 3 of patients are higher than the permissible dose limits.

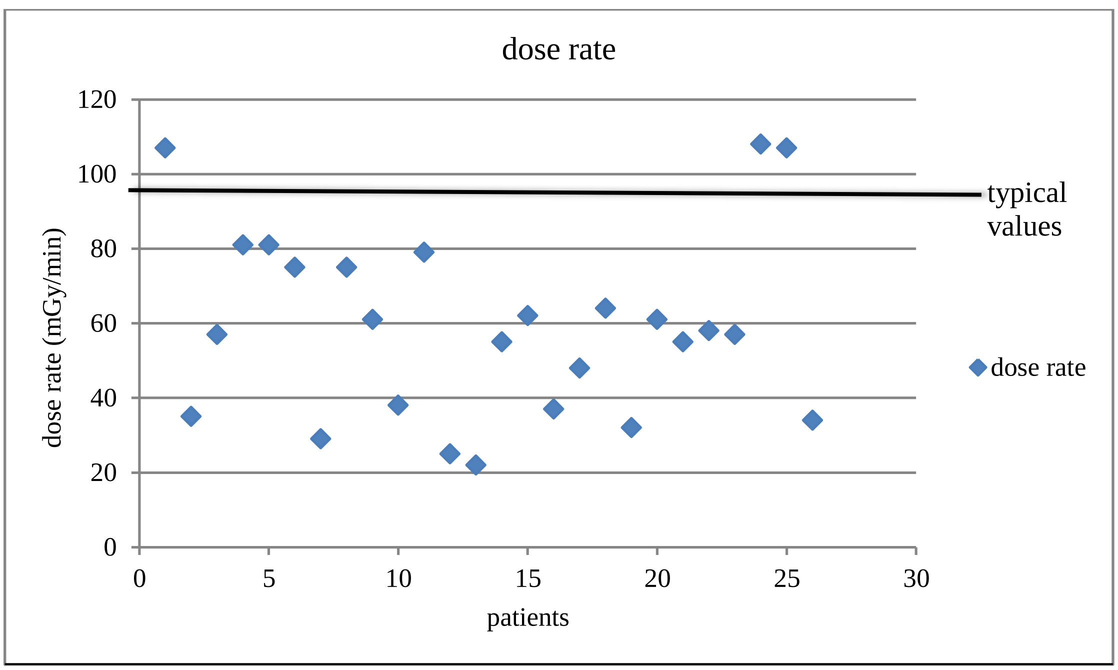

Figure (5): The relationship between the dose rate of patients in (mGy/min) compared with typical values from ICRP-(60).

4. Conclusion

Cardiac catheterization by fluoroscopy device remains an important diagnostic tool to check abnormalities in the heart and can check blood flow in the coronary artery, the patient goes to make cardiac catheterization if the patient suffers from narrowing in the artery of the heart, so the patient dose reduction is a prime importance and practitioners should be optimizing the radiation dose for further dose reduction without compromising the diagnostic finding. The results has shown that the dose rate received by the patient varied from (12-81.6 mGy/min) which is normal for (88.8%) of patients and higher than the normal limits for 3 patients compared to the permissible limits of doses (100mGy\min). Interventional procedures remain operator dependent therefore continuous training is crucial. Additional studies are needed to be conducted in order to establish a reference dose level for patients for each clinical indication individually and does estimation for staff.

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