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The Effect of Barium Swallowing on the Reduction of Artifact of the Inferior Wall of the Myocardium

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Abstract: Occasionally, gastrointestinal activity in radionuclide scintigraphy could be problematic. Drugs which are labeled by Technetium-99m in myocardial perfusion scanning such as tetrofosmin, sestamibi are released mainly through the hepatobiliary system. Following this release, the digestive system adjacent to the myocardium becomes active which is able to create artifact in the resulting images**.** The aim of this study is to propose a method that while being safe and inexpensive can provide the least possible changes in the normal myocardial perfusion imaging procedures and also provide better images with higher quality and fewer artifacts. The study sample consisted of 15 cases (6 male and 9 female) aged 40-70 (mean 55) who were referred to our nuclear imaging centerand were more likely to develop diaphragmatic artifact on the left ventricle walls of the myocardium, i.e., cases with Body Mass Index (BMI) >25 or those with central obesity. About 30 g of barium sulfate which was solved in 200cc of water at room temperature was administered to the patients in sitting position and immediately they underwent planar scanning of the areas under diaphragm for 5 min. Images of each stage were reviewed and analyzed by the Xeleris 2006 software. All phases of the reconstruction of images, selection of the subdiaphragmatic area, calculation of the count in the selected area and also determination of the radiation activity level in each pixel of the selected area was conducted by this software. According to the results of this study, it can be concluded that there is a possibility of reducing the subdiaphragmatic artifact with this method.

Key words: Myocardial perfusion imaging, barium, artifact, drugs, pixel

INTRODUCTION

About 201 Thallium is recognized as a useful tracer for myocardial perfusion imaging (Fallahi *et al*., 2014; Pohost *et al*., 1977). However, due toits physical and biological characteristics, it is not ideal for imaging. Lower photon energy is the major limitation of 201 Tl which causesscattering from overlying tissues. Higher energy of 99 mTc-sestamibi is optimal for gamma camera scintigraphy and it has also less attenuation. Because of thephysical advantages of 99 mTc-sestamibi over 201Tl and alsomore favorable biological characteristics, including rapid lung and liver clearance the development of a myocardial perfusion agent labeled with 99mTc is attractive (Li *et al*., 1988; Leppo and Meerdink, 1989; Haghighatafshar and Farhoudi, 2015). Occasionally, some incidental findings and gastrointestinal activity in radionuclide scintigraphy could be problematic (Eftekhari *et al*., 2010; Haghighatafshar and Khajehrahimi, 2015; Haghighatafshar and Farhoudi, 2015). Drugs which are labeled by Technetium-99m such as tetrofosmin, sestamibi are more favorableradiotracer in Myocardial Perfusion Imaging (MPI) (Ghaedian *et al*., 2015) and are released mainly through the hepatobiliary system (Higley *et al*., 1993). Following this release, the digestive system adjacent to the myocardium becomes active which is able to create artifact in the resulting images (Rehm *et al*., 1996; Karayalcin *et al*., 1998). High colon activity can prevent the detection of defects in the myocardium inferior wall due to its radiations, especially

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in studies with planar images (planar). Accordingly, to reduce the subdiaphragmatic activity or digestive activity and consequently to acquire images with higher quality and accuracy, various studies have been conducted and various methods have been proposed. In these studies, for example, drinkingcold or a large amount of water before scanning, eating before scanning, consuming high fat food, drinking juices and administering various drugs have been examined. In this study, we decided to examine the theory that whether by oral administration of barium sulfate prior to scanning, the subdiaphragmatic activity can be reduced. The reason for choosing barium sulfate in this study is firstly, the very good radiation-absorbing property of this material, that on this basis, it is widely used in the other radiological investigations. Another reason is the safety of this material and finally the low cost, ease of preparation and availability of this material at health care centers of our country. In fact, in this study we aim to propose a method that while being safe and inexpensive, can provide the least possible changes in the normal myocardial perfusion imaging procedures and also provide better images with higher quality and fewer artifacts.

MATERIALS AND METHODS

The study sample consisted of 15 cases (6 male and 9 female) aged 40-70 (mean 55) who were referred to our nuclear imaging center. The cases were selected with simple random sampling method among the patients who were more likely to develop diaphragmatic artifact on the left ventricle walls of the myocardium, i.e., cases with Body Mass Index (BMI)>25 or those with central obesity. Cases who could not swallow barium and cases with contraindication for barium swallowing, i.e., cases who had the possibility or probability of bowel perforation or those who had a history of allergy to barium or cases who were supposed to undergo a CT scan of the abdomen or chest during a few days after the study were excluded from the study. In the studied sample, after obtaining the informed consent from the patients, the intervention took place. The usual method done in this center is the injection of 0.3 mci kg^{-1} of the MIBI intravenously, manufactured by Kavoshyar Company of Iran's Atomic Energy Organization and the phase of stress myocardial perfusion scan is carried out by intravenous administration of the Dipyridumole drug by the Gamma Camera (dual head) GE. Xeleris 2006 device on 1-1.5 h after injection. Upon completion of this phase, the research protocol, without the injection of additional doses compared to the conventional method, was conducted a planar (Anterior Projection) picture were made by the mentioned device for 5 min from the areas under the diaphragm (subdiaphragmatic areas) of the patients. Consequently, 30 g of barium sulfate which was solved in 200 cc of water at room temperature was administered to the patients in sitting position and immediately the y underwent planar re-scanning of the areas under diaphragm for 5 min. In the following, according to the routine method performed at the center, with an intravenous injection of 0.3 mci kg^{-1} of MIBI material, manufactured by the Kavoshyar Company affiliated with Iran's Atomic Energy Organization, on the day of admission, the patients underwent the rest phase.

Ultimately, the obtained planar images were compared and analyzed before and after using barium sulfate. Results were comparedboth visually and statistically. The statistical comparison was done. An area of approximately 1400 pixels in the obtained planar images was isolated from the diaphragmatic area under the heart. Then the amount of activity per pixel (Mean Count Per pixel) in the isolated area under the diaphragm was measured and the amounts of activities in each pixel of both images were compared. Wilcox ontest was used for comparison. SPSS 22 software was used for statistical analysis.

RESULTS AND DISCUSSION

The distribution of age, sex and weight of the subjects is presented in Table 1. At the beginning of the study, 80 g of barium sulfate dissolved in 200 cc of water at room temperature but was reduced to 30 g of barium sulfate due to the high concentration of barium and non-cooperation of the patients.

Images of each stage were reviewed and analyzed by the Xeleris 2006 software. All phases of the reconstruction of images, select the subdiaphragmatic area, calculate the count in the selected area and also determine the radiation activity level in each pixel of the selected area was conducted by this software. The results are detailed in Table 2.

- ROI 1 (kc): The amount of the subdiaphragmatic radioactivity in the initial images in kilo kants
- ROI2 (kc): The amount of the subdiaphragmatic radioactivity after taking barium sulfate in kilo kants
- ROI 1 (pix): The selected subdiaphragmatic area in the primary images in pixels
- ROI 2 (pix): The selected subdiaphragmatic area after taking barium sulfate in pixels

To analyze the statistical data, the Wilcoxon signed ranks test was used. The results are provided in Table 3 and 4.

Table 1: The distribution of age, sex and weight of the studied population

Ages	Sex	Weight (kg)
57	F	70
54	F	70
65	M	80
51	M	97
65	M	85
54	M	72
44	F	73
55	F	57
45	F	55
52	F	63
56	M	75
66	F	83
46	F	80
60	M	74
55	F	58

Table 2: The selected area, the activity level in the selected area and in each pixel of the selected area separately for each patient, before and after using barium sulfate in the planar images

Roi (kc)		Roi (pix.)		Mean count per pixel	
1	2	1	2	1	2
125.89	84.6	1406	1406	8.95	6.01
153.20	118.69	1400	1404	10.94	8.45
183.06	130.32	1400	1404	13.07	9.28
121.08	88.42	1400	1400	8.65	6.31
113.81	94.46	1404	1406	8.11	6.72
148.03	121.40	1394	1400	10.62	8.67
193.69	151.60	1406	1406	13.77	10.78
161.71	111.99	1406	1406	11.50	7.96
161.31	120.43	1406	1406	11.47	8.56
181.88	123.58	1406	1406	12.93	8.97
339.14	265.39	1400	1404	24.22	18.90
176.55	134.69	1404	1406	12.57	9.58
236.19	193.88	1406	1406	16.80	13.79
210.05	163.13	1406	1406	14.94	11.60
270.82	196.86	1406	1406	19.26	14.00

Table 3: The average of activity per pixel and its standard deviation before and after using barium sulfate in the planar images

Pairl	Mean	N	SD	SE
x_2	13.1888	15	4.28768	1.10708
x_2	9.9624	15	3.43826	0.88775

x_1: Activity in each pixel in the first images; x_2: Activity in each pixel after taking barium sulfate

Table 4: The results of Wilcox on test in the study

Parameters	X2-X1
z	-3.408(a)
Asymp. Sig.(2-tailed)	0.00100

Comparing amount of sub cardiac activity in the selected areaof images before and after the barium swallow we can conclude that swallowing barium as a material of contrast in the patients' stomachs can significantly reduce the sub cardiac activity in these patients. The result of this reduction in the sub cardiac activity is the quality improvementof the final images (Boz *et al*., 2001). This reduction can be explained by two mechanisms: The first mechanism is related to the biochemical and physical property of barium, i.e., the high capacity of radiation absorption that leads to wide consumption of this material in radiological studies, thus we supposed that it can absorbs gamma radiations as well as x rays (Iqbal *et al*., 2004). The second supposed mechanism that can illustratethe sub cardiac activity reduction in this study was the effect of the volume of water administered to each patient. In fact, the patient's filled stomach by 200 cc water can somewhat take the gastrointestinal activity away from theinferior wall of myocardium due to its volume and weight effect. This reduction eventually leads to an improvement in the image contrast and the quality of image interpretation. The reduction of background radiations increases the contrast of the images (Heller *et al*., 1997). As the whole steps from capturing the first stage images to swallowing barium and taking the second stage images was roughly 15 min, therefore, decreasing the sub diaphragmatic activity due to time passageis negligible. The contrast used in this study was Barium sulfate. The selection of this material was because of its high radiation absorption characteristics. On the other hand, it is known as a drug with very low side effects used in diagnostic procedures. Comparing the first images and the second images visually, significant difference was noted in the second stage images after swallowing the barium. By dividing the total activity by the separated area, the activity was determined in each pixel (Table 2) and the levels of activity on each pixel of the first and second images of the subcardiac area were compared with each other statistically. After performing statistical analysis, the differences in the pictures with $p<0.001$ are statistically significant as well. According to the results we can conclude that the use of barium sulfate during Myocardial SPECT imaging can significantly reduce the activity of the subdiaphragmatic areas. This reduction in the subdiaphragmatic activity increases the contrast in the images that leads toobtaining higher-quality images of the myocardium. Such as previous study (Haghighatafshar *et al*., 2015) that indicated the importance of fused Single-Photon Emission Computed Tomography (SPECT)/Computed Tomography (CT) images, SPECT/CT imaging may minimize such artifacts.

CONCLUSION

Using this simple, safe and cheap method during the myocardial nuclear scans, we can improve image quality and reduce the diagnostic errors caused by the background radiations and subdiaphragmatic artifact. It should be noted that further researches and studies in this field in order to determine the most appropriate amount of barium and the best time for barium swallowis needed.

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