

## Acute ischaemia / Acute ischaemic syndromes / Injury imaging

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### Effect of thrombus aspiration on infarct size and left-ventricular function in high-risk patients with STEMI treated by PCI. Results of a prospective controlled trial

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**Background:** Thrombus aspiration devices have been shown to improve reperfusion criteria and to reduce distal embolisation in patients treated by percutaneous coronary interventions (PCI) in the acute phase of ST-elevation myocardial infarction (STEMI). There is however a little data about their efficacy in the reduction of infarct size.

**Methods:** We sought to assess in a prospective randomized trial the impact of thrombus aspiration on infarct size and severity and on left-ventricular function in high-risk patients with a first STEMI. The primary end point was scintigraphic infarct size, and secondary end points were infarct severity and regional and global left-ventricular function. 44 patients with completely occluded (TIMI 0-1) proximal segments of infarct related artery (IRA) were randomly assigned to thrombus aspiration group with Export catheter (n=22) or PCI-only group. A rest Tc-99m-mibi gated SPECT and contrast-enhanced MRI imaging were performed 6 ± 2 days later.

**Results:** Infarct size was comparable in patients in thrombus aspiration group and PCI-only group (30.6 ± 15.8% vs 28.5 ± 17.9% of the left ventricle, p = 0.7) as was infarct severity in infarct related artery territory (55 ± 12 vs 55 ± 14, p = 0.9). Transmurality score as assessed by MRI was similar in both groups (2.03 ± 1.05 vs 2.16 ± 1.21, p = 0.7). There was no impact of thrombus aspiration on other secondary end points.

**Conclusion:** In our study thrombus aspiration with Export catheter performed as adjunctive therapy in high-risk patients with total occlusion of proximal part of major coronary arteries does not decrease infarct size or severity and has not effect on left ventricular regional and global function.

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### International variations in the ischemic burden post acute myocardial infarction: Prognostic implications

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**Objectives:** To determine if there is a variation in the ischemic burden post acute myocardial infarction (AMI), as assessed by myocardial perfusion imaging (MPI), between different populations in different geographic locations and to see if this variation is associated with different clinical outcomes.

**Methods and Results:** We characterized the MPI findings in 104 stable patients who were hospitalized with AMI at the American University of Beirut Medical Center (AUBMC), a tertiary referral hospital in an East Mediterranean country and we compared them to 126 patients who were enrolled according to a similar protocol in a previous study done at Baylor College of Medicine (BCM), Houston, Texas. There were no differences between the two populations with respect to prevalence of diabetes, hypertension, smoking, the use of thrombolysis, percentage of anterior MI's, Q-wave MI's, and multivessel disease on coronary angiography. However, the quantified ischemic defect size in the BCM population was double that in the AUBMC population (12 ± 12% vs 6 ± 8%, p < 0.01). This was associated with almost doubling of the one year event rate of death/myocardial infarction (18.3% vs 10.6%, P = 0.02) in the BCM population.

**Conclusion:** Our study suggests that the ischemic burden post AMI, as assessed by MPI, might vary between different populations in different geographic locations. This variation carries important prognostic implications and is associated with different patient outcomes.

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### Correlation between myocardial contrast delayed enhancement by multidetector computed tomography and Dual 123I-BMIPP/201-Thallium SPECT for myocardial viability after acute myocardial infarction

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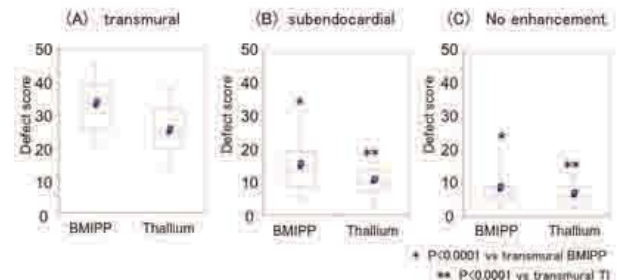
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We sought to evaluate the correlation between myocardial contrast delayed enhancement (DE) by multidetector computed tomography (MDCT) and dual 123I-BMIPP/201-Thallium SPECT to assess myocardial viability after acute myocardial infarction (AMI).

**Methods:** Fifty-one patients with first AMI underwent 64-slice MDCT without contrast re-injection immediately after primary coronary stenting. Dual 123I-BMIPP and 201-thallium SPECT was performed within 5 days after admission. We compared the transmural and size of myocardial contrast DE on MDCT with total defect score (TDS) of SPECT using 17-segment model and a semiquantitative visual score (0 = normal, to 4 = no uptake).

**Results:** Twenty-two patients showed transmural (Group A), 21 patients showed subendocardial (Group B), and 8 patients showed no contrast DE (Group C). The size of myocardial contrast DE showed good correlation to TDS of 123I-BMIPP (r = 0.75, p < 0.0001) and 201-thallium SPECT (r = 0.72, p < 0.0001). The TDS of 123I-BMIPP and 201-thallium SPECT was significantly higher in Group A than in the other groups as shown in the figure.

**Conclusion:** Myocardial contrast DE on MDCT might be useful to assess myocardial viability at very early time after AMI.



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### The effectiveness of 123I-BMIPP myocardial scintigraphy in patients with vasospastic angina and those with stable effort angina pectoris.

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**Background:** There is a growing acceptance that vasospastic angina (VSA) contributes the occurrence of ischemic heart diseases. However, no previous studies have fully investigated the significance of radionuclide study with 123I-beta-methyl-iodophenyl pentadecanoic acid (123I-BMIPP) to evaluate global myocardial fatty acid metabolism in patients with VSA.

**Purpose:** This study was designed to clarify and compare the effectiveness of 123I-BMIPP in myocardial fatty acid metabolism evaluation in patients with VSA and those with stable effort angina pectoris (EAP).

**Methods:** This study was conducted on 16 EAP patients (67.6 ± 11.4 years) and 23 VSA patients (67.6 ± 11.7 years). EAP and VSA were finally detected using cardiac catheters (CC); acetylcholine chloride was used to provoke coronary vasospasm. 123I-BMIPP myocardial scintigraphic images were obtained at the early and delayed phases (15 minutes and 4 hours after tracer injection, respectively) one day after CC in EAP patients and 2 weeks after CC in VSA patients. The heart-to-mediastinum (H/M) ratio and the washout rate (WR) were calculated from planar images. Left ventricular ejection fraction (EF) was assessed on a basis of echocardiograms; the concentration of plasma brain natriuretic peptide was measured.

**Results:** 1) There was no significant difference between the VSA and EAP patients in EF (62.9 ± 12.1 vs. 67.5 ± 12.7%, p > 0.2) and plasma BNP concentration (55.9 ± 49.5 vs. 58.5 ± 23.7 pg/ml, p > 0.2). 2) Significant

differences in the early H/M ( $2.1 \pm 0.3$  vs.  $2.7 \pm 0.4$ ,  $p < 0.001$ ) and the delayed H/M ( $1.8 \pm 0.3$  vs.  $2.2 \pm 0.4$ ,  $p < 0.001$ ) were observed between the VSA and EAP patients. 3) The global WR tended to be higher in the VSA than EAP patients ( $44.6 \pm 9.3\%$  vs.  $38.4 \pm 10.5\%$ ,  $p = 0.059$ ).

**Conclusion:** These data suggested that not EAP patients but VSA patients had a potential disorder of myocardial fatty acid metabolism. These findings might reflect microvascular circulation insufficiency induced by VSA rather than epicardial coronary artery stenosis.

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### The significance of 123I-BMIPP delayed scintigraphic imagings in patients with vasospastic angina

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**Background:** It has been recognized that vasospastic angina (VSA) plays an important role in the pathogenesis of wide-ranged ischemic heart diseases. However, no previous studies have fully investigated the significance of radionuclide isotope 123I-beta-methyl-iodophenyl pentadecanoic acid (123I-BMIPP) to evaluate global myocardial fatty acid metabolism in VSA patients. **Purpose:** This study was designed to clarify and compare the effectiveness of 123I-BMIPP in myocardial fatty acid metabolism evaluation in VSA patients and healthy controls.

**Methods:** This study was conducted on 13 healthy controls (mean age:  $70.4 \pm 10.5$  years) and 22 patients with VSA (mean age:  $61.2 \pm 12.5$  years) which was detected by acetylcholine provocation test for coronary vasospasm using cardiac catheters. Two weeks after cardiac catheterization, scintigraphic images were obtained at the early and delayed phases (15 minutes and 4 hours after tracer injection, respectively) using 123I-BMIPP without using any medications. The heart-to-mediastinum (H/M) ratio and the washout rate (WR) were calculated from planar images. Left ventricular ejection fraction (EF) was assessed on a basis of echocardiograms; the concentration of plasma brain natriuretic peptide was measured.

**Results:** 1) No differences in EF and plasma BNP were observed between the VSA patients and the controls (EF,  $62.5 \pm 12.2$  vs.  $70.4 \pm 8.0\%$ ,  $p > 0.2$ ; and plasma BNP,  $55.6 \pm 50.1$  vs.  $36.3 \pm 32.4$  pg/ml,  $p > 0.2$ , respectively). 2) Significant difference was observed between the VSA patients and the controls in the early H/M ( $2.1 \pm 0.3$  vs.  $2.7 \pm 0.6$ ,  $p < 0.001$ ) and the delayed H/M ( $1.8 \pm 0.3$  vs.  $2.4 \pm 0.4$ ,  $p < 0.001$ ). 3) The global WR was significantly greater in the VSA patients than the controls ( $44.7 \pm 9.5\%$  vs.  $29.3 \pm 11.7\%$ ,  $p < 0.001$ ).

**Conclusion:** It was useful to obtain both the early and delayed BMIPP images to determine whether patients had cardiac diseases, such as VSA, when the coronary angiography indicated nothing abnormal. This study result strongly suggested that the WR of 123I-BMIPP obtained from the planar images enhanced identification of potential myocardial fatty acid metabolic disorders in VSA patients.

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### Chronic Kidney Disease can contribute to later major cardiac events in patients with initial acute myocardial infarction

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**Purpose & Methods:** To evaluate whether chronic kidney disease (CKD) contributes in later major cardiac events (MACE) in patients with initial acute myocardial infarction (AMI), 211 consecutive initial AMI patients (M/F=162/49, age:  $63 \pm 11$  y.o) undergoing successful PCI were enrolled. We examined the relationship between MACE and CKD and other factors including coronary risk factors (diabetes mellitus, hyperlipidemia, hypertension and smoking), perfusion severity estimated by total-defect-score (TDS) of Tc-99m-MIBI-imaging, EF, end-diastolic volume (EDV) and end-systolic volume (ESV) on Tc-99m-MIBI-QGS at rest during subacute period. CKD was defined as renal dysfunction (eGFR  $< 50$  ml/min/1.73m<sup>2</sup>). eGFR was calculated by the following formula:  $194 \times \text{plasma Cr}^{-1.094} \times \text{age}^{-0.287} \times 0.739$  for women). MACE was defined as cardiac death, recurrence of nonfatal myocardial infarction/ACS, heart failure for hospitalization and VT/VF and was researched for over 1 year.

**Results:** MACE was found in 23 patients (cardiac death:0, recurrence of nonfatal myocardial infarction/ACS:11, heart failure for hospitalization:12 and VT/VF:0). eGFR was significantly lower in patients with MACE than patients without MACE ( $51.6 \pm 17.0$  vs.  $68.0 \pm 15.7$ ;  $p < 0.0001$ ). DM ( $p = 0.0097$ ), TDS ( $p = 0.0048$ ), EF ( $p = 0.0015$ ) and ESV ( $p = 0.0039$ ) were also significant. On multivariate analysis, eGFR ( $p = 0.0003$ ), DM ( $p = 0.042$ ) and ESV ( $p = 0.015$ ) were significant. MACE free survival rate in patients with CKD was 68% which was significant lower ( $p < 0.01$ ) than 94% in patients without CKD.

**Conclusion:** Chronic Kidney Disease can contribute to later major cardiac events in patients with initial AMI.

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### Follow-up Data of hANP and Nicorandil combined therapy in AMI shows usefulness to salvage myocardium, improve cardiac function, suppress left ventricular remodelling

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HANP was reported to suppress left ventricular remodelling due to its strong Na diuresis and vascular dilatation. Nicorandil (NCR) also has cardioprotective effect due to its preconditioning effect. But the usefulness of combined therapy of hANP and NCR was not reported.

**Methods:** Sixty patients with initial AMI undergoing successful PCI were divided into 3 groups: 20 patients for control (F/M=5/15, age=62  $\pm$  10y) (group A), 20 patients receiving NCR (F/M=2/18, age=62  $\pm$  12y) (group B) and 20 patients receiving combined therapy (F/M=6/14, age=66  $\pm$  12y) (group C). NCR was administered intravenously (4mg), intracoronary (2mg) and continuously (4mg/h for 24 hours). HANP was started before reperfusion continuously for 0.025 micogram/kg/min for 3 days. The summed defect score (TDS) of Tc-99m-MIBI and I-123-BMIPP on 17 SPECT segments and regional wall motion (RWMS: -1=dyskinesis -4=normal) of AMI segments, cardiac function using MIBI-QGS were estimated at rest on subacute (SUB) and 6 months (F-UP) periods.

**Results:** There were no significant differences on baseline characteristics, BMIPP-TDS (SUB), EDV (SUB, F-UP), among 3 groups. However, some values of group C were significantly better ( $p < 0.05$ ) than group A in MIBI-TDS (SUB) (A:  $15.9 \pm 8.3$  vs. B:  $10.6 \pm 10.3$  vs. C:  $9.0 \pm 7.8$ ), MIBI-TDS (F-UP) (A:  $14.2 \pm 3.8$  vs. B:  $8.5 \pm 9.9$  vs. C:  $5.4 \pm 5.1$ ), ESV (ml) (SUB) (A:  $67 \pm 23$  vs. B:  $63 \pm 24$  vs. C:  $52 \pm 19$ ), ESV (ml) (F-UP) (A:  $61 \pm 24$  vs. B:  $51 \pm 17$  vs. C:  $46 \pm 16$ ), EF (%) (SUB) (A:  $44 \pm 9$  vs. B:  $49 \pm 10$  vs. C:  $54 \pm 10$ ), EF (%) (F-UP) (A:  $51 \pm 9$  vs. B:  $57 \pm 9$  vs. C:  $58 \pm 9$ ). Moreover, some values of group B and C were significantly higher ( $p < 0.05$ ) than group A in BMIPP-TDS (F-UP) (A:  $22.0 \pm 3.6$  vs. B:  $11.8 \pm 6.7$  vs. C:  $10.7 \pm 7.0$ ), RWMS (SUB) (A:  $1.0 \pm 1.4$  vs. B:  $1.5 \pm 1.3$  vs. C:  $1.7 \pm 1.3$ ) and RWMS (F-UP) (A:  $1.9 \pm 1.6$  vs. B:  $2.9 \pm 1.5$  vs. C:  $3.1 \pm 1.1$ ).

**Conclusion:** The combined therapy of HANP and NCR in AMI is useful to salvage myocardium, improve cardiac function and suppress left ventricular remodelling.

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### The 99mTc-Sestamibi washout rate possibly predicts myocardial damages in patients with acute myocardial infarction after percutaneous coronary intervention

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The significance of washout rate (WR) obtained from 99mTc-Sestamibi myocardial scintigraphy has been a matter of debate in patients with heart disease. No previous study has demonstrated whether WR of 99mTc-Sestamibi is associated with myocardial damages in patients with acute myocardial infarction (AMI) after percutaneous coronary intervention (PCI). This study was designed to clarify the significance between WR of 99mTc-Sestamibi and cardiac enzymes in AMI patients after PCI.

**Methods:** This study was conducted on 56 consecutive patients with AMI (mean age:  $65.8 \pm 8.5$  years) who underwent PCI on admission. The actual onset time of AMI was determined based on interviews. Cardiac enzymes, creatinine kinase (CK) and MB isoenzyme of CK (CK-MB), were measured every 3 hours after admission. Two weeks after the onset of AMI, 99mTc-Sestamibi myocardial scintigraphy was performed at the early phase and the delayed phase (30 minutes after and 4 hours after tracer injection, respectively). The heart to mediastinum ratio (H/M) and the washout rate (WR) were calculated. Left ventricular ejection fraction (EF) was calculated from the results of electrocardiographic gated single photon emission computed tomography (SPECT) at the early phase.

**Results:** 1) PCI was performed  $9.4 \pm 6.0$  hr after the onset of AMI. The culprit arteries were the right coronary artery in 27 patients, the left anterior descending coronary artery in 23 patients and the left circumflex coronary artery in 6 patients. 2) The CK and CK-MB on admission and the peak CK and CK-MB were  $410.6 \pm 1318.0$  IU/L,  $39.8 \pm 198.1$  IU/L,  $2689.6 \pm 1167.4$  IU/L ( $15.3 \pm 4.6$  hr), and  $274.0 \pm 169.4$  IU/L ( $13.4 \pm 3.9$  hr), respectively. 3) The early H/M, the delayed H/M and the WR of 99mTc-Sestamibi were  $2.74 \pm 0.58$ ,  $3.00 \pm 0.70$ , and  $58.7 \pm 10.0\%$ , respectively. The EF was  $48.8 \pm 0.7\%$ . 4) The delayed H/M correlated with the peak CK ( $r = -0.32$ ,  $p = 0.015$ ) and peak CK-MB ( $r = -0.37$ ,  $p = 0.005$ ). 5) The WR of 99mTc-Sestamibi also correlated with the peak CK ( $r = 0.32$ ,  $p = 0.017$ ) and peak CK-MB ( $r = 0.34$ ,  $p = 0.012$ ).

**Conclusion:** These results suggested that, in AMI patients after PCI, the WR obtained from the results of 99mTc-Sestamibi myocardial scintigraphy might reflect the extent of their myocardial damages. This study results demonstrated

the significance of capturing the image of 99mTc-Sestamibi myocardial scintigraphy twice.

## Attenuation correction clinical

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### Attenuation-correction of myocardial perfusion SPECT with CT adjusted registration. Comparison with non-attenuation-corrected images.

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**Purpose:** Attenuation correction of myocardial perfusion SPECT can induces false results when misregistration occurs between the SPECT and the CT data. We compared the results of filtered back projection (FBP), iterative reconstruction non-corrected (IRNC) and iterative reconstruction attenuation corrected (IRAC) after adjusted CT registration.

**Methods:** 50 subjects (28 M, 22 F) underwent Tc-99m Tetrofosmin myocardial SPECT/CT on a hybrid system, in a one-day stress-rest protocol (23 exercise, 24 dipyridamole and 3 combined stress-dipyridamole tests). Reconstructed data were checked for registration between emission and CT, and eventually manually adjusted. The slices were visually analyzed and quantified with a 0 (normal) to 4 (abnormal) point-scale system. A fully automated 17-seg-model Emory cardiac toolbox has been also applied to calculate summed stress (SSS) and rest (SRS) scores, and transient ischemic dilatation ratio (TID). Scores  $\geq 4$  were considered abnormal.

**Results:** With visual analysis IRAC stress scores were smaller (mean 1.2) than IRNC scores (mean 2.2) ( $t = 4.53$   $p < 0.001$ ). The IRAC rest scores were smaller (mean 0.5) than IRNC scores (mean 1.1) ( $t = 3.7$   $p < 0.001$ ). When considering the patients as normal by visual analysis (FBP score 0 or 1), there was no difference between IRNC and IRAC at stress or at rest. Considering abnormal patients (FBP score 2 to 4), the IRAC stress scores were smaller (mean 1.9) than IRNC stress scores (3.7) ( $t = 5.35$   $p < 0.001$ ), and IRAC rest scores (mean 0.8) were also smaller than IRNC rest scores (mean 2.1) ( $t = 4.14$   $p < 0.001$ ). Considering the 50 patients, we did not find patient with normal anterior uptake with FBP and IRNC and abnormal anterior uptake on IRAC images; only one patient had normal uptake on FBP, and apical defect on IRNC and IRAC images. When compared to FBP and IRNC images, IRAC increases liver and gastrointestinal activity adjacent to myocardium. The FBP, IRNC and IRAC SSS were not statistically different for the total population. There was also no difference for the FBP, IRNC and IRAC SRS. For the patients with FBP SSS  $< 4$ , IRAC SRS was greater, but still normal, (mean 2.7) than IRNC SRS (0.8) ( $t = 2.89$   $p < 0.01$ ). For the abnormal patients (SSS FBP  $\geq 4$ ), IRAC SSS (6.3) was smaller than IRNC SSS (8.9) ( $t = 2.59$   $p < 0.02$ ).

**Conclusion:** Attenuation correction process, with quality control adjusted CT registration improves myocardial inferior uptake without inducing significant anterior defect. Liver and gastrointestinal activity adjacent to myocardium was increased with IRAC, but did not interfere with inferior myocardial uptake.

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### Clinical validation of hybrid SPECT/CT attenuation correction of stress myocardial perfusion studies

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**Purpose:** The purpose of this study was to evaluate the diagnostic accuracy of hybrid SPECT/CT based attenuation corrected (AC) SPECT myocardial perfusion imaging (MPI) in comparison to uncorrected SPECT (NC) in consecutive patients with angiographic correlates and low likelihood normals.

**Methods:** 360 consecutive patients were studied including 209 with recent coronary angiography and 151 low likelihood normals (pre-scan likelihood  $\leq 5\%$ ). Patients included 214 males/145 females with mean weight  $95.6 \pm 24.2$  Kg (range 48.1–200). Imaging was performed using hybrid SPECT-CT imaging systems (6 slice CT) and a stress Tc-99 sestamibi protocol, either symptom-limited maximal exercise or adenosine stress. Breathhold CT acquisitions were acquired with 0.6 sec rotational speed, effective mAs 18-35, 130 kV, pitch 1.0 at end tidal expiration, 5–7 sec. acquisition time. SPECT images were reconstructed for attenuation correction (including scatter correction and resolution recovery) using manufacturers' software without modification. Perfusion defects were assessed by scoring the severity and extent of perfusion defects in each of the three coronary artery distributions using standard 17 segment model.

**Results:** Sensitivity, specificity, accuracy and normalcy all increased significantly compared to NC SPECT analyzed both by patients and coronary territories. Results are detailed in the table. Defects associated with stenosed vessels were generally preserved or enhanced while attenuation artifacts were generally well corrected. Because of excessive respiratory misregistration at the time of

acquisition or patient / respiratory motion during SPECT imaging, 4.2% of AC SPECT studies were not interpreted.

**Conclusions:** Stress myocardial perfusion studies acquired and processed with hybrid SPECT/CT demonstrate significant improvements in sensitivity, specificity, accuracy and normalcy when compared to conventional uncorrected cardiac SPECT studies.

	Patients		Vessels	
	NC	AC	NC	AC
Sensitivity	76	94*	56	87*
Specificity	48	83*	81	93*
Accuracy	69	91*	69	90*
Normalcy	81	93*	91	99*

\*  $p < 0.05$

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### Impact of CT-based attenuation correction in TI-201 myocardial perfusion imaging

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**Purpose:** The first hybrid SPECT/CT of our medical center level large teaching hospital was just recently installed. A retrospect study was done to determine the clinical utility of this new facility which is composed of 4-slice low-resolution X-ray computed tomography (CT) attached to a gamma camera, utilizing its X-ray CT in attenuation correction (AC) of myocardial SPECT and comparing it with noncorrected (NC) SPECT images and also with the coronary angiography (CAG) results which is considered as the gold standard for coronary artery disease (CAD).

**Methods:** We retrospectively reviewed the myocardial SPECT images of the 1920 continuous patients from May 2007 to Apr 2008 (1209 men, 711 women; mean age 63 years) referred for suspected CAD. These patients had sequential myocardial SPECT imaging and CT. The myocardial perfusion imaging was done with thallium (TI)-201 (74 MBq) under a standard dipyridamole pharmacological stress protocol. Visual interpretation revealed 29% (557 out of 1920) and 41% (787 out of 1920) were positive for CAD in AC- and NC-SPECT images, respectively. Based on the positive clinical interpretation of AC SPECT images, 356 patients (with a total of 484 coronary territory lesions) had underwent CAG within 2 months after SPECT imaging. We compared the attenuation corrected (AC)- and noncorrected (NC) SPECT images with the coronary angiography (CAG).

**Results:** Visual assessment resulted in statistically significant improvements in overall diagnostic accuracy (sensitivity/specificity/accuracy = 81%/86%/85%, 80%/74%/76%, respectively, for AC- and NC-images) with coronary angiography (CAG) as gold standard for CAD. In addition, the CAG reported myocardial bridge systolic compression in 43% (21 out of 49) of false positive CAD in left anterior descending coronary artery.

**Conclusion:** Increase in the specificity and accuracy was significantly increased on AC-images. These preliminary data suggest that X-ray CT based AC of hybrid SPECT/CT in myocardial SPECT imaging has the potential to develop into a preferred standard clinical technique in nuclear medicine myocardial perfusion imaging.

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### Prone Imaging is An Effective Method of Attenuation Correction Even in Obese Women

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We had previously demonstrated that prone imaging (PR) is helpful in reducing breast tissue attenuation artifacts from true perfusion defects. The effect of obesity however, on the effectiveness of prone imaging is unknown.

**Methods:** Consecutive female patients referred to our laboratory for rest/stress Tc-99m MPI had their studies analyzed immediately. Using QGS software patients with a summed stress score greater than 1 in the anterior segments on supine (SU) post stress imaging then underwent repeat scanning in the prone position. The patients summed stress scores (SSS) for the anterior segments were then assessed using QGS software for the supine and prone post exercise images. The SSS were then evaluated by a  $2 \times 2$  ANOVA.

**Results:** 46 consecutive female patients referred to our laboratory (mean age  $61.6 \pm 14$  years, mean BMI =  $32.9 \pm 4.6$ , 40% had a BMI 25-30, 60% had a BMI over 30) had anterior defects and underwent PR imaging post stress. Patients with a BMI  $> 30$  (O) had a higher SSS both with SU and PR when compared to those with a BMI 25-30 (OW). PR reduced the SSS significantly in both groups

(table). With PR the extent of the reduction in the SSS was similar in O and OW ( $63.3\% \pm 44.4$  vs.  $53.3\% \pm 62.2$ ,  $p = \text{NS}$ ).

**Conclusions:** Obesity is a significant contributor to soft tissue attenuation. Even in patient who are obese, prone imaging significantly reduces soft tissue attenuation and is helpful in reducing false positive findings due to soft tissue attenuation.

	SU	PR	p
O	$6.5 \pm 4.4$	$3.2 \pm 3.4$	$<0.05$
OW	$3.0 \pm 2.0$	$0.8 \pm 1.1$	$<0.01$
p	$<0.05$	$<0.05$	

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#### Low dose 16 slice chest computed tomography to correct for photon attenuation in myocardial perfusion single photon emission computed tomography.

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A major limitation in the specificity of myocardial perfusion single photon emission computed tomography (SPECT) is soft tissue attenuation. Reported methods to correct for attenuation (AC) include gadolinium line sources and single slice chest computed tomography (CT).

The purpose of this study was to evaluate the performance of AC using CT data acquired on a hybrid SPECT/16 slice CT scanner.

Patients underwent 99mTc sestamibi stress imaging on a hybrid 16 slice CT/SPECT camera (120kV, 50mAs/Slice). Three experienced readers were blinded to gender and AC status and read 2 SPECT images (with and without AC) in random order on 96 patients with low to intermediate Framingham risk score ( $7 \pm 7\%$  estimate of 10-year risk for major coronary event). The mean age was  $54 \pm 11$  years (range 31-84 years). Forty-three (45%) were females. The raw projection images were interpreted for artifacts, defects were identified and localized, and scans were interpreted as definitely or probably normal, equivocal, probably or definitely abnormal. Final impression was dichotomized as normal or abnormal by consensus that an interpretation of equivocal or abnormal would require a second rest scan. Statistical analysis was performed with 6 observations from 3 readers under 2 conditions (AC yes or no). A Kappa statistic was used to assess observer agreement and logistic regression models with repeated measures for 2 binary outcomes were performed for effect of AC. The overall Kappa value for inter-observer agreement was 0.47. The effect of AC to improve normalcy rate for the entire group was of borderline significance (OR = 1.48, 95% CI (0.99, 2.20),  $p = 0.05$ , unadjusted) but when scans for each gender were analyzed separately in women there was an insignificant effect of AC (OR = 0.65, 95% CI (0.29, 1.46),  $p = 0.29$ ) while for men there was a highly significant effect (OR = 3.53, 95% CI (1.91, 6.53),  $p < 0.0001$ ).

These preliminary results for AC performed on 16 slice CT/SPECT scanner are similar to those reported for scanning gadolinium bar source and for single slice CT showing that any overall improvement in specificity is due to reduction in diaphragmatic attenuation artifacts and not to breast attenuation artifacts.

## Comparative techniques clinical

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#### Dual source CT coronary angiography for assessment of global LV function - Comparison with gated SPECT

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**Purpose:** Coronary CT angiography (CTA) is a robust non-invasive technique to assess the patency of coronary arteries. From the same data set as acquired for CTA, it is possible to evaluate left ventricular (LV) function without any additional contrast or radiation burden. The improved temporal resolution of dual source CT (DSCT) scanners (83milliseconds) allows CTA to be performed without the need for beta-blockers, and hence can assess LV function more accurately. The aim of the present study was to compare the correlation amongst LV functional parameters obtained by Dual Source CTA and resting gated single photon emission computed tomography (SPECT)

**Methodology:** Global LV function was assessed in 54 patients who underwent dual source CTA and gated (99m)Tc-MIBI SPECT within 3 months of each other without any intervening coronary events or interventions. Multi-phase CT reconstructions were made at every 10% of the R-R interval. End-systolic and end-diastolic phases were chosen visually and the LV volumes, ejection fraction (EF) and mass were calculated by threshold based segmentation method with manual adjustment where necessary. The same LV functional parameters were calculated from resting gated (99m)Tc-MIBI SPECT (8 gates/cardiac cycle) using

4D-MSPECT software. The results were compared using Pearson correlation and Bland-Altman analysis.

**Results:** There was a fair correlation between the two techniques for the measurement of LV volumes and mass and a modest correlation for the measurement of LVEF (see table). LV volumes and mass obtained by CTA were higher than those obtained by gated SPECT.

**Conclusion:** Although there was a statistically significant correlation between LV functional parameters obtained by CTA and gated SPECT, these two techniques are not interchangeable. CTA over-estimates LV volumes and mass compared to gated SPECT. This could be due to higher spatial resolution of CT and the inclusion of LV outflow tract and papillary muscles in the volume and mass measurements.

LV functional parameter	gated SPECT (Mean $\pm$ S.D)	CTA (Mean $\pm$ S.D)	Correlation co-efficient (r)	Significance (p)	95% limits of agreement (Mean difference $\pm$ 2 S.D)
EF (%)	$64 \pm 9$	$68 \pm 9$	0.54	$<0.01$	$7 \pm 11$
EDV (ml)	$96 \pm 31$	$118 \pm 31$	0.73	$<0.01$	$27 \pm 33$
ESV (ml)	$36 \pm 20$	$39 \pm 17$	0.81	$<0.01$	$9 \pm 16$
LV Mass (grams)	$135 \pm 25$	$168 \pm 39$	0.8	$<0.01$	$34 \pm 47$

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#### The assessment of myocardial salvage in acute myocardial infarction: Can one MRI study after PCI replace two myocardial perfusion SPECT studies? CEW. Duemcke<sup>1</sup>, P. Buser<sup>2</sup>, J. Marving<sup>3</sup>, D. Atar<sup>4</sup>, B. Hesse<sup>1</sup>

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**Background:** Assessment of myocardial salvage (MSalv) after primary coronary intervention (PCI) in acute myocardial infarction (AMI) is important for comparison of strategies aimed at reducing reperfusion injury. MPS performed before and after PCI is the only available technique. It is widely accepted as the "gold standard" for this assessment, but logistics of MPS are complicated with tracer injection administered before PCI. Recently cardiac MRI, performed only once a few days after AMI, was suggested as an easy alternative for assessing MSalv. We here compared MSalv by MRI with MPS.

**Patients and methods:** 49 patients with first-time AMI, enrolled into the F.I.R.E.-study, were treated with primary PCI and either FX06 or placebo (double-blind, randomized) for mitigation of reperfusion injury. All patients had MPS before (tracer injection before, imaging  $<8$  hrs after PCI) and 6 days after PCI. Perfusion defects before PCI were interpreted as area at risk, defect after PCI as infarcted area, and the difference (scored as SDS in a 17 segment model) as MSalv. Cardiac gadolinium-enhanced MRI was performed once at 6 days post PCI. White hyperenhancement was interpreted as necrotic core zone, grey late-enhancement as MSalv.

**Results:** MSalv estimated by MRI was not correlated to MSalv as measured by MPS (Fig. 1,  $R^2 = 0.011$ ). In contrast, necrotic mass as estimated by MRI was significantly correlated with scores of post-PCI defects ( $R^2 = 0.361$ ).

**Conclusion:** Assessment of myocardial necrosis by MRI and MPS show a high degree of correlation. MRI assessment may be more accurate due to its higher resolution, and since MPS may include ischemic but viable tissue. However, in contrast to recent reports, MRI performed once at 6 days after AMI cannot replace MPS before and after PCI for an accurate estimation of MSalv.

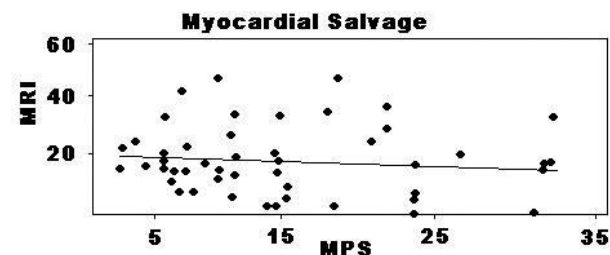


Figure 1. Myocardial Salvage

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### Comparison of 3D Myocardial Wall Measurements using MRI and SPECT on normal subjects

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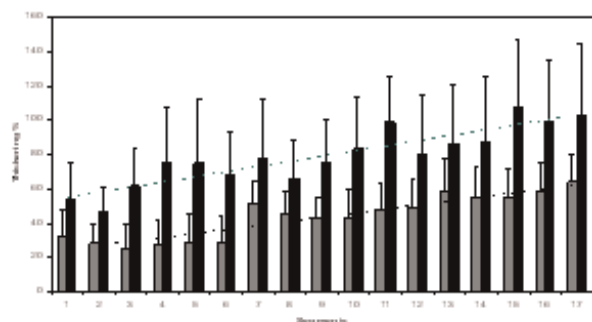
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**Purpose:** The purpose of this work is to compare quantitative 3D myocardial wall thickening and motion on Magnetic Resonance Images (MRI) with technetium-99mTc-sestamibi myocardial perfusion Single-Photon Emission Computed Tomographic (SPECT) images for normal subjects.

**Methods:** We analyzed 25 normal subjects who underwent both gated SPECT and MR imaging in a span of 2 hours. On the SPECT dataset, after left ventricle segmentation, 3D endocardial and epicardial surfaces were automatically determined using rule-based criteria (QGS algorithm). 3D myocardial boundaries were fitted to the MR images, and edited by a cardiologist. Myocardial thickening was computed as percentage increase in myocardial thickness (distance between endocardial and epicardial surfaces) from end-diastole (ED) to end-systole (ES). Regional wall motion was measured as the minimum distance (millimeters) between a given endocardial point at ED and ES. The 3D regional measurements were then transformed into the standard 17-segment polar map representation (American Heart Association).

**Results:** Strong correlation between the average segmental thickening on the two modalities was observed ( $r = 0.83$ ,  $p < 0.0001$ ) compared to wall motion ( $r = 0.65$ ,  $p < 0.0001$ ). We also noticed the lower limits (10th percentile) of the MR thickening scores in the mid and apical regions were closer to SPECT compared to the basal regions (MRI-basal(37), mid(44), apical(50); SPECT-basal(13), mid(32), apical(40)). This can be attributed to the position of the valve plane on the two modalities.

**Conclusion:** For normal subjects, the thickening measurements show strong correlation on MRI and SPECT compared to wall motion.



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### Accuracy of MDCT for defining anatomy in congenital heart disease: comparison with Echocardiography and Cardiac Catheterization

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**Background:** Assessment of congenital heart disease is a challenge for any diagnostic modality. Whereas, echocardiography is a very useful tool for initial diagnosis, cardiac catheterization stays as gold standard test for all patients with congenital heart disease prior to any corrective interventional procedure. The advent of MDCT has stimulated many for its use in congenital heart disease patients owing to its capability of 3D anatomy and non invasive nature of the test.

**Purpose:** The purpose of this study was to judge the diagnostic capability of Cardiac MDCT in comparison with echocardiography and cardiac catheterization.

**Methods:** Sixty patients (42 m, 18f) aged 6 months to 42 years (mean 12.5 years) with initial diagnosis of congenital heart disease on echocardiography were included in the study. All patients underwent cardiac MDCT on GE Lightspeed VCT using acquisition parameters according to their weight so as to minimize the radiation exposure. Iodinated contrast Ultravist 350 was injected during acquisition in a dose of 2ml per kg body weight. Scan data were processed and analyzed on GE Advantage 4.3 workstation using MPRs and volume rendered images. MDCT, Echocardiographic and Cardiac catheterization data were compared with respect to 20 parameters of cardiac anatomy.

**Results:** Echocardiographic data were available in all 60 patients while cardiac catheterization data were available in 34 out of 60 patients. Concordance was seen between MDCT and cardiac catheterization in 96 percent of all parameters

in 34 patients. Discordance in 4 percent parameters was seen with respect to pulmonary arteries, aortic arch abnormalities and the MAPCAs, where MDCT was clearly better able to define the anatomy. Concordance was observed between MDCT and echocardiographic data in 91 percent of parameters. Discordance was seen in two parameter in two separate patients where MDCT missed an ASD and a small muscular VSD. In remaining discordant parameters, MDCT clearly demonstrated anatomy better than echocardiography regarding pulmonary arteries, pulmonary veins, MAPCAs and aortic arch abnormalities.

**Conclusions:** MDCT shows high concordance with cardiac catheterization and echocardiography in defining cardiac anatomy. In discordant cases, MDCT defines cardiac anatomy better than cardiac catheterization and echocardiography.

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### Low sensitivity of Single Photon Emission Computed Tomography for detecting subendocardial necrosis in Ischemic Cardiomyopathy

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**Background:** Prediction of reversible dysfunction is overestimated by single photon emission computed tomography (SPECT) in patients with ischemic cardiomyopathy (IC). The aim of the study was to assess whether suboptimal positive predictive accuracy maybe explained by undetected subendocardial scar due to limited spatial resolution of SPECT

**Methods:** Twenty-five patients with IC (age  $64 \pm 14$  yrs; ejection fraction 32%, left ventricular diastolic diameter  $63 \pm 6$  mm) underwent nitrate enhanced 99mTcsestamibi gated SPECT, gadolinium enhanced magnetic resonance (CMR) and echocardiography within one week. CMR and SPECT images were scored using a 17 segment model for presence and location of infarction, whereas corresponding segments from echocardiography were scored for regional systolic function. For SPECT, regional tracer uptake was automatically scored by a semiquantitative 5 point scoring scale. For CMR the transmural extent of late enhancement (LE) was visually scored by a semiquantitative 4 point scoring scale. Subendocardial or transmural scar were defined as segments with  $<50\%$  or  $>50\%$  enhancement, respectively.

**Results:** A total of 425 segments were analyzed, and at CMR 139(32%) showed LE associated with contractile dysfunction. The overall sensitivity of SPECT to identify dysfunctional segments with LE was 50%, as only 69 of 139 segments with LE showed perfusion defects. Among 70 false negative segments at SPECT, 54(77%) showed subendocardial necrosis at CMR. Of the 97 segments with subendocardial necrosis, only 43(44%) were detected by SPECT, as opposed to 26(62%) of 42 segments with transmural scar.

**Conclusions:** Nitrate SPECT demonstrates suboptimal sensitivity for detecting subendocardial necrosis in patients with IC. Undetected myocardial necrosis may contribute to explain lack of regional functional recovery following revascularization in dysfunctional segments judged viable at SPECT.

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### How many patients scheduled for cardiac SPECT could undergo cardiac CT angiography?

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**Background:** Computed tomographic coronary angiography (CTCA) has been recommended as an alternative to functional testing with SPECT, especially for patients at low/intermediate risk of underlying coronary disease.

**Purpose:** The purpose of this study was to estimate the number of patients currently undergoing cardiac SPECT who may be suitable for CTCA as an alternative.

**Methods:** The waiting list for cardiac SPECT study in a regional cardiac centre was scrutinised by 2 cardiologists to determine which patients might also be suitable for CTCA. In keeping with data showing the excellent negative predictive value of a normal CTCA, patients were deemed suitable if all the following criteria were met: diagnostic study, low/intermediate likelihood of coronary disease, no previous coronary intervention, no known renal disease, presence of sinus rhythm, absence of asthma. Renal function (eGFR) was accessed from the clinical chemistry laboratory database.

**Results:** Of the first 50 patients assessed, 20 (40%) were deemed suitable for CTCA or SPECT, and were referred for CTCA. Of the remaining 30 patients the reasons for non selection for CTCA included request for functional assessment of known stenosis (9 patients), previous coronary intervention (8), lung disease unable to breath hold (4), known arrhythmia (2), high pre-test likelihood (3) and others (5). Some patients had more than factor present. Of the first 8 patients attending for CTCA, 2 were unsuitable due to rapid heart rate ( $> 100$ bpm) poorly controlled after beta blockade (1 patient) and extensive coronary

calcification (1). One patient had an intermediate grade stenosis on CTCA and further assessment was indicated.

**Conclusion:** In this small study around 40% of patients referred for functional testing could be suitable for CTCA using relatively strict criteria. Pre-test knowledge of renal function and heart rate are not routinely collected for cardiac SPECT but need to be available if CTCA is to be considered as an alternative.

## Congestive heart failure

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Withdrawn

### Serial cardiac I-123 metaiodobenzylguanidine scintigraphic studies are more useful for predicting cardiac death than one-time scan in patients with stabilized chronic heart failure

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**Background:** Many studies have shown a one-time I-123 metaiodobenzylguanidine (MIBG) scan during a stable period to be useful for determining the prognosis of patients with chronic heart failure (CHF). However, we recently reported that the delta washout rate (WR) determined from serial I-123 MIBG scintigraphic studies is the best prognostic value in patients with CHF. Accordingly, this study was performed, using previous our data, to determine whether serial I-123 MIBG scintigraphic studies are a more reliable prognostic marker than a one-time scan in CHF patients.

**Methods:** In total of 208 patients with CHF (left ventricular ejection fraction [LVEF] <45%), but no cardiac events for at least 5 months, were identified on the basis of a history of decompensated acute heart failure requiring hospitalization. The patients underwent I-123 MIBG scintigraphy and echocardiography just before leaving the hospital and after 6 months of treatment. We evaluated two models for predicting cardiac death using Cox proportional hazards regression analysis. In addition to clinical characteristics, NYHA functional class and pharmacotherapy, one model included variables of baseline scintigraphic and echocardiographic parameters (model A), and the other model included those of delta (i.e. follow-up minus baseline) scintigraphic and echocardiographic parameters (model B).

**Results:** Of the 208 patients, 56 experienced fatal cardiac events during the study. In model A, a Cox proportional hazards analysis showed baseline WR  $\geq 50\%$  to be the only independent predictor of cardiac death (hazard ratio [HR]=2.335, 95% confidence interval [CI]=1.142-4.774,  $p = 0.020$ ). In model B, delta-WR  $\geq -5\%$  was the only incremental predictor of cardiac death (HR=4.444, 95% CI=1.511-13.069,  $p = 0.009$ ). The survival rates of patients with a delta-WR  $< -5\%$  were significantly higher for those with a baseline WR  $< 50\%$  (93.5% vs. 84.8%,  $p = 0.036$ ).

**Conclusions:** Baseline WR and delta-WR obtained from I-123 MIBG scintigraphy can be used as independent predictors of cardiac death, and two I-123 MIBG scintigraphic studies are more useful than a one-time scan in stabilized patients with CHF.

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### Nuclear cardiology testings in bone marrow cell transplantation for chronic ischemic heart failure. Four-years follow-up

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Emerging evidence suggests that stem cells and progenitor cells derived from bone marrow can be used to improve cardiac function in patients after myocardial infarction. Long-term follow-up of these patients is not sufficiently investigated up to now.

**Purpose:** To evaluate the long-term follow-up of bone marrow stem cell transplantation in a group of patients with prior myocardial infarction and chronic heart failure.

**Methods:** Nine patients (mean age: 56 $\pm$ 8 years) with chronic heart failure and prior myocardial infarction (four anterior, three inferior and two anterior and inferior) were enrolled in this prospective, nonrandomized study. All underwent complete clinical and laboratory evaluations, radionuclide angiography and gated single-photon emission computed tomography perfusion scan with technetium-99m methoxy-isobutyl-isonitrile (protocol dipyridamole - rest). All patients were transplanted with autologous mononuclear bone marrow stem cells, either directly injected into the myocardial wall during surgery or via a balloon catheter placed into the infarct-related artery during percutaneous transluminal coronary angioplasty (PTCA). At three months and at four years of follow-up, nuclear testings were repeated.

**Results:** Sixty-six percent of cases received the transplanted cells in the posteroinferior wall. At three months follow-up there was a significant clinical improvement in 93% of patients (one PTCA patient died before discharge).

Baseline left ventricular ejection fraction was 32 $\pm$ 9%, which significantly improved to 44 $\pm$ 13% at three months after transplantation ( $p = 0.03$ ). At four years was 39 $\pm$ 12% ( $p$  NS vs. baseline). Diastolic function also improved (the peak filling rate increased from 1.20 $\pm$ 11 to 1.96 $\pm$ 45 VTD/sec at three months;  $p = 0.03$ ). At four years was 1.57 $\pm$ 51 VTD/sec. Regarding myocardial perfusion, the summed dipyridamole score significantly decreased from 36 $\pm$ 4 to 16 $\pm$ 2 ( $p = 0.0003$ ); the summed difference score was also significantly reduced from 14 $\pm$ 7 to 3 $\pm$ 5 ( $p = 0.04$ ). This improvement was maintained at four years and was related with the site of the implanted cells (infarction territory) in the 66% of cases. However, the summed rest score did not change significantly (from 22 $\pm$ 8 to 13 $\pm$ 3,  $p = 0.08$ ).

**Conclusion:** Intramyocardial and selective intracoronary transplantation of bone marrow cells is safe and short-term effective in chronic ischemic heart failure.

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### Clinical usefulness of added a dual L/N-type Ca2+ channel blocker, Cilnidipine to Carvedilol for chronic heart failure demonstrated by 123I-MIBG myocardial scintigraphy

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**Backgrounds:** Much attention demonstrated clinical usefulness of Carvedilol for chronic heart failure (CHF) by suppression of sympathetic nerve activities demonstrated by 123I-MIBG scintigraphy to evaluate the kinetics of sympathetic nerve activities such as washout rate. Moreover, Cilnidipine is an antihypertensive drug which blocks not only L-type calcium channels but also N-type calcium channels at the presynaptic terminal.

**Objective:** This study assessed the clinical usefulness of added Cilnidipine to Carvedilol for chronic heart failure by 123I-MIBG myocardial images.

**Methods:** A total of 84 myocardial images of 123I-MIBG were taken at successive intervals on 28 patients with CHF (mean age 62  $\pm$  6 years) before carvedilol, after carvedilol and after added cilnidipine therapy. Each interval was more than at least 6 months and other noninvasive haemodynamic studies (BNP, left ventricular functional parameters) had been worked out. In 123I-MIBG imaging, heart-to-mediastinum activity ratios (H/M) at early and delayed acquisition, and washout rate (WR) were worked out.

**Results:** See table

**Conclusion:** Certainly, this study showed that Carvedilol is clinical useful in treating with chronic heart failure. However, added Cilnidipine to Carvedilol produced more better efficacy than only Carvedilol, probably due to the long-term suppression of the cardiac sympathetic nervous system at the same time. Added Cilnidipine to Carvedilol therapy might be clinical better for chronic heart failure.

	Early H/M	Delay H/M	WR	BNP	EF	LVDd
Before carvedilol	1.95	1.91	53.3	991	32	70
After carvedilol	1.90	1.88	48.8	722	34	67
Added cilnidipine	1.88	1.88	46.6	653	35	67
P value with notes	ns	ns	0.0038	0.0074	ns	ns

P value with notes : after carvedilol vs. added cilnidipine

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### Cardiac death in patients with chronic heart failure: the predictive value of cardiac MIBG scintigraphy compared to renal dysfunction

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**Background:** In patients with chronic heart failure (CHF), sympathetic neuronal dysfunction and renal failure are prognostic markers. However, these variables have never been compared with respect to their predictive value. Therefore, we compared 123I-MIBG assessed myocardial sympathetic activity and renal function as predictors of cardiac death in CHF patients.

**Methods and Results:** Thirty-nine patients with CHF (24 males; Age: 64.4  $\pm$  10.5 [43-83] years; NYHA II/III/IV: 15/19/5; LVEF: 24.0  $\pm$  11.5%) were studied. CHF due to CAD (32/39, 82.1%). During follow-up (60.1  $\pm$  37.2 [1-149.2] months) there were 6 cardiac deaths. Myocardial sympathetic activity was assessed by 123I-MIBG scintigraphy. Semi-quantitative parameters of 123I-MIBG myocardial uptake and washout were calculated: early heart/mediastinum ratio (H/M; 1.61  $\pm$  0.46), late H/M (1.43  $\pm$  0.38) and washout (i.e. [early H/M-late H/M]/early H/M\*100; 10.1  $\pm$  10.4%). Renal function was calculated using Cockcroft-Gault (i.e. estimated creatinine clearance: e-CC) - and the abbreviated MDRD-formula (estimated glomerular filtration rate: e-GFR). Cox proportional hazards regression analysis showed that late H/M was the only, although modest, independent predictor for



0.2,  $p > 0.2$ ) and the global WR (41.3  $\pm$  7.3%, vs. 46.5  $\pm$  8.5%,  $p > 0.1$ ). 4) Between 0M and 6M, no improvement of 123I-BMIPP myocardial uptake was observed in the both groups.

**Conclusion:** These data suggested that 123I-BMIPP myocardial scintigraphy in VSA patients depicted the presence of fatty acid metabolism disorder even in a stable condition. These results might indicate silent myocardial ischaemia due to microcirculatory insufficiency in VSA patients.

## Myocardial viability and hibernation

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### Evaluation of washout rate of Tc-99m sestamibi in addition to its % uptake can more accurate predictor for left ventricular wall motion recovery in patients with one-vessel acute myocardial infarction

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**Background:** Rest Tc-99m sestamibi (MIBI) myocardial perfusion imaging (MPI) can assess left ventricular (LV) wall motion recovery after myocardial infarction (MI). In early images, the %uptake of MIBI in MI territory has been thought to be a powerful predictor for myocardial viability and LV wall motion recovery. Washout of MIBI from myocardium is related with mitochondrial function in normally perfused myocardium. Several previous studies have showed that decreased MIBI uptake and excess MIBI washout show myocardial mitochondrial damage. We investigated the usefulness of evaluation of MIBI washout rate in addition to its %uptake for predicting LV wall motion recovery in patients with acute one-vessel MI after successful percutaneous coronary intervention (PCI).

**Methods:** Rest MIBI MPI was performed 11 days after acute one-vessel MI in 26 patients with successful PCI (mean age=60, mean LV ejection fraction=58%). Images were acquired 30min and 4h after 740MBq of MIBI injection. The %uptake of MI territory was preserved (more than 50%) and considered to be viable in all patients. Difference of MIBI washout between MI territory and non-MI territory and MIBI %uptake of MI territory was calculated. LV wall motion was assessed by left ventriculogram 1 month and 7 months after MI.

**Results:** In patients without LV wall motion recovery, MIBI %uptake in early images of MI territory was lower (58.5% vs. 70.0%,  $p = 0.003$ ) and difference MIBI washout between MI territory and non-MI territory was greater (14% vs. 7.0%,  $p < 0.001$ ) compared with those LV wall motion recovery. As shown in the table, the combination of MIBI %uptake in early images of MI territory and difference of MIBI washout was a better predictor of LV wall motion recovery.

**Conclusion:** Combination of MIBI %uptake in early images of MI territory and difference of MIBI washout could be a better predictor for LV wall motion recovery in patients with acute one-vessel MI after successful PCI.

	odds ratio	p-value
A: MIBI %uptake of MI territory > 65%	3.9	0.049
B: Difference of MIBI washout rate between MI territory and non-MI territory <12%	13.6	<0.001
Both A and B	14.4	<0.001

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### Q-wave regression predicts of myocardial viability after myocardial infarction

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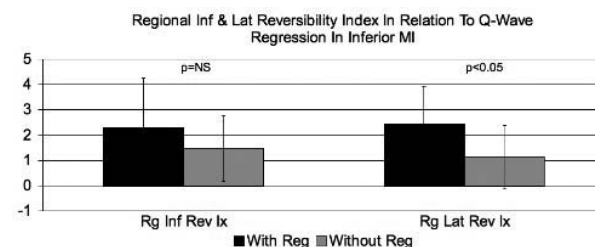
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4 weeks or later after Q-wave myocardial infarction (MI), 186 patients were subjected to scintigraphic studies for evaluation of their myocardial viability. According to regression or persistence of Q-waves, patients were classified into two groups: Group I included 45 patients with Q-wave regression, and group II: included 141 patients with persistent Q-wave.

Each patient was subjected to: history taking, clinical examination, resting ECG, myocardial perfusion study (exercise-reinjection thallium scintigraphy in 138 patients & exercise Sestamibi-resting thallium scintigraphy in 48 patients) as well as resting ERNA study. All patients were followed-up for one year for death, myocardial infarction or revascularization.

The size of scar in group 1 was significantly smaller than that in group 2, but no significant difference was found between the two groups in the amount of ischemic viable myocardium, global EF, and total event rate. The hard event rate tended to be lower in group 1 than in group 2 but without statistical significance. Most of Q-wave regression in anterior MI was partial (87.5%), while most of Q-wave regression in inferior MI was total (85.7%). Q-wave regression might be

an indicator of better myocardial viability after inferior MI. However in anterior MI, it was not found to be a marker of myocardial viability. Furthermore, Q-wave regression was not found to be a predictor for a good prognosis after MI.



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### Assessment of viability after myocardial infarct using Nitroglycerine-enhanced Tc99m Sestamibi-gated SPECT

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**Purpose:** The goal of this study is to determine the effectiveness of Nitroglycerine enhanced Tc99m Sestamibi Gated-SPECT investigation in the detection of viable tissue after myocardial infarct.

**Methods and Materials:** 35 male patients (mean age 53.1  $\pm$  7.69, range 37-69yy) with confirmed myocardial infarction with mean EF was 38.7%  $\pm$  5.8. All of the patients underwent myocardial perfusion studies using Tc-99m Sestamibi Gated SPECT acquisition at rest and after I/V infusion of Nitroglycerine. 21 patients with sufficient myocardium in infarcted area underwent revascularization procedures. Gated-SPECT acquisition was carried out on a single-head large field of view gamma camera.

**Results:** The fixed perfusion defects were found in all cases confirming the diagnosis of previous myocardial infarct. Tracer uptake > 30% in areas of fixed perfusion defects was found in 22 cases (62.9%). In 14 cases (40%) improvement was revealed, and in 3 cases (8.6%) worsening of perfusion after I/V infusion of Nitroglycerine. The improvement of tracer uptake had been developed in 5 cases with severely decreased tracer uptake in infarcted area. In 12 cases from 35 (34.3%) the decreased tracer uptake was found in areas at a distance from the scars, which could be considered as additional damage of myocardium. The improvement of contractility after revascularization was revealed in 16 patients (76.2%). Mean EF rose after surgery from 38.7% to 46.4%. There was a good correlation in the improvement of contractility in patients with increased tracer uptake after Nitroglycerin administration compared to the rest studies. The patients with reduction of tracer uptake after nitroglycerin infusion also revealed the improvement of contractility.

**Conclusion:** Myocardial SPECT perfusion is important tool in assessment of viability in patients after myocardial infarct. Nitroglycerin enhanced images provides with the additional information regarding improvement of contractility and predicting outcomes of revascularisation procedures. Patients with worsening of tracer uptake after Nitroglycerin infusion should also undergo revascularisation procedures.

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### Prevalence of viable and ischemic myocardium in patients with chronic coronary artery disease and left ventricular dysfunction

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**Background:** In patients with coronary artery disease (CAD) and left ventricular (LV) dysfunction, it has been shown that improvement of global LV function after revascularization is related to the extent of viable myocardium. It has also been shown that recovery of regional function is more likely in asynergic regions with reversible (ischemic) compared to mild-moderate irreversible thallium defects. In this study we determined the prevalence of viable and ischemic myocardium in patients with chronic CAD and LV dysfunction.

**Methods and Results:** One hundred-thirty seven patients (mean age = 64  $\pm$  11 years) with chronic CAD and LV dysfunction (mean LVEF = 33  $\pm$  10%) underwent stress-redistribution-reinjection SPECT thallium. The distribution of thallium and the presence of reversible thallium defects were visually assessed in 17 segments per patient. Myocardial viability was considered extensive if it was present in  $\geq 4$  segments (23.5% of LV). Among the 137 patients, 40 (29%) did not show viable myocardium and 97 (71%) showed viable myocardium. Extensive myocardial viability was present in 43 (31%) of the 137 patients. Among the 731 myocardial segments analyzed in the 43 patients with evidence

of extensive myocardial viability, stress-induced perfusion defects developed in 267 (37%) segments of which 117 (44%) where reversible on redistribution-reinjection images and 139 (52%) where mild-moderate irreversible. In these 43 patients, the number of stress-induced reversible thallium defects ranged from 1 to 7 per patient; 26 (61%) of these 43 patients demonstrated  $\geq 4$  segments with reversible perfusion defects.

**Conclusions:** These findings suggest that post-revascularization improvement of global LV function may be expected in 31% of patients with chronic CAD and LV dysfunction. Moreover, the likelihood of functional improvement is expected to be higher in the subset of patients with a greater number of stress-induced reversible perfusion defects (ischaemia).

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### Clinical role of Nitrate-enhanced Tc99m MIBI SPECT Imaging for recovery of viable myocardium

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Tc99m MIBI can underestimate the presence of viable myocardium in reduced perfusion because of MIBI uptake is coronary blood flow rather than tissue viability. This study aimed to assess whether nitrate-enhanced technetium-99m sestamibi SPECT improves the capability of quantitative perfusion analysis to predict recovery of viable myocardium.

The study included 83 patients (62 men, mean age  $60 \pm 5$  years) who prior myocardial infarction, impaired left-ventricular function. Baseline rest-stress Tc99m MIBI SPECT were performed and had persistent defects received sublingual nitroglycerin administration, followed by repeat MIBI SPECT imaging. A single-head gamma camera with high-resolution collimators and a 15% window centered on the 140-keV photopeak of technetium-99m was used. SPECT was performed with 32 projections over a  $180^\circ$  elliptical orbit at 45 s/projection,  $64 \times 64$  matrixes. The studies were reconstructed using filtered back-projection. The reconstructed slices were realigned along the heart axis and short-, horizontal long-, and vertical long-axis views were obtained. For tracer activity quantification, the MIBI SPECT images were summed, obtaining a standard perfusion study. The regional perfusion score (extent score and reversibility score) were assessed rest-stress and rest-nitrate imaging.

Among the 67 patients with persistent defects in the rest-stress images. Following nitroglycerin, Tc99m MIBI uptake was found to be significantly increase in patients with perfusion defects. The left ventricular perfusion measurements are presented in the table below.

Rest Stress SPET Rest-nitrate SPET

ES 194.7 9.5 135.8 5.9

RS 37.2 2.1 67.2 4.3

**Conclusions:** These results suggest that Tc99m MIBI after nitrate-enhanced improves detection of defect reversibility.

## Pacemakers, ICD

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### Do radionuclide angiography derived indices synchrony and entropy identify responders to cardiac resynchronization therapy?

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<sup>1</sup>Nuclear medicine Unit, Viterbo, Italy; <sup>2</sup>Cardiac Intensive Care Unit, Viterbo, Italy;

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**Aim:** To evaluate the predictive value of two novel radionuclide indices, i.e. synchrony (S) and entropy (E) in p undergoing biventricular pacing (BiV).

**Methods:** we studied 16 patients, mean age 70 years, with congestive heart failure (50% CAD) and optimal medical therapy who underwent BiV. Clinical and nuclear data were obtained at baseline and after 8 months of follow-up (FU). Recently Synchrony (S) and Entropy (E), derived from Fourier analysis and from "information theory", have been proposed. Synchrony is evaluated assigning to each pixel i of the LV images a vector  $v_i$  of components ( $v_{icos\theta_i}$ ;  $v_{isin\theta_i}$ ), where  $v_i$  and  $\theta_i$  are amplitude and phase value of the pixel i and calculating the module of the vector sum divided by the sum of the length of all vectors. Entropy is derived from Shannon information theory and expresses the dispersion of LV phase values during the cardiac cycle; it is calculated from the frequency of occurrence  $P_i$  of all phase values  $\theta_i$  along the phase histogram. S and E were calculated with in-house software. Data from patients were compared with those from healthy volunteers.

**Results:** SD, S and E in CHF p were significantly different with respect to normal subjects ( $p < 0.001$ ). Two groups were identified: in group A an improvement in mechanical synchrony was noted, with significantly different values of FE, SD, S and E between baseline and FU, while in group B no significant variations of the RNA parameters were observed. Among the two groups, FU variation of EF, S and E were significantly different ( $p < 0.05$ ), whereas SD variation did not reach statistical significance.

**Conclusions:** p with a worse haemodynamic and dyssynchrony setting showed an improvement in LV mechanics with respect to less ill patients. Improvement in nuclear dyssynchrony was in agreement with EF improvement in group A. We believe that S and E may be useful to identify responders to CRT, whereas ultrasound may be disappointing.

	Group A			Group B		
	BASELINE	FU	p	BASELINE	FU	p
EF(%)	$24 \pm 7$	$38 \pm 14$	0.04	$32 \pm 7$	$31 \pm 10$	0.87
S	$0.887 \pm 0.084$	$0.955 \pm 0.06$	0.02	$0.955 \pm 0.032$	$0.914 \pm 0.062$	0.13
E	$0.633 \pm 0.117$	$0.479 \pm 0.104$	0.008	$0.508 \pm 0.11$	$0.605 \pm 0.124$	0.12
SD(°)	$56 \pm 18$	$26 \pm 14$	0.002	$42 \pm 21$	$48 \pm 21$	0.59

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### Improvement of dyssynchrony assessed by novel program cardioGRAF after Cardiac Resynchronization Therapy can improve remodelling in congestive heart failure patients

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<sup>1</sup>Hukaya Red Cross Hospital, Hukaya, Japan; <sup>2</sup>gunma prefectural cardiovascular center, Maebashi, Japan

**Background:** Left ventricular(LV) dyssynchrony has been reported to play an important role in the advanced stage of congestive heart failure(CHF). It has been already proved by the improvement of CHF with cardiac resynchronization therapy(CRT). However, the usefulness of dyssynchrony estimated by a novel program "cardioGRAF" has not been reported in CHF patients after CRT.

**Purpose and Methods:** To evaluate whether the improvement of dyssynchrony assessed by cardioGRAF after CRT can improve remodelling in 21 CHF patients (DCM/ICM=12/9,M/F=15/6, age $67 \pm 7$ y.o, EF=26.7 $\pm$ 14%, EDV=248 $\pm$ 120ml, ESV=192 $\pm$ 118ml), underwent Tc-99m-MIBI gated SPECT before and 6 months after CRT. Summed defect score(TDS), LVEF, end-diastolic volume (EDV) and end-systolic volume (ESV) and the severity of LV dyssynchrony which was expressed as Standard Deviation (SD) of TES(time to end systole) during 17 segments for all patients were estimated.

**Results:** After CRT, SD improved from  $76 \pm 34$  to  $51 \pm 36$ , EDV from  $248 \pm 120$ ml to  $223 \pm 107$ ml and ESV from  $192 \pm 118$ ml to  $171 \pm 98$ ml, but not in EF(from 26.7 $\pm$ 14% to 26.9 $\pm$ 10.9%) and TDS(from 15.2 $\pm$ 9.7 to 14.6 $\pm$ 10.6). Change in SD between before and 6 months well correlated with in EDV( $r = 0.51, p < 0.05$ ) and ESV( $r = 0.58, p < 0.01$ ) but not in EF( $r = 0.35$ ) and TDS( $r = 0.36$ ).

**Conclusion:** Improvement of dyssynchrony assessed by a novel program "cardioGRAF" after cardiac resynchronization therapy can improve LV remodelling after 6 months in patients with congestive heart failure.

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### MSCT visualization of the heart in patients with cardiac pacemakers - difficulties and solutions

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The presence of implanted cardiac pacemakers (PM) makes it impossible to perform MSCT in some patients. We assessed the hypothesis that the problem might be the ECG of patients with antiarrhythmic devices, and that suitable programming of the PMs might resolve it.

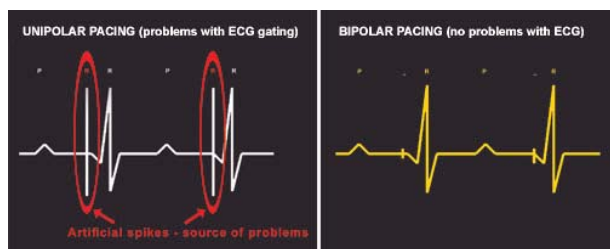
**Purpose:** evaluate what PM program is the best before MSCT.

**Methods:** In 63 pts. (35 men; aged  $67 \pm 14$ ) a 64-slice CT (Aquilion 64, Toshiba) was performed. In 44 pts. (69.8%) 0.5 mm layer was used (ECG gating) and in 19 pts. (30.2%) 2.0 mm (without ECG gating). The current program of the implanted device was checked and in some cases devices were reprogrammed before MSCT.

**Results:** In all 19 pts. with non-ECG gating MSCT, there was no problem with image quality. In 18 (40.9%) with visible spikes in the ECG-gating group, there were difficulties in differentiating the R spike from an artificial spike (when working as unipolar pacing - image below) by MSCT gating software. In 14 (31.9%) after reprogramming, it was possible to obtain good quality images. In 4 (9.0%) it was not possible to reprogram devices (old unipolar leads), but in 2 case (4.5%) ECG gating was corrected manually and good image quality was obtained. An explanation is presented on the figure below. The parameters of device programming which were identified as optimal in 40 pts. (90.9%) were: bipolar pacing (sensing optional: bi or unipolar), R function: off, no threshold

capture function, programmed A-V delay to obtain stable artificial pacing (usually shorter than 200 ms).

**Conclusions:** In conclusion, the ECG gating process was identified as the main cause of the imaging problems. Bipolar lead(s) working as bipolar pacing system seem to be necessary to perform MSCT with ECG gating. A unipolar lead(s) may cause serious problems with reconstructions.



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### Can radionuclide angiography derived indices synchrony and entropy identify responders to cardiac resynchronization therapy

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<sup>1</sup>Nuclear medicine Unit, Viterbo, Italy; <sup>2</sup>Viterbo, Italy; <sup>3</sup>Medical Physics Unit, Viterbo, Italy; <sup>4</sup>Cardiac pacing and Electrophysiology unit, Viterbo, Italy

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**Methods:** We studied 16 patients, mean age 70 years, with congestive heart failure (50% CAD) and optimal medical therapy who underwent BiV. Clinical and nuclear data were obtained at baseline and after 8 months of follow-up (FU). Recently S and E, derived from Fourier analysis and from "information theory", have been proposed. S is evaluated assigning to each pixel  $i$  of the LV images a vector  $v_i$  of components ( $v_{i\cos\theta}$ ;  $v_{i\sin\theta}$ ), where  $v_i$  and  $\theta_i$  are amplitude and phase value of the pixel  $i$  and calculating the module of the vector sum divided by the sum of the length of all vectors. E is derived from Shannon information theory and expresses the dispersion of LV phase values during the cardiac cycle; it is calculated from the frequency of occurrence  $P_i$  of all phase values  $\theta_i$  along the phase histogram. S and E were calculated with in-house software. Data from patients were compared with those from healthy volunteers.

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**Conclusions:** patients with a worse haemodynamic and dyssynchrony setting showed an improvement in LV mechanics with respect to less ill patients. Improvement in nuclear dyssynchrony was in agreement with EF improvement in group A. We believe that S and E may be useful to identify responders to CRT, whereas ultrasound may be disappointing.

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E	0.633 ± 0.117	0.479 ± 0.104	0.008	0.508 ± 0.11	0.605 ± 0.124	0.12
SD(°)	56 ± 18	26 ± 14	0.002	42 ± 21	48 ± 21	0.59

## Coronary revascularisation

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### Impact of myocardial perfusion SPECT on restenosis of the patients treated with sirolimus-eluting stent

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**Background:** Drug-eluting stent have emerged as an effective solution to the problem of restenosis. However, the clinical characteristics of myocardial perfusion stress imaging about restenosis in patients treated with Sirolimus-Eluting stent (SES) are unknown on comparison of new generation bare metal stents (BMS) in real world setting. The aim of this study is to assess

the patients with restenosis after SES implantation using submaximal exercise stress 99m technetium myocardial perfusion imaging (MPS) compared to the patients with restenosis after BMS.

**Methods:** 423 pts who demonstrated angina ( $\geq$ CCSII) without previous myocardial infarction were treated with stenting at our laboratory between Jan. 2006 -Dec. 2007 (21% female, age  $63 \pm 11$ , 38% diabetes). All patients were randomized to SES or BMS (SES: 285 pts, BMS: 138 pts). All patients underwent angiograms within 8-months after stenting. Of these patients, who revealed angiographic restenosis were evaluated with MPS. A 17-segment, 4-point scoring model was used to calculate a summed stress score (SSS), a summed rest score (SRS) and a summed difference score (SDS).

**Results:** After 8 months, the rate of angiographic restenosis was 7.1%. Restenosis rate was significantly lower in pts with SES versus BMS (3.6% vs. 11.8%;  $p \leq 0.05$ ). There were no significant differences in the mean exercise time, double products and ST-depression between two groups in the stress study. On the other hand, the SES group had a significantly larger SDS comparable to the BMS group (SDS:  $10.4 \pm 4.2$  vs.  $6.8 \pm 4.8$ ;  $p \leq 0.05$ ). The rate of asymptomatic (no anginal chest pain) patients in the stress study was 48% : SES; 68% vs. BMS; 39% ( $p \leq 0.05$ ).

**Conclusion:** Compared to BMS, SES proved effective in reducing target vessel ischaemia rates in a real world setting. On the other hand, the patients with restenosis after SES had a larger extent of significant ischaemia than those with restenosis after BMS. Furthermore, asymptomatic restenosis tended to be higher in patients with SES when compared with BMS. Thus, nuclear assessment using stress perfusion imaging may identify the endothelial dysfunction of coronary artery in the restenosis patients treated with SES.

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### Utility of 64-slice MDCT coronary angiography in the strategic evaluation of coronary artery bifurcation lesions interventions

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**Purpose:** bifurcation lesions (BL) remain challenging in the percutaneous intervention of coronary artery disease. The strategy of intervention depends greatly on the coronary lesions morphology and localisation. We sought to elucidate whether 64-slice MDCT coronary angiography prior to the intervention could change the strategy of intervention.

**Method:** we retrospectively recruited thirteen consecutive patients (12 men; mean 64 years  $\pm 7$ ) with recent CT coronary angiography (CTA) and a conventional coronary angiography (CA) describing a BL. Images from the CA were presented as a DICOM format and images from CTA were presented as snapshots of MIP (Maximum Intensity Projection) as well as 3-D reconstruction with semi-transparent background and digital subtraction images of the coronary arteries selected purposely by a trained cardiovascular radiologist. They were then anonymized and each set was presented randomly to two experienced core lab practitioners for consensual classification of BL according to Medina, characterization of lesions in type A, B1, B2 and C as established by the joint ACC/AHA task force and definition of interventional strategy according to the manner in which the first stent should be implanted (MADS: Main, Across, Distal, Side branch). CA and CTA images of each patient were then paired and presented together to evaluate the added value of CTA images in the planification of intervention.

**Results:** of 48 bifurcations with side branch over 2 mm in diameter on CA, 45 could be evaluated by CTA (94%). Thirteen BL were diagnosed from CA and sixteen from CTA. All bifurcation lesions detected on CA were also found on CTA (sensitivity 100%, specificity 90%, positive predictive value 81%, negative predictive value 100%, accuracy 93%). The Medina classification was concordant in 10 lesions over 13 (77%). Of the 13 BL seen on CA, 6 were characterized as type B1, 5 as type B2 and 2 as type C whereas they characterized as type B1 (1), B2 (7) and C (5) by analysis of CTA images sets. 1 lesion was characterized of lower type by CTA and 8 of higher type ( $p: 0.045$ ; 95%CI 0.003-0.93). The interventional strategy was concordant in 11 out of 13 cases (85%). When comparing the interventional strategy established on CA with and without the corresponding CTA set of images, first stent implantation was the same in all 13 cases whether CTA images were given to the intervention practitioner or not.

**Conclusions:** CTA evaluation provided accurate identification of BL and added value on CA for the characterization of lesion morphology but failed change the strategic planification of percutaneous intervention.

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### Stem cell therapy. New therapeutic modality of the treatment patients with coronary heart disease

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**Background:** Coronary heart disease has a strong influence on the life expectancy as well as the quality of life. After the infarction, we can distinguish the ischemic

zone and scar zone in the muscle. There are some previous reports concerning the possibility of the conversion of the injected stem cells to the cardiomyocytes in the border zone of the infarct. The aim of this study was to evaluate the heart viability before the stem cell therapy and the results on the myocardial perfusion of this therapy.

**Material and methods:** 25 patients, 3-7 days after acute MI were included to the study. In all patients GSPECT were performed before (1 to 5 days before therapy) and 3 months after revascularization. Additional in all patients the labeling of implanted cells with HMPAO was performed and the SPECT and the whole body examination were also evaluated.

**Results:** In the impaired segments, improvement in both perfusion and ejection fraction was observed in the 3-month examination. Mean isotope uptake of the implanted stem cells measured, as a percentage of the total activity was  $5.6\% \pm 2.1$ . In 14 patients the greater activity of the implanted cells was observed in the border zone of the infarct. In 8 patients the activity of the stem cells was homogenic in the whole infarct segments, in 3 patients the activity of the isotope uptake was very low ( $<3\%$  of the whole activity of implanted cells).

**Conclusions:** Our preliminary results support the hypothesis that implantation of the stem cells in the revascularized regions of the infarct has of positive influence of the processes of the "healing" of the heart, represented by the improvement of its function. However more studies need to be performed before this strategy can become a clinical reality

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### SPECT MPI in prediction of clinical outcome in patients with ischemic cardiomyopathy treated with CABG surgery

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**Aim:** to determine whether ischemic cardiomyopathy preoperatively, predicts worse clinical outcome in post CABG patients.

**Methods:** 494 pts ( $54.8 \pm 9.2$  y) were comparatively analyzed as ICMP (EF  $\leq 40\%$ ) -93 and non ICMP group (EF  $> 40\%$ ) - 401 pts. Their demographic, clinical, LV functional, perfusional and angiographic preoperative, operative variables, cardiac events during the follow-up period ( $8.4 \pm 4.2$  y.) and time to event were analyzed.

**Results:** No differences were found for age, gender or risk factors. ICMP pts more frequently had HOPD (OR 2.8;p = 0,022), HRF (OR 2.6;p = ns), previous MI (OR 2,6; p = 0,001) and PCI (OR 1,5;p = ns). They were in higher NYHA (1,66 vs. 1,12;p = 0,000), but same CCSC class (2,35 vs. 2,38;p = ns). Mean EF in ICMP group was 29% vs. 56% in non ICMP group (p = 0,000), LVED and LVES dimensions were higher (65 vs. 55;p = 0,000; and 50 vs. 37; p = 0,000), as were LV volumes: 278 vs. 180;p = 0,000 for EDV; 149 vs. 89;p = 0,000 for ESV. WMSSI was higher in ICMP group (1,86 vs. 1,24;p = 0,000) and LV aneurism more frequent (OR 9,2;p = 0,000). Valvular dysfunction was more frequent in ICMP group: OR 4,0;p = 0,000 for MR; OR 2,9;p = 0,009 for TR and OR 10,6;p = 0,000 for AoR. No differences in angiographic, as opposite to significant differences in myocardial perfusion variables were found. ICMP pts had higher SSS (26 vs. 19;p = 0,006) and SRS scores (23 vs. 15;p = 0,002), more hibernated myocardium (15% vs. 6% of MV mass, p = 0,003) and scar (26% vs. 14%;p = 0,000), as opposite, non ICMP pts had more ischaemia (19% vs. 8%;p = 0,000). There were no differences in operative characteristics, only ICMP pts more often underwent co operations: ventricular restoration (OR 8,3;p = 0,000) and valvular reconstruction (OR 2,7;p = 0,022), and had urgent CABG (OR 2,1;p = 0,077). ICMP pts had significantly higher hospital morbidity (OR 5,9;p = 0,026), placement of IABP, arrhythmias, infections and haemodynamic instability (OR 1,4..1,7..1,4..1,6, all p = ns), and mortality (OR 2,7;p = 0,061). Normalisation of EF was registered in 45,3% ICMP pts, while 12% non ICMP pts developed ICMP during the follow-up period (OR 1,94 and OR 0,22;p  $< 0,000$ ). ICMP pts more frequently developed HF (OR 3,4;p = 0,000), had lower incidence of repeat revascularisation (OR 0,5;p = 0,074) but no significant difference in survival (ICMP group OR 1,2; p = ns). Kaplan-Meier curves of event free survival show no significant differences in time to event for heart failure and for cardiac death.

**Conclusion:** ICMP patients carried higher risk for operative morbidity and mortality and heart failure during the follow-up period, but their life expectancy was same as non ICMP patients.

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### Assessment of saved myocardium by primary angioplasty with myocardial perfusion imaging

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Early primary percutaneous coronary revascularization (PCR) is a very effective technique in the treatment of the acute myocardial infarction (AMI), since it allows the recanalization of the affected coronary vessel.

**Objective:** The aim of the study was to evaluate the extension of saved myocardium defined as the difference of perfusion score pre and post PCR.

**Patients and methods:** 33 patients with AMI and ST segment elevation were studied prospectively (7 women, mean-age:  $64.1 \pm 10.4$  years).Two myocardial perfusion SPECT detections were acquired after 99mTc-MIBI injection in all cases: first injection was previous PCR procedure in the Catheterization Lab, and the second rest gated-SPECT study at  $34.69 \pm 36.57$  days after, with the standard acquisition methodology. The initial acquisition was carried out at the exit of the Catheterization Lab in 32 patients ( $82.16 \pm 52$  minutes) and after seven hours of stay in the Coronary Unit in 1 patient. The quantitative automatic valuation of the 17 segments was performed by the software QPS (Cedars). Pre and post PCR(SSS, SRS) score, the difference of the score (SDS) and the percentage of extension (SS%, SR% and SD%) was evaluated. According to the coronaryangiography the dilated arteries were 20 Left Anterior Descending Arteries (LAD), 11 Right Coronary Arteries (RC), 3 Circumflex (CX) and in 1 patient LAD and RC. In 32 patients the revascularization was angiographically effective.

**Results:** In 2 patients there were not significant difference between pre and post SPECT quantification (1 not effective revascularization and 1 with large AMI). In the rest of patients salvaged myocardium is showed. SSS shows the pre-dilatation defect, SRS shows the residual defect (AMI) and SDS shows the saved myocardium.

**Conclusions:** The myocardial perfusion quantification by gated-SPECT allows a precise evaluation of saved myocardium by primary PCR in the treatment of AMI.

N = 31	SSSpre PCR	SRSpost PCR	SDS saved	SS%pre PCR	SR%post PCR	SD% saved
Mean	26.66	10.47	16.19	39.06	15.31	23.75
SD	9.57	9.63	9.43	13.87	14.16	13.51
Min	7	0	0	10	0	0
Max	41	34	36	60	50	47

SD% represents the extension of saved myocardium by PCR.

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### Prediction of ischaemic cardiomyopathy development in CAD patients treated with CABG surgery with Tc99m mibi ECG-GATED SPECT MPI

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**Aim:** to determine prognostic power of preoperative SPECT MPI in prediction of ICMP and HF in CAD patients treated with CABG. Methods:78 pts underwent ECG-GATED SPECT MPI before CABG. Divided in two groups: ICMP - 26, and non ICMP -52 pts.

**Results:** Clinical and angiographic variables show no significant differences, as opposite to MPI variables (Table 1). ICMP pts had higher hospital mortality (OR

Variable	non ICMP pts	ICMP pts	p
SSS	19 $\pm$ 10	26 $\pm$ 8	0,006
SRS	15 $\pm$ 10	23 $\pm$ 9	0,002
SDS	4 $\pm$ 3	3 $\pm$ 3	0,046
ischaemia	19 $\pm$ 13	8 $\pm$ 9	0,000
hybernated myocardium	6 $\pm$ 9	15 $\pm$ 16	0,003
scar	13 $\pm$ 13	26 $\pm$ 11	0,000
EFs	48 $\pm$ 11	33 $\pm$ 7	0,000
EFr	46 $\pm$ 13	27 $\pm$ 7	0,000
delta EF	-1 $\pm$ 5	-5 $\pm$ 2	0,000
EDVs	179 $\pm$ 94	277 $\pm$ 86	0,000
EDVr	180 $\pm$ 90	277 $\pm$ 75	0,000
ESVs	92 $\pm$ 77	160 $\pm$ 65	0,000
ESVr	99 $\pm$ 86	158 $\pm$ 64	0,004

6,8;p=0,034). MPI perfusion parameters: SSS (OR 2,8;p=0,006), SRS (OR 3,3;p=0,002), extent of hibernated myocardium (OR 3,0;p=0,003) and scar (OR 4,0;p=0,000) were positive, and SDS (OR 1,1;p=0,049) and extent of ischaemia (OR 1,1;p=0,049) negative predictors of ICMP. Independent predictors were extent of hibernated myocardium and scar (p=0,009; p=0,006 respectively).

Positive predictors of HF were: SSS (OR 1,1;p=0,049), SRS (OR 1,1;p=0,020), extent of hibernated myocardium (OR 1,1;p=0,004), scar (OR 1,1;p=0,004), end-diastolic volumes at stress and rest (OR 1,0;p=0,007 and OR 1,01;p=0,003), and negative predictors were: extent of ischaemia (OR 0,9;p=0,003) and delta EF (OR 0,9;p=0,034). In multivariate analysis, four independent predictors were identified: extent of ischaemia (p=0,024), EFs (p=0,022); ESVr (p=0,021) and EDVr (p=0,001).

**Conclusion:** MPI variables are powerful predictors of ICMP and HF in post CABG patients.

## Perfusion imaging methods and protocols

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### Clinical use of stress-first SPECT myocardial perfusion imaging studies in an emergency department chest pain unit

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**Purpose:** To determine the prognosis of stress-first SPECT myocardial perfusion imaging (MPI) in an emergency department (ED) chest pain unit. In the setting of normal stress perfusion images, rest imaging appears superfluous. Stress-only imaging saves time by eliminating rest imaging which is important for ED patient throughput. A benign prognosis of stress-only imaging has not been studied in an ED population.

**Methods:** Patients at lower pre-test risk for coronary artery disease (CAD) without known CAD presenting for a Tc-99m SPECT MPI over a 26 month period from the ED after ruling out for myocardial infarction underwent a stress-first protocol (). If the stress images were normal (with or without attenuation correction), rest images were not performed. If they were abnormal, a clinical decision was made to either perform rest images the next day, undergo a coronary angiogram, or recommend medical therapy. All cause mortality was determined using the Social Security Death Index; survival was analyzed using Kaplan-Meier statistics.

**Results:** Out of 1431 patients who underwent stress testing in the ED chest pain unit, 547 patients without known CAD (346 exercise and 201 pharmacologic stress) underwent a stress-first protocol. There were 346 (63%) females and 201 (37%) males with a mean age of  $51 \pm 12$  years and 503 (92%) were low risk, 30 (5%) intermediate risk, and 14 (3%) high-risk patients. There were 515 (94%) normal and 32 (6%) abnormal MPI studies. The average follow-up was  $23.4 \pm 7.7$  months and the one year all-cause mortality was 0.4% in the entire cohort, 0% in the exercise group, and 1% in the pharmacologic cohort. Mortality was 0.4% in patients with normal studies and 0% with abnormal studies, and 0.2% in low risk, 3.3% in intermediate risk, and 0% in the high risk group.

**Conclusions:** A normal stress-only SPECT MPI in the ED chest pain unit population has an excellent one year prognosis with both exercise and pharmacologic stress. The ability to triage patients with chest pain more rapidly in the ED and reduce their radiation exposure represents an attractive alternative in low risk patients.

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### Survey of myocardial perfusion scintigraphy in Germany in 2007: a status report

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**Purpose:** Since 2006 the working group Cardiovascular Nuclear Medicine of the German Society of Nuclear Medicine in cooperation with the working group Nuclear Cardiology of the German Cardiac Society conducts an annual national survey to deliver information about the performance and the development of myocardial perfusion scintigraphy (MPS). Data of the years 2005 and 2006 are available and have been published.

**Methods:** A questionnaire to evaluate MPS for the year 2007 was sent by e-mail or fax. The survey was started in May 2008. By the end of September 339 questionnaires had been returned, 203 from private practices (PP), 106 from hospitals (HO), and 30 from university hospitals (UH).

**Results:** MPS of 106,422 patients were reported. 82% were investigated with 99mTc-perfusion tracers. 77% of the MPS were performed in PP, 14% in HO and 9% in UH. Of the institutions which participated in the 2006 and 2007 query the number of MPS did not change on average (PP +1.9%, HO -5.0%, UH -7.9%) and from 2005 to 2006 the number of MPS increased by 1.3% on average (PP

+3.9%, HO no change, UH -13.0%). The type of stress was pharmacological in 26%. 68% of the pharmacological stress tests were performed with adenosine (of these 24% with adenosine and exercise), 30% with dipyridamole (of these 17% with dipyridamole and exercise), and 2% with dobutamine. Gated SPECT was performed in 47% of all rest- and in 43% of all stress MPS. Gated SPECT of both the rest and the stress MPS occurred in 32%. In 2005 these numbers amounted to 36%, 32%, and 14% respectively. Perfusion scores were permanently applied by 16%, frequently by 12%, rarely by 9% and ignored by 63% of the participating institutions. 19% of the MPS were performed with a 1-head camera. 21% of all institutions reported changes in the use of MPS by competing methods. About 21% of the MPS patients were diabetics. MPS were requested in 47% by ambulatory care cardiologists, in 23% by internists, in 12% by primary care physicians, in 15% by hospital departments and in 3% by others. These numbers did not change in the survey years.

**Conclusions:** There is a small increase of MPS in Germany between 2005 and 2007 but a shift from HO and UH to PP due to structural changes of the health care system, which affects UH considerably. From 2005 to 2007 a growing increase in the use of gated SPECT can be observed. The application of perfusion scores must still be regarded as an exception. To meet the full potential of MPS (1) all studies should be performed as gated SPECT and (2) perfusion scores should routinely be applied to allow risk stratification and therapeutical decision making.

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### Automated quality control for myocardial perfusion SPECT segmentation

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**Background:** The first step in the quantification of the myocardial perfusion and function is the computer segmentation of the left ventricle (LV) from myocardial perfusion SPECT (MPS), which sometimes may be incorrect. We aimed to develop a technique to automatically detect LV segmentation failures for both ungated and gated studies.

**Methods:** We have applied standard Cedars-Sinai segmentation algorithm to segment 300 consecutive clinical Tc-99m sestamibi stress/rest MPS studies consisting of stress/rest scans with and without attenuation correction (AC-S/AC-R, NAC-S/NAC-R) and gated stress/rest images (Gated-S/Gated-R) (1795 scans in total). Our algorithm detects two major types of segmentation failures (incorrect LV shape determination and incorrect valve-plane position). We derive two numerical quality control (QC) parameters, shape QC - SQC and valve-plane QC - VQC, to categorize these respective segmentation failures. The results of the automated algorithm were compared with the manual classifications by an experienced observer (JG) blinded to the QC results.

**Results:** The overall success of the QGS/QPS LV segmentation in 1795 cases was 85%, ranging from 74.7% for AC-S to 92.8% for Gated-S. The observer agreement between failures detected with gray scale and color scale display was 87%. To improve the objectivity of visual evaluation, the cases with intra-observer discrepancies were excluded from the analysis of all datasets and remaining 1565 datasets were considered (96 with incorrect LV shape, 120 with incorrect valve-plane position). For the SQC, receiver operator characteristics area under the curve (ROC-AUC) was 1.0 for all datasets with optimal sensitivity of 100%, specificity of 92% (p < 0.0001). The ROC-AUC was 1.0 in all specific datasets. The algorithm was also able to detect the LV valve-plane position errors: valve-plane overshooting (VPO) with ROC-AUC = 0.91, sensitivity of 100%, specificity = 70% (p < 0.0001) and valve-plane undershooting (VPU) with ROC-AUC = 0.92, sensitivity = 96%, specificity = 73% (p < 0.0001).

**Conclusion:** A new automated method for quality control of LV segmentation for MPS has been developed and shows very high accuracy for the detection of computer algorithm failures in segmentation of the LV. This technique may lead to more automated and objective analysis of MPS.

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### Ranolazine improves myocardial perfusion in patients with coronary artery disease

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**Purpose:** Myocardial ischaemia enhances late sodium current (INa, L), which then causes cellular calcium overload leading to increased diastolic tension and a decrease in myocardial blood flow. Ranolazine (RAN) is a novel anti-anginal medication which has been shown to inhibit INa, L. This study examined the hypothesis that RAN could improve myocardial perfusion.

**Methods:** A total of 21 patients (67% men, mean age  $65 \pm 9$  yrs) with CAD on optimal medical therapy who had ischaemia on stress/rest gated SPECT myocardial perfusion imaging (MPI) were recruited in this study. A follow-up MPI

was performed after 4 weeks of additional RAN therapy (1 g PO BID) in an open-labeled study. The images were subjected to automated quantification using polar maps and 17-segment model to determine the total perfusion defect size (PDS), ischemic PDS (expressed as % of left ventricle) and severity of total and ischemic PDS, summed stress score (SSS), summed difference score (SDS) and summed rest score (SRS).

**Results:** Treadmill exercise was performed in 18 patients and 3 patients underwent vasodilator stress. 1 patient had a normal vasodilator baseline study by automated quantification and was excluded from the analysis. Overall, angina improved in 16 patients (80%) and among those who underwent treadmill exercise, the exercise time increased ( $432 \pm 108$  vs.  $398 \pm 121$  seconds,  $P = 0.02$ ) after RAN. QT intervals and left ventricular ejection fraction did not change after RAN therapy. Overall, SDS decreased ( $4.7 \pm 4$  vs.  $7.2 \pm 5$ ,  $P = 0.006$ ) in the whole cohort and a qualitative visual improvement was noted in 13 patients (65%) after RAN (Table, mean  $\pm$  std deviation amongst the 13 responders).

**Conclusions:** This is the first study in humans to demonstrate the anti-ischemic effect of RAN by markedly reducing stress induced ischaemia after short-term RAN therapy using entirely automated quantification of perfusion defect extent and severity in patients with CAD. This improvement was associated with a decrease in angina and supports the novel mechanism of action.

MPI variables	Baseline	After RAN	P value
SSS	$13 \pm 9$	$8.8 \pm 8$	0.0001
SDS	$7.8 \pm 5$	$3.5 \pm 3$	0.0001
Total PDS	$24 \pm 16$	$17 \pm 15$	0.003
ischaemia PDS	$16 \pm 11$	$8 \pm 5$	0.005

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### Feasibility and diagnostic accuracy of gated early imaging protocol using Tc99m tetrofosmin in diagnostically challenging patients

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**Purpose:** The aim of this study was to investigate whether early (T1) myocardial tetrofosmin imaging is as feasible and accurate as standard (T2) imaging in detecting CAD in a challenging patient population, in which obese, female and multivessel CAD patients are substantially represented.

**Methods:** 40 patients (24 men and 16 women), with mean age  $63 \pm 8.9$  years, mean BMI  $30 \pm 5.8$  kg/m<sup>2</sup> and known or suspected CAD underwent tetrofosmin gated SPECT stress/rest imaging. 26 patients underwent a stress test according to Bruce protocol and 14 patients had adenosine induced stress. Stress/rest T1 imaging was performed at 15 min and T2 imaging at 45 min after injection. Image quality was visually evaluated using a 4-point scale. Heart (H), lung (L), liver (Liv) and subdiaphragmatic (Sub) counts and the derived ratios were measured. Myocardial perfusion analysis was performed on a 20-segment semiquantitative model and reversible ischaemia was scored as a summed difference score (SDS). Coronary angiography was performed within 40 days on all patients. 12 patients had 1 vessel disease, 17 2 vessel disease, 6 3 vessel disease and 5 patients had no significant CAD.

**Results:** Overall, quality was scored as optimal or good for 95% of T1 images and 97.5% of T2 images ( $P = NS$ ). Count ratios had no statistically significant differences for stress and rest T1 and T2 imaging. Mean SDS were similar for T1 and T2 imaging ( $4.28 \pm 5.05$  and  $4.85 \pm 4.18$  respectively,  $p = 0.457$ ). A good linear relationship was observed between T1 and T2 SDS ( $r = 0.9326$ ,  $p = 0.0022$ ). Mean post-stress ejection fractions (EFs) were similar in T1 and T2 imaging ( $56 \pm 10.27$  vs.  $57.4 \pm 10.97$ ,  $p = 0.39$ ) as were mean EFs at rest ( $60.2 \pm 10.47$  vs.  $60.6 \pm 11.86$ ,  $p = 0.8$ ). Linear regression analysis showed a good correlation between T1 and T2 for both post-stress and rest EFs.

**Conclusion:** T1 imaging is feasible and as accurate as T2 imaging in identifying coronary artery disease in a wide variety of CAD patients.

	STRESS		p	REST		p
	T1	T2		T1	T2	
H/Lratio	$2.23 \pm 0.24$	$2.29 \pm 0.31$	0.18	$2.27 \pm 0.30$	$2.33 \pm 0.30$	0.065
H/Liv ratio	$0.63 \pm 0.33$	$0.64 \pm 0.3$	0.9	$0.47 \pm 0.10$	$0.39 \pm 0.11$	0.058
H/Sub ratio	$1.27 \pm 0.57$	$1.20 \pm 0.52$	0.36	$1.09 \pm 0.59$	$1.13 \pm 0.34$	0.72

H/L, H/Liv and H/Sub ratios had no statistically significant differences in stress-rest T1 and T2 imaging ( $p > 0.05$  for all ratios)

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### Diaphragmatic attenuation artifact on SPECT myocardial perfusion imaging: comparing the results of three modalities

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**Purpose:** Diaphragmatic attenuation may cause inferior wall defect on SPECT MPI leading to decreased test specificity. Several techniques have been suggested for recognizing the artifact; CT attenuation correction seems to be the most promising technique.

The aim of our study was to correlate the results of three different modalities in detecting the artifact.

**Methods:** Sixty consecutive male patients (29 with IHD and 31 without IHD) were evaluated with Dual-isotope SPECT and transmission study using a low voltage CT. Each patient also underwent stress prone SPECT and left lateral planar image in supine position (LL) and right lateral decubitus (RLD). When inferior wall defect due to diaphragmatic attenuation was detected, resolution of the artifact was correlated visually and Semi-quantitatively on attenuation corrected images (AC) and on prone SPECT and visually on RLD static image in each patient. Patients were followed up for a median of 33 months.

**Results:** Inferior wall defect due to diaphragmatic attenuation was identified in 22/60 patients (36%). AC images showed normal inferior wall uptake in 19 patients and partially improved uptake in 3 patients. RLD static image showed normal uptake in 21 and fixed defect in one patient, while prone SPECT showed normal inferior wall uptake in 7 patients, partial uptake in 3 and a fixed defect in 12 patients. Upon comparison of changes in inferior wall uptake on RLD and AC images, we found similar changes in 18 patients: on RLD, improvement of inferior wall uptake was more evident in 3 patients and less evident in one. Both methods showed better results than prone SPECT.

Follow-up of 15 patients was unremarkable with no cardiac complications documented. Three patients underwent coronary angiography that showed patent right coronary artery and three other patients had unchanged finding on repeated SPECT at two years. One case of non cardiac death was reported.

**Conclusion:** Our study showed an excellent correlation between RLD image and CT attenuation corrected images in identifying diaphragmatic attenuation artifact and both methods were more accurate than prone SPECT. RLD image is simple, time saving, readily available and needs no additional software or hardware.

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### Low radiation SPECT / CTA cardiac fusion imaging from stand-alone devices

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Hybrid software combining functional information obtained by SPECT myocardial perfusion imaging (MPI) and morphological information of coronary CT angiography (CTA) offers an alternative to high cost hybrid devices. However increased radiation exposure from both techniques is a major constrain. The aim of our study is to validate this novel software by using low dose CTA and fast protocol SPECT obtained from stand-alone devices and determine quality of images, diagnostic information, applied effective radiation dose and the total workload.

**Methods:** A one-day fast-track stress(300MBq)/rest (600) SPECT with 99mTc-tetrofosmin and a contrast-enhanced 64-slice CTA with prospective ECG-gating was performed in 20 consecutive patients with known or suspected CAD. 3D volume-rendered fused SPECT-CTA images were generated and its findings were compared to the findings from the separate analysis.

**Results:** Three out of 20 pts were excluded due to suboptimal CTA study, i.e. unstable HR, heavily calcified vessel, respiratory movements and 1/10 due to technically suboptimal SPECT study. The remaining 16 pts (10men; 2 woman mean age  $55.2 \pm 14$  yrs ;age range 41-72 yrs) had fusion images of a quality suitable for qualitative clinical interpretation. 3D fused SPECT/CT images showed a match of coronary anatomy and myocardial perfusion in 12 pts (75%) and discordant data in 4 of them (25%). In six pts (37%) with known CAD, CTA revealed an open stent, an occluded bypass(two pts) and several lesions in whom the culprit lesions were identified with hybrid fusion imaging. CTA revealed unknown CAD in 3 pts (35%) and MPI in another 3 (35%), who subsequently underwent fusion to determine the clinical significance of the findings. In 4 pts (25%), CAD was ruled out when an equivocal SPECT was fused to a negative CTA. Fusion took less than 15 minutes and interobserver variability was excellent. Mean effective radiation dose was 3.5 - 6 mSv (mean dose 5.5 mSv) and  $6 \pm 0.2$  mSv for CTA(including calcium scoring) and SPECT respectively, favouring low heart rate  $62 \pm 3$  bpm and body mass index ( $29 \pm 4$ ).

**Conclusion:** Hybrid software is an attractive alternative to hybrid hardware offering reliable matching of perfusion and anatomy, Protocols of low radiation dose and fast acquisition can improve both patient's safety and compliance in SPECT/CTA fusion imaging.

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### Positive predictive value of stress-first SPECT myocardial perfusion imaging

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**Purpose:** To determine the positive predictive value of stress-first SPECT myocardial perfusion imaging (MPI) to detect obstructive coronary artery disease (CAD). In the setting of normal stress perfusion images, rest imaging appears superfluous. Stress-only imaging saves time and reduces radiation exposure by eliminating rest imaging. The accuracy of abnormal stress-only MPI has not been studied.

**Methods:** Patients at lower pre-test risk for CAD presenting with symptoms suggestive of CAD for a Tc-99m SPECT MPI over a 53 month period between January, 2004 and June, 2008 underwent a stress-first protocol (). In those with abnormal stress images, a clinical decision was made to either perform subsequent rest images or not. Patients with abnormal MPI who underwent coronary angiography within 6 months of the MPI were analyzed for correlation between the MPI and the angiogram. Obstructive CAD was considered epicardial stenosis of >50%.

**Results:** Out of 10,609 patients who underwent stress MPI, 2,701 patients underwent a stress-first protocol. A total of 367 stress-first patients without known CAD had abnormal MPI studies. The average age was  $59 \pm 15$  years, 187 (51%) were females, and 266 (72%) were low pre-test risk for CAD, 70 (19%) were intermediate risk, and 31 (8%) were high risk. 174 (47%) had stress-only studies and 193 (53%) had stress imaging followed by rest imaging. Of the 367 abnormal studies, 134 had subsequent coronary angiography which found obstructive CAD in 67 (positive predictive value of 50%). Of 64 stress-only studies, 34 had obstructive CAD (positive predictive value of 53%), compared to the 70 stress-rest studies with 33 of them having obstructive CAD (positive predictive value of 47%) ( $p = 0.27$  for comparison).

**Conclusions:** In patients with a lower pre-test risk for coronary disease, subsequent rest imaging does not increase the positive predictive value of abnormal stress-first MPI. Appropriate clinical management decisions can be based on stress-first imaging alone.

Positive predictive value of MPI

	All Stress First N=134	Stress-Only N=64	Stress-Rest N=70
Obstructive CAD	67	34	33
Non-Obstructive CAD	67	30	37
Positive Predictive Value	50%	53%	47%

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### The effect of CT attenuation correction on infarct size determination of inferior infarcts

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**Purpose:** Attenuation correction (ATC) has been shown to improve the accuracy of single photon emission computed tomography (SPECT) for the detection and evaluation of patients with coronary artery disease. The purpose of this study was to evaluate the value of ATC for the assessment of infarct size in CAD patients after inferior myocardial infarction (MI).

**Materials & Methods:** gated-SPECT with Tc labelled compounds with ATC by hybrid SPECT/CT was performed in 59 patients (53 M, 6 F) with documented previous inferior MIs. Both corrected and uncorrected SPECT images were reconstructed after motion correction, scatter correction by OSEM iterative reconstruction. When needed a manual realignment between SPECT and CT sections, was performed. Uncorrected and corrected SPECT images were analyzed for regional perfusion using a 5-point segmental scoring scale from 0 (normal) to 4 (absent). Summed Stress Score (SSS), Summed Rest Score (SRS) and Summed Difference Score (SDS) of the inferior LV wall (inferoseptal, inferior, infero-apical and infero-lateral segments) were determined and compared with the regional wall motion score as determined by uncorrected gated-SPECT.

**Results:** The inferior wall SSS, SRS, SDS for ATN uncorrected and correct studies were  $14.02 \pm 7.9$ ,  $6.5 \pm 7$ ,  $4.5 \pm 3.2$  and  $9.4 \pm 7.1$ ,  $5.6 \pm 6.1$ ,  $3.8 \pm 2.8$ , respectively. Differences were statistically significant ( $p < 0.0001$ ) for SSS and SRS but not for SDS. The ATN corrected infarct size (SRS) showed a better correlation with the regional wall motion score  $R = 0.71$  in comparison to uncorrected SRS,  $R = 0.68$ .

**Conclusions:** The combination of diaphragmatic attenuation and inferior MI determines an artifactual overestimation of infarct size of inferior infarcts. ATN corrected infarct size (SRS) better correlates with regional wall motion score of

the inferior wall in comparison to uncorrected SRS. ATC does not affect detection and size of residual peri-infarctional ischaemia (SDS).

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### Comparison of 180 and 360 degrees acquisition protocols in myocardial perfusion SPECT with opposed dual head camera

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**Purpose:** Aim of this study was to investigate how the different acquisition protocols, 180° or 360°, influence the tomographic images of myocardial perfusion in males and females.

**Methods:** 50 patients (30 males, 20 females, mean age  $52.5 \pm 10$  years old) underwent stress/rest myocardial perfusion SPECT on an opposed dual head  $\gamma$ -camera, and tomographic images were obtained by separate reconstructions of the 360° and 180° projection data. The reconstructed images were put into 'blind' evaluation by two nuclear medicine physicians. The myocardium was divided in 20 segments and each segment was evaluated on a scale from 0 to 3 (0: normal perfusion, 1-2-3: mild, moderate, severe reduction of radiopharmaceutical uptake respectively). In addition, a total evaluation score for each examination (stress-rest, 360°-180°) was derived by summing the values for all 20 segments. The total evaluation scores as well as the segments that corresponded to either 360° or 180° studies were then statistically compared by paired t-Tests.

**Results:** The total evaluation scores (stress and rest) showed that the 180° acquisition protocol performed statistically significant ( $p < 0.001$ ) higher values than the 360° acquisition protocol (total scores = 478.5 and 322 respectively). The 180° stress and rest studies showed higher evaluation scores (289 and 189.5,  $p < 0.005$ ) than the 360° stress and rest studies (208 and 114,  $p < 0.005$ ). The comparison between the myocardial segments indicated statistically significant differences in the inferior wall, the inferior lateral wall and the posterior wall both for stress and rest acquisitions ( $p < 0.005$ ). There were no significant differences between the results of females and males examinations. However, the 180° acquisition protocol in females examinations performed higher score concerning the anterior wall (58.5 and 22 for 180° and 360° acquisition protocols respectively,  $p < 0.05$ ).

**Conclusions:** The results of this study showed that, in myocardial perfusion SPECT with an opposed dual head  $\gamma$ -camera, 360° acquisition protocol leads to better tomographic image quality in comparison to 180° acquisition protocol in stress and rest examinations for both males and females. Regarding this the 180° acquisition protocol should be avoided. Specifically, poorer image quality with 180° acquisition protocol was observed in the inferior, inferior lateral and posterior wall of the left ventricle and, additionally, for females, in the anterior wall.

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### Characteristics of normal myocardial SPECT database created by Japanese multiple nuclear medicine centers

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**Purpose:** Appropriate normal databases are essential for the diagnosis of coronary artery disease using quantitative software. However, common databases authorized by the scientific committee have not been created. The aim of this study was to generate normal myocardial single-photon emission computed tomography (SPECT) databases in a Japanese population applicable to any types of computer software packages.

**Methods:** A total of 326 sets of exercise-rest myocardial perfusion images were accumulated from subjects with a low-likelihood of cardiac diseases with collaboration of nine hospitals. The normal myocardial perfusion database included a Tc-99m MIBI/tetrofosmin myocardial perfusion study with 360-degree and 180-degree rotations. The database for TI-201 was also created with 360-degree and 180-degree rotations. The projection images were transferred by a DICOM format from various SPECT systems with the collaboration of major software vendors and radiopharmaceutical companies. The SPECT images were reconstructed and analyzed in the core laboratory using the same processing conditions. The characteristics of the non-gated and gated SPECT databases were analyzed by QPS and QGS software.

**Results:** When the average values were analyzed using a 17-segment model, myocardial counts in the septal segment differed significantly between 180-degree and 360-degree rotation acquisitions. Regional differences were observed between males and females in the inferior and anterior regions. A tracer difference between Tc-99m and TI-201 was also observed in some segments. Normal ranges of ejection fraction and volumes differed significantly between genders. Systolic wall thickening (%) was generally higher in females than in males irrespective of the use of tracers, rotation angles or frame rates,

and the difference was highly significant in the mid and apical regions. Different rotation angles showed no difference in wall thickening, but different frame rates and tracers showed significant difference in both genders. The database showed different characteristics when compared with an American database from Cedars Sinai Medical centre (GB).

**Conclusion:** We developed normal databases by the two-year working group activity. The database could be transferred into any software commonly available for quantitative SPECT analysis. The database created in Japan and US showed significant difference. Appropriate databases may enhance the diagnostic ability for coronary artery disease and may be used for multi-center studies.

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### Multiple post-stress imaging more accurate than rest-stress imaging in detecting ischaemia

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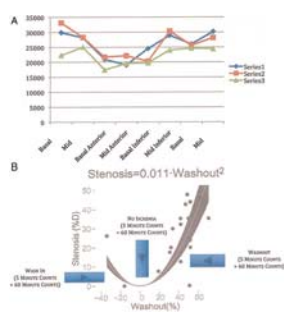
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**Background:** Blumgart first described Nuclear Cardiac imaging in 1926 using continuous data collection. Crane demonstrated in 1993 that sestamibi uptake by myocytes was determined by mitochondrial calcium, which is dependent upon the level of ischaemia. More than 25 studies have shown that using washout data at 5 and 60 minutes post stress can be used to find heart disease missed when only the 60-minute study is obtained. Our initial investigations presented at the C-care conference in 2008 demonstrated that quantification of regions of interest (ROIs) at 5 and 60 minutes can unmask hidden heart disease.

**Methods:** We studied 120 men and women with chest pain using the standard rest-stress imaging approach and compared their results with images obtained at 5 and 60-minutes post-stress. The images obtained at 5 and 60 minutes had ROIs analyzed to determine radioactive counts, including total heart and lung, basal and mid anterior, anterolateral, inferior and inferoseptal regions. Washout results were determined for total heart and each of 8 vascular regions from the ROIs. These results were compared with coronary angiography.

**Results:** When compared with the results obtained with cardiac catheterization, the results of conventional rest-stress imaging yielded sensitivity and specificity of coronary artery disease of 75 and 90%. Washout data was calculated using ROIs as shown in Figure 1 where series 1,2 and 3 were obtained at 5, 10 and 60-minutes. Washout data correlated with coronary arteriography as shown graphically in Figure 2. In the 15% of individuals with washin, the conventional approach showed "normal" results at 60 minutes. Those individuals with washin required intervention in the catheterization laboratory.

**Conclusion:** Regression of stenosis upon washout yielded an effect size of  $R(CI95\%) = 0.72$  to 0.95. Washout can be used to accurately predict the result of coronary artery stenosis. Individuals with washin demonstrated critically narrowed arteries and vulnerable plaques requiring urgent intervention; but, were missed using conventional imaging. Multiple imaging at 5 and 60-minutes post-stress provides more accurate detection of ischaemia and identifies vulnerable plaques.



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### Usefulness of 99mTc-sestamibi muscle scans to assess perfusion reserve in the lower limbs of patients with rheumatoid arthritis

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**Introduction:** A relationship between inflammatory Rheumatologic Disease (RD) and atherosclerotic occlusive disease had been highlighted in various studies by the finding that the latter progression may be accelerated in patients with RD. 99mTc-Sestamibi is a myocardial perfusion imaging agent that has been suggested to be used for the investigation of Peripheral vascular disease (PVD) of lower limbs muscles. The objective of this study is to detect the presence of

asymptomatic hypoperfusion (sub clinical PVD) in RA patients by measuring the perfusion reserve of lower limbs of those patients using 99mTc-Sestamibi.

**Methods:** This study included 25 female patients with RA and no clinical symptoms of chronic ischaemia of lower limbs (age  $39.3 \pm 9.5$  years). Of the 25 patients with RA, 13 patients were receiving corticosteroids. In addition, 25 healthy, age matched, female subjects were studied to served as a control group. Database included full history taking, clinical examination, relevant laboratory tests and lower limbs 99mTc-Sestamibi perfusion scan. Right lower limb exercise was performed for each subject by alternating active dorsi and plantar flexion of the right foot for at least 40 times or till fatigue. Five mCi of 99mTc-Sestamibi was injected intravenously at least 10 seconds prior to exercise termination. Posterior image of both calves was obtained ten minutes post injection, using gamma camera. Two equal rectangular regions of interest were placed symmetrically over both calves. The percentage of increase in the total count (Ct) in the exercising right calf, termed perfusion reserve was calculated as: perfusion reserve (%) = (exercising calf Ct - resting calf Ct) ÷ (resting calf Ct) × 100%.

**Results:** The mean perfusion reserves of RA patients was significantly lower than that of the control group ( $30.7 \pm 22.6$  and  $48.3 \pm 27.2$  respectively,  $P = 0.015$ ). Moreover, using the ANOVA test, Significant difference was found between the mean perfusion reserves of patients receiving corticosteroids ( $24.8 \pm 20.8$ ), those not receiving corticosteroids ( $36.6 \pm 23.6$ ) and the control group ( $P = 0.026$ ). A significant negative correlation between the perfusion reserve and the duration of the disease was observed ( $r = -0.37$ ,  $P = 0.024$ ).

**Conclusion:** In conclusion, 99mTc-Sestamibi lower limb muscle scan through assessment of perfusion reserve is a useful method in detection of asymptomatic hypoperfusion in the lower limbs of RA patients. By identifying at risk patients for premature atherosclerosis and PVD, early prophylactic measures could be targeted to such patients through risk factors and therapy modifications.

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### What is the influence of left bundle branch block on assessing functional parameters of Gated-SPECT?

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**Purpose:** Perfusion defects are often found in myocardial perfusion scintigraphy (gated-SPECT) in the presence of left bundle-branch block (LBBB). However, data about the diagnostic role of quantitative assessment by gated-SPECT in LBBB is scarce. We aimed to investigate the influence of LBBB on gated-SPECT and its correlation with coronary artery disease (CAD).

**Methods:** We analyzed 46 patients with LBBB, 29 (63%) women, mean  $63.8 \pm 11.6$  years, twenty-one (GI) with CAD and  $>70\%$  luminal narrowing in at least one vessel, and 25 (GII) with normal coronary arteries. All underwent gated-SPECT with 99mTc-Sestamibi with dipyridamole (DIP) and treadmill exercise test (ET). Left ventricle ejection fraction (LVEF), myocardial wall motion (WM) and myocardial thickening (MT) in the anterior, septal, inferior, lateral and apical areas of the left ventricle were automatically obtained through QGS software. These parameters were compared with those obtained from a group of 150 healthy individuals without LBBB (GIII), mean  $43.7 \pm 12.2$  years, only at rest. WM  $> 5\text{mm}$  and MT  $> 30\%$  were considered normal values.

**Results:** WM and MT of the anterior, septal and inferior areas did not discriminate between GI and GII, for both tests ( $p > 0.05$ ). Differences of MT were significant only in the lateral area ( $31.6 \pm 12.9\%$ ,  $28.3 \pm 12.2\%$ , and  $33 \pm 13.7\%$  vs  $35.1 \pm 9.2\%$ ,  $35.9 \pm 10.1\%$ , and  $36.6 \pm 10.4\%$ ,  $p = 0.01$ ), and of WM only in the apical area ( $3.6 \pm 2.6\text{mm}$ ,  $3.1 \pm 2.5\text{mm}$ , and  $4.2 \pm 2.3\text{mm}$  vs  $4.8 \pm 1.8\text{mm}$ ,  $4.7 \pm 1.8\text{mm}$ , and  $5.2 \pm 2.1\text{mm}$ ,  $p = 0.04$ ), respectively at rest, ET and DIP. In ET and under DIP, LVEF at rest did not discriminate between GI and GII ( $46 \pm 16\%$ ,  $42 \pm 16\%$ , and  $47 \pm 18\%$  vs  $49 \pm 12\%$ ,  $48 \pm 13\%$ , and  $52 \pm 13\%$ ;  $p = 0.28$ , respectively), although it was considerably decreased after ET ( $p = 0.0003$ ). Compared with GIII at rest, significant differences of LVEF were found in WM in all areas, and in MT in all but the lateral area, being the values of GI and GII significantly lower than those of GIII ( $p \leq 0.004$ ).

**Conclusion:** By gated-SPECT, quantitative assessment showed a detrimental influence of LBBB over the ventricular dynamics, that does not depend either of the presence of DAC or the kind of stress utilized.

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### Association between ST-segment changes during pharmacological stress test with dipyridamole and ischaemia on myocardial perfusion scintigraphy

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**Background:** The use of myocardial perfusion scintigraphy (MPS) to detect ischaemia is already established on daily clinical practice. As important as it use

has been the comprehension of the significance of ST-segment changes on ECG during pharmacological stress test with dipyridamole (Dipy). Objectives: The main objective is to verify the association between ST-segment changes during Dipy infusion and the presence and amount of ischaemia on MPS. Secondary objectives includes evaluate which magnitude of ST-segment depression is associated with ischaemia and also to assess the impact of beta-blockers use on these findings.

**Methods:** It was selected 600 patients (p) who performed Dipy MPS between 06 and 09/2008. From those it was included 213 p (no use of digitalis, no left bundle branch block, no atrial fibrillation, no atrial flutter and no artificial pacemaker). Clinical data was collected from medical records. The Dipy MPS were performed by standard protocol and it was considered changes on the ECG if presence of at least 1,0mm of ST-segment depression during/after Dipy infusion in relation to the basal. The MPS images were obtained by 2-day standard protocol, gated-SPECT technique and with sestamibi-Tc-99m. Qualitative and semi-quantitative analysis using Summed Difference Score (SDS) were considered to evaluate presence and magnitude of ischaemia on MPS. Statistical analysis were performed by Pearson's qui-square, Mann-Whitney and Spearman non-parametric test, Kruskal-Wallis' test and Logistical regression analysis. It was considered statistically significant p value  $\leq 0.05$ .

**Results:** From the total, 29% p presented ST-segment changes during Dipy and 43,7% presented MPS suggestive of ischaemia. Forty-four percent presented suggestive of ischaemia MPS and also ST-segment depression while 12,2% presented both tests suggestive of ischaemia with a statistical significant association ( $p=0,007$ ). A greater amount of ischaemia was associated to a greater ST-segment depression ( $p=0,002$ ). The ST-segment depression magnitude during Dipy associated with greater accuracy to detect ischaemia on MPS was 0.25mm, with 85% specificity and 36% sensitivity. Although the use of beta-blockers decrease ST-segment changes ( $p=0,017$ ) it does not decrease the detection of ischaemia on MPS.

**Conclusion:** The obtained results may suggest that in the studied group the presence of depression in the ST-segment during Dipy infusion  $\geq 0.25$ mm is associated with ischaemia on MPS. The greater ST-segment depression values were associated with greater amount of ischaemia on MPS. The use of beta-blockers did not change the detection of ischaemia.

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### Myocardial perfusion scintigraphy associated with dobutamine stress. Comparison between maximal and submaximal tests

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**Purpose:** Dobutamine is used as an alternative to exercise in conjunction with SPECT perfusion imaging for detection of coronary artery disease (CAD). Conventionally, the dobutamine stress should be interrupted when 85% of maximal heart rate is achieved. The goal of this study is to compare the efficacy and side effects of dobutamine stress with maximal (M) or submaximal (SM) protocol.

**Methods:** We analyzed 56 pts with known or suspected CAD, 71% female, mean  $66 \pm 11$  years. All underwent technetium-99m-Sestamibi Gated-SPECT associated with dobutamine stress protocol. After rest imaging, dobutamine stress was infused intravenously in an incremental fashion of  $10 \mu\text{g/kg/min}$  during 3 min, until a maximum dosage of  $40 \mu\text{g/kg/min}$  or SM heart rate was achieved. Pts who signed the informed consent were incentivated to try to achieve M heart rate. When necessary, atropine was used to a maximal dosage of 2 mg. All pts were monitored during the stress. Electrocardiogram and blood pressure were recorded in the end of each stage and at the 2nd, 5th and 10th min after the stress. Qualitative analysis was performed in 17 segments using a 5-point scoring system (0-normal; 4-absence) for perfusion and 6-point scoring system (0-normal; 5-dyskinesis) for wall motion. Parameters analyzed: symptoms, arrhythmias and ST-segment depression.

**Results:** See table below. The main symptoms were palpitation and atypical angina. Only two pts, one with SM and another with M protocol, had non sustained ventricular tachycardia during the test. Of the six pts with ST-segment depression, five had fixed or transient defects by the Gated-SPECT.

**Conclusion:** Dobutamine stress test interrupted at M heart rate showed more ST-segment depression than at SM heart rate, without increasing the incidence of side effects. The M protocol with dobutamine was safe and effective.

Abstract 76 table

Heart rate(n)	Asymptomatic	Supraventricular arrhythmia	Ventricular arrhythmia	Supraventricular and Ventricular arrhythmia	ST-segment Depression
<85%(14)	2(14%)	4(29%)	5(36%)	1(7%)	0
SM(25)	8(32%)	4(16%)	6(24%)	4(16%)	1(4%)*
M(17)	5(30%)	2(12%)	6(35%)	6(35%)	5(30%)*

\*p = 0.015; SM = submaximal; M = maximal

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### Non clinical reporting of normal myocardial perfusion scans

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**Purpose of study:** The number of myocardial perfusion scans performed in Leeds has recently increased from 2840 patients per year in 2006 to an estimated 4000 in 2008. There has been increased demand to comply with NICE guidelines and government directives to reduce waiting times. There has been no parallel increase in consultant time causing considerable pressure on the reporting system. Reporting in Leeds is by consensus report jointly with either a cardiologist or radiologist and a clinical scientist (CS). We hypothesised that we could reduce consultant reporting time if the CS reported normal scans, without compromising the quality of the MPS service.

**Method:** Normal scans were defined as those with normal perfusion at stress and rest (with accepted artefacts due to movement and attenuation) and a normal gated scan. The CS identified normal scans from 425 consecutive patients. These were all reviewed by a reporting consultant.

**Results:** 151 scans (35%) were classed as normal by the CS. Four of these scans were classed as not warranting a normal report by the reviewing consultant. One was reported as minor anterior thinning, one as 'cannot exclude a minor anterior defect', one as a small fixed apical defect and one as an inferior fixed defect. Non of these were however reported as having any clinically significant disease. The CS report agreed in 97% of cases and most importantly did not class any scans as normal which were subsequently reported as having significant disease. Seventeen scans which were not classed as normal by the CS were reported as 'no significant perfusion defect' by the reporting consultants. These were scans with very minor abnormalities which could not be reported as normal but did not have significant defects. This is only 4% of the total scans. Thus if the CS reported the normal scans the reporting consultants would only need to review 5% of scans with no significant disease rather than the 39% of the total with no significant abnormality, resulting in considerable time saving. This number of 'missed' normals was considered to be acceptable. Females account for 51% of the total number of MPS scans performed. However 69% of the 151 normal scans were female. This is in line with NICE guidelines which recommend that women with angina like chest pain should have MPS as the first line test.

**Conclusion:** A large reduction in consultant time can be achieved if normal scans which do not require a clinical comment are reported by an experienced clinical scientist. The validity of the reporting system is not compromised by the use of non-clinical reporting.

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### Comparison between sub-maximal and maximal exercise myocardial perfusion scintigraphy in the detection of ischaemia and in the evaluation of myocardial ischaemia severity and extension

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**Background:** The diagnostic value of exercise myocardial perfusion scintigraphy (MPS) in the detection of ischaemia is already been known. It was also known that severity of ischaemia is important in risk stratification and in clinical management. Although, it has not been completely established the difference in detection of severity of ischaemia between maximal and sub-maximal exercise MPS. The aim of the present study is to compare maximal and sub-maximal MPS in the detection and evaluation of myocardial ischaemia severity.

**Methods:** It was a prospective study including in 31 patients (p) who performed 2 exercise MPS (one maximal and one sub-maximal) within 2 months and without any cardiovascular procedures in between. The same group of p (87% male, mean age  $63,32 \pm 8,36$  y, 22% diabetic, 74% hypertension, 79% smoker, 80% with high cholesterol levels and 83% with known CAD) performed both exercise MPS with MIBI-Tc-99m, 2 day standard protocol and gated-SPECT technique. Brude protocol was used in all exercise tests and It was considered as maximal if the heart rate achieved during exercise was  $\geq 95\%$  of maximal predicted heart rate (MPHR) and sub-maximal if in between 85-95%. It was considered ischaemia in MPS the presence of reversible defect in at least 2/17 analyzed segments. The magnitude of ischaemia was evaluated using the standard semi-quantitative score giving to each segment a score between 0-4

after stress and at resting phase. Statistical analysis were performed by Qui-square and Student T tests and it was considered significative if p value.

**Results:** There were no difference in detection of ischaemia between the 2 studies ( $p = 0,127$ ). The mean score calculated to sub-maximal stress MPS was 2,42 ( $+/- 2,16$ ), while for maximal stress MPS was 5,61 ( $+/- 3,35$ ), with  $p = 0,023$ .

**Conclusion:** The obtained results may suggest in the studied group that although detection of ischaemia was similar after maximal and sub-maximal stress, the severity of ischaemia were higher in the maximal stress MPS.

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#### Glyph-based visualisation of myocardial SPECT - Clinical assessment

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Myocardial perfusion scintigraphy yields a larger number of regional parameters such as tracer uptake during stress and at resting conditions, regional wall thickening and derivative values such as difference scores and deviations from normal values. Traditionally, these data are presented side-by-side either by two-dimensional images, by bull's eye plots or by three-dimensional mappings on the left-ventricular surface. This side-by-side representation is time consuming and difficult because data integration has to be performed mentally.

**Methods:** We propose an integrated three-dimensional visualization approach using a combination of glyphs and myocardial segmentation to display a multiparameter data set from perfusion imaging within one image (see Figure 1A). Tracer uptake during stress is mapped onto the surface, uptake at rest as the colour of the glyphs, wall thickening as the roundness of the glyphs, glyph size represents the stress-rest-difference. Opacity is determined by a deviation from the norm. For in-depth analysis a two-dimensional slice view can be obtained by clicking on a glyph (Figure 1B).

**Results:** Four physicians tested this approach in clinical routine imaging. It was deemed superior and time-efficient, especially by the lesser experienced physicians.

