Radiol Oncol 1997; 31: 348-52.

Tl-201 SPECT for the detection of viable hybernating myocardium in chronic coronary occlusion

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Twelve patients with 17 chronic occlusions over the last 1- 14 months were examined with the SPECT Tl-201 myocardial perfusion scintigraphy and angiography before and 2 months after the PTCA (CABG), for the assessment of the improvement of the perfusion and kinetics. This improvement served as a reference method for the positive and negative predictive value of the SPECT study for the detection of viable hybernating myocardium. There were 52 segments (67%) with severe reduced uptake of Thallium from the infarcted area and 44 (56%) were viable. On the basis of angiography the kinetics of 55 segments was assessed. Of the segments with mild wall motion abnormalities (WMA) (19/55), 95% (18/19) were viable. Of the segments with severe WMA (36/55), 14/36 (39%) were viable. A good correlation between the severity of perfusion defects and WMA was demonstrated. The positive and negative predictive values of the SPECT-study were 87% and 84%. No influence of the duration of occlusion was proved. The presence of angiographycally detected collateral circulation was related to the higher percentage of viable segments. The kinetic improvement after PTCA was detected in 34 segments (16 of those with mild WMA - 84%, and 16 of those with severe WMA - 45%). Functional improvement was detected in 8 patients. The left ventricular ejection fraction increase was 5.6% + 4.6%. It was greater in the group with left ventricular dysfunction (7.6%4.8% versus 1.75%1.08%, p<0.01).

Key words*: coronary disease; tomography, emission-computed, single-photon; thallium radioisotopes; myocardial stunning*

Introduction

The detection of viable hybernating myocardium is important for the prediction of the functional improvement after revascularization.[1-4]

The comparison of different radio- and non-radionuclide methods for the evaluation of myocardial viability demonstrates a good position of Tl-201 rest-redistribution technique.[5-8] In this method the accepted criteria of viability are: a significant increase of delayed (redistribution) uptake with >10% in the infarct area, and final (post- procedure) Tl-201 content ≥ 50%.[9,10]

The aim of the study was to evaluate the viable hybernating myocardium in chronic occlusions with previous myocardial infarction according to the SPECT criteria of Tl-201 myocardial perfusion scintigraphy. The influence of both: the duration of occlusion and of the presence of collateral circulation were also under estimation. The post-procedural changes in the function and perfusion served as a reference method.

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UDC: 616.127-005.8-073.-7568:539-163

Material and methods

Twelve patients intended for PTCA with chronic occlusions and documented myocardial infarction during the last 1 to 14 months were included in the study. The left ventricular function was altered to a different degree (Table1). In 10 patients the revascularization (PTCA,CABG) was carried out and the changes in the function and the perfusion were evaluated 2 months later. They were the base for the evaluation of the accuracy of previous viability determination.

SPECT studies

The myocardial perfusion abnormalities were assessed before and reassessed 2 months after revascularization. SPECT was performed using a rotating large-field-of-view camera equiped with a low-energy all-purpose parallel hole collimator. Thirthy-two projections (40 sec/ projection) were being: 0-normokinetic, 1-hypokinetic, 2-akinetic and 3-dyskinetic.

Table 1. Pre- and post-procedural characteristics of patients.

			Before PTCA (CABG)							Ater PTCA (CABG)		
No	Sex	Age	MI-WMA	Occlu -sion	Dura -tion (mon)	Coll. circul	IA sgts	Viable sgts	LVEF %	Procedure	Res stenosis	ΔLVEF
1	M	48	Ant A/D	LAD	6	0	7	0	31			
2	M	65	Inf,PB H	RCA	3	0	7	7	50	PTCA	0%, 0%	+ 10%
				Rcx		1						
3	M	38	Apic H	LAD	6	1	1	1	69	PTCA	0%	0%
4	M	60	AL,Apic H	LAD	14	2	9	3	62	CABG	CABG	+3%
5	M	50	AL H	LAD	11	1	10	9	35	PTCA	50%	+10%
			Apic D			1						
			Inf, PB A	RCA								
6	M	50	AB H	RCA	2	0	7	4	31	PTCA	40%,	+14%
			AL A			0					100%	
			Apic D	LAD								
			PB A									
7	F	47	Inf H	RCA	12	2	5	5	62	PTCA	100%	+2%
			PB H	Rcx		2					0%	
8	M	58	AB,AL H	LAD	6	0	6	5	50	PTCA+	dis+	0%
			Apic, Inf H							CABG	CABG	
9	M	64	Apic H	LAD	12	1	7	4	37	CABG	CABG	+8%
			Inf A	Rcx		0						
10	M	56	Al,	LAD	8	1	4	3	65	PTCA+	15%	+2%
			Apic H							CABG	CABG	
11	M	17	AL A	LAD	2	0	9	1	34	PTCA	20%	+1%
			Apic D									
12	M	63	Apic D	LAD	7	br.	7	2	45			
			Ant A									
Total							79	44	47.6%± 14.4%			+5.6%± 4.6%

MI - myocardial infarction, WMA- wall motion abnormalities
IA - infarction area, Ant - anterior, AL - anterolateral
AB - anterobasal, Inf - inferior, PB - posterobasal
Apic - apical, A - akinesis, H - hypokinesis, D - dyskinesis
sgts - segments, LVEF - left ventricular ejection fraction
br. - bridging, Res - residual, dis - dissection
Δ LVEF - left ventricular ejection fraction improvement

Angiographic examinations

The coronary anatomy was evaluated before and 2 months after the revascularization. Seventeen occlusions (10 of LAD, 4 of RCA and 3 of Rcx) were detected. Collateral circulation was detected in 10 vascular territories and graded from 0 to 3. The wall motion abnormalities (WMA) were estimated from the contrast ventriculography at 30 degrees of the right anterior oblique projection (RAO) with the Stanford method and semiquantitatively, the score obtained over a semicurcular 180 arch, which extended from 30 of the right anterior oblique to the left posterior oblique position. A 20% symmetric energy window centered on the 68 kev peak was used. All projection images were stored on a magnetic disk in 64x64 word matrix. After the filtered backprojection of the raw images the data were proceeded with Butterworth filter with a cutoff frequency of 0.5 cycles/pixel, order 5.0 to reconstruct transverse axial tomograms of 6.2 mm thickness per slice.

Sagittal and oblique tomograms parallel to the long-axis and the short axis of the left ventricle were extracted from the filtered transaxial tomograms. No attenuation, or scatter corrections were applied. Two sets of images were obtained on the 30-th minute and on the 4-th hour after application of 92 MBq Tl-201.

Analysis of SPECT images of myocardial perfusion

Six tomograms (2 apical, 2 mid-ventricular and 2 basal) were divided into 4 myocardial segments for each study (anterior, inferior, lateral and septal). For the quantitative assessment of regional tracer activities, a circumferential profile analysis was performed on an operator-defined region of interest (ROI), around the left ventricular activity. The maximum pixel activity within each of 60 sectors for the early and delayed images was standartized to the peak activity, which was assigned a value of 100%, without correction or normalization relative to a normal data base. Resting Tl-201 defects were defined as relative regional activities < 80% of peak. The sectors were then grouped into four segments and the segmental activity was obtained as the average of the individual segmental activities within each segment. The extent of the defect was determined by the number of segments with the rest perfusion defect within the vascular territory or in adjacent territories of the occluded artery.

Comparison of perfusion and WM abnormalities

The left ventricle from the RAO 30 degrees projection of angiography was divided into 5 segments: antero-basal, antero-lateral, apical, posterior, postero-basal. They corresponded to the segmentation from the vertical long axis of SPECT perfusion scintigraphy. The projection of WMA on the short axis slices is shown in Figure 1. The segments in septal and lateral regions remained without wall motion determination.

Statistic

The variation analysis was used. All data were presented as the mean value ± SD. The significance of the differences was evaluated by Students t-test.

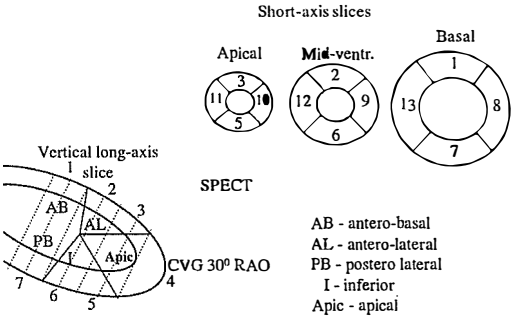

Figure 1. SPECT and CVG segments

Results

PTCA was done in 11 vascular territories. The primary success (residual stenosis <50%) was achieved in 7 of them. From those 2 months later 1 reocclusion occured. In 4 occlusions the procedure was unsuccessful (including 1 dissection and 3 residual stenoses >50%). In 2 of the patients a CABG was performed in the second stage because of the dissection in one case and because of the developpement of the LCA-stem stenosis in the other one. Functional improvement was detected in 8 patients. The mean left ventricular ejection fraction (LVEF) increase was 5.6%±4.6%. One patient demonstrated deterioration of left ventricular function (dissection) and one remained without changes. The group with the left ventricular dysfunction (initial LVEF 39.5%±2.63%, n=6) had an increase of 7.6%±4.8%. The group without dysfunction (initial LVEF 64.5%±2.87%, n=4) had an increase of 1.75%±1.08%.

Detection of viable hybernating myocardium. The quantitative analysis of the percentage of Tl-201 uptake in the segments with perfusion abnormalities before and after revascularization. Of 79 segments included in the infarct area, 52 were with severe uptake reduction of Tl-201 uptake(<50%) and 27-with moderate or mild reduction (≥50%). Forty-four segments (56%) were evaluated to be viable.

Fifty-seven segments were reassessed after revascularization: 38 viable and 19 without viability according to the SPECT study. An improvement in Tl-201 uptake after PTCA was determined in 33 segments. Five segments remained without improvement and showed Tl-uptake after procedure <50%. They were accepted to be false positive. Of the nonviable segments 16 showed no improvement

after revascularization and 3 increased their Tl-uptake to more than 50%. They were accepted to be false negative.

The positive predictive value of the study was 87% (PPV= TP/TP+FP=33/38). The negative predictive value of the study was 84% (NPV= TN/TN+FN=16/19).

Perfusion, wall motion abnormalities and viability. Determination of WMA was done for 55 segments. 36 segments (66%) showed severe WMA (akinetic, dyskinetic) and 19 segments (34%) mild WMA (hypokinetic). According to this analysis, 31/36 (86%) of segments with severe WMA showed severe uptake reduction and 14 of them (39%) were viable. Sixteen out of 19 with mild WMA (84%) showed moderate uptake reduction (>50%) and 18 (95%) of them were viable (Figure 2).

Relation between the viability and the duration of occlusion, as well as the collateral circulation. The patients with duration ≤3 months (n=3) had 52% viable segments (12 from 23 segments) . The patients with duration >3 months (n=9) were with 57% viable segments (32 from 56). For the vascular territories with angiographically detected collateral circulation (n=10) the percentage of viable segments was higher 69% (34/49) than for the territories without collateral circulation (n=7) 33% (10/30 segments). The extent of perfusion defects and the viability score (the number of viable segments) are shown in Table 1.

Changes in the wall motion and perfusion after revascularization. WM improvement appeared in 45% (16/36) from akinetic (dyskinetic) segments and 84% (16/19) of hypokinetic segments. There was a good coincidence of the percentage of the segments with improved WM and the percentage of the previously detected viable segments for both: the severe and the mild WMA (Figure 2).

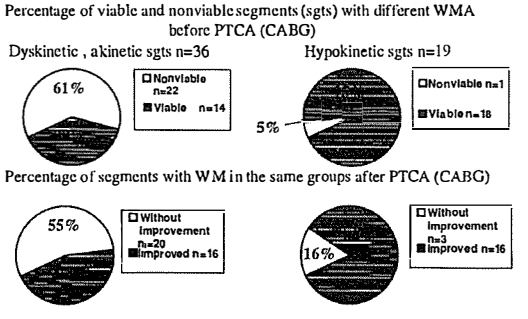

Figure 2. Kinetic changes after PTCA (CABG)

Changes in Tl-201 uptake after revascularization (Figure 3). Of all segments included in the infarcted area (n=79), 27 (x=58.9%±7.3%) were with mild altered uptake and 52 segments showed severe altered uptake (x=33.1%±8.4%). Four hours later, there was an increase in the delayed uptake in both groups as a sign of viability. After revascularization, 37% (21/57) of of reassessed segments remained with severe reduced uptake, while 63% (36/57) of segments showed an uptake ≥50%. It seemed very important that while 66% of the segments (52/79) were with severe uptake abnormality, 58% (32/55) of the segments reassessed after procedure demonstrated functional improvement.

Discussion

There was a substantial number of viable segments in the vascular territory of the coronary arteries with chronic occlusions and previous myocardial infarction. The patients were with different alterations of left ventricular function: n=4 were with saved left ventricular ejection fraction and n=8 were with severe or moderate alterations. Segments with viable hybernating myocardium existed in both groups. The initial Thallium uptake was not predictive for the viability of myocardium. According to our findings, the group of segments with severe reduced early Thallium-uptake (<50%) contained segments with uptake improvement on the delayed images and with uptake improvement after procedure to > 50% (Figure 3). The WMA were not

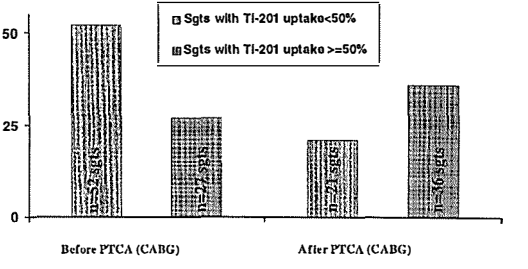

Figure 3. Changes in T1-201 segmental uptake after procedure

predictive and improvement in the kinetic after revascularization occured in both hypokinetic and akinetic (dyskinetic) segments (Figure 2). The myocardial perfusion criteria for viability seemed most important for the determination of hybernating myocardium in the segments with severe WMA-aki-

netic segments. The percentage of viable segments in this group was high enough according to our data (39%). The demonstration of viability in the hypokinetic segments was not so important because almost all of them (95%) were viable. The positive and negative predictive value of the study were similar to those in the literature.[10,11]

The influence of the duration of the occlusion was not proved in this study. The presence of collateral circulation was a predictor of high percentage of viable segments, its absence-predicted 2-fold lower percentage of viable segments.

A substantional functional improvement was detected in 8/10 patients post revascularization. The improvement was more pronounced in the patients with left ventricular dysfunction.

Conclusions

Tl-201 perfusion scintigraphy has high positive predictive value for the detection of hybernating myocardium in patients with chronic occlusions and previous infarction, and can predict the benefitial effect of revascularization.

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