Estimation the Doses of patients resulting from Diagnostic Cardiac Imaging Modalities

[1]Shaban Alramlawy, I.Maamoun[1]

Department of critical care medicine, cairo university hospitals, faculty of medicine, cairo, Egypt.

Abstract

Evaluating the risks and benefits of cardiac imaging for patients is considered of high concern. Because of the lack of solid evidence that would suggest disease-management strategies guided by cardiac imaging more often lead to better patient outcomes than empirical medical strategies. Also, there is a lack of information and direct evidence for harm from cardiac imaging modalities of diagnostic medical radiation .The aim of work: Estimation of Patient Radiation Doses Due to Diagnostic Cardiac Imaging Modalities. Method : 120 patients (weight = 85±10 Kg and Age =50 ±10) are divided into three groups according to cardiac diagnostic procedures (A: n=20, SPECT (Siemens Symbia) , Injected activity=950 MBq for stress/rest on two days) ; (B : n=20 , Fluoroscopy (Siemens), The average time of fluoroscopy and cine-modes was 4.2±1.8 min and 10.7±2.9min respectively)) and (C: n=20 ,CT Coronary (Philips 256) , KV =120 ,MA = 300). Results: CT Coronary (Gp. C) are highly significant patient dose (P<0.005) than SPECT (Gp .A). Where the average effective doses of groups C and A are 32.0±10.5 mSv and 13.5±1.7 mSv respectively. The effective dose of ICA (Gp. B) is 49.1±2.5 mSv which is highly significant (P<0.05) than A and C groups. Conclusion: Our results concluded that there is evidence supportive of high effective dose which reflect an increased risk of cancer incidence at levels of radiation commonly received by cardiac diagnostic imaging modalities.

keywords: Cardiac Imaging Modalities, CT Coronary, interventional cardiology (ICA)

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Introduction:

There is a significant effect on the public health from growing use of imaging procedures that rely on ionizing radiation [1].

The potential health risks of ionizing radiation are rarely highlighted in the patterns of use of medical imaging and the uncertainties about the magnitude of risk of cancer [2].

Risks associated with radiation exposure are classified into deterministic and stochastic effects. Deterministic effects are radiation dose dependent [3].while, stochastic effects can be occurred without any dose threshold. It happens at all time and the damages are not depending on the amount of dose received. Ionizing radiation-induced cancer and genetic changes belong to the stochastic effects. However, previous studies have reported that the increment of radiation dose could increase the chance of developing cancer.

Radiation dose estimates for cardiac CT examinations are best expressed as the CT volume dose index (CTDIvol), dose-length product (DLP) and effective dose (E) [4].

In the past decade, various strategies of dose saving have been instituted to reduce the radiation exposure to patients from coronary CT angiography, with effective dose ranging from 10 mSv to as low as 1 mSv [5].

According to the results published by the United Nations Scientific Committee on the Effects of Atomic Radiation, Interventional radiology and interventional cardiology (ICA) contribute 10% to the collective of dose of radiation in diagnostic field to collective dose is 10% [6]. Long Fluoroscopy time and a large number of images are the main cause of high radiation dose levels to cardiac patients.

For Single Photon emission Computed Tomography (SPECT) myocardial perfusion, the mean radiation dose is 10.9 mSv, while lowest dose is 7.9 mSv at Europe [7,8].

The effective doses of patients from cardiac imaging procedures (SPECT, CT Coronary and Fluoroscopy) are the highest radiation dose among all imaging procedures [1]. This paper concern with an effective dose of patients who referred to cardiac imaging procedures in short period. This concern to shed the light on the hazards for these patients in our developing country (EGYPT).

This study concern with radiation dose estimation of patients who are referred to do three cardiac diagnostic procedure (SPECT, CT Coronary and Fluoroscopy).

Materials and Method:

120 patients (weight = 85±10 Kg and Age =50 ±10) are divided into three groups according to cardiac diagnostic procedures (A: n=20, SPECT (Siemens Symbia) , Injected activity=950 MBq for stress/rest on two days) ; (B : n=20 , Fluoroscopy (Siemens), The average time of fluoroscopy and cine-modes was 4.2±1.8 min and 10.7±2.9min respectively)) and (C: n=20 ,CT Coronary (Philips

256) , KV =120 ,MA = 300).

Patients effective doses are calculated using the conversion factor 0.01 mSv/MBq [10] for SPECT Cardiac Scan, while the radiation dose in ICA was represented by dose-area product (DAP), measured in µGy.m2 which is collected from the summary pages .The effective doses due to CT Coronary are calculated by multiplying the dose length product (DLP) times tissue weighting factor (0.016mSv/mGy.cm) [9].

DLP reflects the integrated radiation dose for a complete CT examination and is calculated by equation [10]

$$DLP = CTDI_{vol} \times \text{length irradiated.}$$

DLP can be related to Effective dose (E) by the formula equation

$$E = E_{DLP} \times DLP$$

Where EDLP, measured in units of mSv/(mGy•cm), is a body region–specific conversion factor.

The effective dose of ICA is calculated by multiplying DAP by conversion factor 0.22 mSv/(Gy•cm2) according to he National Radiological Protection Board [11]

The patient doses of all groups (A, B and C) are statistically studied using Statistical Package for the Social Sciences (IBM SPSS) 2015).

Results and discussion:

The powerful diagnostic and risk-stratification data provided by these procedures play a central role in clinical cardiology and have contributed to the decrease in morbidity and mortality from coronary heart disease. Nevertheless, performance of any diagnostic test requires a careful assessment of the risks and benefits of the test and optimization of protocols to minimize risks to patients, staff members, and the public. Procedures that utilize ionizing radiation should be performed in accordance with the As Low As Reasonably Achievable (ALARA) philosophy [12].

CT Coronary (Gp. C) are highly significant patient dose (P<0.005) than SPECT (Gp .A) study as shown in table 1. Where the average effective doses of groups C and A are 32.0±10.5 mSv and 13.5±1.7 mSv respectively.

The mean effective dose of ICA (Gp. B) patients is 49.17±2.5 which is highly significant (P<0.05) than A and C groups (Table 1).

The results of SPECT study are in an agreement with The ICRP (103) report (effective dose =12.1 mSv) [13], while the estimated effective doses and DLP of CT coronary (GP C) are in an expected values over 30 mSv and 2000 mGy.cm respectively. Our results are satisfying with the published study evaluating radiation dose from 50 sites worldwide [14]. We had a study before provides more insights in a quantitative basis on the distribution of radiation burden in nuclear cardiac laboratory. Handling patient post-stress either during treadmill exercise or pharmacological stress are the most critical time points where staff members receive the highest radiation dose. New imaging technologies including sophisticated [15].

There was a dose-dependent relation between exposure to radiation from cardiac procedures and subsequent risk of cancer. For every 10 mSv of low-dose ionizing radiation, there was a 3% increase in the risk of age- and sex-adjusted cancer over a mean follow-up period of five years (hazard ratio 1.003 per milliSievert, 95% confidence interval 1.002-1.004). Exposure to low-dose ionizing radiation from cardiac imaging and therapeutic procedures after acute myocardial infarction is associated with an increased risk of cancer [16].

Procedure	DLP mGy.cm	DAP µGy.m2	Effective dose mSv
SPECT (GP. A) N=20	*****	*****	13.5±1.7 (P<0.005)
ICA (GP. B) N=20	*****	4917±255	49.17±2.5 (P<0.005)
CT Coronary (GP. C) N=20	1974.5±661.8	*****	32.0±10.5 (P<0.005)

Table 1: shows the patient dose values of different cardiac diagnostic modalities.

This study is a technical note to all cardiac physicians to be aware of the radiation risk followed by their referring to diagnostic cardiac procedures. S. Alramlawy showed that Patient dose levels in cardiac imaging using radiological as well as nuclear techniques vary considerably with prominent manifestation of many technical and personnel inputs. In addition, intramodality comparison revealed significant differences in patient dose as appeared in CT coronary angiography. A risk estimate based on an experimental radiobiological model would be the best approach to signify the importance of dose reduction in cardiac modalities. This would encourage the scientific and medical community to work potentially in shaping the future of radiological and nuclear based cardiac techniques. [17,18].

Conclusion:

Our results concluded that there is evidence supportive of high effective dose which reflect an increased risk of cancer incidence at levels of radiation commonly received by cardiac Diagnostic and therapeutic imaging modalities. For that we must had concerned with all modalities, and must have careful attention to technique, including the medical physist use all physics parameters such as dose-reduction strategies, can minimize dose to patients. Also Selection of protocols for individual patients and for laboratories needs to be determined from an ALARA approach, and understanding the dosimetry of cardiac imaging protocols is a first step toward implementing a test selection strategy that minimizes risk to patients while providing optimal diagnostic information. We concluded that risk is small but from some cardiac imaging procedures non-trivial. There exist internationally accepted principles of radiation protection, namely justification and optimization, designed to optimize the balance of benefits and risks from radiation.

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