ORIGINAL RESEARCH PAPER

Medicine

COMPARISON OF [99MTC] MIBI INFUSION WITH [99MTC] MIBI+GIK INFUSION IN ASSESSING THE MYOCARDIAL VIABILITY

KEY WORDS: Myocardial Viability, [99mtc] Mibi Infusion, Gik Infusion

Halil Komek* Department of Nuclear Medicine, Saglik Bilimleri University Diyarbakir Gazi Yasargil Training and Research Hospital. Diyarbakir, Turkey *Corresponding Author

Halil Kaya Department of Nuclear Medicine, Dicle University Medical Faculty. Diyarbakir, Turkey

ABSTRACT

Objective: This study aims to compare the [99mTc] MIBI infusion and [99mTc] MIBI + GIK (glucose, insulin, potassium) infusion works for demonstrating the myocardial viability in patients with chronic ischemic segmental wall motion disorder.
Method: The study includes 20 patients with left ventricular wall motion abnormality detected in echocardiography and vascular occlusion detected in angiography. The myocardial SPECT images of all patients were taken with both MIBI infusion and MIBI + GIK protocols at 1-week intervals.
Results: When evaluated according to the scores of 400 segments in total, the total score was found to be 203 in the MIBI infusion study and to be 160 in the MIBI infusion + GIK infusion study.
Conclusion: MIBI infusion + GIK infusion study was found to be more successful compared to the MIBI infusion study in the evaluation of the myocardial viability and it was concluded that it could be used in the evaluation of the viability.

INTRODUCTION:

Approximately 480,000 PTCA, 371,000 bypass operations and 3191 cardiac transplantations are performed annually in the United States (1). The surgical mortality after bypass is 1-2% for patients with normal ventricular function, whereas the mortality rate is up to 20% within 30 days after surgery for patients with left ventricular dysfunction (2). Therefore, a viable myocardium in patients to undergo to revascularization is highly important.

It was first observed in 1975 that there is an improvement in the akinetic segments of the left ventricle after revascularization. Myocardial viability is described as the ventricular dysfunction without tissue necrosis after myocardial injury.

In viability studies, the nuclear medicine techniques have high sensitivity, while tests showing the contractile reserve have a higher specificity. Imaging methods such as computed tomography (CT), positron emission tomography (PET), myocardial scintigraphy, dobutamine echocardiography and magnetic resonance imaging have been used for creating the best method of demonstrating the myocardial viability (3).

Although there are different definitions such as hibernating and stunned myocardium, Chareonthaitawee et al. describe the hibernating myocardium as the adaptation of the disease to recurrent episodes of the stunned myocardium (4). Stunned myocardium may develop following the recovery of the coronary flow after a severe and sudden coronary occlusion. A sudden drop in the coronary flow causes contractile dysfunction that continues even after a restoration. Despite minimal necrosis, a ventricular dysfunction may last for hours or even weeks (5).

In a study, it was shown that the viability is not associated with the myocardial wall thickness. A thin wall does not mean that there is no myocardial viability (6). In a study comparing the dobutamine echocardiography and [99mTc] the MIBI in which viable kinetic segments were evaluated, more kinetic segments were seen with the MIBI (7). Thirty-five years ago, soli-Pollares showed that the systemic administration of GIK (Glucose, Insulin, Potassium) polarized solution prevented the spread of acute myocardial infarction (In ECG), decreased the ventricular ectopia, and improved survival after early myocardial infarction (8).

In addition, Budinger and Pohost reported that the uptake of radiopharmaceuticals into the cell increased in hibernating myocardium when the cell membrane was exposed to radiopharmaceuticals for a long time in T1 201 models (9,10).

The present study aims to compare [99mTc] MIBI infusion and [99mTc] MIBI + GIK infusion works for showing the myocardial viability in patients with chronic ischemic segmental wall motion disorder.

MATERIAL AND METHOD:

The study includes 20 patients (12 males and 8 females) with an average age of 44.5 (27-64) with left ventricular dysfunction who underwent angiography and treadmill ECG and were detected to have segmental wall motion impairment in two-dimensional echocardiography. All patients underwent MIBI infusion and MIBI infusion + GIK infusion. All patients were asked to discontinue the beta blockers 48 hours before the imaging. All patients were asked for at least 8 hours of fasting. The 12 derivation ECGs of all patients were evaluated. A maximum of 1 week of time was left between the two images.

SPECT STUDY:

The (Cardio-Spect™ FJC Hungary) MIBI kit was used in all works. Each kit was added 5 cc Tc 99 m pertechnetate to be 30 mCi in 1 cc and was boiled for 10 minutes. The kits were used after being cooled at ambient temperature. In all patients, 740 MBq 99mTc MIBI was infused in 50 ml of saline for 2 hours using an infusion pump. Milk and chocolate were given 15 minutes after the infusion was finished and SPECT images were taken 1 hour later. The GIC solution was prepared as 50 IU insulin, 80 mEq KCl in 1000 cc 30% glucose solution for all patients and infused for 2 hours infusing 3 ml/kg per hour. The MIBI infusion was performed on the other arm at the same time. Milk and chocolate were given 15 minutes after the completion of the infusions. The SPECT images were taken 1 hours later.

The Myocardial perfusion SPECT (Milwaukee, Wisconsin, USA) images were taken with GE millennium MPS branded gamma camera in all patients and a total of 64 images were taken in a 64x64 matrix at 180 circular axes using a low energy high resolution (LEHR) collimator in the supine position. During the information gathering, the energy peak was set at 140 keV for the Tc-99 m in a symmetrical 20% window spacing. The raw data were processed using the Butterworth filter with the 'Filtered back-projection' method.

Data Analyses:

The raw data and all processed stress and rest images were examined in the appropriate format with the short axis (SA), vertical (VLA) and the horizontal long axis (HLA) plans one under the other. 20 segments were formed from the SA (apikal, Mid, basal) and VLA (apex divided into two segments.)sections.These 20 segments were scored out of 5 points and evaluated by the semiquantitative segmental visual analysis method. All segments were evaluated as 0: normal, 1: slight decrease in involvement, 2: moderate decrease in involvement, 3: advanced decrease in involvement, and 4: no radioactivity involvement.

Visual Evaluation (Total scoring system)

The results from 20 segments were collected and the total scores were obtained.

Statistical Evaluation:
The results of total perfusion scoring obtained from the MIBI infusion and MIBI infusion + GIK infusion works were compared with the one-way variance analysis and the Mann Whitney-U test, which is a nonparametric test. The $p<0.05$ was accepted as significant.

RESULTS:
Following the MIBI infusion, MIBI infusion + GIK infusion works, the MIBI infusion + GIK infusion work was found to be more successful than the MIBI infusion work in showing the viability in 17 patients. The MIBI infusion was found to be more successful than the MIBI infusion + GIK infusion in 1 patient. The scores were found equal in 2 patients (Figure1).

Considering the number of viable segments, the viability was observed in the MIBI infusion + GIK infusion compared to the MIBI infusion in 20 segments.

When evaluated according to the scores of the 400 segments, the total score was found as 203 in the MIBI infusion and as 160 in MIBI infusion + GIK infusion (Figure2).

Considering the total scores, the MIBI infusion + GIK infusion work showed significantly more viable area than the MIBI infusion alone ($p<0.005$) (Tables 1).

DISCUSSION:
Following the MIBI infusion, MIBI infusion + GIK infusion works, the MIBI infusion + GIK infusion work was found to be more successful than the MIBI infusion work in showing the viability in 17 patients. The MIBI infusion was found to be more successful than the MIBI infusion + GIK infusion in 1 patient. The scores were found equal in 2 patients.

Considering the number of viable segments, the viability was observed in the MIBI infusion + GIK infusion compared to the MIBI infusion in 20 segments.

When evaluated according to the scores of the 400 segments, the total score was found as 203 in the MIBI infusion and as 160 in MIBI infusion + GIK infusion.

Considering the total scores, the MIBI infusion + GIK infusion work showed significantly more viable area than the MIBI infusion alone $p<0.005$.

The investigation of myocardial viability in AMIs without complication is important in determining the treatment strategy. The presence of live tissue in these patients is an indication for revascularization and the presence of necrosis is an indication for medical treatment.

The evaluation of myocardial viability is very important to identify those who will benefit from a revascularization procedure. Various imaging methods are used such as positron emission tomography (11) thallium -201 (12), myocardial perfusion scintigraphy, and low dose dobutamine echocardiography (13).

[99mTc] MIBI is a perfusion imaging agent that has been shown to have an accuracy similar to thallium-201 for the diagnosis of coronary artery disease (14,15).

It has been shown that there is a good correlation between the MIBI Involvement and the severity of coronary artery stenosis (16).

Reliable estimates of the extent of the recoverable myocardium can be obtained using resting [99mTc] MIBI imaging before and after thrombolytic therapy for acute myocardial infarction (17).

In a study in which the myocardial tissue was evaluated histologically with the [99mTc] MIBI during the cardiac transplantation, there was a correlation between the normal myocardium and the MIBI activity. Areas showing normal MIBI uptake (1>85% maximum activity) were completely normal or there was <15% fibrosis at the trichrome stage. To the contrary, areas with <30% histologically normal myocardium showed much lower Sestamibi activity than normal. The myocardial regions, which are a mixture of fibrosis and normal myocardium (containing 31% to 84% of normal myocardium), have been shown to have a moderate MIBI activity (18)

Some studies indicate that MIBI is not a viability agent but only a perfusion agent (19-23).

However, some researchers reported that the [99mTc] MIBI accurately predicted the viability (24-28). Although [99mTc] MIBI passes cell membranes through the passive transport, studies have shown that it is comparable to thallium-201 in the estimation of viability (29-31).

Despite the initial concerns, however, the myocardial perfusion imaging has been shown to provide reliable results in the detection of viable hibernating myocardium and in the prediction of post-revascularization healing particularly along with the [99mTc] MIBI (32-35).

Experimental and clinical studies have shown that oral nitrate administration increases the regional blood flow in the ischemic myocardial tissue (36). Maura S. et al. found that 27% of 31 patients with chronic left ventricular dysfunction, without [99mTc] MIBI involvement, were reperfused with oral nitrate (37). The combination of [99mTc] MIBI SPECT work and Dobutamine stress echocardiography has been shown to be a highly accurate, reliable, practical, and well-tolerated method of evaluating the coronary artery diseases (38).

In a patient who had a stable perfusion defect after the MIBI stress and resting images, a 2-hour infusion following the Tl-201 bolus followed by a 2-hour MIBI infusion without a bolus showed that the same regions were viable on both MIBI infusion and Tl 201 bolus + infusion. After the operation, it was observed that those regions had completely recovered both in terms of echocardiography and the MIBI resting stress images (39). The MIBI infusion was applied for two hours in the present study.

In a prospective study of 25 patients where the 1-hour MIBI infusion and a 24th hour Tl reinjection methods were compared for the evaluation of myocardial viability, the MIBI infusion was reported to give the same results as the 24th hour Tl 201 reinjection method (40).

In a study by Tartagni et al., a new method has been described for the cardiac imaging. They used a 30-min Tl 201 infusion and an infusion of insulin potassium and glucose solution to increase the detection of myocardial viability. They prepared GIK solution with 10% glucose to 250 ml, 5% IU insulin and 10 mEq K (41). It is well known that insulin enhances myocardial involvement of K through Na-K ATPase (42). Similarly, Tl 201 is taken up by the myocardium via the Na-K ATPase (43) and uptake is increased by the insulin administration.

In studies where Tl 201 and GIK infusions were used together and were reported to be more effective at demonstrating the viability, it was stated 30-minute (44) and 2-hour infusion durations were appropriate for the GIK infusion (45). In the present study, a 2-hour GIK infusion was applied.

Toyama et al. (46) compared rest T1-201 SPECT with post-nitrate [99mTc] MIBI SPECT and T-201 SPECT after GIK to detect viable hibernate myocardium in chronic coronary artery disease. They indicated that the T1-201 GIK was the best method in the determination of viable myocardium tissue even in small quantities and that nitrate [99mTc] MIBI and T1-201 rest, however, are useful methods to detect viable myocardium, respectively, according to total stress score. In the same study, the sensitivities of the recovery in the wall motions after coronary revascularization was 62% in the T1-201 rest, 79% in the nitrate-[99mTc] MIBI, and 85% in the T1-201 GIK (46).

In another GIK infusion study, a T1-redistribution group and a control group were compared, and it was seen that GIK increased the reperfusion (47).

B. Gökalp et al. used a scoring system of 5 according to semiquantitative segmental visual analysis method in their dobutamine MIBI study (48). In the present study, the TPS values were calculated for all groups using the same visual analysis method.

The FDG myocardial uptake has been reported to be a method with high sensitivity and specificity in evaluating the myocardial viability (49). It is the most common clinically approved glucose metabolism approach with blood flow among different PET studies. Normal flow and/or metabolism indicates stunned (50) myocardium in N-13 and FDG studies, while the classical inconsistency is compatible with hibernating myocardium (51). A blood flow less than 25% reflects the transmural scar formation, and therefore irreversibility (52).

With the data obtained in the present study, quite significant results were obtained with the MIBI infusion + GIK infusion both in the segmental basis and in terms of TPS compared to the MIBI infusion. Therefore, it was determined that the MIBI infusion+GIK infusion protocol alone gave more significant results in showing the myocardial viability compared to the MIBI infusion.

Limitations of the Study:
Whether or not the tissues were viable was not verified histopathologically. The scores were only visually evaluated. In addition, the fact that no comparison was made with the results of echocardiography on the segmental basis is one of the limitations of the study.

Conclusion:
In evaluating myocardial viability, the [99mTc] MIBI infusion + GIK infusion protocol was found to be more successful than the [99mTc] MIBI infusion protocol and it was concluded that it could be used in the evaluation of viability.

Table 1. findings of patients

Patient No	MIBI infusion TS*	MIBI inf+GIK inf TS	Angiography	ECO	
				Wall	Motion
1	9	8	LAD25%, CX 100%	AD LD	AK HK
2	12	5	LAD100%	AD	DK
3	5	2	LAD 100%	AD	AK
4	9	7	LAD 80%,RCA 60%	AD S	HK HK
5	13	12	RCA %75,LAD:50%	S	AK
6	7	5	LAD:100%	AD	AK
7	5	9	LAD:55,OM:40%	LD	DK
8	10	8	LAD:80%	Ad LD	AK HK
9	16	12	LAD 100%, RCA 50%	AD	DK
10	11	8	D1:70%,OM:55%	LD	HK
11	17	12	LAD 80%, CX: 60%	Apex	HK
12	6	6	LAD70%, OM50%	ALD	DK
13	12	8	RCA60%,OM:55 %	ID	AK
14	6	6	D1:%75,D2:80%	ID	DK
15	7	5	LAD 70%,CX:50%	AD	DK
16	12	11	LAD100%	AD	AK
17	9	6	RCA:80%,OM:70 %	ID	AK
18	7	4	LAD55%, CX:45%	AD	HK
19	14	11	OM:70%,D1:80%	LD	HK
20	16	15	LAD100%	AD	DK

TS: Total Score
AW: Anterior Wall
LW: Lateral Wall
ALW: Anterolateral Wall
IW: Inferior Wall
S: Septum
HK: Hypokinesia
AK: Akinesia
DK: Dyskinesia

Figure1: MIBI infusion and MIBI infusion + GIK infusion scores Mann Whitney U P<0.005

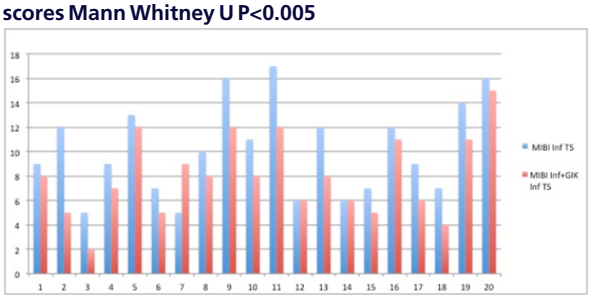
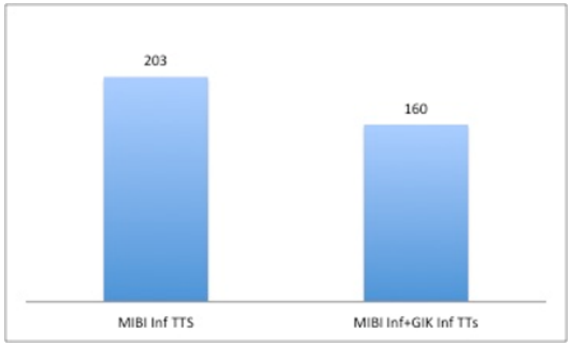


Figure 2) Total scores for 400 segments



Source of founding: There is no funding resource supporting the work submitted

Conflicts of interest: The authors have no conflict of interests to declare.

References

1. American Heart Association Statistical Update. Heart and stroke statistic- 2018 update.,Circulation. 2018;137:e67–e492. DOI: 10.1161/ CIR.00000 0000 0000558
2. Londoni C, Lucignani G, Paolini Get al: Assessment of CABG-related risk in patients with CAD and LVD. Contribution of PET whit (18F)FDG to the assesment of myocardial viability.J Cardiovascular Surg (Torino) 1999;40 (3):363-372.
3. Fernandes H, Sousa A, Campos J et al.:Acta Med Port. Suppl 4. Dec 24, 2011. pp. 989–994.
4. Chareonthaitawee P, Gersh BJ, Araoz PA, Gibbons RJ: Revascularization in severe left ventricular dysfunction: the role of viability testing. J Am Coll Cardiol. 2005;46 (4):567–574
5. Barnes E, Dutka DP, Khan M, Camici PG, Hall RJ.: Effect of repeated episodes of reversible myocardial ischemia on myocardial blood flow and function in humans. Am J Physiol Heart Circ Physiol. 2002;282 (5):H1603-8.
6. Camici PG, Prasad SK, Rimoldi OE: Stunning, hibernation, and assessment of myocardial viability. Circulation. 2008;117 (1):103-14.
7. Pagano D, Bonser RS, Townend JN, Ordoubadi F, Lorenzoni R, Camici PG: Predictive value of dobutamine echocardiography and positron emission tomography in identifying hibernating myocardium in patients with postischaemic heart failure. Heart. 1998;79 (3):281-8.
8. Sodi-Pallres D, testelli M, Fishleder F: Effects of an intravenous infusion of potassium-insulin-glucose solution on electrocardiographic singns of myocardial infarction.Am J Cardiol.!962;9:166-181
9. Budinger TF, Pohost GM: Thallium "redistribution"-An explanation (abstract). JNuclMed 1986;27:996
10. Pohost GM, Alpert NM, Ingwall JS, Strauss HW: Thallium redistribution: mechanism and clinical utility. SeminNUCIMed1980;1070-92
11. Tillisch JH, Brunken R, Marshall R, et al.: Reversibility of cardiac wall motion abnormalities predicted by positron tomography. N Engl J Med 1986;314:884–8
12. Ragosta M, Beller GA, Watson DD, Kaul S, Gimple LW. :Quantitative planar rest-redistribution 201Tl imaging in detection of myocardial viability and prediction of improvement in left ventricular function after coronary bypass surgery in patients with severely depressed left ventricular function. Circulation 1993;87:1630–41
13. Meluzin J, Cerny´ J, Fre˘lich M, et al: Prognostic value of the amount of dysfunctional but viable myocardium in revascularized patients with coronary artery disease and left ventricular dysfunction. J Am Coll Cardiol 1998;32:912–20
14. Kahn J, Mc shie 1, Akers M, et al.: Quantitative rotational tomography with T1-201 and Tc-99m 2-methoxy-isobutyl-isonitrile : a direct comparison in normal individuals and patients with coronary artery disease. Circulation 1989;79 :1282-

93.
15. Maddahi J. Kiat 1T, Van Train K, el al.: Myocardial perfusion imaging with technetium-99m sestamibi SPECT in the evaluation of coronary artery disease. Am J Cardiol 1990;66 :55E-63E
16. Dilsizian V, Rocco TP, Strauss HW, Boucher CA: Technetium-99m isonitrile myocardial uptake at rest I: Relation to severity of coronary stenosis. J Am Coll Cardiol 1989;14:1673-1677) computed tomographic imaging. J Am Coll Cardiol 1997;30:1687–1692.).
17. Gibbons R. Verani M, Behrenbeck T. et al.: Feasibility of tomographic Tc-99m-hexakis-2-methoxy-2-methylpropyl-isonitrile imaging for the assessmentof myocardial area at risk and the effect of treatment in acute myocardial infarction. Circulation 1989 :80:1277-86.
18. R Medrano, RW Lowry, JB Young, et al:Assessment of Myocardial Viability With 99mTc Sestamibi in Patients Undergoing Cardiac Transplantation A Scintigraphic/Pathological Study. Circulation. 1996;94:1010-1017.
19. Machac J: Technetium-99m isonitrile: A perfusion or a viability agent? JAm Coll Cardiol 1989;14:1685-1688.
20. Freeman I, Grunwald AM, Robin B, Hoory S, Bodenheimer MM: Contrasting flow and myocardial distribution characteristics of myocardial ischemia and infarction (abstract). Jam Coll Cardiol 1988;11:34A
21. Dilsizian V, Marin-Neto J, Arrighi J. Bachrach S. Peronne-Filardi P, Bonow R. Myocardial viability: comparison of thallium reinjection, rest-stress sestamibi, and positron emission tomography]abstract]. J Am Coll Cardiol 1992;19 Suppl A :21A.
22. Cuecolo A, Pace L. Ricciardelh B, Chiariello M, Trimarco B, Salvatore M, identification of viable myocardium in patients with chronic coronary artery disease : comparison of thallium-20I scintigraphy with reinjection and technetium-99m-methoxyisobutyl isonitrile. J Nucl Med 1992 :33 :505- 11.
23. Altehoefer C. Kaiser 1-1-J, Dorr R, et al.: Fluorine-18 deoxyglucose PET for assessment of viable myocardium in perfusion defects in "Tc-MIBt SPECT: a comparative study in patients with coronary artery disease. Eur J Nucl Med 1992 :334-42.
24. Rocco TP, Dilsizian V, Strauss HW, Boucher CA.: Technetium-99m isonitrile myocardial uptake at rest: the relation to clinical markers of potential viability. J Am Coll Cardiol 1989;14:1678–1684.
25. Sansoy V, Glover DK, Watson, DD, et al: Comparison of thallium-201 resting redistribution with technetium-99m sestamibi uptake and functional response to dobutamine for assessment of myo- cardial viability. Circulation 1995;92:994–1004.
26. Marzullo P, Sambuceti G, Parodi O. :The role of sestamibi scintigraphy in the radioisotopic assessment of myocardial viability. J Nucl Med 1992;33:1925– 1930.
27. Marzullo P, Sambuceti G, Parodi O, et al:. Regional concordance and discordance between rest thallium 201 and sestamibi imaging for assessing tissue viability: comparison of post revascularization functional recovery. J Nuc Cardiol 1995;2:309–316.
28. Maublant JC, Citron B, Lipiecki, J, et al: Rest technetium 99m-sestamibi tomoscintigraphy in hibernating myocardium. Am Heart J 1995;129:306–314.
29. Bax JJ, Wijns W, Cornel JH, Visser FC, Boersma E, Fioretti PM.: Accuracy of currently available techniques for prediction of functional recovery after revascular- ization in patients with left ventricular dysfunction due to chronic coronary artery disease: comparison of pooled data. J Am Coll Cardiol 1997;30:1451–1460.
30. Sansoy V, Glover DK, Watson, DD, et al:. Comparison of thallium-201 resting redistribution with technetium-99m sestamibi uptake and functional response to dobutamine for assessment of myo- cardial viability. Circulation 1995;92:994–1004.
31. Sinusas AJ, Trautman KA, Bergin JD, et al:. Quantification of 'area at risk' during coronary occlusion and degree of myocardial salvage after reperfusion with technetium-99m-methoxyisobutyl- isonitrile. Circulation 1990;82:1424–1437
32. Bisi G, Sciagra` R, Santoro GM, Fazzini PF.:Rest technetium-99m sestamibi tomography in combination with short-term administration of nitrates: feasibility and reliability for prediction of postrevascularization outcome of asynergic territories. J Am Coll Cardiol 1994;24: 1282–9.
33. Sciagra` R, Bisi G, Santoro GM, et al. :Comparison of baseline-nitrate technetium-99m-sestamibi with rest-redistribution thallium-201 tomography in detecting viable hibernating myocardium and predicting postrevascularization recovery. J Am Coll Cardiol 1997;30:384 –91.
34. Dakik HA, Howell JF, Lawrie GM, et al. :Assessment of myocardial viability with 99mTc-sestamibi tomography before coronary bypass graft surgery. Correlation with histopathologic and postoperative improvement in cardiac function. Circulation 1997;96:2892– 8.
35. Schneider CA, Voth E, Gawlich S, et al.: Significance of rest technetium-99m sestamibi imaging for the prediction of improvement of left ventricular dysfunction after Q-wave myocardial infarction: importance of infarct location adjusted thresholds. J Am Coll Cardiol 1998;32:648 –54.
36. Brown BG, Balson E, Pterson RB,et al :The mechanism. Jof nitroglyccrin action; stenosis vasodilatation as a major component of drug response. Circulation 1988;1089-097
37. Maurea S, Cuocolo A, Soricelli A, et.Al: Enhanced detection of viable myocardium by Tc-99m-MIBI imaging after nitrate administration in chronic coronary artery disease. J Nucl Med:361945/1952,1995
38. Danies PG, Ahlberg AW, Clar BA 3 rd.: Combined assessment of myocardial perfusion and left ventricular function with exercise technetium-99m sestamibi gated single-photon emission computed tomography can differentiate between ischemic and nonischemic dilated cardiomyopahy. Am J Cardiol 1998 Nov 15;82 (10): 1253-8
39. Worsset DF, Fung AY, Hue J, Burn RJ.:Identification of viable myocardium with tecnetiim-99m-MIBI. j Nucl Med;36:1037-1039
40. Miron SD, Finkelhor R, Bahler, R, Sodeo DB, Bellon EM.: Use of Tc99m sestamibi infusion for detection of hibernating myocardium. A preliminary report. Clin Nucl Med. 1995 May;20 (5):440-5.
41. Tartagni F., Fallani F, Corbelli C, balletta A.: Detecting hibernated myocardium with SPECT and thallium-glucose-insulin infusion. J Nucl Med. 1995 Aug;36 (8):1377-83.
42. Omatsu-Kanbe M, Kitasato H.: Insulin stimulates the translocation of Na+/K (+)-dependent ATPase molecules from intracellular stores to the plasma membrane in frog skeletal muscle. Biochem J. 1990 Dec 15;272 (3):727-33
43. Gehring PJ, Hammond PB.: The interrelationship between thallium and potassium in animals. J Pharmacol Exp Ther. 1967 Jan;155 (1):187-201.
44. Wilson RA, Okada RD, Harris DD, Strauss HW, Boucher CA, Pohost GM. :Circulation 64, IV (1981). (Abstr.))
45. RA Wilson, RD Okada, M Barlai-Kovach.:The effect of glucose-insulin-potassium on thallium-201 myocardial redistribution. ht. J. Nucl. Med. Biol. Vol I?. No. 2, pp. 97-101, 1985
46. Toyama T,hozhizaki H, Isobe N, Adachi H, Naito S. :Detection viable hibernating myocardium in chronic coronary artery disease a comparison of resting 201 Tl single photon emission computed tomography (SPECT) 99 m Tc-MIBI spect after nitrat administration and Tl 201 SPECT after Tl 201 glucose – insulin infusion. Jpn Cire J.2000 Dec;64 (12):927-42
47. Wilson RA, Okada RD, Barlai-Kovach M, Strauss HW. :The effect of glucose-insulin-potassium on thallium-201 myocardial redisriution. Int J.Nucl Med Biol,. 1985;12 (2):97-101
48. Gunalp B, Dokumacı B, Uyan C, Vardarel E, Isık E.: Value of dobutamine technetium-99m-sestamibi SPECT and echocardiography in the detection of coronary artery disease compared with coronary angiography. J Nucl Med 1993;34:889-894
49. Martin WH. Joner RC, Delbeke D, Sandler MPA :simpliified intraveous glucoes loading protokol for FDG cardiac SPECT.
50. Tiliseh J,Brıchen R, Marshall R,et al.: Reversibility of cardiac wall motion abnormalities predicted by positron tomography.New Engl J Med 1986;314:884-888
51. Tamaki N, Yonekura Y, Yamahita K, et al. :Pozitron emission tomography using FDG in evaluation of coronart artery by-pass grafting. Am J Cardiol 1989;64:860-865
52. Gewirtz H, Fischman A- Abraham S, et al: positron emission tomography measurements of abslute regional myocardial blood-flow permits identification of nonviable myocardiim in patients with chronic myocardial infaretion J Am Coll Cardiol 1994_23:851-859