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Evaluation of Radiation Dose Received By Patient during Cardiac Catheterization Procedure

Mohamed E. M. Gar-elnabi[1], Abdoelrahman Hassan. A. B[1, 2, 3], Abdoelrahman A. Ahmed[1], Mohamed Yousef [1]

[1]Sudan University of Science and Technology, College of Medical Radiological Science, Khartoum, Sudan

[2]Radiology Department, Elnileen Diagnostic Medical Center, Khartoum, Sudan

[3]Radiology Department, Antalya Medical Center, Khartoum, Sudan

Abstract: ***The current study intends to measure patient dose and estimate the radiation dose received for patient in (IC) procedures. The study was measured radiation doses to (212) patients during interventional cardiology procedures 161to coronary angiography (CA) and 51 to percutaneous coronary interventions (PCI) was carried out in this study patient doses were calculated from patient body characteristics and exposure parameters using dose area product (DAP) meters. The mean age of patients 57.42 ±11.65 was ranging (21to 86) years. The mean value of tube parameter was 86.17 ± 8.32KVp, ranges (to 63 from 105) Kvp, 5.59 ± 0.844mAs range (to 3.2 from 10.2) mAs. The mean duration time of fluoroscopy was 6.87 ± 7.06 mentis and the number of films per procedure was 9.17 ± 4.53 films, range was (3 to33) films. All the investigations were performed in same center and department. The DAP measured in this study was lower than the previous reported studies in the literature. Because they can be attributed to the use of high voltage, long distance between patient and ionizing radiation source in all examinations.***

Keywords: Cardiac Catheterization Procedure, Hassan, patient dose, dose area product

1. Introduction

Interventional cardiology (**IC**) which involves coronary angiography (**CA**) diagnostic procedures and percutaneous coronary interventions (**PCI**) therapeutic procedures is becoming progressively more common [1]. Patient and staff dose during cardiac interventional procedures is considered to high due to the existence of the operators , protections, beside the patient while X- ray procedures is undergoing and the prolonged exposure time to the patient. It not enough assessment were made at the national level to estimate the significance of radiation dose measurement required [1, 2].

In diagnostic and therapeutic in interventional cardiology procedures performed with the use of X-ray diagnostic imaging system, the long fluoroscopy time and the large number of cine projections, as well as repetition of the procedure due to the recurrence of lesion, a common event, result in a high locally delivered skin dose, which may even lead to patient skin necrosis [3, 5]. In Sudan few studies was conducted in the field of patient and staff dose evaluation in interventional cardiology. Studies on patient and staff in interventional procedures in Sudan are very limited. Therefore the main objectives of this study was measurement the dose receive by the patient and to evaluate the level of radiation dose and estimate the related risks to patient during interventional catheterization.

2. Material and Method

Patient radiation dose measurement during cardiac catheterization were made using dose area product (DAP) meter. In this study DAP meter was used for measuring patient's dose. DIAMENTOR M4 (PTW, Germany Company) is a state of the dose area product (DAP) as shown in Figure: 1. the dual channel device measures the total procedures during radiography and fluoroscopy according to international regulations. Its digital display can simultaneously show the reading from both channels. In addition exposure time during fluoroscopy is measured without the need any connection to an X-ray generator. The RS232 interface enables data transfer to a computer. Features of dual channel device for single plane and bi- plane fluoroscopic and radiographic X- ray unites:

- Complies with international standard IEC 60580.
- Displays the selectable DAP units ($Gycm^2$, $mGycm^2$ and Rcm^2).
- Measures fluoroscopy exposure time from beam analysis.
- Displays DAP rate during fluoroscopy, switches automatically over to DAP after examination.

The study was carried out from November 2012 to June 2013 and included 212 patients, 161 of whom underwent coronary angiography (CA) diagnostic procedures and 51 percutaneous coronary interventions (PCI) therapeutic procedure with stenting in more coronary stenosis. The data used in this study was collected from Alshaab teaching hospital Khartoum- Sudan. The main objective of this study was evaluating the patient dose during the interventional cardio-logical procedures. The following parameter was recorded such as patient body characteristic (age, weight, height (BMI), clinical indication, sex and type of procedures). In all procedures patient dose area product were evaluated using DAP in included to the C- arm machine. The patient dose categorized according to the types of procedures, patient body characteristic and the mean ESD was calculated for each examination. Additionally the effect doses were estimated for measured ESD using appropriate conversion factor found in the literature.

Figure 1: DAP meter

The c-arm machines were used throughout this study. As describes in the table below table1. It is equipped with high frequency (HF) generator and has last image hold capability. Air Kerma Product (AKP) was not available for all machines, all machines have ability to pulse fluoroscopy but operator used both continues and pulse beam during different procedures. The machine describes are shown in table.

Table 1: C- arm machines Specifications

Model	Shimadzu
Manufacturing date	2007
Installation date	2007
Type	Fixed
Focal spot	0.6-1.0
filtration	1.5mm
Max KV	150
Max mA	1000
Generator Type	HF

3. Result Presentation

Table 2: Statistical summary of Patient body characteristics and Tube parameters

Variable	***Mean± std. deviation***
Age	57.42±11.651
Weight	76.02±12.108
Height	167.25±10.801
BMI	27.319±4.7224
Kvp	86.17±8.320
mAs	5.592±.8436
SSD	110.72±28.54
mG/cm^2	917.07±68.174
Time(m)	6.87± 7.059
No of films	9.17±4.53

Table 3: Statistical summary of Patient body characteristics and tube parameters in CA Procedure

Variable	***Mean ± std. deviation***
Age	57.45±12.019
Weight	75.14±14.878
Height	166.7±11.244
BMI	26.989±4.7434
Kvp	86.91±9.297
mAs	5.628± .9197
SSD	111.45±3.118
mG/cm^2	1783.25±815.647
time(m)	14.567±9.5714
NO of films	14.31±6.27

Table 4: Statistical summary of Patient body characteristics and tube parameters in PCI Procedure

Variable	*Mean ± std. deviation*
Age	57.40± 11.571
Weight	76.30±11.128
Height	167.41±10.688
BMI	27.423±4.7257
Kvp	85.94±8.003
mAs	5.581±.8207
SSD	110.49±2.735
mG/cm^2	642.69±30.0197
time(m)	4.432±3.4960
NO of films	7.54±1.92

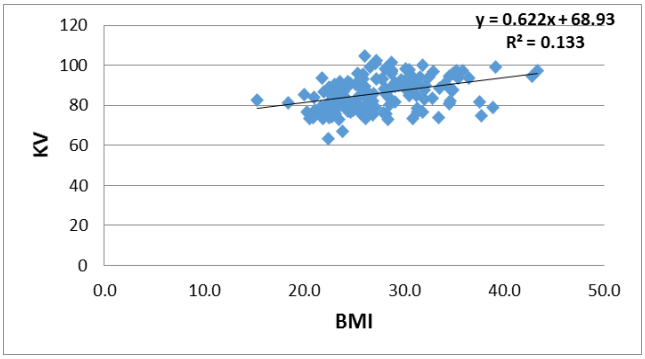

Figure 2: showed the linear correlation between the kvp and BMI with R2=0.133 during **CA procedures**

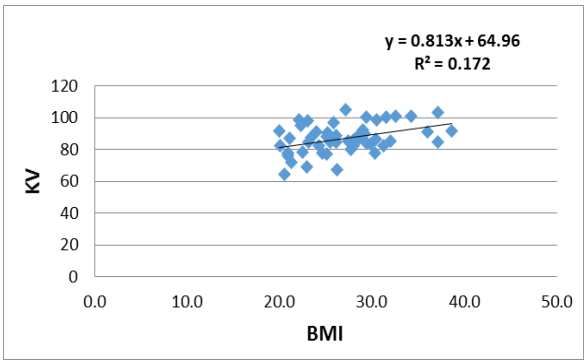

Figure 3: showed the linear correlation between the kvp and BMI with R2=0.172 during in the PCI procedures

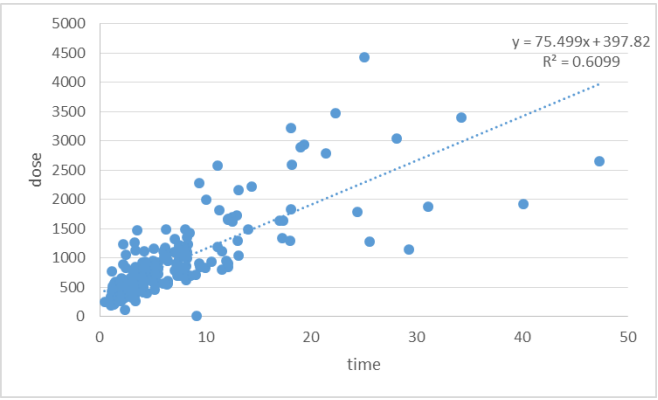

Figure 4: showed the linear correlation between the mGy/cm^2 and fluroscopic time with ***R^2=0.6099*** during CA procedures

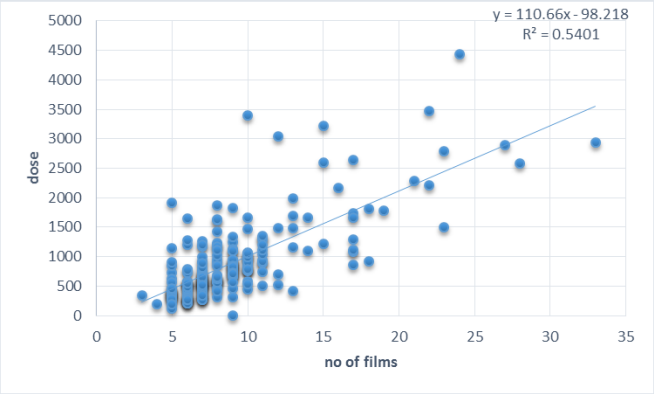

Figure 5: correlation between mG/cm^2 and NO of films in the CA procedures.

Table 5: Comparison with other studies

Year	*(Gy/cm^2) CA*	*PCI (Gy/cm^2)*	*Reference*
1997	109 55.9	163 91.8	Micha et al [10]
2000	60.1 27.3	NA NA	Micha et al [10]
2003	29.2 47.3	75 68	Micha et al [10]
2006	39.8±19.1	71.6±39.0	A. Trianni et al [11]
2009	33±18.8 2.7± 2.4	83.2±62.6 10.0 ± 6.8	andretsis et al [3]
2015	0.643 ± 0.3002	1.783 ± 0.816	Current study

4. Discussion

The statistical of patient body characteristic are given in table 2. Total procedures in this study are 212 procedures, 161 in diagnostic catheterization (CA) and 51 in therapeutic catheterization (PCI). Body mass index (BMI) where considerable variations were observed among patient population in terms of radiation dose, and fluoroscopic time. Table 3, shows the statistical summary of patient radiation dose during (CA) interventional procedures, DAP values to patient is higher in relation to the body characteristic due to the scanning plane when using under couch X- ray tube in procedure. The therapeutic procedure result in high dose to patient and longer fluoroscopy time than diagnostic catheterization are given in table 4.

The patient body characteristics data ware comparable to mean values were higher compared to these of **DAP** standard level [9, 14]. The mean age of patients was ***57.42±11.65, 57.4 ± 11.57 and 57.45 ± 12.02*** year in range (21-85) year for CA and PCI respectively as illustrated in table 2, 3, and 4. These parameters that can affect the dose to the patient during the cardiac catheterization procedure was given mean± std. deviation as in table 1, 2, 3, and 4 respectively the PCI procedure it has higher fluoroscopy time and more number of films this lead to increase the patient dose.

It is important to note that the patient body characteristics and tube parameters in interventional procedures studies can affect patient dose significantly. The mean patient radiation dose in this study was ***917.07±68.174mGy/cm^2, 642.69±30.0197 mGy/cm^2 for CA and 1783.25±815.647 mGy/cm^2 for PCI.*** The correlation was made to investigate the effect of these parameters in patient dose, so controlling one of these factors is expected to reduce drastically the patient dose. This study relieved that the duration time of catheterization and number of films can be a good indicator of patient dose.

Figure:1 showed the linear correlation between the kvp and BMI in direct relationship noted with significant acossiation which increased by 0.622 kg/m^2 for every one kv increment in tube voltage when the mean value of kvp where equal to **85.94±8.003** with **R^2=0.133**, and the linear regression equation that can descripe this correlation was **y=0.622x+68.9** during **CA procedures.** This was campared with the relation in PCI procedure when the mean value of BMI and Kvp was ***86.91±9.297 and 26.989±4.7434*** respectively. In more strong correlation that CA where the ***R2= 0.172.***

Time, distance and shielding considered the three main ways to protect the worker and the staff during and radiological procedure and investigation also the patient (minimum time, far distance and maximum shielding with minmum radiation dose) here because we using the foluroscopic operation the cathetrization procedure so more time and more radiation used; a correlation was made between this time and dose alinear relationship explored by ***y=75.499-98.21***, when ***R^2=0.6099 the dose increased by 75.499 mGy/cm2 for ever one minit increament in time and this may give raise to show how the time can affact the dose level uring these procedure.***

Fiure 5: showed the relationship between the dose per ccubic centmenters and the number of film uesd in this study a strong elation noted when the number of film increaesd so the dose raise by the value of ***110.66mGy/cm^2***. This study result was compared with other scholary articles as stated in table 5: with Micha et al [10], A. Trianni et al [11] and andretsis et al [3].

5. Conclusion

Patient radiation doses vary widely among the different interventional cardiology procedures but also among published studies. Discrepancies of the derived results are patient dose, type of procedure, physician, fluoroscopic equipment and duration time of procedure related. Nevertheless, interventional cardiology (IC) procedures can subject patients to considerable radiation doses and efforts to minimize patient exposure should always be undertaken.
The reported DAP in this study was lower than the previous reported studies in literature. This can be attributed of high voltage (kV), long focal side distance (SSD) and high speed films. An optimization technique is required in the light of current practices in order to reduce the unnecessary exposure.

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Author Profile

Prof Mohamed Elfadil Mohamed Gar-elnabi (Sudan) awarded the B. Sc. in Radiotherapy and Nuclear Medicine (1987) and M.Sc. in Radiation Therapy (2000-SUST) and Ph. D. degree in Medical Physics (Natal University-South Africa) in 2007. During 1996-2012 he has been working as lecturer as well as Associate Prof. at SUST department of Radiation therapy. Also he has been active in Computerized Texture Analysis, Radiotherapy-Oncology, Ultrasound and Nuclear Medicine researches.

Mr. Abdoelrahman Hassan Ali Bakry (Sudan) received the B.Sc. in radiotherapy technology from College of Medical radiological Science, Sudan University of Science and Technology in 2013, M.Sc. student (2014) in radiotherapy technology (SUST). During 2013 up to date, he is staying in College of Medical radiological Science, Sudan University of Science and Technology, Radiology Department, Antalya Medical Center and Elnileen Diagnostic Medical Center, Also he has been active in Computerized Texture Analysis, Radiotherapy-Oncology, nuclear Medicine and radiation protection researches. Now he is assistant teacher at college of medical radiologic science, SUST also.

Mr. Abdoelrahman Adam Ahmed Amer (Sudan) award B.Sc. in science of physics university of Elfashir, he was working as secondary school teacher and assistant teacher at university of zaligei, he received M.Sc. science of physics university of bagdhdad republic of Iraq in 1998, 2001, 2002 and 2005 respectively. Also he was a lecturer at university of zalingei from 2011 and now he is PHD student at Sudan University of science and technology.