Increased accuracy of single photon emission computed tomography (SPECT) myocardial perfusion scintigraphy using iterative reconstruction of images

Povećana tačnost *single photon emission computed tomography* (SPECT) perfuzione scintigrafije miokarda korišćenjem iterativne rekonstrukcije

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Abstract

Background/Aim. Filtered back projection (FBP) is a common way of processing myocardial perfusion imaging (MPI) studies. There are artifacts in FBP which can cause false-positive results. Iterative reconstruction (IR) is developed to reduce false positive findings in MPI studies. The aim of this study was to evaluate the difference in the number of false positive findings in MPI studies, between FBP and IR processing. **Methods.** We examined 107 patients with angina pectoris with MPI and coronary angiography (CAG), 77 man and 30 woman, aged 32−82. MPI studies were processed with FBP and with IR. Positive finding at MPI was visualization of the perfusion defect. Positive finding at CAG was stenosis of coronary artery. Perfusion defect at MPI without coronary artery stenosis at CAG was considered like false positive. The re-

sults were statistically analyzed with bivariate correlation, and with one sample *t*-test. **Results.** There were 20.6% normal, and 79.4% pathologic findings at FBP, 30.8% normal and 69.2% pathologic with IR and 37.4% normal and 62.6% pathologic at CAG. FBP produced 19 false-positive findings, at IR 11 false positive findings. The correlation between FBP and CAG was 0.658 ($p < 0.01$) and between IR and CAG 0.784 ($p < 0.01$). The number of false positive findings at MPI with IR was significantly lower than at FBP ($p < 0.01$). **Conclusion.** Our study shows that IR processing MPI scintigraphy has less number of false positive findings, therefore it is our choice for processing MPI studies.

Key words:
angina pectoris; diagnosis; scintigraphy; coronary angiography; technology, medical; methods.

Apstrakt

Uvod/Cilj. Filtrovana projekcija unazad (FBP) uobičajen je način za obradu slika dobijenih pomoću SPECT perfuzionom scintigrafijom miokarda (MPI). FBP obradom moguća je pojava artefakata koji mogu da dovedu do pojave lažno pozitivnih rezultata. Iterativna rekonstrukcija (IR) razvijena je sa ciljem redukovanja lažno pozitivnih rezultata na MPI scintigrafijama. Cilj ove studije bio je procena razlike u broju lažno pozitivnih rezultata na MPI scintigrafijama, korišćenjem FBP i IR. **Metode.** Ukupno smo pregledali 107 bolesnika sa anginom pektoris, 77 muškaraca i 30 žena, starih od 32 do 82 godine, koristeći SPECT MPI scintigrafiju i koronarnu angiografiju (CAG). MPI scintigrafske slike su rekonstruisane korišćenjem FBP i IR. Pozitivan nalaz na MPI scintigrafijama bio je vizualizacija perfuzionog defekta. Pozitivan nalaz na CAG bio je vizualizacija stenoze koronarne arterije. Perfuzioni defekt na MPI bez stenoze

koronarne arterije na CAG smatran je lažno pozitivnim MPI rezultatom. Rezultati su statistički analizirani bivarijantnom korelacijom i *t*-testom. **Rezultati.** Na MPI scintgrafijama obrađenim postupkom FBP bilo je 20,6% normalnih, i 79,4% patoloških rezultata. Ukupno 30,8% normalnih i 69,2% patoloških rezultata dobili smo iz IR, dok je na CAG bilo 37,4% normalnih i 62,6% patoloških rezultata. Tehnika FBP je pokazala 19 lažno pozitivnih rezultata, dok smo pomoću IR dobili 11 lažno pozitivnih nalaza. Povezanost rezultata FBP i CAG iznosila je 0,658 ($p < 0,01$), a povezanost IR i CAG 0,784 ($p < 0,01$). Broj lažno pozitivnih rezultata bio je značajno niži primenom IR ($p < 0,01$). **Zaključak.** Naš rad pokazuje da IR MPI scintigrafije ima manji broj lažno pozitivnih rezultata, zbog čega je to naš metod izbora za rekonstrukciju MPI studija.

Ključne reči:
angina pektoris; dijagnoza; scintigrafija; angiografija koronarnih arterija; tehnologija, medicinska; metodi.

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Introduction

Filtered back projection (FBP) is the oldest and the most common way of processing single photon emission computed tomography (SPECT) myocardial perfusion imaging (MPI) studies [1]. It is a rapid way to get images of the left ventricle with good contrast and respectable accuracy in assessing myocardial perfusion. But, there are possible arti-
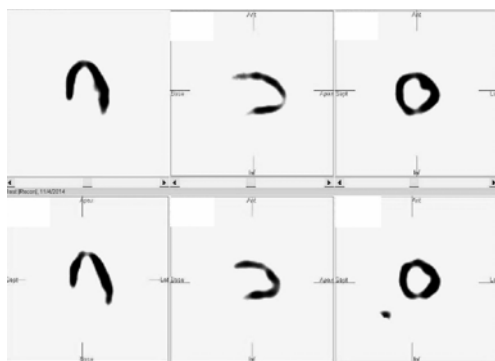

Fig. 1 – Patient 31: filtered back projection processed myocardial perfusion imaging with perfusion defects in the anterior wall and apex of the left ventricle.

facts related to scattering of gamma photons within adjacent structures, which can cause the onset of the false positive results. Iterative reconstruction (IR) is developed with the aim to reduce the impact of attenuation and scatter, and in the final to avoid false positive findings at MPI studies [2]. Although IR is more demanding way of processing MPI studies, nowadays, computing power of SPECT devices allows the use of almost every processing modality [3, 4].

The aim of this study was to evaluate the difference in the number of false positive findings with MPI studies, between FBP and IR processing.

Methods

We examined 107 patients with symptoms of angina pectoris. There were 77 men and 30 women, 32 to 82 years of age. For MPI studies we used 99^mTc-SESTAMIBI, standard two-day protocol, with exercise stress test [5, 6]. All studies were done on a double headed E-Cam (Siemens) gamma camera, and processing was done on a processing station dedicated to it, with preinstalled INVIA software (® INVIA, LLC). MPI studies were FBP processed with order 5 and a cutoff of 0.7 and 0.5 Nyquist (0.53 cycles/cm) [7–9], and after that we repeated reconstruction of MPI images with ordered subset expectation maximization (OSEM) IR. The number of iterations was 8 with 2 subsets. The images reconstructed with OSEM were filtered with a symmetric 3-D Gaussian function with full width at half maximum of 3.3 mm. All of the patients underwent CAG, with standard Seldinger approach. A positive finding for myocardial ischemia at MPI was visualization of the reversible perfusion defect in the myocardium of the left ventricle [10]. A positive finding at CAG was stenosis of coronary artery equal to or bigger than 50%. Perfusion defect

at MPI without coronary artery stenosis at CAG was considered as false positive MPI finding (Figures 1−3) [11].

The results of FBP, IR and CAG were statistically analyzed with bivariate correlation test and Pearson's correlation coefficient was calculated between the groups. Two tailed significance test was done, with the significance of correlation at the 0.01 level. The difference between false positive findings with FBP and IR was calculated with one sample t-test.
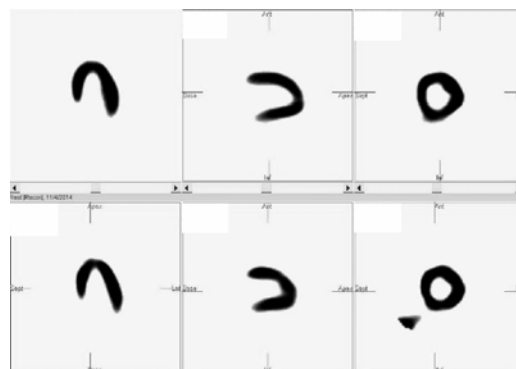

Fig. 2 – Patient 31: iterative reconstruction processed myocardial perfusion imaging (normal perfusion).
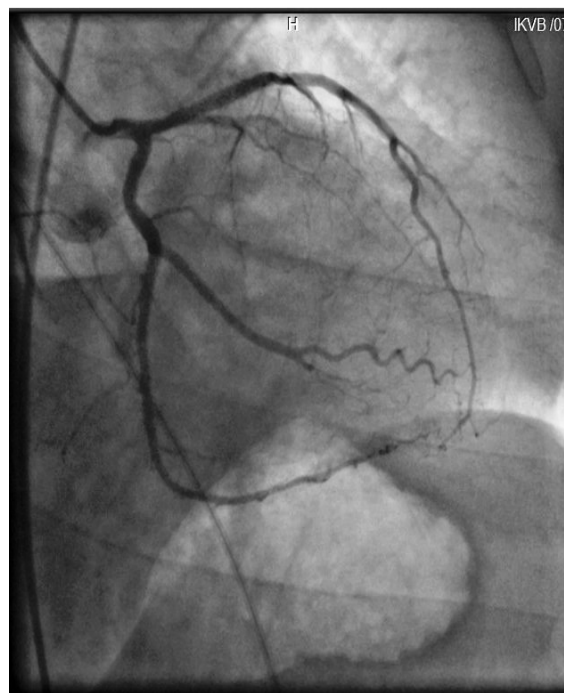

Fig. 3 – Patient 31: coronary artery without stenosis on coronary angiography.

Results

There were 22 (20.6%) normal, and 85 (79.4%) pathologic findings at FBP, 33 (30.8%) normal and 74 (69.2%) pathologic with IR, and 40 (37.4%) normal and 67 (62.6%) pathologic findings at CAG. FBP produced 19 (17.8%) false positive findings, while with IR we got 11 (10.3%) false positive findings. The correlation between FBP and CAG was

0.658 ($p < 0.00$), and between IR and CAG 0.784 ($p < 0.00$). The number of false positive findings on MPI with IR was significantly lower than on FBP ($p < 0.01$) (Table 1).

re time consuming for elder SPECT devices [5]. Computing power of newer devices makes this difference in the duration of computing insignificant. With IR processing it is possible

Table 1

Significantly smaller number of false positive findings at iterative reconstruction (IR) of myocardial perfusion imaging

Technique	Patients (n)	Normal findings n (%)	Pathologic findings n (%)	False positive findings n (%)	Correlation with CAG
FBP	107	22 (20.6)	85 (79.4)	19 (17.8)	0.658
IR	107	33 (30.8)	74 (69.2)	11 (10.3)	0.784
CAG	107	40 (37.4)	67 (62.6)		

FBP – filtered back projection; CAG – coronary angiography.

Discussion

FBP processing MPI studies was a common way of processing. It is fast and reliable, but insufficient when there is the need for handling with scatter artifacts [12]. It was the method of choice, because less demanding in computing power, and the results were clinically acceptable [13]. However, scatter artifacts can cause the appearance of perfusion defects at MPI studies in the myocardium with normal perfusion *eg* appearance of false positive MPI finding [14]. IR processing for MPI scintigraphy is more demanding and mo-

to avoid artifacts related to scatter or attenuation of gamma photons, which can result in perfusion defects at MPI, without existence of ischemia or stenosis of coronary arteries. Avoiding scatter artifacts which results in false positive finding, can increase diagnostic accuracy of MPI [15].

Conclusion

Our study shows that IR processing MPI scintigraphy has less number of false positive findings than processing with FBP, therefore it is our choice for processing MPI studies.

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