Research Article

Interventional Cardiology

Assessment of cardiovascular technologists radiation exposure during percutaneous coronary intervention

Thirumurugan E[1*], Gomathi K[1], Swathy P[1], Syed Ali Afrin[1], Karpaga Pavithra[1], Sudesan J[2]

[1]Department of Cardiology, Dr. M.G.R. Educational and Research Institute, ACS Medical College and Hospital, Chennai, Tamilnadu, India

[2]Department of Optometry, Dr. M.G.R. Educational and Research Institute, ACS Medical College and Hospital, Chennai, Tamilnadu, India

*Author for correspondence:
Thirumurugan E, Department of Cardiology, Dr. M.G.R. Educational and Research Institute, ACS Medical College and Hospital, Chennai, Tamilnadu, India, E-mail: thirumurugan.cct@drmgrdu.ac.in

Received date: 14-Dec-2021, Manuscript No. FMIC-21-49819;
Editor assigned: 16-Dec-2021, PreQC No. FMIC-21-49819 (PQ);
Reviewed date: 03-Jan-2022, QC No. FMIC-21-49819;
Revised date: 07-Jan-2022, Manuscript No. FMIC-21-49819 (R);
Published date: 14-Jan-2022,
DOI: 10.37532/1755-5310.2022.14(s8).184

Abstract

Background: Percutaneous coronary intervention utilize an X-ray machine for visualization of coronary artery and it is considered as the major keystone in diagnosis of coronary artery disease. Cardiovascular technologists operate, maintain X-ray generating laboratory and they are susceptible to innumerable radiation dose. Minimizing radiation in the cardiac catheterization laboratory is important to prevent long term complications. To minimize the cardiovascular technologists radiation exposure without compromising the quality of PCI, deep understanding of factors which are associated with high radiation exposure is needed.

Objectives: The aim of the study was to correlate the cardiac technologists radiation exposure between standard projection and modified projections, comparison of the cardiac technologists radiation exposure between Magnification-15 and Magnification-20, Allura Xper FD-20 and Allura Xper FD-10 Cath Lab Systems and assessment of cardiac technologists radiation exposure between radial and femoral angioplasty.

Methods: In a study population of 101 patients aged >18 years old who undergone Percutaneous Coronary Intervention Technique for revascularization of high-grade coronary artery stenosis between January 2020 to January 2021, among which 72 (71.3%) were males and 29 (28.7%) were females. For those patients, procedural cardiac technologists radiation dose in respect with beam angulation are noted from digital pockect dosimeter by the single observer.

Results: In patients who underwent percutaneous coronary angioplasty, for those patients, we compared the standard projections with modified projections. Mean projection-specific dosimeter dose in modified-RAO 10 Cranial 40 views (0.20 ± 0.09) associated with reduced radiation exposure, when compared with standard-RAO 35 Cranial 35 views (3.83 ± 27.54). Then mean projection-specific dosimeter dose in modified-LAO 20 Caudal 40 views (0.06 ± 0.08) associated with reduced radiation exposure, when compared with standard-LAO 35 Caudal 35 views (0.20 ± 0.33). And then we compared the magnification-20 with magnification-15. Mean dosimeter dose in magnification-20 was 0.64 ± 0.61 vs. 0.54 ± 0.40 for magnification-15. Mean dosimeter dose in Philips Allura Xper FD-20 System was 0.82 ± 0.536 vs. 0.49 ± 0.38 for Philips Allura Xper FD-10 System. For radial angioplasty mean dosimeter dose was 0.55 ± 0.42 vs. 0.61 ± 0.48 for femoral angioplasty respectively.

Conclusion: In this study, we analysed few factors can be optimized to minimize radiation exposure in cath lab. We founded that modified projections is associated with low radiation exposure compared to standard projections. Allura Xper FD-10 Cath Lab system is associated with lower radiation compared to Allura Xper FD-20 Cath Lab System. Magnification-20 is associated with high radiation than Magnification-15. Femoral approach is associated with high radiation than radial angioplasty. Optimizing

the factor which is discussed above, can potentially reduce radiation exposure to the technologists in cardiac cathlab.

Keywords: Radiation exposure • Cardiovascular technologists • Projection • Percutaneous coronary intervention

Introduction

Human beings are persistently exposed to natural radiation as well as to man-made sources of radiation. Peoples living in the southwest coast of Kerala in India, Yangjiang province in China, Ramsar in Iran acquires a high radiation doses throughout their life span due to long-standing low-level radiation dose from environmental radioactive elements. Man-made sources of ionizing radiation are currently helpful in evaluation, diagnosis and treatment of diseases. The cumulative exposure of ionizing radiation may lead to potential serious health problems [1,2].

Cardiovascular disease has lifted as an extensive barrier of health in developing countries. Acute coronary disease is a noticeable intention for cardiovascular morbidity and mortality. Revelant finding and definite treatment is a clinically indispensable to enhance clinical outcome [3,4]. The attractiveness of applying cine radiography to study the cardiovascular disease had been evident, however the restrictions obligatory by high radiation exposure [5]. Percutaneous Coronary Intervention (PCI) has emerged as leading therapy for coronary artery obstructive disease, and every PCIs are done under the guidance of fluoroscopy using ionizing radiation. Due to complex anatomical challenges such as diseased lesions, and total occlusion, the procedure has overshawdowed by increased radiation exposure to the cardiovascular technologists and operators [6,7].

Induction of tumors of the lung, thyroid and liver cancer in the operators may occur as a result of radiation Exposure. The chance of occurrence of skin desquamation and ulcers depends on significant body threshold dose. Even at low doses, the probability of malignancy occurrence is high [8,9].

Minimizing radiation in the cardiac catheterization laboratory is important to prevent long term complications due to radiation exposure. The amount of radiation dose aquired by the cardiovascular technologists depends on site of access, involved vessels and its severity, emergent case, patient's body mass index, magnification and the type of X-ray equipment used. To minimize the radiation exposure without compromising the quality of PCI, deep understanding of factors which are associated with high radiation exposure is needed. The purpose of the study is to look for the association of cardiovascular technologists radiation dose and its dependent factors [10].

Materials and Methods

In this prospective, single-center trial, 101 patients aged >18 years old who undergone Percutaneous coronary intervention Technique for revascularization of low to high-grade coronary artery stenosis between Jan 2020 to Jan 2021, among which 72 (71.3%) were males and 29 (28.7%) were females. Patients with prior coronary artery bypass surgery, abnormal Allen's test results, and emergency angiography were excluded. The study protocol was approved by the institutional review board, Kasturba hospital, Manipal, Karnataka and all patients provided informed consent.

Coronary angioplasty techniques and radiologic equipment

Coronary angiography was performed *via* a transradial and transfemoral access and when the angiogram identified with coronary lesions, the cardiologists decides to proceed to an Percutaneous coronary intervention, the procedural equipment table is prepared in sterile manner and includes Guide-cather, Guide-wires, balloons, balloon inflating/deflating device, and diluted contrast, sterile syringes, steering devices etc.

A guiding catheter is inserted into a large peripheral artery and threaded to the appropriate coronary ostium. A balloon-tipped catheter, guided by fluoroscopy or intravascular ultrasonography, is aligned within the stenosis, then inflated to disrupt the atherosclerotic plaque and dilate the artery. Angiography is repeated after the procedure to document any changes. The procedure is commonly done in 2 or 3 vessels as needed [11,12].

A total of 9 Standard Projection and two modified Projections were obtained: Left coronary projections consists of Anterior and Posterior (AP)-caudal, Cranial, Right Anterior Oblique (RAO)-caudal, RAO-cranial, Left Anterior Oblique (LAO)-cranial, and LAO-caudal (spider) views. Right coronary projections includes LAO, RAO, and LAO-cranial views. Modified Projections includes LAO 20 caudal 40 and RAO 10 Cranial 40 respectively.

This study was performed according to the Standard technical recommendations for minimising the radiation dose as follows: The minimal distance between the patient and image intensifier and maximal application of collimation.

The Allura Xper FD20 and Allura Clarity FD10 system equipped with new software version and lead shields were used for all procedures. The pulse rates of both fluoroscopic and cineangiography were acquired at 15 frames/second. Radiation dose measured using Dose Area Product (DAP rate in $mGycm^2 S^{-1}$),which were automatically estimated, displayed on the X-ray Equipment Monitor and mean Cardiovascular Technologists radiation exposure (scatter rate in microsieverts per hour) were

reported in microroentgen by a pockect dosimeter placed in the left upper pocket of the lead apron. By using this scatter radiation, allows us to analyse few factors in respect with X-ray equipment used, number of vessel involved, access site and Magnification that can be optimized to minimize radiation exposure in Cardiac catheterization laboratory [13].

Sample size estimation and statistical analysis

No randomized clinical trials regarding cardiovascular technologists Scatter dose during Percutaneous Coronary Intervention (PCI) have been conducted. However, the sample size was formulated based on observational data of radiation dose (Standard Deviation-1340 μGym^2) during coronary angiography performed over a 3 months in our cardiac catheterization laboratory. The number of patients needed in each group to observe a 25% reduction in the radiation dose and to achieve an 95% power at the level of significance 0.05 was estimated at 50 (total n=100).

Baseline characteristics and procedural characteristics were represented using descriptive statistics for continuous variables in form of frequency tables or Percentage (%) for discrete variables. Radiation parameters include FluoroTime, Cumulative DAP, and cardiovascular technologists Scatter Dose values were expressed as mean ± standard deviation.

Continuous variables were compared with an Independent t-test. A man whitney U-test (non-parametric test) was used if the distribution was skewed. All statistical analysis was performed with SPSS software. A p-value of less than 0.05 is considered as statistically significant.

Results

Procedural characteristics of patients

In total 101 patients were included in the study with PCI performed in 53 (52.5%) patients *via* the femoral access and in 48 (47.5%) patients *via* the radial access. The visualization of coronary artery on the x-ray equipment monitor can be electronically deepen to enhance the spatial resolution. Among which 76 (75.2%) patients were performed under magnification-15 and 25 (24.8%) patients were performed under magnification-20.

The Allura Xper FD20 uses an MRC GS 0407 tube while the majority of FD10s use the MRC GS 0508 tube that differs in focal spot and heat dissipation in which our study had 28 (27.7%) patients were performed in Allura Xper FD20 and 73 (72.3%) patients were performed in Allura Xper FD10.

The PCI may be performed during the same session as diagnostic catheterization in individuals with myocardial infarction (Adhoc PCI) or at a later session in individuals who presented with angina and remains problematic, in spite of extreme medical treatment (Elective PCI). Out of 101 patients, 34 (33.7%) patients had undergone Adhoc PCI and 67 (66.3%) patients had undergone Elective PCI.

Various imaging modalities used in Percutaneous coronary intervention includes Intravascular ultrasound and optical coherence tomography imaging improves diagnostic accuracy in measuring vessel, stenosis dimension and characterising lesion morphology in which our study analysed 101 patients in whom IVUS guidance 55 (54.5%) patients and OCT guidance 15 (14.9%) patients.

The classification of coronary artery disease is also assessed based on the involvement of number of coronary arteries, in our study single vessel disease was reported among 75 (74.3%) patients, double vessel disease was reported among 24 (23.8%) patients and multivessel disease was seen in 2 (2%) patients (Table 1).

Radiation parameters characteristics

The modern X-ray Equipment facilitate radiation data to the operators on the quantity of patient's radiation dose during procedure. Fluoroscopy time is the time during a procedure that fluoroscopy is used and our study reported a mean Fluoro time value of 949.2 ± 478.7. The standard quantities are dose area product reported in Gy.cm2 and cumulative air kerma in reference point of the patient measured in milligram. Cumulative DAP and Cumulative Airkerma was calculated for the PCI group which showed a mean value of 48374.7 ± 38720.9 and 1173.7 ± 2301.4 respectively.

For cardiovascular technologists, personal dosimeter gives values of personal dose equivalent reported in millisieverts. The mean Cumulative Scattered Dose of the study population was found to be 0.58 ± 0.45 (Table 1).

Table 1: Table summarising the core set of views recommended for the left coronary system and right coronary system in respect with mean cardiovascular technologists scatter dose and time.

Projections	Dose
AP Plain	0.03 ± 0.02
LAO Cranial	0.18 ± 0.21
LAO Caudal	0.20 ± 0.33
RAO Cranial	3.83 ± 27.54
RAO Caudal	19.03 ± 133.76
AP Cranial	8.97 ± 46.17
AP Caudal	0.13 ± 0.15
LAO Plain	0.06 ± 0.08
RAO Plain	0.07 ± 0.07
RAO10 Cranial40	0.20 ± 0.09
LAO20 Caudal40	0.06 ± 0.08
Lateral 90	0.3

Comparison of standard projection vs. modified projection

In Patients who underwent Percutaneous Coronary Angioplasty (PCI), for those patients, we compared the standard projections with modified projections. Mean projection-specific dosimeter dose in modified-RAO 10 Cranial 40 views (0.20 ± 0.09) associated with reduced radiation exposure, when compared with Standard-RAO 35 Cranial 35 views (3.83 ± 27.54). Then mean projection-specific dosimeter dose in modified-LAO 20 Caudal 40 views (0.06 ± 0.08) associated with reduced radiation exposure, when compared with standard-LAO 35 Caudal 35 views (0.20 ± 0.33).

Comparison of magnification-15 vs. magnification-20

Radiation parameters like mean Cumulative scattered dose 0.64 ± 0.61 (Cardiovascular technologists dose) in magnification-20 is observed as highest mean dose than 0.54 ± 0.40 in magnification-15.

Comparison of Philips Allura FD10 vs. Philips Allura FD20

In Patients who underwent Percutaneous Coronary Angioplasty (PCI), for those patients, we compared the Philips Allura FD10 with Philips Allura FD20. Mean projection-specific dosimeter dose in Philips Allura FD10 (0.49 ± 0.38) associated with reduced radiation exposure, when compared with Philips Allura FD20 (0.82 ± 0.536).

Estimation of scatter dose between radial and femoral approach

In our study population of 101 cases performed, the mean air kerma, mean cumulative scattered dose (cardiac technologists dose) were higher with use of the right femoral approach and lower with the right radial approach.

The average dosimeter dose difference for each projection was observed between the Right Radial Approach and the Femoral Approach. The mean dose recorded through Right Radial Approach (0.55 ± 0.42) and the dose recorded through right femoral approach (0.61 ± 0.48).

Discussion

Percutaneous coronary intervention utilize an X-ray Machine for visualization of coronary artery and it is considered as the major keystone in diagnosis of coronary artery disease. Cardiovascular technologists operate, maintain X-ray laboratory and they are susceptible to innumerable radiation dose.

The Food and Drug Administration (US) regulates the manufactures in relation to every Imaging X-ray equipment to ensure that those machines are safe. Moreover, the Food and Drug Administration (FDA) restrict at most the highest absorbed dose of fluoroscopy and it is evaluated by passive radiation detection devices. In present clinical catheterization laboratory setting, cardiovascular technologists must be cognizant of the machine generating radiation principles and the radiation-reducing strategies. Radiation Protection devices include radiation protection shield, aprons, and eye glasses can minimize the radiation risk.

The Thermo luminescent dosimeter is the commonly used device to estimate the effective radiation dose in cardiac catheterization laboratory. It is also important to measure the amount of radiation dose aquired by the cardiovascular technologists with the help of modern radiation dosimeters available, because the TLD does not have access to the real time exposure to the cardiovascular technologists in order to minimize or eliminate the unwanted radiation exposure.

The amount of radiation dose aquired by the cardiovascular technologists depends on site of access, involved vessels and its severity, emergent case, patient's body mass index and the type of X-ray equipment used [13]. In the current study, 101 subjects were participated to look for the association of cardiovascular technologists radiation dose and their dependent Factors mentioned above.

In a research conducted by Farman, et al. The period of study was July 1, 2009, to Sept 30, 2009. They studied 1016 adults patients reffered for coronary intervention. Out of these 928 were diagnostic (734 through femoral approach and 194 through radial approach) 88 cases referred for PCI (64 through femoral and 24 through radial approach). Fluoro time was noted as an alternative of radiation exposure. From this research, fluoro time was higher in patients with r-CA and r-PCI [14].

Our study had mean age of 62.65 ± 12.32, 29 (28.7%) of the population were found to be females and 72 (71.3%) were males. In the literature the Access site based Cardiac Technologists dose in association with various projections and time are not well studied especially in Indian population, only few recent studies have been conducted by industries to look for the primary operator radiation exposure in association with radial and femoral access.

Conclusion

Minimizing radiation in the cardiac catheterization laboratory is important to prevent long term complications due to radiation exposure. To minimize the radiation exposure without compromising the quality of PCI, deep understanding of factors which are associated with high radiation exposure is needed. So in this study, we analysed few factors can be optimized to minimize radiation exposure in cath lab.

a) We founded that Modified angulation compared with standard projection, especially shallow LAO Caudal and shallow RAO Cranial projections reduce radiation exposure significantly.

b) Magnification-20 is associated with high radiation compared to Magnification-15.

c) Philips Allura FD-20 is associated with high radiation compared to Philips Allura FD-10.

d) Femoral Approach is associated with high radiation than Radial approach angioplasty.

Optimizing the factor which is discussed above, can potentially reduce radiation exposure to the technologists in cardiac cathlab.

Limitations

• Relatively low number of patients and study conducted in a single-center.

• This study was non-randomized for standard and modified views.

References

1. Mehta SR, Suhag V, Semwal M, et al. Radiotherapy: Basic concepts and recent advances. Med J Armed Forces India. 66(2): 158-62 (2010).
2. Christian S. The human coronary collateral circulation. Heart (British Cardiac Society). 89(11): 1352-7 (2003).
3. Reddy KS, Yusuf S. Emerging epidemic of cardiovascular disease in developing countries. Circulation. 97(6): 596-601 (1998).
4. Curry TS. "Production of X-rays". Christensen's physics of diagnostic radiology. Lea and Febiger, U.S, Lippincott Williams and Wilkins Publication, 4th Eds. (1990).
5. Abrams HL. History of cardiac radiology. AJR Am J Roentgenol. 167(2): 431-8 (1996).
6. Chon MK, Chun KJ, Lee DS, et al. Radiation reduction during percutaneous coronary intervention: A new protocol with a low frame rate and selective fluoroscopic image storage. Medicine (Baltimore). 96(30): 7517 (2017).
7. Park SM, Kim HC, Lee MS, et al. A randomized comparison of estimated radiation exposure between Low and conventional dose protocol during invasive coronary angiography (ERICA trial): Pilot study. Eur J Radiol. 129 (2020): 109120.
8. Hirshfeld JW, Balter S, Brinker JA, et al. ACCF/AHA/HRS/SCAI clinical competence statement on physician knowledge to optimize patient safety and image quality in fluoroscopically guided invasive cardiovascular procedures: A report of the American College of Cardiology Foundation/American Heart Association/American College of Physicians Task Force on Clinical Competence and Training. Circulation. 111(4): 511-32 (2005).
9. Khelassi-Toutaoui N, Toutaoui A, Merad A, et al. Assessment of radiation protection of patients and staff in interventional procedures in four Algerian hospitals. Radiat Prot Dosimetry. 168(1): 55-60 (2016).
10. de Mattos EI, Cardoso CO, de Moraes CV, et al. Radiation exposure in coronary procedures using the radial and femoral approaches. Rev Bras Cardiol Invasiva. 21(1): 54-59 (2013).
11. Samady H. Anatomy for interventional cardiology. Interventional Cardiology. 2e Eds. McGraw-Hill Education LLC. (2017).
12. Baim DS, Grossman W. Cardiac catheterization, Angiography and Intervention. 5th ed. Baltimore: Williams and Wilkins. (1996).
13. Watson S. Radiography a manual for cath lab personnel. Invasive cardiology. 3rd Eds. Jones and Bartlett Learning International, London. (2016).
14. Farman MT, Khan NU, Sial JA, et al. Comparison of fluoroscopy time during coronary angiography and interventions by radial and femoral routes- can we decrease the fluoroscopy time with increased experience? An observational study. Anadolu Kardiyol Derg. 11(7): 607-12 (2011).