Optimal positioning in the detection of inferior wall infarct size with myocardial perfusion scintigraphy: prone vs. supine

Miyokart perfüzyon sintigrafisiyle inferiyor duvarda infarkt boyutunun saptanmasında optimal pozisyonlama: Supin veya pron

İsmail Doğan, Bircan Sönmez, Kayıhan Karaman, Şükrü Çelik*, Ömer Türker[1]*

From Departments of Nuclear Medicine and *Cardiology, Faculty of Medicine, Karadeniz Technical University, Trabzon
[1]Department of Nuclear Medicine, Akademy T.M., İzmir, Turkey

ABSTRACT

Objective: The prone position is commonly utilized to reduce false positive perfusion defects because this position overcomes the diaphragmatic inferior wall attenuation in single-photon emission computerized tomography (SPECT) studies. We investigated whether the prone position had an important advantage over the supine position in determining the severity and extent of infarct in patients with acute inferior myocardial infarction (MI).

Methods: Twenty-nine male patients (mean age 61±10 years) with acute inferior MI were enrolled in the cross-sectional study. After injection of thallium-201 (^{201}Tl) under resting conditions, redistribution SPECT imaging was twicely performed in each subject, in both the supine and prone positions, consecutively. The extent and severity scores of the perfusion defects were calculated from the sum of individual segment scores. Myocardial infarction size was also evaluated using peak cardiac troponin T (cTnT) levels. Wilcoxon rank and Spearman's rank correlation tests were used for statistical analyses of data.

Results: For the supine vs. prone positions, the median defect severity scores were 8 (4-13) vs. 5 (0.5-8.5) and the defect extent scores were 4 (3-5.5) vs. 3 (0.5-4.5), respectively. Both perfusion defect scores in the prone position were significantly lower than those in the supine position (p<0.001). The mean peak cTnT level during hospitalization was 7.2±3.9 µg/l. Peak cTnT levels were correlated with all SPECT parameters. However, the correlation was greater in the prone position (defect severity: r=0.712, p<0.001) (defect extent: r=0.790, p<0.001) than in the supine position (defect severity: r=0.495, p<0.01) (defect extent: r=0.481, p<0.01).

Conclusion: In patients with inferior MI, the SPECT results revealed a significant difference between the supine and prone images. The perfusion extent and severity scores of SPECT in the inferior wall with prone imaging correlates better with the peak troponin compared to the supine position. Comparative studies that use advanced imaging tools are needed to verify our present findings. *(Anadolu Kardiyol Derg 2010 December 1; 10(6); 539-43)*

Key words: Myocardial infarction, prone position, SPECT, troponin

ÖZET

Amaç: Miyokart perfüzyon SPECT (single-photon emission computerized tomography) çalışmalarında, inferiyor duvarda diafragm atenüasyonuna bağlı olarak gelişen yalancı pozitif perfüzyon defektlerinin azaltılmasında, pron pozisyon yaygın olarak kullanılmaktadır. Bu çalışmada, inferiyor miyokart enfarktüslü (Mİ) hastalarda, infarktüsün şiddeti ve yaygınlığının belirlenmesinde pron pozisyonunun supin pozisyona göre üstünlüğü olup olmadığı araştırıldı.

Yöntemler: Akut Mİ'li yirmi dokuz erkek hasta (ortalama yaş 61±10 yıl) enine-kesitli çalışmaya dahil edildi. İstirahat koşullarında Talyum-201 enjeksiyonundan sonra, her bir hastaya supin ve pron pozisyonlarda, redistribüsyon miyokart perfüzyon SPECT görüntülemesi yapıldı. Perfüzyon defektlerinin genişlik ve şiddet derecesi, her bir segment skorunun toplamından hesaplandı. Miyokart infarktüs büyüklüğü pik kardiyak troponin T (cTnT) düzeyleri değerlendirildi. Verilerin istatistiksel analizinde Wilcoxon rank ve Spearman's rank korelasyon testleri kullanıldı.

Bulgular: Supin ve pron pozisyonlar için sırasıyla ortanca defekt skorları 8 (4-13) ve 5 (0.5-8.5), defekt genişlik skorları 4 (3-5.5) ve 3 (0.5-4.5) idi. Pron pozisyonda her iki perfüzyon defekt skorları, supin pozisyondan belirgin olarak daha düşüktü (p<0.001). Yatış esnasındaki ortalama pik cTnT düzeyleri 7.2±3.9 µg/l. idi. Pik cTnT düzeyleri tüm SPECT parametreleri ile korele edildi. Bununla birlikte, korelasyon pron pozisyonunda (defekt şiddeti: r=0.712, p<0.001) (defekt genişliği: r=0.790, p<0.001), supin pozisyonundan (defekt şiddeti: r=0.495, p<0.01) (defekt genişliği: r=0.481, p<0.01) daha iyiydi.

Address for Correspondence/Yazışma Adresi: Dr. İsmail Doğan, Department of Nuclear Medicine Medical Faculty, Karadeniz Technical University, 61080 Trabzon, Turkey Phone: +90 462 377 57 34 Fax: +90 462 377 57 42 15 E-mail: drismaildogan@yahoo.com

Accepted Date/Kabul Tarihi: 09.02.2010 **Available Online Date/Çevrimiçi Yayın Tarihi:** 15.10.2010

doi:10.5152/akd.2010.161

Sonuç: İnferiyor MI'lü hastalarda, SPECT sonuçları supin ve pron görüntüler arasında önemli bir farklılığı ortaya koymaktadır. İnferiyor duvarda, pron görüntüleme ile SPECT'in perfüzyon genişlik ve şiddet skorları, supinle kıyaslandığında daha iyi bir korelasyon göstermektedir. Bulgularımızı destekleyecek ileri görüntüleme yöntemlerinin kullanıldığı karşılaştırmalı çalışmalara ihtiyaç var. *(Anadolu Kardiyol Derg 2010 Aralık1; 10(6); 539-43)*
Anahtar kelimeler: Miyokart enfarktüsü, pron pozisyon, SPECT, troponin

Introduction

The evaluation of infarct size after acute MI is important for predicting the subsequent clinical course (1) and to validate the effectiveness and clinical relevance of therapeutic interventions. Various methods, such as radionuclide-based measurements, cardiac magnetic resonance imaging (CMRI), and the release of cardiac biomarkers, have been proposed (1-4). Thallium-201 (^{201}Tl) redistribution single-photon emission computerized tomography (SPECT) is one of these methods and it is very valuable in detecting infarct size and viability in the MI area (5, 6). Traditionally, image acquisition of ^{201}Tl SPECT is performed with the patient in the supine position. However, supine tomographic images frequently demonstrate relative reduction of ^{201}Tl activity in the left ventricular inferior wall, presumably due to increased attenuation of photons from that region. Such attenuation of myocardial tracer activity occasionally results in false-positive findings for the diagnosis of right coronary artery disease (CAD) (2, 3, 7-9).

The prone position is widely used as a solution to inferior wall attenuation in myocardial perfusion scintigraphy (3, 4). ^{201}Tl counts of the inferior wall acquired in the prone position have been shown to be significantly higher than in the supine position (10, 11). Attenuation correction is another technical approach to the attenuation artifact, but needs an extra charge. There is an improvement in the size of defects when attenuation correction methods are used in imaging made with ^{201}T of patients with inferior MI (7, 9). Similarly, it is naturally to be expected that the prone position also could help patients with inferior MI. However, as far as we know, no study has evaluated the contribution of the prone position to the determination of the severity and extent of infarct in patients with inferior MI.

Therefore, we investigated whether the prone position had an important advantage over the supine position in accurately determining the severity and extent of infarct in patients with acute inferior MI.

Methods

Study population

Twenty-nine male patients with acute inferior wall MI were included in the cross-sectional study. The mean age was 61±10 years. The diagnosis of MI was established clinically with electrocardiography (ECG) and cardiac enzymes. Patients with previous MI or cardiogenic shock were excluded. Patient management during the hospital stay was unaffected by enrollment in the protocol. Thrombolytic therapy was administered to 13 patients. The remaining patients did not receive thrombolytic therapy due to late admission after the onset of the pain. Eleven patients had myocardial revascularization with coronary angioplasty. All patients were clinically stable during the entire study protocol, and none suffered from post-infarction angina or other complications. The local ethics committee approved the study, and written consent was received from all patients. Clinical evaluations, electrocardiogram recordings, blood pressure monitoring and routine laboratory tests were performed every day during hospitalization.

Laboratory assays

We measured single-point serum cardiac troponin T (cTnT) levels upon patient admission and after 24, 48, 72, and 96 h. The peak cTnT after 96 h was determined by taking serial samples. A value was defined as a peak if it was the highest in the concentration during the 96 h time course and if there was at least one lower value before and after this maximum value (12).

^{201}Tl SPECT acquisition and reconstruction protocols

SPECT studies were performed at mean 4.5±1.6 days after the acute infarction. Patients were intravenously administered 111-148 MBq of ^{201}Tl, under resting conditions. A dual-head gamma camera (Ecam; Siemens Medical Systems) equipped with a low-energy, high-resolution collimator (32 projections over 180°, 35 s per projection) was used to acquire SPECT images 15 min after injection, 4 h after injection. Two energy windows were used, including a 15% window centered on the 70 keV peak and a 20% window centered on the 167 keV peak. Images were acquired using a 64x64 image matrix. Supine redistribution SPECT examination was followed by prone redistribution SPECT using the same parameters (7).

Reconstruction protocol and redistribution image analysis

Two experienced observers blinded to the results of the quantifications algorithms analyzed all myocardial studies. Disagreements in interpretation were resolved by consensus (15). An automated computer 4D-MSPECT software-based scoring system (Siemens Medical Solutions) was used to assign scores. After back projection reconstruction with Butterworth prefiltering (cut-off frequency 0.35 Nyquist, order 5) for supine and prone redistribution images, short and long axis images were automatically generated. No attenuation or scatter corrections were applied. For the quantification of infarct size, the ^{201}Tl redistribution images were used (1, 7).

The size of the perfusion defects in the redistribution images of the supine and prone positions were assessed. These images were compared with those of age-matched normal subjects on a pixel-by-pixel basis (13, 14). The myocardium was divided into

17 segments following the American Society of Nuclear Cardiology/American College of Cardiology/American Heart Association guidelines. A 5-point scoring system was used for assessing ^{201}Tl uptake (0 for normal, 1 for equivocal, 2 for moderate, 3 for severe, and 4 for absent perfusion defects). To calculate the infarct extent and severity, only segments showing a reduction in myocardial perfusion considered. The extent score of perfusion defects was calculated for each patient by multiplying the number of these segments. The severity score was calculated for each patient by summation of the perfusion scores of these segments (7, 15).

Statistical analysis

Data were analyzed by using a commercially available statistics software package SPSS® for Windows version 15.0 (Chicago, USA). The SPECT scores were summarized as median values. The other data were expressed as mean±SD. Differences between the supine and prone position values were compared using a Wilcoxon signed-rank test for paired data. Spearman's rank correlation test was used to assess the correlation between the SPECT scores and the cTnT levels. Statistical significance was assumed at p values <0.05.

Results

The severity and extent of the perfusion defects were significantly decreased in the prone position compared to the supine position (p<0.001) (Table 1, Fig. 1, 2). The mean peak cTnT level during hospitalization was 7.2±3.9 μg/l (normal<0.1 μg/L). Peak cTnT levels were correlated with all SPECT parameters. However, the correlations was greater in the prone position (defect severity: r=0.712, p<0.001) (defect extent: r=0.790, p<0.001) than in the supine position (defect severity: r=0.495, p<0.01) (defect extent: r=0.481, p<0.01) (Fig.3, 4).

Table 1. Perfusion defect scores in images of the supine and the prone positions

Variables	Supine	Prone	p*
Defect severity score	8 (4-13)	5 (0.5-8.5)	<0.001
Defect extent score	4 (3-5.5)	3 (0.5-4.5)	<0.001

Values are expressed as median (range)
*Wilcoxon's signed rank test

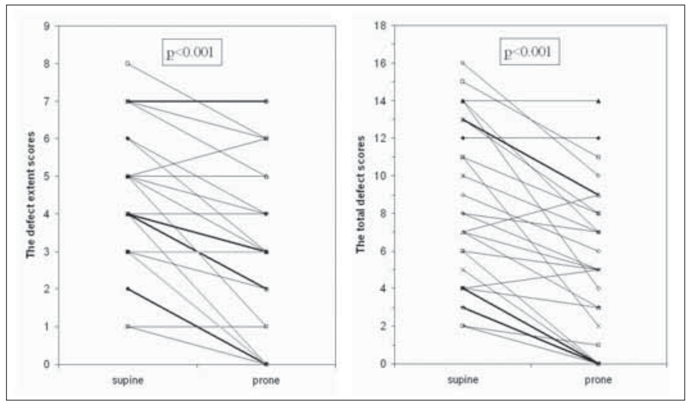

Figure 1. The defect extent and severity scores calculated from prone and supine acquisition of SPECT

Bold lines represent more than one case. The p values from the Wilcoxon signed-rank tests are shown

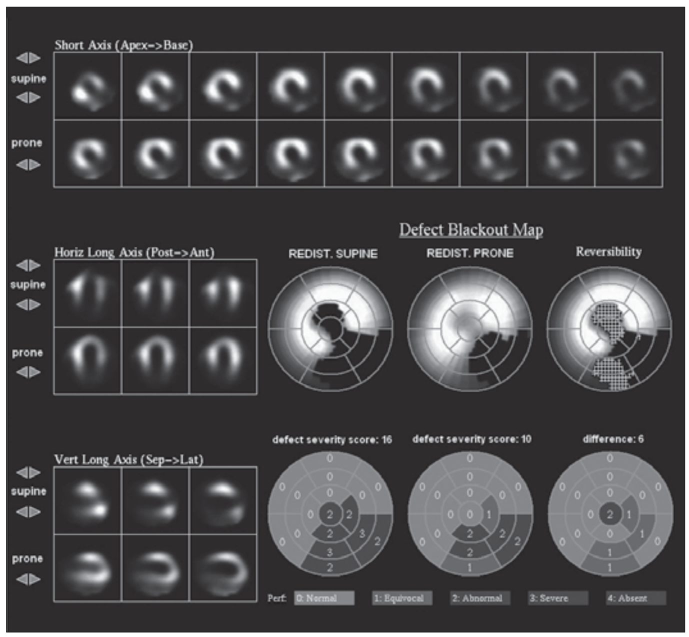

Figure 2. Redistribution ^{201}Tl SPECT images belonging to a sixty-four-year-old male patient with inferior MI. The images, displayed on short (SA), horizontal long (HLA), and vertical long (VLA) axes, reveal an apparent perfusion abnormality in the inferior wall in the supine images. However, the prone images show partial improvement. The segmental scores were smaller in the prone position than in the supine position

Discussion

Our study demonstrated that extent and severity of perfusion defects detected in prone position had stronger correlation with MI damage as estimated by troponin T levels than in supine position in the setting of inferior MI.

The prone position is widely used to eliminate inferior wall attenuations in myocardial perfusion SPECT studies. However, previous findings related to the prone position (10, 11, 16-21) are not specific to the sub-population of patients with inferior MI. This study's infarct extent estimations are the first such results to be reported.

SPECT is a method widely used and mostly accepted in the evaluation of infarct size (1). In our study, the strong relationship that we found between the peak cTnT level and scintigraphic infarct size has been pointed out in previous studies (1, 22, 23). Moreover, SPECT results have also been correlated with results from other biochemical, radiologic and echocardiographic methods (1). However, because of the method's low spatial resolution (2), SPECT has some disadvantages, such as not showing nontransmural defects (1, 24, 25). Comparative studies carried out with CMRI have shown that nontransmural MIs can be overlooked by SPECT (24, 25). In our study, some of our MI patients who were

Anadolu Kardiyol Derg 2010 December 1; 10(6); 539-43
doi:10.5152/akd.2010.161

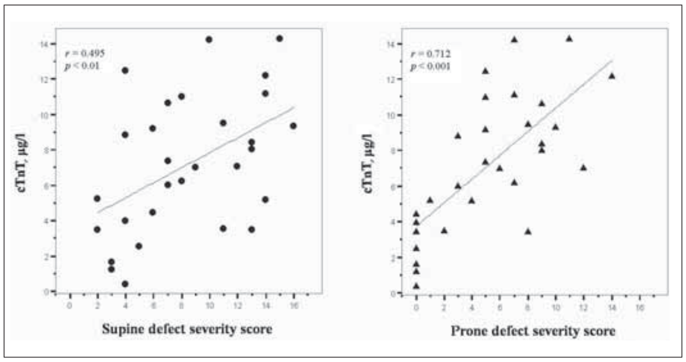

Figure 3. Correlation between defect severity scores and peak cTnT levels using Spearman's rank correlation test
cTnT - cardiac troponin T

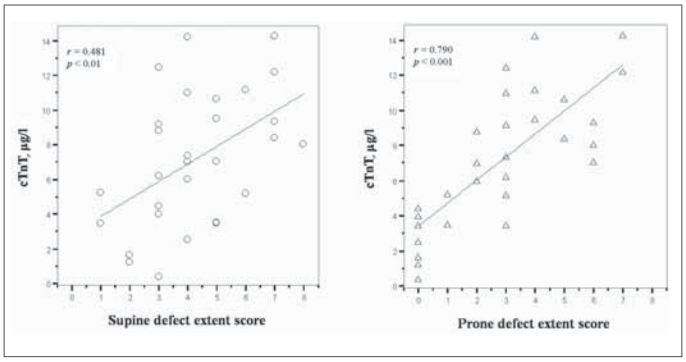

Figure 4. Correlation between defect extent scores and peak cTnT levels using Spearman's rank correlation test
cTnT - cardiac troponin T

kept in the prone position had low troponin values. Possibly, this explains their complete recovery from perfusion defects.

Decreased count matter in the inferior wall from being in the supine position has been demonstrated with positron emission tomography (PET) and attenuation correction methods (7-9). A comparison with nitrogen-13 ammonia PET studies revealed that standard supine imaging causes underestimations of existing perfusion defects in inferior wall segments (8). To evaluate infarct size in patients with MI, it has been reported that the size of ^{201}T1 perfusion defects is decreased by attenuation correction methods (7, 9). This situation is true for both ^{201}T1- and technetium-99 m-labeled radiotracers in various attenuation correction systems (8, 26). The assessment of the inferior wall seems to benefit most from attenuation correction (3, 8).

Counts obtained at the inferior wall generally increase when the prone position is used, in comparison to use of the supine position (10, 19). Counts in the anterior and neighboring areas have been reported to decrease in the prone position (10,16), and false positive defects can develop (18-20). In the detection of perfusion defects, it has been asserted that the sensitivity is not generally affected (10, 19, 21, 27). However, a moderate drop from using the prone position has also been mentioned in a few studies (17, 18, 20). In terms of our findings, the reported results related to the sensitivity of the prone position do not completely reflect our study population or our criteria. First of all, the sensitivity in these studies is mainly based on the results of angiography (17, 18, 20). Although angiographic intervention is the gold standard in the diagnosis and treatment of CAD, angiography cannot be expected to directly show infarct size (1). Our study is also different from those just mentioned in terms of patient population. In one of those studies (18), the selected populations did not consist only of patients with MI, and in the other two studies (17, 20), patients with MI were not included. Given the fact that, in the prone position, the counts at the inferior wall generally increase (10, 19), it is likewise reasonable to expect a decrease in the severity of defects. Our study indicates that this is so. In fact, the strong correlations with the results obtained using cTnT support our findings.

Study limitations

Several limitations of this study should be mentioned. Our study was limited by the small number of patients. Another drawback was that various methods could not have been used in comparisons of scintigraphic results. For instance, we were not able to use CMRI, which is a powerful imaging tool (2). We could not perform the attenuation correction due to technical insufficiencies (3). Although echocardiographic measurements of global and regional left ventricular functions are often used clinically in the estimation of infarct size, these measurements are less than direct, and are influenced by the presence of arrhythmias, cardiomyopathies, valvular heart disease, and ventricular loading (28). Electrocardiographic assessment of infarct size is also useful clinically; however, even when carefully analyzed and expressed on an ordinal scale, such assessment has limited ability to resolve small differences in infarct size (1). For this purpose, the peak cTnT level that we used is a biochemical marker that has been extensively utilized in patients with MI (1).

Conclusion

In patients with inferior MI, SPECT results revealed a significant difference between images taken in the supine and prone positions. The perfusion extent and severity scores of SPECT in the inferior wall with prone imaging correlates better with peak troponin compared to supine. Comparative studies by using advanced imaging tools are needed to verify our present findings.

Conflict of interest: None declared.

References

1. Gibbons RJ, Valeti US, Araoz PA, Jaffe AS. The quantification of infarct size. J Am Coll Cardiol 2004; 44: 1533-42.
2. Kıraç S. The role of advanced cardiac imaging methods in coronary artery disease. Anadolu Kardiyol Derg 2008; 8: 1-4.
3. Ünlü M. Myocardial perfusion scintigraphy in the diagnosis and prognostic assessment of coronary artery disease: SPET and PET. Anadolu Kardiyol Derg 2008; 8: 5-11.
4. Akıncıoğlu C, Atasever T, Caner B, Kaya GC, Kıraç S, Ünlü M. Turkish Society of Nuclear Medicine Nuclear Cardiology Task Group. Nuclear cardiology-procedure guideline. Türk J Nucl Med 2001; 10: 41-9.

5. Fieno DS, Thomson LE, Slomka P, Abidov A, Friedman JD, Germano G, et al. Quantitation of infarct size in patients with chronic coronary artery disease using rest redistribution Tl-201 myocardial perfusion SPECT: correlation with contrast-enhanced cardiac magnetic resonance. J Nucl Cardiol 2007; 14: 59-67.
6. Slomka PJ, Fieno D, Thomson L, Friedman JD, Hayes SW, Germano G, et al. Automatic detection and size quantification of infarcts by myocardial perfusion SPECT: clinical validation by delayed-enhancement MRI. J Nucl Med 2005; 46: 728-35.
7. Chouraqui P, Livschitz S, Baron J, Moalem I, Shechter M. The assessment of infarct size in postmyocardial infarction patients undergoing thallium-201 tomographic imaging is improved using attenuation correction. Clin Nucl Med 2004; 29: 352-7.
8. Fricke E, Fricke H, Weise R, Kammeier A, Hagedorn R, Lotz N, et al. Attenuation correction of myocardial SPECT perfusion images with low-dose CT: evaluation of the method by comparison with perfusion PET. J Nucl Med 2005; 46: 736-44.
9. Gallowitsch HJ, Unterweger O, Mikosch P, Kresnik E, Sykora J, Grimm G, et al. Attenuation correction improves the detection of viable myocardium by thallium-201 cardiac tomography in patients with previous myocardial infarction and left ventricular dysfunction. Eur J Nucl Med 1999; 26: 459-66.
10. Segall GM, Davis MJ. Prone versus supine thallium myocardial SPECT: a method to decrease artifactual inferior wall defects. J Nucl Med 1989; 30: 548-55.
11. Esquerre JP, Coca FJ, Martinez SJ, Guiraud RF. Prone decubitus: a solution to inferior wall attenuation in thallium-201 myocardial tomography. J Nucl Med 1989; 30: 398-401.
12. Giannitsis E, Steen H, Kurz K, Ivandic B, Simon AC, Futterer S, et al. Cardiac magnetic resonance imaging study for quantification of infarct size comparing directly serial versus single time-point measurements of cardiac troponin T. J Am Coll Cardiol 2008; 51: 307-14.
13. Maddahi J, Van Train K, Prigent F, Garcia EV, Friedman J, Ostrzega E, et al. Quantitative single photon emission computed thallium-201 tomography for detection and localization of coronary artery disease: optimization and prospective validation of a new technique. J Am Coll Cardiol 1989; 14: 1689-99.
14. Cloninger KG, DePuey EG, Garcia EV, Roubin GS, Robbins WL, Nody A, et al. Incomplete redistribution in delayed thallium-201 single photon emission computed tomographic (SPECT) images: an overestimation of myocardial scarring. J Am Coll Cardiol 1988; 12: 955-63.
15. De Sutter J, Van de Wiele C, D'Asseler Y, De Bondt P, De Backer G, Rigo P, et al. Automatic quantification of defect size using normal templates: a comparative clinical study of three commercially available algorithms. Eur J Nucl Med 2000; 27: 1827-34.
16. Hayes SW, De Lorenzo A, Hachamovitch R, Dhar SC, Hsu P, Cohen I, et al. Prognostic implications of combined prone and supine acquisitions in patients with equivocal or abnormal supine myocardial perfusion SPECT. J Nucl Med 2003; 44: 1633-40.
17. Berman DS, Kang X, Nishina H, Slomka PJ, Shaw LJ, Hayes SW, et al. Diagnostic accuracy of gated Tc-99m sestamibi stress myocardial perfusion SPECT with combined supine and prone acquisitions to detect coronary artery disease in obese and nonobese patients. J Nucl Cardiol 2006; 13: 191-201.
18. Doğruca Z, Kabasakal L, Yapar F, Nisil C, Vural VA, Önsel Q. A comparison of Tl-201 stress-reinjection-prone SPECT and Tc-99m-sestamibi gated SPECT in the differentiation of inferior wall defects from artifacts. Nucl Med Commun 2000; 21: 719-27.
19. Kiat H, Van Train KF, Friedman JD, Germano G, Silagan G, Wang FP, et al. Quantitative stress-redistribution thallium-201 SPECT using prone imaging: methodological development and validation. J Nucl Med 1992; 33: 1509-15.
20. Nishina H, Slomka PJ, Abidov A, Yoda S, Akıncıoğlu C, Kang X, et al. Combined supine and prone quantitative myocardial perfusion SPECT: method development and clinical validation in patients with no known coronary artery disease. J Nucl Med 2006;47:51-8.
21. Schoss RM, Gorten RJ. Comparison of supine versus prone tomographic myocardial imaging. Effect on false-positive rate. Clin Nucl Med 1996; 21: 445-51.
22. Licka M, Zimmermann R, Zehelein J, Dengler TJ, Katus HA, Kübler W. Troponin T concentrations 72 hours after myocardial infarction as a serological estimate of infarct size. Heart 2002; 87: 520-4.
23. Tzivoni D, Koukoui D, Guetta V, Novack L, Cowing G. Comparison of Troponin T to creatine kinase and to radionuclide cardiac imaging infarct size in patients with ST-elevation myocardial infarction undergoing primary angioplasty. Am J Cardiol 2008; 101: 753-7.
24. İbrahim T, Bülow HP, Hackl T, Hörnke M, Nekolla SG, Breuer M, et al. Diagnostic value of contrast-enhanced magnetic resonance imaging and single-photon emission computed tomography for detection of myocardial necrosis early after acute myocardial infarction. J Am Coll Cardiol 2007; 49: 208-16.
25. Wagner A, Mahrholdt H, Holly TA, Elliott MD, Regenfus M, Parker M, et al. Contrast-enhanced MRI and routine single photon emission computed tomography (SPECT) perfusion imaging for detection of subendocardial myocardial infarcts: an imaging study. Lancet 2003; 361:374-9.
26. Malkerneker D, Brenner R, Martin WH, Sampson UK, Feurer ID, Kronenberg MW, et al. CT-based attenuation correction versus prone imaging to decrease equivocal interpretations of rest/stress Tc-99m tetrofosmin SPECT MPI. J Nucl Cardiol 2007; 14: 314-23.
27. Slomka PJ, Nishina H, Abidov A, Hayes SW, Friedman JD, Berman DS, et al. Combined quantitative supine-prone myocardial perfusion SPECT improves detection of coronary artery disease and normalcy rates in women. J Nucl Cardiol 2007; 14: 44-52.
28. Califf RM, Harrelson-Woodlief L, Topol EJ. Left ventricular ejection fraction may not be useful as an end point of thrombolytic therapy comparative trials. Circulation 1990; 82: 1847-53.