The effects of mineral water drinking and extra-abdominal pressure in elimination of attenuation artifacts on myocardial perfusion SPECT

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Abstract

Myocardial perfusion scintigraphy is often used non-invasive diagnostic test for detection of coronary artery disease, myocardial viability, risk assessment and prediction of prognosis. The aim of this study was to evaluate of mineral water drinking and extra-abdominal pressure for elimination of attenuation artifacts on myocardial perfusion SPECT. A total of 27 patients (20 males, 7 females) who have suspicious findings on stress image were included in this study. If patients were reported ischemia or infracted on myocardial perfusion SPECT, they were excluded from the study. Stress SPECT imaging was repeated continuously three times following basal imaging, application of extra-abdominal pressure and after mineral water drinking. SPECT slices were obtained and "Summed Stress Scores" were calculated from three SPECT imaging. Double-blinded two clinicians visually evaluated these slices and have rated based on ease of evaluation as "best image", "Medium" and "Low". Additionally four groups were created from 4 rating areas which had Summed Stress Scores of 3 or above on Polar Map. Mineral water drinking and application of extra-abdominal may be better than basal imaging. Although a method selecting was difficult in theassessment of inferior and inferoseptal wall. Among the three applications for "Summed Stress Scores" were statistically significant differences with Friedman's test in the 1st, 2nd, 3rd and 4th groups (p=0.03, p=0.008, p=0.005 and p=0.0001, respectively). For evaluation of suspicious lesions in the anterior and anteroseptal region, basal imaging did not significantly differ from application of extra-abdominal pressure. Mineral water drinking (and close to the pressure) was found better than basal imaging in Group 2 and 3. In Group 4, there was not significant difference between the application of extra-abdominal pressure and mineral water drinking. On static images, we did not found any significant change for intrathorasic localization and axis of left ventricul among three SPECT. The most remarkable finding among three SPECT was gradually decreasing of hepatic uptake. We though that change in "Summed Stress Score" in both application of extra-abdominal pressure and mineral water drinking may only be due to decreases in hepatic activity associated with time.

Keywords: SPECT, myocardial, extra-abdominal pressure, mineral water, attenuation artifacts

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Introduction

Myocardial perfusion scintigraphy is often used non-invasive diagnostic test for detection of coronary artery disease, myocardial viability, risk assessment and prediction of prognosis [1-3]. Attenuation artifacts are a problem in the accurate evaluation of myocardial perfusion scintigraphy. The left anterior-lateral attenuation artifact depending on breast tissue in female and inferior walls attenuation artifact due to diaphragm in men can lead to false positive evaluation on myocardial perfusion SPECT [4-15].

We thought that in addition to some acquisition and processing procedures, simple applications can eliminate these attenuation artifacts and the false positive rate may be reduced. The aim of this study was to evaluate of mineral water drinking and extra-abdominal pressure for elimination of attenuation artifacts on myocardial perfusion SPECT.

Material and Method

This study was approved by Inonu University School of Medicine Human Ethics Committee with 2010/172 number of document. A total of 27 routine patients (20 males, 7 females, and mean age 53.2 ± 11.1 years, range 26-72 years) who have suspicious findings on stress image were included in this study. If patients were reported ischemia or infracted on myocardial perfusion SPECT, they were excluded from the study. Demographic data of patients and end-diastolic diameter values by using echocardiography were recorded.

"Procedure Guideline for Myocardial Perfusion Imaging 3.3" criteria were used to patient preparation. Stress imaging was performed after at least 4-6 hours of fasting. Treadmill exercise was performed in all patients [16].

Stress SPECT imaging was repeated continuously three times following basal imaging, application of extra-abdominal pressure and after mineral water drinking. Total acquisition was lasted approximately 60 minutes for each patient.

Basal stress acquisition protocol:

One day stress/rest protocol was performed in all patients.Venous pathway was opened with i.v. cannula. They were monitored with 12 lead electrocardiography and automatic blood pressure monitor. According to the modified Bruce protocol, treadmill exercise test was performed. After patients reached > or = 85% of maximum predicted heart rate, Tc-99m-MIBI 740 - 925 MBq (Mon.MIBI kit, Eczacıbaşı-Monrol Nuclear Products Inc., Gebze, Turkey) was injected intravenously. Treadmill exercise was continued for one minute. Myocardial perfusion SPECT was performed in supine position at 45th minute after injection. Because they may affect the results of application of pressure and mineral water drinking, any food (milk or chocolate) was not provided to patients for gall bladder emptying after exercise.

All studies were conducted using a dual-headed ADAC gamma camera (Vertex V60, Adac, Milpitas, CA, USA) equipped with a low-energy high-resolution collimator. A total of 64 images at 32 projections, 25 s in duration, were acquired over 180° (45° right anterior oblique to 135° left posterior oblique) on a 64 × 64 matrix.Filtered back-projection reconstruction was performed with a low pass Butterworth filter (cut-off 0.38; order7). After reconstruction, short axis,vertical long axis and horizontal long axis sections were obtained.

Processing protocol:

Stress Polar Maps were created. 20 regional "Summed Stress Score" which developed by Cedars-Sinai Hospital (Los Angeles, California, USA) was calculated. Basal short axis, mid short axis and apical short-axis was considered as three main regions on Stress Polar map. Main regions were divided three lower assessment areas. The first of these was covered regions of the anterior and anteroseptal. The second was covered the inferior and inferoseptal regions and the third was covered the regions of anterolateral and inferolateral. By adding the apex, 10 ratings regions were determined. Summed Stress Scores of these 10 ratings areas were calculated by using “Emory CardiacToolbox^{TM}” software. Four groups were created from 4 rating areas which had Summed Stress Scores of 3 or above on Polar Map (Figure 1).

First Group (n=4): anterior and anteroseptal areas of the medium short-axis.

Second Group (n=8): inferior and inferoseptal areas of the medium short-axis.

Third Group (n=16): anterior and anteroseptal areas of the basal short-axis.

Fourth Group (n=15): inferior and inferoseptal areas of the basal short-axis

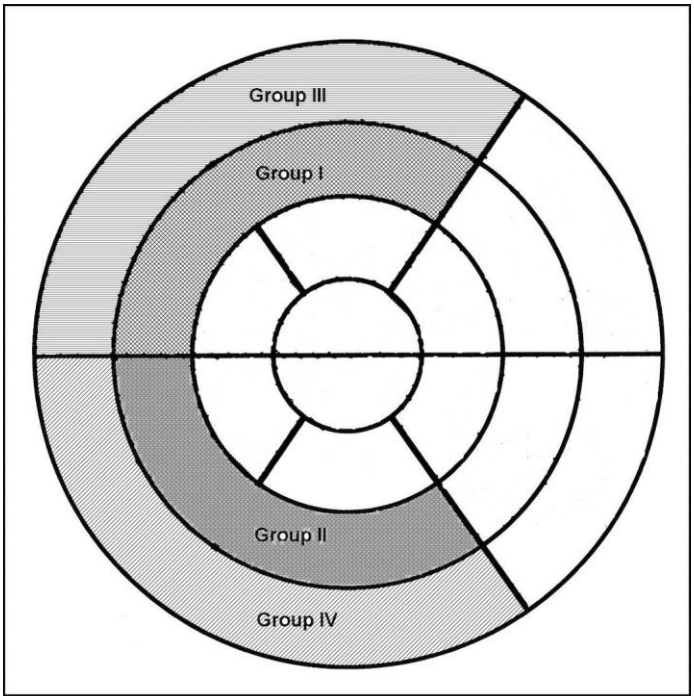

Figure 1. Localizations of four groups on Polar Map

Application of extra-abdominal pressure

After basal stress imaging, reconstruction was rapidly performed and suspected region was seen. Patients did not moved and removed from bed of Gamma Camera. Adult blood pressure cuff was placed as airless on epigastric area which especially to start from the left costal border. Whole abdomen was transversely rolled over cuff to bed with large sticky cloth immobilization material (30 cm wide and 150 cm long) for the most effective application of extra-abdominal. Subsequently, blood pressure cuff was inflated up to maximum tolerated pressure. Reached to 200-300 mmHg pressure can be tolerated by patients. SPECT imaging which had same acquisition protocol was performed again under extra-abdominal pressure.

Mineral water drinking:

At the end of imaging guided to extra-abdominal pressure, 200 cl Natural Mineral Water [Kızılay Natural Mineral Water(non-recyclable bottle), Turkish Redcrescent, Afyonkarahisar, Turkey] was drunk. After five minutes, the patient was laid to bed in the supine position. SPECT imaging which had same acquisition protocol was performed again.

Visual and Statistical analysis:

SPECT slices were obtained and "Summed Stress Scores" were calculated from three SPECT imaging (basal imaging, application of extra-abdominal pressure and after drinking mineral water). Double-blinded two clinicians visually evaluated these slices and have rated based on ease of evaluation as "best image", "Medium" and "Low". Visual evaluation results and "Summed Stress Scores" of the groups were compared statistically.

Double-blinded two clinicians visually evaluated 45° left anterior, anterior and left lateral static images of three SPECT. Three box region of interest was drawn on inferior wall, hepatic region (which is same level of inferior wall and on midclavicular line), and gastric region (Figure 2). Myocard/hepatic and myocardial/gastric ratios were obtained with using mean values of these ROI. These rates were used in statistical comparisons.

Ethical approval was taken from Clinical Research Ethics Board of Malatya. Informed consent was obtained from all patients. Statistical analysis was performed using the SPSS 16.0 for Windows (SPSS Inc., Chicago, Illinois, USA). Averages are given as mean ± standard deviation. A p value of less than 0.05 was considered statistically significant.

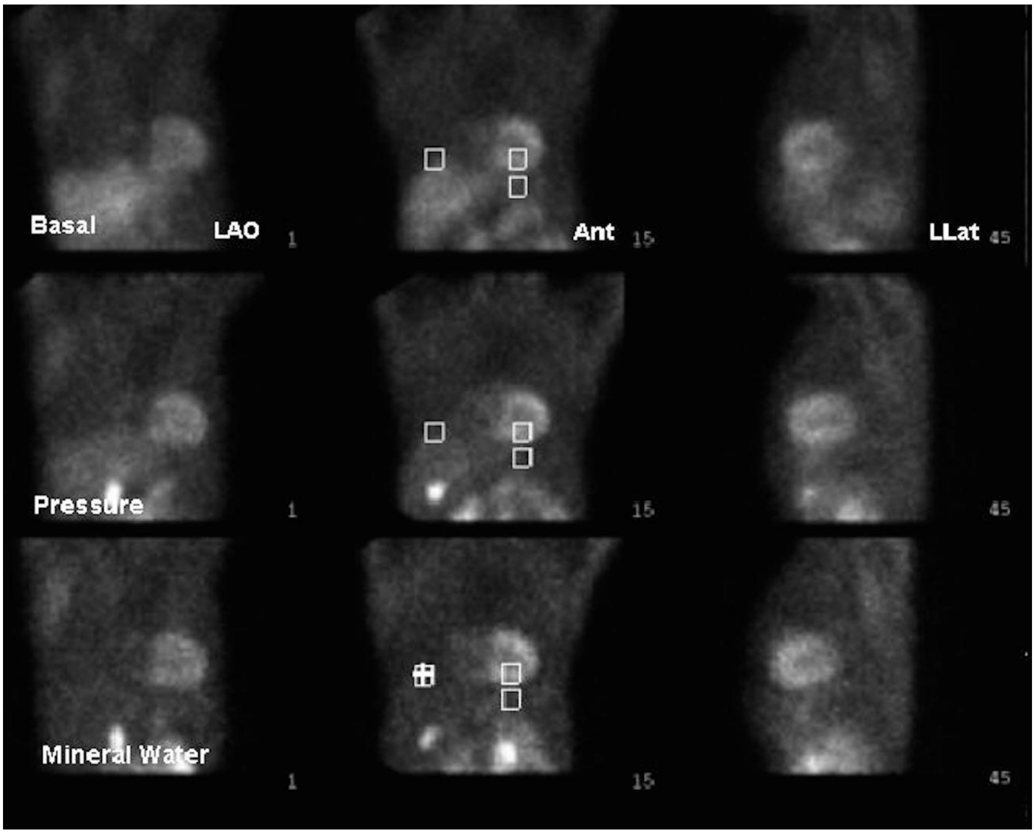

Figure 2. Three box region of interest on anterior static image

Results

The demographic data of the four groups were presented in Table 1. Age, height, weight, body mass index and end-diastolic diameter values of the groups were statistically compared but were not significant differences (p> 0.05).

Table 1: The demographic data of the four groups (BMI= Body mass index, EDD= end-diastolic diameter)

	Grup 1 (n=4) Mean ± SD	Grup 2 (n=8) Mean ± SD	Grup 3 (n=16) Mean ± SD	Grup 4 (n=15) Mean ± SD	p
Age (year)	51.3 ± 9.9	57.3 ± 9	56.5 ± 7.8	53.2 ± 10.5	0.31
Height (cm)	169.3 ± 9.4	173.3 ± 4.2	167.1 ± 7.7	167.9 ± 10.4	0.91
Weight (kg)	85.3 ± 17.3	80.3 ± 9.3	85.5 ± 12.8	86.5 ± 12.6	0.99
BMI	29.3 ± 5.7	26 ± 1.7	30.1 ± 4.3	30.4 ± 5.7	0.96
EDD	45.7 ± 3.6	50 ± 2.8	47.2 ± 3.7	47.6 ± 3.7	0.53

The results of visual evaluation of the groups were presented in Table 2. Mineral water drinking and application of extra-abdominal may be better than basal imaging. Although a method selecting was difficult in the assessment of inferior and inferoseptal wall.

Table 2. The results ofvisual evaluationof the groups

		Best	Middle	Low
Group 1 (n=4)	Basal	0 (0%)	1 (25%)	3 (75%)
	Pressure	2 (50%)	1 (25%)	1 (25%)
	Mineral Water	2 (50%)	2 (50%)	0 (0%)
Group 2 (n=8)	Basal	4 (50%)	2 (25%)	2 (25%)
	Pressure	2 (25%)	4 (50%)	2 (25%)
	Mineral Water	2 (25%)	2 (25%)	4 (50%)
Group 3 (n=16)	Basal	2 (12.5%)	4 (25%)	10 (62.5%)
	Pressure	8 (50%)	5 (31.2%)	3 (18.8%)
	Mineral Water	6 (37.5%)	7 (43.8%)	3 (18.8%)
Group 4 (n=15)	Basal	4 (26.7%)	3 (20%)	8 (53.3%)
	Pressure	6 (40%)	7 (46.7%)	2 (13.3%)
	Mineral Water	5 (33.3%)	5 (33.3%)	5 (33.3%)
Total (n=27)	Basal	9 (33%)	5 (18.5%)	13 (48.1%)
	Pressure	9 (33%)	12 (44.4%)	6 (22.2%)
	Mineral Water	9 (33%)	10 (37%)	8 (29.6%)

Among the three applications for "Summed Stress Scores" were statistically significant differences with Friedman's test in the 1st, 2nd, 3rd and 4th groups (p=0.03, p=0.008, p=0.005 and p=0.0001, respectively) (Table 3).

Table 3. At the end of three application, computed "Summed Stress Scores" of the groups and statistical comparison.

	Grup 1 (n=4)	**Grup 2 (n=8)**	**Grup 3 (n=16)**	**Grup 4 (n=15)**
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Basal	3 ± 0	3.38 ± 0.744	3.75 ± 0.93	3.73 ± 0.8
Pressure	2 ± 0.82	1.88 ± 0.99	3.31 ± 1.49	2.4 ± 1.24
Mineral Water	1 ± 0	2.38 ± 1.19	2.31 ± 1.25	2.2 ± 1.21
p value	0.03	0.008	0.01	0.0001

There was statistically significant difference between the basal imaging and application of extra-abdominal pressure in Group 2 and 4 (p=0.016 and p=0.003, respectively). Significant difference between the basal imaging and mineral water drinking were found in Group 1, 3 and 4 (p=0.046, p=0.002 and p=0.001, respectively). In addition, similar difference between the application of extra-abdominal pressure and mineral water drinking were detected in Group 2 and 3 (p=0.046 and p=0.011, respectively). For evaluation of suspicious lesions in the anterior and anteroseptal region, basal imaging did not significantly differ from application of extra-abdominal pressure. Mineral water drinking (and close to the pressure) was found better than basal imaging in Group 2 and 3. In Group 4, there was not significant difference between the application of extra-abdominal pressure and mineral water drinking (Table 4).

Double-blinded two clinicians did not found any change for intrathorasic localisation and axis of left ventricul visually on 45° left anterior, anterior and left lateral static images of three SPECT. Not only between the basal imaging and the application of extra-abdominal pressure but also between the basal imaging and the mineral water drinking, gastric activity was reported unchanged in 23 and increased in 4 patients. Hepatic activity was reported unchanged in 5 and decreased in 22 patients in the application of extra-abdominal pressure. Hepatic activity was decreased in all patients after mineral water drinking.

Table 4. Binary comparison of Groups for computed "Summed Stress Scores"

	Grup 1 (n=4) p value	Grup 2 (n=8) p value	Grup 3 (n=16) p value	Grup 4 (n=15) p value
Basal- Pressure	0.102	0.016	0.185	0.003
Basal- Mineral Water	0.046	0.071	0.002	0.001
Pressure-Mineral Water	0.102	0.046	0.011	0.417

Myocardial/hepatic and myocardial/gastric ratios of Groups were presented in Table 5. Myocardial/gastric ratios was not different among Groups (p>0.05). Myocardium/ hepatic ratio was gradually decreased associated with time (Table 6).

Table 5. Myocardial/hepatic and myocardial/gastric ratios of Groups with associated three aplication.

		Basal Mean ± SD	Pressure Mean ± SD	Mineral Water Mean ± SD	p value
Grup 1 (n=4)	Inf/Hep	1.06±0.40	1.31±0.32	1.57±0.29	0.039
	Inf/Gast	2.07±0.30	2.22±0.35	2.57±0.74	0.779
Grup 2 (n=8)	Inf/Hep	1.14±0.44	1.47±0.54	1.84±0.46	0.001
	Inf/Gast	2.14±0.29	2.20±0.36	2.51±0.66	0.687
Grup 3 (n=16)	Inf/Hep	1.26±0.45	1.58±0.61	2.01±0.51	0.0001
	Inf/Gast	2.38±0.54	2.30±0.55	2.60±0.57	0.210
Grup 4 (n=15)	Inf/Hep	1.30±0.44	1.63±0.64	1.98±0.51	0.0001
	Inf/Gast	2.17±0.51	2.18±0.43	2.51±0.6	0.085

Table 6: Binary comparison of Myocardial/gastric ratios of Groups

Myo/Hep	**Grup 1 (n=4) p value**	**Grup 2 (n=8) p value**	**Grup 3 (n=16) p value**	**Grup 4 (n=15) p value**
Basal-Pressure	0,144	0,036	0,001	0,005
Basal-Mineral Water	0,068	0,012	0,0001	0,001
Pressure-Mineral Water	0,068	0,012	0,001	0,004

Discussion

As a result of injection into catheter or extravasation, counting statistics can be disrupted with reduced activity and false-positivity can be seen. Control of injection site can be provide early detection of this situation before imaging. Patient discomfort during acquisition and movement can cause artifacts. Minor motion artifact can often be corrected with correction algorithms but repeated imaging may be need frequently for major motion artifact. Not only suboptimal teradmil exercise, but also failure to provide peak serum concentration of oral pharmacological stress agents (delayed gastric emptying, etc.) will reduce the sensitivity of the test. If there is an increase of attenuation in soft tissue (breast size, brown adipose tissue, obesity, breast prostheses, space-occupying lesions, etc.), attenuation correction procedures should be performed. Breast tissue should be given as possible as the same position during exercise and at rest. Prone or side lying position in imaging may reduce false positivity. High uptake in organs neighbor to the heart (liver, intestines, etc) and tumoral lesions of this organ will reduce it's ability to accurately evaluate of test. Fatty foods, chocolate, mineral water and carbonated drinks are frequently used for this purpose [16,17].

Jakob et al reported that extra-abdominal pressure application increased intraperitoneal pressure from 6 +/- 1 mm Hg to 9 +/- 2 mm Hg, urinary bladder pressure from 6 +/- 2 mm Hg to 11 +/- 2 mm Hg, intragastric pressure from 6 +/- 2 mm Hg to 11 +/- 2 mm Hg, and inferior vena cava pressure from 11 +/- 4 mm Hg to 15 +/- 4 mm Hg[18]. We thought that attenuation artifacts in MPS may reduce due to the effects of intragastric pressure and the movement of diaphragm. In our study, “Summed stres Scores” of basal imaging did not significantly differ from application of extra-abdominal pressure for evaluation of suspicious lesions in the anterior and anteroseptal region. Furthermore, application of extra-abdominal pressure significantly differ from basal imaging and in Group 2 and 4 (p=0.016 and p=0.003, respectively). On static images, we did not found any significant change for intrathorasic localization and axis of left ventricle among three SPECT. The most remarkable finding among three SPECT was gradually decreasing of hepatic uptake.

Natural mineral waters in Turkey include 450-3150 mg/l of HCO3 [19]. Redcrescent Natural Mineral Water which we used contains 2123 mg/l of HCO3. Excessive oral intake of bicarbonate blocks excess stomach acid and plays an important role in the treatment of peptic ulcer disease. It reduces gastric complaints such as burning and acidity. Nausea, bloating and gas can be as side effect. This side effect was used by some clinics for improving the quality of the image in MPS.

Hara and colleagues studied Tc-99m tetrofosmin myocardial perfusion SPECT in 95 patients with single-day protocol using adenosine stress. They published that infracardiac activity with 100 ml of mineral water was dropped significantly in 63 patients and was increased image quality of the inferior wall [20].We performed 200ml of natural mineral water. In our study, mineral water drinking (and close to the pressure) was found better than basal imaging in Group 2 and 3. In Group 4, there was not significant difference between the application of extra-abdominal pressure and mineral water drinking. By visual analysis of static images, we found that gastric activity was unchanged in 23 (85%) and increased in 4 (15%) patients both application of extra-abdominal pressure and mineral water drinking. We though that change in “Summed Stress Score” in both application of extra-abdominal pressure and mineral water drinking may only be due to decreases in hepatic activity associated with time.

Risk assessment, particularly for myocardial infarction and cardiac death, has a great importance for optimal follow-up of patients had known or suspected coronary artery disease. This assessment can distinguish to patients as low and high-risk. While the high risk patients are great benefit of coronary angiography and revascularization procedures, low risk patients are followed-up with conservative treatments [21].

"20 regions Summed Stress Score” is a measurement method which developed by Cedars-Sinai Hospital (Los Angeles, California, USA) and used for calculation of total ischemia in myocardium, the effectiveness of treatment options, the risk assessment and the investigation of survival. In a study on more than 20000 patient, while normal summed stress score (0-3) was associated with low mortality (1%), cardiac mortality risk was increased proportionally to "Summed Stress Score".

Hachamovitch et al evaluated the effects of medical treatment and revascularization procedures on mortality with "Summed Stress Score". Low-risk group who had 4-8 of "Summed Stress Score" had similar mortality and there was not survival advantage of revascularization procedures. Revascularization procedures were resulted in a significant increase to improve survival in the larger defect areas ("Summed Stress Score"> 9) [22].

Lee et al studied risk factor analysis between "Summed Stress Score" and death or incidence of myocardial infarction over 9600 patients and published that Summed stress scores ≤6 were not associated with significantly increased risk of death or MI, but Summed stress scores ≥7 were associated with increased risk of death or MI, with an adjusted hazard ratio of 1.47[17]. In another study, Modarres Mosalla et al had followed-up 482 patients who had myocardial perfusion imaging for 1.5 years and reported that 42.9% of patients with cardiac death and 17.2% of patients with myocardial infarction had Summed Stress Score>13 [23]. Summed stress score can be calculated as 17 and 20 regions. We preferred the most widely used 20-regions scoring.

There were some notable limitations to our study. This was a single-center evaluation but user-dependent variability is low. Only two nuclear medicine specialists who are working in same clinic have made double-blind visual evaluation. Patients who had suspected area on stress myocardial perfusion imaging but evaluated as normal after added two imaging or rest were included in this study. But without of coronary artery disease in patients had not been proved other imaging modalities or follow-up. We don't know how these findings will change in patients with myocardial ischemia or infarction.

Conclusion

We found that mineral water drinking and application of extra-abdominal may be visually better than basal imaging. For evaluation of suspicious lesions in the anterior and anteroseptal region, basal imaging did not significantly differ from application of extra-abdominal pressure. Significant difference of "Summed Stress Score" between the basal imaging and mineral water drinking were found in Group 1, 3 and 4. Double-blinded two clinicians did not found any change for intrathorasic localisation and axis of left ventricul visually on 45° left anterior, anterior and left lateral static images of three SPECT. Hepatic activity was reported unchanged in 5 and decreased in 22 patients in the application of extra-abdominal pressure. It was decreased in all patients after mineral water drinking. We though that change in "Summed Stres Score" in both application of extra-abdominal pressure and mineral water drinking may only be due to decreases in hepatic activity associated with time.

Conflict of interest: We have no financial or commercial conflicts of interest.

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