

Remarkable reduction of exposure rate in patients with stress-only myocardial perfusion scan: Let's safe mankind from unjustified radiation exposure

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(Received 26 July 2013, Revised 26 August 2013, Accepted 28 August 2013)

ABSTRACT

Introduction: To measure radiation exposures rate in low-risk patients having stress-only and stress-rest myocardial perfusion imaging.

Methods: This was a prospective study conducted from January 2012 till November 2012 upon patients with low pre-test probability for coronary artery disease (CAD). A stress MPI (stress-only if MPI is normal and no resting study) followed by a resting MPI study (same day) if stress study was positive or equivocal. Exposure rates (in milli-Roentgen/hour, mR/hr) from injected patients at 1 meter distance were measured at 10 minutes, 1 hour and at time of releasing patients in both groups.

Results: Total 369 patients were included and 104 (28%) patients had stress-only and 265 (72%) had stress-resting studies. Mean administered ^{99m}Tc-MIBI dose in Stress-only and Stress-rest groups was 8 ±1 mCi and 24 ±03 mCi respectively (p<0.05). Exposure rates (in mR/hr) within 10 min, 1 hour and at release time in Stress-only and stress-rest groups were 0.394, 0.294, 0.194 and 1.540, 1.431, 1.207 respectively (p<0.05). Mean stay of patients in laboratory was 90 ±39 minute in Stress-only and 156 ±53 minute in Stress-Rest group (p <0.0001). There was a significantly widening gap between exposure rates from patients with Stress-only and stress-rest protocols as 26:74%, 21:79% and 16:84% at 10 min, 1 hour and at time of release respectively.

Conclusion: We conclude that adopting a Stress-only MPI protocol in low risk patients ensures significantly lower radiation doses to patients and technologists. A worldwide paradigm shift in nuclear cardiology practice would safe mankind from unjustified radiation exposure.

Key words: Stress-only MPI; Stress-rest MPI; Radiation exposure rate; Effective dose

Iran J Nucl Med 2014;22(1):11-15

Published: December, 2013

<http://irjnm.tums.ac.ir>

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INTRODUCTION

According to a recent report by National Council for Radiation Protection (NCRP), over the last 30 years there has been a six fold rise in radiation exposure to Americans and this has raised serious concerns about stochastic effects of ionizing radiations [1]. The seminal reason for this hike is overwhelming use of computerized tomography (CT) and nuclear medicine (NM) procedures. Interestingly 50% of worldwide NM procedures are performed in United States and myocardial perfusion imaging (MPI) and CT are responsible for >75% of total effective radiation dose [2]. Considering the impact of this staggering trend, International Atomic Energy Agency (IAEA) [3] and American Society of Nuclear Cardiology (ASNC) [4] have stressed upon the need of optimization-justification policy, following appropriate use criteria (AUC) and also recommended various modifications in imaging protocols and hardware to minimize radiation exposure to patients and technologist. In MPI various strategies have been employed like avoiding dual isotope (resting ^{201}Tl and stress $^{99\text{m}}\text{Tc}$ -agents) imaging (except in viability protocol), use of wide beam reconstruction or resolution recovery strategies, use of low radiotracer with semiconductors (Cadmium Zinc Telluride, CZT) cameras and performing normal Stress-only or stress first imaging protocols [4].

Advantages of normal stress-only imaging protocol are short imaging time (90 minutes as compared to 3-5 hour for stress-rest protocol), cost effectiveness, better patients' throughput and lower radiation doses to patients and imaging staff [5]. The major apprehension with normal stress-only protocol was safety profile and negative predictive value but a large number of published studies including from our group have shown similar NPV of two protocols [6-9].

The aim of this study was to measure radiation exposures rate in low risk patients having stress-only and both stress-rest protocols.

METHODS

This was a prospective study conducted at Nuclear Cardiology Department of Karachi Institute of Heart Diseases (KIHD) from January 2012 till November 2012 and was approved by Institute Ethical Committee. As per ASNC recommendation [4], in patients with low pre-test probability for CAD, we do stress (stress-only if MPI is normal) followed by a resting study (same day) if stress study is positive or equivocal.

A normal gated MPI was defined as absence of perfusion defects on stress images, normal left

ventricular ejection fraction (EF >50%) and normal wall motion. Patients with positive or equivocal stress gated MPI underwent a same day resting study. For stress and resting studies $^{99\text{m}}\text{Tc}$ MethoxyIsoButylIsonitrile (MIBI) was injected at 1-2 minutes prior to terminating the exercise or 3-4 minutes after completion of dipyridamole infusion and at rest respectively. Exposure rates from injected patients at 1 meter distance were measured by a technologist at 10 minutes and 1 hour after stress injection in Stress-only and after resting injection (second radiotracer injection) in Stress-rest groups. Similarly exposure rates were also measured in both groups at time of release. A hand held dose meter (Radiation Alert Monitor, SE Int, TN, USA) was used to measure the exposure rate in milli-Roentgen/hour (mR/hr).

Statistical analysis

Data was analyzed by using commercially available packages the Medcalc® statistical software version 11.3.10 and statistical package for social sciences (SPSS version 17®). Demographic and stress test variables were prospectively collected for all patients at the time of stress testing in the Nuclear Cardiology Database. Characteristics of the study population were described based on the type of stress protocol employed. A two-tailed student t-test was used to compare continuous variables and a chi-squared test was used to compare categorical variables. P value <0.05 were considered significant.

RESULTS

During the study period, 369 patients were accrued with a mean age of 56 ± 11 years, Male: Female 54%:46% with a mean body mass index (BMI) 28.26 ± 13.03 Kg/m². 104 (28%) patients had stress-only (mean age 53 ± 11 years) and 265 (72%) had both stress-resting studies (mean age 57 ± 11 years) (Table 1). The mean administered radiotracer dose in Stress-only group was 8 ± 1 mCi and 24 ± 03 mCi in Stress-Rest group (significant p value). Exposure rate at 1 meter within 10 min after administration of stress dose of $^{99\text{m}}\text{Tc}$ -MIBI in Stress-only group was 0.394 ± 0.059 milli-Roentgen/hour (mR/hr) and 1.540 ± 0.657 mR/hr in patients after resting injection (second radiotracer injection) in Stress-Rest group (p <0.0001). Similarly the exposure rate at 1 meter distance at 1 hour and at time of releasing the patients was significantly low (0.294 ± 0.059 and 0.194 ± 0.060 mR/hr respectively) in Stress-Only group than Stress-Rest group (1.431 ± 0.670 and 1.207 ± 0.733 mR/hr respectively). Mean time between stress injection and release was 90 ± 39 minute in Stress-only and 156 ± 53 minute in Stress-Rest group (p <0.0001) (Table 1 and Figure 1).

Table 1. Patients' demographics.

Variable	Total MPIs (369)	Comparison between sub-groups			
		Stress only 104 (28%)	Stress-Rest 265 (72%)	Test values	P value
Age (Mean \pm SD) years	56 \pm 11	53 \pm 11	57 \pm 11	3.143	0.0018*
BMI (mean \pm SD) Kg/m ²	28.26 \pm 13.03	28.55 \pm 5.30	28.14 \pm 15.00	-0.272	0.786
Male: Female	54% : 46%	25% : 75%	65% : 35%	46.472	<0.0001*
Cumulative Dose (mean \pm SD) mCi	20 \pm 8	8 \pm 1	24 \pm 3	53.204	<0.0001*
Exposure Rate at 1 meter (mean \pm SD) mR/hr Within 10 minutes	1.225 \pm 0.763	0.394 \pm 0.059	1.540 \pm 0.657	15.502	<0.0001*
Exposure Rate at 1 meter (mean \pm SD) mR/hr At 01 hr	0.773 \pm 0.709	0.294 \pm 0.059	1.431 \pm 0.670	17.266	<0.0001*
Exposure rate at 1 meter (mean \pm SD) mR/hr At discharge	1.217 \pm 0.759	0.194 \pm 0.060	1.207 \pm 0.733	14.064	<0.0001*
Duration between injection & discharge: (mean \pm SD) minutes	137 \pm 58	90 \pm 39	156 \pm 53	11.529	<0.0001*

*p<0.05, MPI=Myocardial Perfusion imaging, SD= Standard Deviation , BMI=Body Mass index, mCi=milli Curie, mR/hr=milli Roentgen/hour

There was a significantly widening gap between exposure rates from patients with Stress-only and stress-rest protocols as 26:74%, 21:79% and 16:84% at 10 min, 1 hour and at time of release respectively (Figure 2).

DISCUSSION

In last few years medical community has become more cognizant about the enormous radiation exposure due to radiation based procedures, primarily CT and myocardial perfusion imaging. Recently Einstein AT et al [10], revealed that about one-third of patients undergoing multiple MPI testing at a

single center received a cumulative estimated effective dose over 100 mSv, a level believed to be associated with an increased cancer risk. In compliance with IAEA [3] and ASNC [4] guidelines, Department of Nuclear Cardiology, KIHD has been practicing stress-only protocol in low risk patients since its inception (December 2008) and have shared our results [7] regarding negative predictive value of this truncated protocol.

This prospective study has shown impact of two imaging protocols upon radiation exposure from these respective patients at various time intervals. This data has clearly shown remarkably reduced exposure rate from patients entitled for Stress-only protocol and assumedly reduced effective dose.

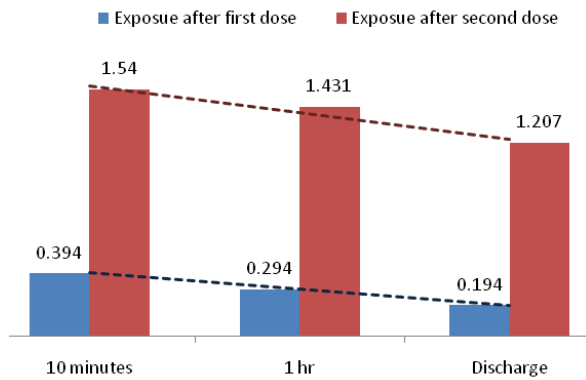


Fig 1. Comparative analysis of average exposure rates (mR/hr) at 1 meter distance after administration of first and second dose of Tc-99m MIBI, respectively.

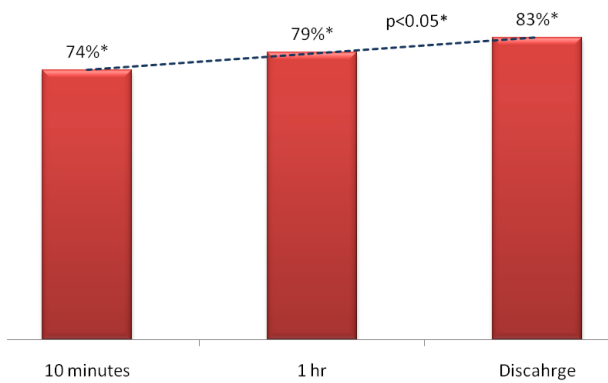


Fig 2. Illustrate % reduction in exposure rate at different time in single dose versus after double dose of Tc-99m MIBI in myocardial perfusion imaging.

Our results are in concordance with a recently published study which has shown significantly reduced exposure to staff of nuclear cardiology by using Stress-only protocol and semiconductor gamma camera [5]. But magnitude of reduction of dose exposure in Stress-only protocol in our study is much higher (70%) than this study [5]. This could be explained by the fact that we used low dose of ^{99m}Tc-MIBI for stress (mean 8 ±1 mCi). This is in accordance with ASNC’s goal of no more than a 9mSv patient exposure in 50% of studies by 2014 [4]. In this study progressively increasing gap of radiation exposure among two protocols (declining for Stress-only and vice versa) was due to sluggish clearance of MIBI through hepatobiliary system and prolong residence in bowel loops. We must acknowledge that

Stress-first imaging requires availability of a qualified nuclear cardiologist for appropriate patient selection and reviewing of stress images immediately to decide the need for resting images. This must be a limitation for those laboratories where availability of credentialed reporting physician is time based.

In last few years two important studies have pointed out increased incidence of brain tumor in interventional cardiologist [11] and higher incidence of cancer in offspring of radiation workers [12]. However, earlier a study published by Roman et al in 1996, regarding childhood cancer incidence in the offspring of medical radiographers found no significant excess [13]. The results of our study showing markedly lower exposure rate from injected patients with Stress-only protocol is also ensuring for the staff of every nuclear cardiology laboratory. The limitation of this study was that we did not measure effective dose delivered to patients in both groups and effective dose received by our technologists for each protocol separately. The reason was limited technical resources and practically was not possible to use separate TLD readers.

Another important aspect of this study was significantly lower stay in laboratory of patients who underwent Stress-only protocol. This also has imparted in lower radiation exposure to technical staff and also to family members and general public who have an annual dose limits of 1 mSv [14].

The results of this study become more important in view of a recent study which has shown significant decline in incidence of abnormal MPIs from 41% in 1991 to 8.7% in 2009 [15]. This reciprocally shows an increasing number of normal MPI which must be the major contributor of radiation doses from nuclear cardiology procedures. Therefore a worldwide paradigm shift towards stress first (and Stress-only if it is normal) in patients with low pre-test probability for coronary artery disease would certainly bring down the unjustified radiation exposure to mankind. This would indeed settle down the unrest among radiation workers who are concerned due to recently revealed threatening facts and reports of higher incidence of malignancy and congenital anomalies in sibling of radiation workers [11, 12]. We believe that this single but important step would help ASNC to achieve its goal of no more than a 9 mSv patient exposure in 50% of studies by 2014 [4].

CONCLUSION

We conclude that adopting a stress first and Stress-only protocol for MPI in low risk patients ensures significantly low radiation doses to patients and technologists, cost and time effective and improves patient throughput of stress laboratory. A worldwide

paradigm shift in nuclear cardiology practice would lower down unjustified radiation exposure and enhance the confidence of radiation workers regarding biological effects of ionizing radiations.

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