Evaluation of Blood Parameters Alteration Following Low-dose Radiation Induced by Myocardial Perfusion Imaging

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ABSTRACT

Introduction: With increasing the usage of myocardial perfusion imaging (MPI) for the diagnosis of ischemic heart disease, we aimed to evaluate the side effects of low-dose radiation induced by this technique on blood elements, especially proteins and liver function factors.

Material and Methods: 40 eligible patients (Mean age: 54.62±10.35, 22 female and 18 male), who had referred to the nuclear medicine department for MPI from May till August 2014, were enrolled in the study. A blood sample was taken from each patient just before and 24 hours after the injection of 740Mbq of Tecnetium-99m Methoxy isobutyl isonitrile (99mTc-MIBI) in the rest phase of the MPI in a reference medical laboratory; blood tests included total protein (TP), albumin (Alb), globulin (Glo), aspartate aminotransferase (AST), alanine transaminase (ALT), alkaline phosphatase (ALP), direct bilirubin (D.Bili), total bilirubin (T.Bili), serum iron (SI), total iron bounding capacity (TIBC), Albumin globulin ratioA/G ratio), and complete blood count (CBC).

Results: Injection of 740Mbq99mTc-MIBI caused a significant increase in serum levels of AST ($p= 0.001$), ALT ($p= 0.001$), SI ($p= 0.030$), TIBC ($p= 0.003$) and A/G Ratio ($p= 0.020$). However, following radiotracer injection, a significant decrease was noted in the serum levels of TP ($p= 0.002$), Alb ($p= 0.014$), Glo($p= 0.002$), ALP ($p= 0.001$), D.Bili ($p= 0.003$) and T.Bili ($p= 0.000$).

Conclusion: Due to increased usage of MPI, our data highlights the importance of monitoring the clinical and paraclinical effects of the procedure on vital organs and physiological pathways to reduce their adverse effects.

Keywords

Low-dose Radiation, Blood Biomarkers, Myocardial Perfusion Imaging

Introduction

Currently, radioactive tracers play a significant role in the field of biological sciences, particularly nuclear medicine [1]. Radionuclides are used in nuclear medicine in a variety of ways. Two risk groups are identified following the administration of radiopharmaceutical: the patient and the groups of individuals exposed to the patient. According to a recent report by the National Council on Radiation Protection and Measurements, the number of people exposed to radiation from medical imaging has increased by six-folds in the past three decades

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and at present approximately 40% of medical radiation exposure (excluding radiotherapy) comes from cardiovascular imaging and image-guided interventions [2]. Patients usually receive low-dose radiation following the administration of diagnostic radiopharmaceutical. In most diagnostic procedures, radiation dose is less than 20mSv. Some studies have shown that many patients are being exposed to multiple doses of radiation which can lead to high cumulative dose, therefore, it is necessary to take a more cautious approach regarding the patient's absorbed dosage [3].

Myocardial Perfusion Imaging (MPI) is one of the most common techniques which is used in the field of nuclear medicine. Technetium-99m compounds are used to image heart muscle perfusion and emits photons with energies 140 KeV [4] It is usually performed by Technetium-99m methoxy isobutyl isonitrile (99mTc-MIBI), in two separate stress and rest phases [6]. The bio-distribution of 99mTc-MIBI is characterized by a rapid blood clearance and consequently early myocardial uptake. The initial intense hepatic activity is cleared into the gall bladder after 1h and the best target to non-target ratio is observed at 60–90 min post injection. Absorbed radiation dose calculation demonstrates that thyroid is the critical target organ (230 mRad/mCi at rest), apparently because of 99mTc-pertechnetate generated in vivo [5]. Recently, scientists focused on the effects of exposure on liver function in the nuclear medicine department [6-11].

The aim of this study was to evaluate the early fluctuations of some blood proteins and liver function tests following the rest phase of the MPI.

Material and Methods

According to Helsinki Declaration, forty patients were enrolled in this randomized controlled trial study. All these patients were referred to nuclear medicine department of Namazi Hospital for MPI from May 2014 for 4 months. Amongst them, 22 were female and 18 were male with age range of 36-72 years old. The inclusion criterion for this study was normal hepatic function tests without any history of hematologic disorders.

The exclusion criteria were kidney disorders, hepatic or hematological disorders and abnormal liver function tests. All experiments with human subjects were approved by the Ethics Committee of Shiraz University of Medical Sciences. Verbal and written informed consent was taken from each patient.

MPI was performed at rest phase of the study on the first day followed by stress phase on the second day. In each phase, 740 MBq (20 mci) 99mTc-MIBI was injected intravenously. From each patient, 4 milliliter of blood samples were collected before as well as 24 hours after injection of 99mTc-MIBI in the rest phase of the study. Blood samples were taken before stress phase of the study to exclude the potential effects of the stressors on the results. All kits are from Audit Company.

Laboratory tests including Total Protein(TP), Albumin(Alb), Globulin(Glo), Aspartate Aminotransferase (AST), Alanine Aminotransferase (ALT), Alkaline Phosphatase (ALP), Direct Bilirubin (D.Bili), Total Bilirubin (T.Bili), Serum Iron (SI), Total Iron Bounding Capacity (TIBC), Albumin Globulin ratio(A/G Ratio) and complete blood Count (CBC) were measured in a reference medical laboratory. Each test was duplicated to confirm the reproducibility of the results.

Statistical Analysis

The gathered data were analyzed by SPSS V.20 software. A paired-sample t-test was used to determine whether there was a statistically significant mean difference between the mentioned blood parameters before and after injection of 99mTc-MIBI. Data are mean ± standard deviation, unless otherwise stated. In all cases, $p < 0.05$ was considered statistically significant.

Results

Forty patients, 18 males and 22 females participated in the study. Demographic data are shown in Table 1.

Blood levels measurement of TP, Alb, Glo, AST, ALT, ALP, D.Bili, T.Bili, SI, TIBC and A/G Ratio are shown in Table 2.

Based on the results, AST, ALT, SI, TIBC and A/G Ratio levels increased significantly in patients' blood samples 24 hours after injection of 740 Mbq99mTc–MIBI in comparison to pre-injection levels; whereas, TP Alb, Glo, ALP, D.Bili and T.Bili significantly decreased when compared to pre-injection levels. CBC levels exhibited no significant changes. There were no correlations between biochemical parameter changes and the patient's age or sex.

Table 1: Demographic data of patients.

Items		Mean±SD	Minimum-Maximum
Age (years)		54.62±10.35	36-72
Sex (%)	Male		18 (45%)
	Female		22 (55%)

Discussion and Conclusion

Recent exposure to low-dose radiation has become an interesting subject for many scientists[12-16]. The use of diagnostic imaging particularly MPI which has low-dose ionizing radiation has increased in recent years; this has created a renewed interest in the evaluation of early adverse effects of low-dose radiation exposure for patients.

According to analyzed data, the mean value of statistical variables of TP, Alb, Glo, AST, ALT, ALP, D.Bili, T.Bili, SI, TIBC and A/G Ratio were statistically significant ($P< 0.05$). While the injection of 99mTc MIBI showed no statistical significant changes on the CBC level (P value > 0.05). Sony et al. reported that by increasing the radiation dose in the animal model P decreased [17]. These data are consistent with data obtained in our study. Nwozo et al. showed that irradiation of 6Gy y-radiation to male Wistar rats caused an increase in serum concentrations levels of ALT

Table 2: The results of laboratory analysis. 1 represents before and 2 represent after radiotracer injection.

Paired-Samples Sig. (2-tailed)	Paired Differences			P- Value
	Mean	SD	Std. Error Mean	
TP 1 - TP 2	0.2450	0.4585	0.0725	0.002
Alb 1 – Alb 2	0.1050	0.2572	0.0407	0.014
Glo 1 – Glo 2	0.1475	0.2764	0.0437	0.002
AST 1 – AST 2	-9.5250	17.4694	2.7621	0.001
ALT 1 – ALT 2	-9.1250	16.8632	2.6663	0.001
ALP 1 – ALP 2	19.0250	34.9105	5.5198	0.001
D.Bili 1 - D.Bili 2	0.0350	0.0700	0.0111	0.003
T.Bili 1 - T.Bili 2	0.2075	0.3092	0.0489	0.000
SI1 – SI2	-13.4250	37.6413	5.9516	0.030
TIBC 1 – TIBC 2	-20.9500	42.0524	6.6491	0.003
A/G 1 - A/G 2	-0.0450	0.1176	0.0186	0.020

and AST [18]. In addition, Li et al. proved that the use of ALT was a significant predictive factors for radiation-induced liver injury [19]. In our study, we revealed that radiation dose could cause an increase in the level of ALT and AST. Chi C. et al. reported that following exposure to Co γ-ray albumin serum level decreased while globulin serum level increased [20]. Our study showed a decrease in A/G ratio after exposure to low-dose radiation which was in contradiction to pervious study. In our study, we observed a statistically significant decrease in T.Bili and D.Bili serum levels after the injection of 99mTc MIBI. Similarly, many other studies have shown that after exposure to low-dose radiation, serum levels of D.Bili and T.Bili decreased as well as uur results [21-23]. Our results showed that 99mTcMIBI significantly increased SI and TIBC serum levels. These results are relevant with previous studies [24-25]. The study also found that a significant difference exists in the A/G ratio before and after injection of 99mTcMIBI. As A/G ratio in serum increased after injection of 99mTc-MIBI; however, we observed that Alb and Glo amounts decreased. Our study also exhibited a statistically significant decrease in TP and Alp serum levels as well. CBC was also checked before and after the injection of the radio tracer and no statistical differences were observed.

We evaluated the effects of radiation on the resting phase of the procedure to eliminate the possible effects of the stressors. Radiation-induced effects of MPI would be much higher if the radiation caused by stress phase was added.

In our study, statistical biomarker changes following low-dose radiation was confirmed. This might cause adverse effects on vital organs especially liver or promote the deterioration of physiological functions. Further studies on the long-term effects of low-dose radiation on the blood biomarkers are suggested.

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Conflict of Interest

The authors report no declarations of interest.

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