POSTER SESSION III
Friday, September 12, 2008, 2:30 p.m. – 4:00 p.m.
Perfusion Methods and Image Acquisition

15.19

SIGNIFICANCE OF PRONE IMAGING FOR WOMEN WITH BREAST ATTENUATION ARTIFACT ON SUPINE MYOCARDIAL PERFUSION SPECT SCANS

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Background: Coronary artery disease (CAD) causes significant morbidity and is now the leading cause of death in women in the United States. Myocardial perfusion imaging (MPI) is highly accurate in identifying obstructive CAD and yields important prognostic information. In women, however, breast attenuation (BA) artifacts pose a significant challenge. While attenuation correction can mitigate BA, not all cameras are so equipped. We tested the hypothesis that prone imaging would reliably assist in differentiating BA artifacts from perfusion abnormalities in women undergoing MPI.

Methods: Supine and prone post-stress MPI of 195 consecutive women (age 60 ± 13 yr) whose scans were interpreted by experienced readers to be normal with BA artifact were analyzed. All patients were referred for pharmacologic or symptom-limited exercise treadmill testing (ETT) with dual-isotope imaging because of chest pain and/or dyspnea. The anterior wall in the vertical long-axis projection was divided into basal, mid, and apical segments, Tc-99m uptake in each segment was scored from 0 (normal) to 4 (severely reduced), and scores were added to give a summed stress score (SSS) of 0 to 12. Images obtained after sub-maximal ETT (< 85% age-predicted heart rate attained) and images interpreted as showing ischemia or infarction were not analyzed.

Results: By design, all supine images showed BA artifact. In contrast, prone MPI were read as completely normal (no BA artifact) in 61% of patients. The average SSS decreased from 1.9 ± 0.9 (supine SSS) to 0.3 ± 0.7 (prone SSS) when women were imaged in the prone position ($P < 0.005$).

Conclusions: Imaging women undergoing dual-isotope MPI in the prone position frequently eliminates BA artifacts, increasing the accuracy with which perfusion of the anterior wall and apex can be assessed. Thus, MPI scans suspected of showing BA artifact can be interpreted as showing normal perfusion with greater confidence if the image improves or normalizes when the patient is imaged in the prone position.

15.20

EFFECT OF PROTON PUMP INHIBITORS AND H2 ANTAGONISTS ON STOMACH WALL UPTAKE OF TC^{99M} SESTAMIBI

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Background: We hypothesized that prolonged use of proton pump inhibitors (PPIs) causes an increase in Tc-99m sestamibi uptake in the stomach wall, manifested as curvilinear activity surrounding the photopenic fundus of the stomach cavity. We prospectively evaluated the frequency of stomach wall uptake in patients (pts) undergoing myocardial perfusion single-photon emission computed tomography (SPECT) who were taking PPIs and/or H2 antagonists.

Methods: One hundred thirty-eight pts were randomly selected who were scheduled for single-day rest/stress Tc-99m sestamibi SPECT. Post-stress SPECT was acquired 30 min. after treadmill exercise or 45 min after dipyridamole infusion. All pts drank 16 oz. water 5-10 minutes following stress radiotracer injection. Pts were questioned regarding use of PPIs and H2 antagonists. The significant use of either was defined as ≥ 2 weeks of continuous therapy prior to cardiac SPECT. Blinded observers assessed post-stress planar projection images in endless-loop cinematic format for 3 patterns: (1) stomach cavity uptake, attributable to duodeno-gastric reflux of tracer, (2) stomach wall uptake and (3) no stomach uptake. A two-tailed Chi-square test with Yates correction was used to calculate statistically significant association among variables.

Results: Only pts with observed patterns of stomach wall uptake ($n^u = 30$) and no stomach wall uptake ($n^0 = 91$) were included. Pts with stomach cavity uptake (17 pts) were excluded because the assessment of the stomach wall uptake was not possible. Of the pts included (n = 121), there were 30 men, 91 women. Sixty-seven pts were > 60 yrs. old. Twenty-six pts were taking PPIs. Of the 95 pts not taking PPIs, 14 were taking H2 antagonists. No pts were taking both medications.

Stomach wall uptake was strongly associated with prolonged use of PPIs (Chi square = 51.9, $p < 0.0001$). No statistically significant association was noted with the age, gender, or the use of H2 antagonists.

	On PPI	No PPI
Stomach Wall Uptake (n^u)	21	9
No Stomach Wall Uptake (n^0)	5	86
Total (n)	n = 121	

Conclusion: Prolonged PPI therapy, but not H2 antagonist therapy, contributes to a significant increase in stomach wall activity, potentially resulting in Compton scatter or Ramp filter artifacts affecting the inferior wall of the left ventricle. Stomach wall activity, unlike the stomach cavity activity, is not prevented by ingestion of water before imaging. Therefore, it is important to elicit a history of prolonged PPI use to anticipate the possibility of increased stomach wall activity which can confound the image quality and interpretation.

15.21

ATTENUATION CORRECTION IMPROVES SPECIFICITY OF MYOCARDIAL PERFUSION IMAGING: ANALYSIS WITHOUT VERIFICATION BIAS

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Background: Attenuation artifacts reduce the specificity of coronary artery disease (CAD) diagnosis by myocardial perfusion imaging (MPI). Prior studies evaluating the diagnostic accuracy of attenuation corrected (AC) MPI were confounded by verification bias resulting from selective referral of patients with abnormal MPI to coronary angiography (CA) and absence of a diagnostic gold standard for CAD in those with normal MPI. To avoid verification bias we evaluated AC MPI in patients in whom the presence or absence of obstructive CAD could be definitively established.

Methods: Among consecutive patients who had both MPI and coronary calcium scoring (CCS) we evaluated 56 patients who had CCS < 10 Agaston units (absent obstructive CAD) or underwent a CA. Single-photon emission computed tomographic (SPECT) MPI was acquired using a standard rest thallium-201/stress Tc-99m sestamibi protocol with quantitative attenuation correction using a Gadolinium-153 line source. MPI was read blindly and categorized as normal (read probably or definitely normal) or abnormal (read probably or definitely abnormal). CCS was acquired with a 16-slice multidetector computed tomography scanner using parameters of 3 mm thickness, 120 kV and 50-100 mA. CA was obtained within three months of SPECT, and any stenosis ≥ 50% was considered significant CAD.

Results: When analyzed on a per-patient basis, the diagnostic values for CAD were as follows:

		Obstructive CAD	
		+	-
SPECT	+	12	15
	-	0	29
AC SPECT	+	12	4
	-	0	40

	SPECT	AC SPECT
Sens (%)	100	100
Spec (%)	66 (52-80)	91 (82-99)
PPV (%)	44 (26-63)	75 (54-96)
NPV (%)	100	100

Numbers in parenthesis indicate 95% CI.
PPV/NPV=Positive/Negative Predictive Value.

The distribution of pretest probability of CAD was 44% low, 43% intermediate, and 13% high/ known CAD.
Conclusions: When analyzed without the confounding effects of verification bias, AC improved the diagnostic specificity and PPV of MPI for CAD. Therefore, using AC may avoid unnecessary further downstream testing for CAD.

15.22
ADHERENCE TO THE UPDATED 2007 APPROPRIATENESS CRITERIA FOR SINGLE-PHOTON EMISSION COMPUTED TOMOGRAPHY MYOCARDIAL PERFUSION IMAGING AT A TERTIARY CARE MEDICAL CENTER
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Background: In 2005 the American College of Cardiology/American Society of Nuclear Cardiology (ACC/ASNC) published appropriateness criteria (AC) for the indications of Single-Photon Emission Computed Tomography Myocardial Perfusion Imaging (SPECT MPI). This was updated in 2007 by ASNC to include new indications as well as changes to the published AC. We sought to evaluate our practice patterns for SPECT MPI ordering compared to the ACC/ASNC AC both from an ongoing quality assessment standpoint and to identify areas of improvement.
Methods: We conducted a retrospective study of 375 consecutive patients who underwent a stress SPECT MPI. The patients' electronic medical records and stress data were collected and all baseline pre-stress electrocardiograms were reviewed for interpretability by qualified cardiology personnel. Framingham risk score, pre-test probability of coronary artery disease using Diamond Forrester chart, imaging results, and the subsequent management were all recorded. Based on the ASNC criteria, SPECT MPI studies were classified into appropriate (A), inappropriate (I), or uncertain (U).
Results: The overall age of the study group was 65 ± 11.9 with 50.7% males and approximately 49% were Caucasian. The most common indication for the SPECT MPI was chest pain evaluation for suspected coronary artery disease (50.4%). Overall adenosine SPECT MPI was the predominant modality used (77%). Applying the AC, 338 (90.1%) were A, 21 (5.6%) were I, and 16 (4.3%) were U. Out of 176 studies ordered by cardiologists, 161 (91%) were A, 8 (4%) were I, and 7 (3%) were U. Out of the remaining 199 studies ordered by non-cardiologists, 177 (88%) were A, 13 (6%) were I, and 9 (4%) were U.

Variables	Appropriate N = 338	Inappropriate N = 21	Uncertain N = 16
Framingham:			
Low	64 (19.0%)	15 (71.4%)	9 (56.3%)
Intermediate	44 (13.1%)	3 (14.3%)	5 (31.3%)
High	229 (68.0%)	3 (14.3%)	2 (12.5%)
Diamond Forrester:			
Very Low	15 (4.4%)	4 (19.0%)	2 (12.5%)
Low	59 (17.5%)	10 (47.6%)	7 (43.8%)
Intermediate	158 (46.7%)	3 (14.3%)	4 (25.0%)
High	106 (31.4%)	4 (19.0%)	3 (18.8%)
Normal SPECT MPI	186 (55.0%)	20 (95.2%)	13 (81.3%)
Catheterization after SPECT MPI	32 (9.5%)	0 (0.0%)	1 (6.3%)
Revascularization	7/32 (21.9%)	0/0 (0.0%)	0/1 (0.0%)

Conclusions: Majority of the indications were classified into the A group suggesting strict adherence to the published criteria in our institution. A normal SPECT MPI occured in the majority of the I and U group. None of the patients in the I group and only 1 patient in the U group underwent invasive workup. Thus the updated 2007 ASNC criteria utilizing Framingham risk score and Diamond Forrester appears robust in identifying the groups (A, I, U) where SPECT MPI may or may not be indicated. Whether order entry systems to provide feedback of appropriateness based on the ASNC AC would help cost effective testing by ordering physicians will be explored as an extension of the findings of this project.

15.23
INTEGRATED REST/STRESS MYOCARDIAL PERFUSION SPECT (MPS) AND 64-SLICE CORONARY CT ANGIOGRAPHY: IMPACT ON MANAGEMENT OF PATIENTS POST-REVASCULARIZATION
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Background: To determine the impact of integrated myocardial perfusion single-photon emission computed tomography (MPS) and coronary computed tomography angiography (CCTA) on management of patients post-revascularization (percutaneous coronary intervention and/or coronary artery bypass graft).
Methods: Twenty patients underwent rest/stress MPS and CCTA with an integrated system (Ventri/VCT, GE Healthcare). The impact on management was reviewed using the following algorithm: the second non-invasive test is performed if the first is equivocal and catheterization is performed if a non-invasive test is definitely abnormal. Potentially avoided invasive catheterization procedures were determined using the following hypothesis: catheterization would be done when the first test is equivocal and the second test was not available. The most helpful test was identified by a panel of cardiologists with knowledge of clinical data.
Results: The same six patients (30%) would be selected for catheterization if MPS or CCTA was the first study respectively. Table 1 shows the percent of patients for whom a second test was necessary, for whom the second test did not change management and for whom catheterization was avoided. MPS was most helpful in 20% of patients and CCTA in 10% of patients. Either MPS or CCTA would have sufficed in 20% of patients but the combination of both was useful in 50%.
Conclusions: MPS and CCTA have complimentary roles in post-revascularization patients: 1) Regardless whether MPS or CCTA was the first study the same patients were selected for catheterization; 2) The addition of a second non-invasive test avoids invasive procedures in greater than 20% of patients; 3) The functional impact evaluated by MPS is critical: No other test was necessary in 50% of patients if MPS was first and MPS would have been requested in 75% of patients if CTA was first.

Table 1.

Percent of patients	MPS First (percent)	CCTA First (percent)
Necessity of second test	25	75
Second test did not change management	50	15
Second test avoids catherization	20	55

15.24
COCAINE USE DECREASES THE POSITIVE PREDICTIVE VALUE OF DIPYRIDAMOLE TECHNETIUM-99M SESTAMIBI STRESS SCINTIGRAPHY FOR OBSTRUCTIVE CORONARY ARTERY DISEASE
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Background: Each year, over 64,000 people in the United States present to the emergency room with cocaine-associated chest pain. Chest pain is often attributed to demand ischemia or vasospasm; however, cocaine is also associated with endothelial damage and accelerated atherosclerosis. Symptomatic patients should therefore undergo evaluation for coronary artery disease (CAD), but the ideal test in this situation has not been established. In patients with cocaine use, the ability of stress scintigraphy to distinguish true atherosclerotic CAD from non-stenotic mechanisms of chest pain is unclear.
Methods: Retrospective analysis was performed on all patients undergoing coronary angiography within 6 months of an abnormal dipyridamole technetium-99m (^{99m}Tc) sestamibi stress test at a single institution from January 1, 2005 to August 1, 2007 (n = 580). True obstructive CAD was defined as a lesion ≥ 50% by visual estimation during angiography.
Results: Coronary angiography revealed CAD in 36.5% of cocaine-positive patients (n = 82) and 72.6% of cocaine- negative patients (n = 498) with abnormal stress results. The positive predictive value of stress scintigraphy was significantly lower in cocaine patients (36.6% vs. 72.7%, $P < 0.0001$). At baseline, cocaine patients were younger, and had fewer CAD risk factors: hypertension, diabetes, hyperlipidemia, and peripheral vascular disease. Beta-blockers were used less frequently in cocaine patients.
Conclusions: Stress scintigraphy may have little prognostic value for CAD in patients with cocaine-associated chest pain. The adverse effects of cocaine on the coronary microvasculature may play a role in a higher

number of false positive results. These damaging effects on the endothelium make appropriate risk stratification even more prudent.

True positive vs. false positive technetium-99m scintigraphy

	(+) CAD	(-) CAD	Positive predictive value
Cocaine Positive	30	52	36.6% ± 10.14% (95% CI 25.9-46.1%)
Cocaine Negative	362	136	72.7% ± 3.8% (95% CI 69.2-76.8%)
P-Value			P < 0.0001

15.25

LOWERING RADIATION DOSE OF COMBINED PET-CT AND CT ANGIOGRAPHY IN THE BIOMORPHOLOGIC ASSESSMENT OF CORONARY ARTERY DISEASE: FIRST EXPERIENCE WITH PROSPECTIVELY GATED CT ANGIOGRAPHY

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Objective: Reduction of radiation exposure from computed tomography coronary angiography (CTA) will be a key factor for more liberal use in cardiac hybrid positron emission tomography (PET)-computed tomography (CT). We tested the feasibility of a new algorithm for low dose CTA based on a prospectively gated step-and-shoot technique. This limits acquisition to the diastolic phase and minimizes exposure time versus the previous standard of retrospectively gated helical acquisitions.

Methods: In 15 patients referred for biomorphologic workup by 82Rb perfusion PET-CT, step-and-shoot CTA (SnapShot Pulse, GE Healthcare; 120kV, 600-800mA) was acquired on a 64-slice GE Discovery Rx VCT PET-CT scanner, and compared to a group of patients with conventional helical CTA (120 kV, mA modulated) which was matched for clinical variables. Effective dose was estimated from dose length product (DLP). The American Heart Association 15-segment coronary tree model was used to determine study interpretability. Potential for fusion with 82Rb perfusion PET was tested using commercial software. Additionally, direct dose measurements were conducted using an anthropomorphic phantom for more accurate dosimetry.

Results: DLP-derived effective patient dose for helical and step-and-shoot CTA was 5.5 ± 0.1 vs 20.5 ± 3.5 mSv ($p < 0.0001$). Evaluable segments/patient for the best phase of helical CTA were 12.5 ± 2.8 (83.3 ± 18.7%) vs 13.3 ± 2.2 (88.7 ± 14.7%; p = ns vs helical) for step-and-shoot. Review of multiple phases increased the number for helical to 13.7 ± 1.7 (91.3 ± 11.3%; p = ns vs step-and-shoot, where this was not an option). Semiautomated fusion with corresponding PET was feasible for all studies. Phantom data confirm effective doses of 5.4 mSv for step-and-shoot and 19.6 mSv for helical acquisition.

Conclusions: Low dose prospectively gated CTA reduces radiation exposure by nearly 70% vs. the previous standard of helical acquisition, without significant loss in interpretability and integrative potential with 82Rb perfusion PET. This represents a step towards a broader, routine integration of CTA and perfusion PET for assessment of coronary morphology and physiology by cardiac PET-CT.

15.26

PROMPT GAMMA COMPENSATION IMPROVES THE DIAGNOSTIC ACCURACY OF RB-82 MYOCARDIAL PERFUSION 3D PET/CT

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Objective: Prompt gammas may represent a significant problem in 3-dimensional (3D) scanners because the wide axial acceptance angle increases the sensitivity to scattered and random events. We compared the diagnostic accuracy of adenosine stress Rb-82 myocardial perfusion 3D positron emission tomography(PET)/computed tomography (CT) with and without prompt gamma compensation (PGC) using coronary angiography as the gold standard.

Methods: Nineteen patients (10 men, mean age 43 ± 7 years) had low likelihood (LLK) of coronary artery disease (CAD) based on a 2% or less Framingham risk score, and a calcium score of zero. Forty patients (13 men, mean age 63 ± 11 years) had coronary angiography within 38 days of Rb-82 imaging. The patients with LLK of CAD were considered free of obstructive disease because of the small number of patients with nonobstructive CAD at coronary angiography. All studies were acquired using a Siemens Biograph-40 3D PET/CT scanner. Dedicated software was used for registration, processing, and interpretation. Two readers blinded to clinical information independently scored 4 different stress reconstructions on each patient: ordered subset expectation maximization (OSEM; 7 mm post filter) and filtered back projection (FBP; 10 mm post filter), both with and without PGC (1 = definitely normal, 2 = probably normal, 3 = probably abnormal, 4 = definitely abnormal). Average scoring on a patient level and on a vascular territory level was used to generate the receiver operating characteristic curves (ROC). The criterion for significant stenoses at coronary angiography was ≥ 50%.

Results:

	Area under the ROC curve			
Reconstruction	LV	LAD	LCX	RCA
OSEM PGC on	0.95	0.80	0.82	0.78
OSEM PGC off	0.79[1]	0.69	0.82	0.83
FBP PGC on	0.83[2]	0.70	0.69	0.70
FBP PGC off	0.79[3]	0.69	0.85	0.81

[1]p = 0.006, [2]p = 0.009, [3]p = 0.006 versus OSEM PGC on.

Conclusions: Prompt gammas should be accounted for in the reconstruction of Rb-82 myocardial perfusion 3D PET. In this population OSEM with PGC provided the best area under the ROC curve. Further studies should be performed to determine if this is a superior reconstruction method or if the different filtering was the cause.

15.27

DOUBLE-BLINDED COMPARISON OF THE SIDE EFFECTS ASSOCIATED WITH PHARMACOLOGIC STRESS INDUCED WITH BINODENOSON AND ADENOSINE

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Background: Pharmacologic stress (PS) with adenosine (ADO) is contraindicated in patients with asthma and 2nd to 3rd degree atrioventricular (AV) block, and is associated with a high incidence of side effects (SEs) such as chest pain, dyspnea, and flushing. Previous studies showed that the experimental PS agent binodenoson (BINO), a highly selective adenosine A_{2A} agonist, detected similar ischemia in the same patient population, and was tolerated better than ADO. The nature, incidence, intensity, time to onset, and duration of pre-specified SEs associated with BINO and ADO were compared in the same patients.

Methods: Two similar, multi-center, risk-stratified, full crossover studies (VISION 302, n=419; VISION 305, n=433) were conducted to test the safety and efficacy of BINO as a PS agent. Patients completed 2 double-blinded PS-SPECT studies within 7 days, using a double-dummy drug administration procedure. Patients received an intravenous bolus of BINO, 1.5 ìg/kg + 6-minute placebo infusion or a placebo bolus + ADO, 140 ìg/kg/min for 6 minutes, in random order. Investigators recorded occurrence of 2nd to 3rd-degree AV block and SEs, severity (mild, moderate, severe) and times of onset and resolution of SEs. One hour later, patients rated intensity of 7 pre-specified SEs (flushing, chest pain, dyspnea, nausea, headache, abdominal discomfort, and dizziness) using a validated 1-10 visual analog scale. While still blinded, patients rated their preference for the procedures 2-4 days after the 2nd study. Results indicate descriptive statistics.

Results: No 2nd to 3rd degree AV block occurred during BINO vs. 1 and 3% with ADO. In both trials, BINO was associated with significantly less flushing (302: 32 vs. 50%; 305: 38 vs. 58%), chest pain (302: 38 vs. 61%; 305: 38 vs. 61%), and dyspnea (302: 42 vs. 51%; 305: 45 vs. 54%). The incidence of nausea was lower with BINO than ADO in VISION 305 (16 vs.

22%), and similar (18 vs. 22%) in VISION 302. The incidence of headache was higher with BINO than ADO in VISION 302 (43 vs. 35%), and similar (47 vs. 42%) in VISION 305. Differences in abdominal discomfort and dizziness were not significant. Patients who experienced the SE rated the intensities of flushing, chest pain, dyspnea, headache, and abdominal discomfort significantly lower during BINO than ADO in both trials. Investigators rated significantly more SEs "mild" during BINO than ADO (VISION 302: 38% vs. 22%; VISION 305: 42% vs. 28%. Investigator- and patient-rated SE intensities were highly correlated. Median times to onset and durations of the 7 SEs were similar with BINO and ADO. In addition, 71% and 68% of patients preferred the procedure in which BINO was the PS agent used.

Conclusions: Results from 2 randomized, controlled trials in which the same patients received double-blinded BINO and ADO within 1 week showed BINO produced fewer and less intense SE than ADO, that BINO SE resolved as quickly as ADO, and that patients preferred BINO over ADO by a wide margin.

15.28

PREDICTORS OF ABNORMAL HEART RATE RESPONSE TO DIPYRIDAMOLE IN PATIENTS UNDERGOING MYOCARDIAL PERFUSION SPECT

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Background: Patients with a reduced heart rate (HR) response to dipyridamole(Dip) have higher cardiac mortality but the mechanism is unknown.We aimed to identify predictors of abnormal HR response to Dip in patients undergoing myocardial perfusion single-photon emission computed tomography (MPS).

Methods: We studied 432 patients who underwent dual-isotope gated MPS. Dip (0.56 mg/kg) was infused over 4 min, and Tc-99m-tetrofosmin was injected 3 min after the end of the infusion. Semiquantitative visual interpretation of MPS images was performed using 17-segment model. Each segment was scored by consensus of 2 expert observers using a 5-point scale (0, normal; 1, equivocal; 2, moderate reduction; 3, severe reduction; and 4, absence of activity). The summed stress score (SSS) and summed rest score (SRS) were obtained by adding the scores for the 17 segments of the stress and rest images, respectively. The difference between the SSS and SRS was defined as the summed difference score (SDS). Left ventricular ejection fraction (LVEF) was automatically calculated. The population was categorized into quartiles according to HR ratio and characteristics in each quartile were compared. Logistic regression analysis was performed to identify predictors of abnormal HR response, using the lowest quartile as the independent variable.

Results: Group 1 included patients with HR ratio ≤ 1.14, group 2 was composed of patients with HR ratio between 1.14 and 1.22, group 3 was composed of patients with HR ratio between 1.22 and 1.32, and group 4 included patients with HR ratio ≥ 1.32. Age was not significantly different across the groups, except for group 4 whose patients were younger. Group 1 patients had more often history of chronic renal failure and less frequently history of chest pain. Prior coronary artery disease had a similar distribution among patients from all groups. Of note, patients with the least HR ratio were taking digoxin more frequently than those from the other groups. The use of beta-blockers and calcium channel antagonists was not different, though. Baseline HR was higher and peak HR, lower in group 1 patients, when compared to the others. Group 1 patients had fewer symptoms during DIP stress. SSS and the SRS were higher and LVEF was lower in patients from group 1, while the SDS was not significantly different among patients from all groups. The prevalence of left ventricular dysfunction was significantly higher in patients with blunted HR response than in those with normal response (22.7% vs 4.3%, $p < 0.0001$). Multivariable logistic regression analysis demonstrated that the independent predictors of abnormal HR response were baseline HR ($\div^2 = 4.4$, $p = 0.03$, 95% CI 1.001-1.038) and LVEF ($\div^2 = 6.6$, $p<0.01$, 95% CI 1.005-1.036).

Conclusions: LV dysfunction is an independent predictor of abnormal HR response to DIP and the association between low LVEF and low HR ratio may explain the link between abnormal HR ratio and increased mortality.

15.29

PRELIMINARY RESULTS OF A NEW PHARMACOLOGIC STRESS PROTOCOL FOR MYOCARDIAL PERFUSION IMAGING

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Background: Pharmacologic stress is often used with vasodilators or inotropic agents. The 2 drugs most frequently used are dipyridamole (Dip) and dobutamine (Dob). Sherata et al (Am J Cardiol 1998; 82:520-3) evaluated the association of the two drugs in moderate doses showing larger perfusion defects without changing the safety. We aimed to evaluate the safety and the results obtained with a new protocol associating Dip, Dob, and atropine compared to the traditional Dip protocol.

Methods: Ten patients underwent same-day, rest Tl-201/Dip stress Tc-99m sestamibi myocardial perfusion single-photon emission computed tomography (MPS). For rest imaging, Tl-201 (2.5-3.0 mCi) was injected intravenously, and image acquisition was started 10 minutes after radioisotope injection. Dip was intravenously administered (0.56 mg/Kg) in 4 minutes and Tc-99m sestamibi (20-25 mCi) was injected 3 min after the end of the Dip injection. In another day, patients received the same Dip dose, immediately followed by the infusion of Dob (20 ìg/Kg/min for the first 2 minutes and 40 ìg/Kg/min in the next 2 min, with atropine [1 mg] given in the interval between the 2 Dob doses). MPS imaging was initiated 40 minutes after stress. Image acquisitions were obtained with a 2-detector camera (Millenium MG; GE Medical Systems, Milwaukee, WI) over a 180° arc starting from the 45° right anterior oblique position. Semiquantitative visual interpretation of MPS images was performed using a 17-segment model. Each segment was scored by consensus of 2 expert observers using a 5-point scale (0, normal; 1, equivocal; 2, moderate reduction of tracer uptake; 3, severe reduction of tracer uptake; and 4, absence of detectable radiotracer activity in a segment). The summed stress score (SSS) and summed rest score (SRS) were obtained by adding the scores for the 17 segments of the stress and rest images, respectively. The difference between the SSS and SRS was defined as the summed difference score (SDS).

Results: No serious complication was found in any patient independently of the protocol used. Minor complaints were observed with the same frequency (70%) but chest pain was more common during Dip-Dob (20% vs 70% - $p < 0.05$). Heart rate (HR), systolic and diastolic blood pressure and double product were similar in both protocols in baseline. Maximum HR (136.8 ± 18.3 vs 91.5 ± 9.5, $p < 0.01$)and the double product ($19{,}056 \pm 4{,}328$ vs $12{,}617 \pm 1{,}727$, $p < 0.01$) had a significant increase in the tests which employed Dob and atropine compared to the Dip protocol. Stress studies with Dip-Dob had higher SSS than in Dip (11.1 ± 11.4 vs 8.1 ± 10.4, respectively. $P < 0.05$). SDS was also higher in the Dip-Dob than in Dip protocol (6.5 ± 6.9 vs 4.4 ± 5.8, respectively. $P < 0.05$).

Conclusions: Preliminary data suggest that this new pharmacologic stress protocol with the association of Dip, Dob in full dose, and atropine is safe and may show higher sensitivity to detect ischemic myocardium.

15.30

INFLUENCE OF RECONSTRUCTION TECHNIQUE, CT-BASED ATTENUATION CORRECTION AND SCATTER CORRECTION ON RELATIVE AND ABSOLUTE COUNTS ON SPECT MYOCARDIAL PERFUSION IMAGES IN OBESE SUBJECTS

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Background: Attenuation and photon scatter adversely impact single-photon emission computed tomography (SPECT) myocardial perfusion images. With SPECT/computed tomography (CT) cameras, it is possible to correct perfusion images for both attenuation and scatter. In obese patients, we hypothesized that attenuation correction (AC) or attenuation correction plus scatter correction (AC + SC) would alter relative and absolute myocardial count distributions relative to images reconstructed with filtered back projection (FBP) or iterative reconstruction (IT).

Methods: In 25 obese patients (pts) without significant CAD on angiography, (10 men, BMI = 41.0 ± 9.3; 15 women, BMI 50.9 ± 7.0), 22 stress and 20 rest perfusion images were acquired with a Symbia T6 camera. Two skilled observers generated polar maps of relative and absolute count distributions in blinded fashion on FBP, IT, IT+AC and IT+AC+SC

images with 4-dimensional MSPECT, and mean values were generated for each image set.

Results: Relative Myocardial Counts (% Maximum).

	FBP	IT	IT + AC	IT +AC + SC
All (n=42)				
Total	76.6 ± 4.6	76.5 ± 4.8	80.5 ± 3.2***	79.2 ± 3.6$^{\#}$
LAD	76.6 ± 6.7	77.4 ± 5.2	77.1 ± 4.0	75.8 ± 4.4
CFX	77.7 ± 6.7	74.8 ± 7.3	84.5 ± 5.0$^{\#\#\#}$	84.8 ± 5.3$^{\#\#\#}$
RCA	74.2 ± 8.4	74.8 ± 8.7	83.5 ± 5.1$^{\#\#\#}$	81.3 ± 5.6$^{\#\#}$
Men (n=18)				
Total	75.8 ± 4.3	75.7 ± 3.9	80.3 ± 3.1**	79.1 ± 3.6^{+}
LAD	76.8 ± 4.2	78.7 ± 4.7	77.5 ± 3.9	76.0 ± 4.5
CFX	78.0 ± 6.5	73.9 ± 6.6	85.2 ± 5.0**	85.9 ± 4.8**
RCA	70.3 ± 8.6	70.4 ± 8.8	81.6 ± 6.0**	79.8 ± 6.5**
Women (n=24)				
Total	77.3 ± 4.8	77.1 ± 5.3	80.8 ± 3.4*	79.4 ± 3.8
LAD	76.4 ± 5.7	76.5 ± 5.5	76.9 ± 4.2	75.7 ± 4.4
CFX	77.5 ± 6.9	75.4 ± 7.9	83.9 ± 4.9$^{\#}$	84.0 ± 5.6**
RCA	77.0 ± 7.2	78.0 ± 7.1	84.9 ± 3.8**	82.5 ± 4.7^{++}

*p< 0.05 vs FBP and IT; **p< 0.005 vs FBP and IT; ***p< 0.0001 vs FBP and IT; $^{\#}$p< 0.02 vs FBP and IT; $^{\#\#}$p< 0.0002 vs FBP and IT; $^{\#\#\#}$p< 0.00002 vs FBP and IT; $^{+}$p< 0.05 vs IT, p = 0.05 vs FBP; ++p<0.05 vs FBP, p=0.055 vs IT.

For total counts and for each vascular distribution, raw AC and AC+SC myocardial image counts were significantly increased (up to 7-fold greater on the IT+AC images and 8-fold greater on the IT+AC+SC images) than on conventional FBP images.

Conclusions: Application of AC or AC+SC significantly alters both normalized and raw count distributions on SPECT myocardial perfusion images, indicating that attenuation correction with or without scatter correction must be considered when comparing individual image data to normal databases for both men and women. Moreover, the increase in myocardial image counts with AC and AC+SC suggests that these reconstruction techniques may benefit image quality.

15.31

MYOCARDIAL PERFUSION SPECT: REST AND STRESS IN ONE ACQUISITION

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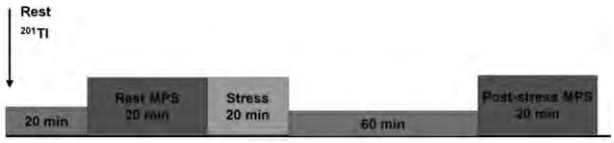
Background: Simultaneous Dual Isotope (SDI) acquisition of ^{201}Tl rest/^{99m}Tc-sestamibi stress-myocardial perfusion single-photon emission computed tomography (MPS) is a desirable new procedure in nuclear cardiology. In this protocol ^{201}Tl is injected at rest but imaging is performed not earlier than after exercise. Therefore one must be convinced that throughout exercise ^{201}Tl remains distributed in an identical pattern as at rest. Before SDI can be applied clinically, ^{201}Tl rest MPS before and after an exercise test need to be compared for equality. This study assesses the variation in washout of Thallium in normally perfused and ischemic myocardium subjected to exercise.

Methods: In 102 patients ^{201}Tl was injected in rest. Rest ^{201}Tl MPS was performed, followed by an upright bicycle exercise-test, without injection of any tracer. Subsequently post-stress ^{201}Tl imaging was performed (see figure). All images were corrected for attenuation and decay. Quantitative analysis of mean counts-per-pixel for each segment in a 17-segment model was done using MunichHeart. Differences between rest and post-stress ^{201}Tl MPS were calculated. Normal segments were compared to ischemic segments. Visual analysis was performed by two independent observers scoring the 17 segments on a scale of 0-4.

Results: Overall global difference between rest ^{201}Tl and post-stress ^{201}Tl MPS was 15.4% (± 0.7% ,s.e.m.). Normal (N=66) and ischemic (N=36) patients demonstrated 16.2% (± 0.7%) and 14.0% (± 1.4%) (p=0.17) washout respectively. Quantitative analysis demonstrated no significant segmental differences between normal and ischemic myocardium. Visual assessment by two independent observers revealed a significant difference between rest ^{201}Tl and post-stress ^{201}Tl MPS in only one patient. The clinical diagnosis in this patient would have altered from ischemia only to infarct with ischemia.

Conclusions: ^{201}Tl post-stress MPS demonstrates significant redistribution of Thallium. This washout is global over the myocardium. The post-stress ^{201}Tl MPS is a reliable reflection of the rest perfusion, even in ischemic segments. SDI acquisition of ^{201}Tl rest/^{99m}Tc-sestamibi stress-MPS is clinically applicable.



15.32

DIAGNOSTIC ACCURACY OF HYBRID CARDIAC SPECT/CT FOR ATTENUATION CORRECTION OF STRESS MYOCARDIAL PERFUSION IMAGING IN OBESE COMPARED TO NORMAL WEIGHT PATIENTS

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Background: The purpose of this study was to evaluate the diagnostic accuracy of computed tomography (CT)-based attenuation corrected (AC) single-photon emission computed tomography (SPECT) myocardial perfusion imaging compared to uncorrected SPECT (NC) in consecutive obese (body mass index [BMI] > 30) compared to normal weight patients (pts) with angiographic correlates.

Methods: We studied 234 pts with recent coronary angiographic correlates. This study included 101 pts with BMI < 30 (normal group) and 133 pts with BMI > 30 (obese group). The mean weight of normal pts was 75.9 ± 13.0 Kg (range 46.4-104.5 Kg) and mean weight of the obese group was 107.8 ± 19.7 Kg (range 63.2-181.8 Kg); BMI averaged 25.5 ± 3.2 (range 16.5-29.8) in the normal group and 37.1 ± 6.97 (range 30.1-66.6) in the obese group. Imaging was performed using Siemens SYMBIA-T6 SPECT-CT imaging systems (Siemens Medical Solutions, Hoffman Estates, IL) and a stress Tc-99 sestamibi protocol. Breathhold CT acquisitions were acquired 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 the standard 17-segment model. For statistical purposes, p < 0.05 was considered significant.

Results: With AC sensitivity increased from 86% to 94% in normal weight pts and from 76% to 94% in obese pts (p < 0.05). Specificity increased from 81% to 94% in normal weight pts and from 48% to 83% in obese pts (p < 0.05). Accuracy increased from 85% to 94% in normal weight pts and from 69% to 91% in obese pts (p < 0.05). Increases in sensitivity, specificity and accuracy all occurred. These improvements were larger and all were significant in the obese patient group. The normal weight group also demonstrated significant improvements in sensitivity and accuracy with a trend to increased specificity.

Conclusion: CT-based attenuation correction significantly improves the diagnostic accuracy of MPI SPECT in normal weight and obese patients, but the improvements are greater in obese patients. Although significantly improved, specificity is still significantly reduced in obese compared to normal weight patients.

15.33

DIAGNOSTIC ACCURACY OF HYBRID SPECT/CT FOR ATTENUATION CORRECTION OF STRESS MYOCARDIAL PERFUSION IMAGING IN WOMEN COMPARED TO MEN

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Objective: The objective of this study was to evaluate the diagnostic accuracy of computed tomography (CT)-based attenuation corrected (AC) single-photon emission computed tomography (SPECT) myocardial perfusion imaging compared to uncorrected SPECT (NC) in female compared to male patients (pts) with angiographic correlates.

Methods: We studied 237 pts with recent coronary angiographic correlates including 143 consecutive male (mean age 61.2 ± 10.6 and mean weight 98.9 ± 21.4 Kg (range 54.5-174.1 Kg)) and 94 consecutive female patients (mean age 62.5 ± 12.8 and mean weight 86.8 ± 24.3 Kg (range 46.4-181.8 Kg)). Imaging was performed using Siemens SYMBIA-T6 SPECT-CT imaging systems (Siemens Medical Solutions, Hoffman Estates, IL) and a stress Tc-99 sestamibi protocol. Breathhold CT acquisitions were acquired 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 severity and extent of perfusion defects in each of the three coronary artery distributions using the standard 17-segment model. For statistical purposes, $p < 0.05$ was considered significant.

Results: With attenuation correction, sensitivity increased from 78% to 93% in female pts and from 82% to 94% in male pts. Specificity increased from 57% to 82% in female pts and from 61% to 91% in male pts. Accuracy increased from 72% to 90% in female pts and from 78% to 93% in male pts. Sensitivity, specificity, and accuracy all increased significantly with AC compared to NC SPECT. The increase in specificity in male pts was slightly greater than in female pts.

Conclusion: CT-based attenuation correction of myocardial perfusion images showed significant improvements in sensitivity, specificity and accuracy in both female and male patients of widely varying body habitus. Specificity improvements in female patients were not as great as in male patients.

15.34

EFFECT OF RECONSTRUCTION PARAMETERS AND ACQUISITION TIMES ON MYOCARDIAL PERFUSION DISTRIBUTION IN NORMALS

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Background: Iterative reconstruction may achieve comparable image quality with reduced number of detected counts. This study looked at differences between conventional filtered backprojection (FBP) reconstructions compared to iterative reconstructions (IR) for data acquired using standard and half-time acquisitions.

Methods: A random selection of patients (n = 74, 37F and 37M) with low pre-test likelihood (≤ 5%) for coronary artery disease undergoing a stress-rest one day protocol were included in this study. Patients were acquired with a standard single-photon emission computed tomography (SPECT) perfusion protocol defined by American Society of Nuclear Cardiology guidelines. Half-time projection data sets were computed from the acquired data by decreasing the effective pixel intensities by 50% using a Poisson statistical model where the variance of the pixel counts is consistent with a true half-time acquisition. Images were reconstructed from both projection data sets using FBP with low pass filter and an IR algorithm incorporating 3-dimensional collimator modeling (Siemens CardioFlash, Hoffman Estates, IL). The IR algorithm is a maximum-likelihood expectation maximization using 8 ordered subsets and iterations of 4, 8, and 12 iterations to further investigate the effect of iteration number used. All of the iterative reconstructed data sets were smoothed with 9.6mm Gaussian kernel to effectively match the resolution of the FBP images. Reconstructed images were resampled into polar map format using Corridor4DM software (INVIA, Ann Arbor, MI) and gender-specific databases were compiled. Regional (9 segments) and global differences between the databases, within gender, were computed using paired Students t-test.

Results: For the full-time acquisition data, statistically significant ($p<0.05$) differences were seen in 4 of 9 regions between FBP and IR databases. Between IR databases, 2 of 9 regions were different for images reconstructed with 4 vs. 8 iterations. No differences were seen between 8 and 12 iterations, suggesting that convergence is achieved with 8 iterations and not 4. In comparing full-time to half-time databases, no differences were seen with the IR algorithms while 2 or 9 regions were statistically different for FBP.

Conclusions: In normal patients, IR can handle reduced imaging times with no change in the normal perfusion distribution. This was not seen with FBP. The distribution with IR is different with FBP which necessitates processing specific databases for quantifying perfusion defects. Extending this analysis to patients with known CAD for the validation of reduced-time imaging is warranted.

15.35

EFFECT OF POST-FILTERS ON LEFT VENTRICULAR EJECTION FRACTION FOR GATED CARDIAC SPECT STUDIES

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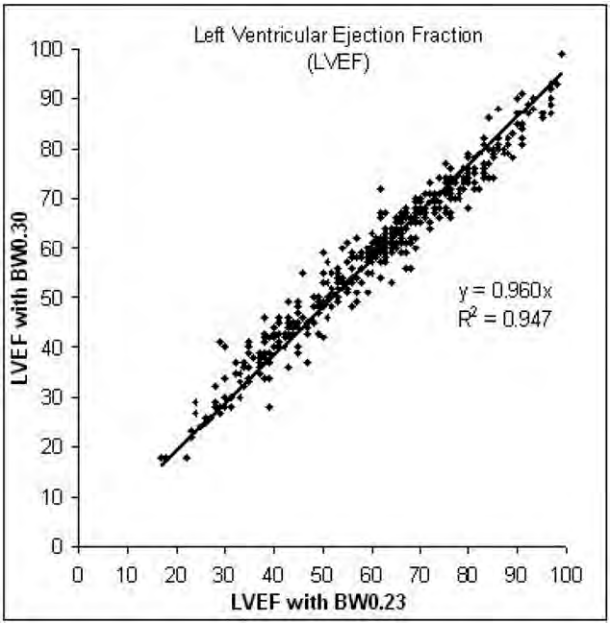
Background: For image reconstruction using 3-dimensional (3D) algorithms in cardiac single-photon emission computed tomography (SPECT), users may have different preferences of post-filters. However, different post-filters can affect the calculated end-diastolic volume (EDV) and end-systolic volume (ESV) and hence the left ventricular ejection fraction (LVEF). In this work, we quantitatively evaluate the effect of different post-filters on the calculated LVEF using a large number of patient studies.

Methods: We first reconstructed gated volumes for 448 gated cardiac studies using 3D Ordered Subset Expectation Maximization (OSEM) iterative reconstruction technique with resolution recovery. We then applied two different post-filters to the gated volumes. Filter 1 was Butterworth filter with cut-off frequency=0.30, order=6 (BW0.30) and filter 2 was Butterworth filter with cut-off frequency=0.23, order=6 (BW0.23). Finally, we calculated the EDV, ESV and LVEF using Cedar-Sinai's quantitative gated SPECT package and compared the LVEF from the two post-filters using linear correlation fitting.

Results: The linear trend line through the LVEF data from filter 1 and filter 2 was $y = 0.960x$ and correlation $R^2 = 0.947$. The results showed that on average the calculated LVEF was 4% lower when using BW0.30 than when using BW0.23.

Conclusions: Different post filters can change the calculated LVEF for gated cardiac SPECT studies. Users need to be aware of the significance of the difference when choosing different filters for their practice.



15.36

REPROJECTED DATA FROM RECONSTRUCTED VOLUME IMAGES CANNOT REPLACE THE ACQUIRED RAW PROJECTION DATA FOR THE PURPOSE OF QUALITY ASSURANCE WHILE DIAGNOSING CARDIAC SPECT STUDIES

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Background: The published American Society of Nuclear Cardiology guidelines for cardiac single-photon emission computed tomography (SPECT) imaging require cine review of the acquired raw projection data for diagnosis quality assurance (DQA) purposes to identify potential patient motion, tissue attenuation, bowel uptake, etc. This work is to investigate if reprojected data from reconstructed volume images can be used to replace the acquired raw projection data for DQA purposes, especially if the latter is not available.

Methods: We first collected a set of conventional raw projection data by (1) simulation using mathematical phantoms modeling non-uniform attenuation and noise, (2) acquisition of a physical anthropomorphic phantom with cardiac insert on a SPECT system, and (3) obtaining patient data from clinical studies. Then, we reconstructed volume images from the raw projection data without attenuation correction (AC). Later, we reprojected the reconstructed volume images to generate reprojected data. In the reprojection process, we modeled the geometry that the original raw projection data was generated/acquired so that the reprojected data had the

same orientation as the original raw projection data. And finally, we compared the reprojected data with the original raw projection data to identify if the two showed similar patient motion, breast/diaphragmatic attenuation, liver uptake, heart/liver overlapping, cardiac shape, etc.

Results: The cine of the reprojected data showed breast shadow in the female patient studies with breast attenuation, but not as clear as the cine of the original raw projection data did. The cine of reprojected data did not show any patient motion despite of the degree of motion in the original raw projection data. The reprojected data also lost the differential attenuation and depth information of the heart relative to liver and diaphragm as compared to the original raw projection data. For example, at a projection angle when the heart was closer to the detector and the liver was farther away, the original raw projection data showed that the heart was "standing" in front of the liver and not attenuated by the latter. On contrast, in the reprojected data, the liver and the heart overlapped, the depth information was lost, and one could not tell if the heart was attenuated by the liver or not either. Due to the loss of differential depth and attenuation information, the shape of the heart in the reprojected data could differ significantly from that in the original raw projection data at some projection angles.

Conclusions: Reprojected data from volume images reconstructed without AC loses critical physical information (e.g., patient motion) as compared to the conventional raw projection data. It was not adequate, nor could be used to replace the conventional raw projection data, for the required DQA in cardiac SPECT imaging as per the recommended ASNC guidelines.

15.37

DOES ROUTINE MOTION CORRECTION CORRUPT SPECT MYOCARDIAL PERFUSION IMAGES WHEN APPLIED TO DATA CONTAINING NO CARDIAC MOTION?

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Background: Post-acquisition motion correction (MC) in single-photon emission computed tomography (SPECT) myocardial perfusion imaging has been found to be helpful in decreasing artifacts that result from cardiac movement during acquisition. Some nuclear labs apply MC routinely to all studies. The effect of MC on the count distribution and on the calculated volumetric results when MC is applied to studies with minimal or no cardiac motion has not been well studied.

Methods: We prospectively collected data on 100 consecutive gated SPECT myocardial perfusion studies that had no visual or quantitative motion during scanning (motion <0.5 pixel on X and Y axes). All patients were scanned and images processed using the same camera, computer and software. The data were reconstructed both with and without MC. QPS© software was used to generate the counts in each of 20 segments of both the uncorrected and the motion corrected perfusion data sets. QGS© software was used to calculate left ventricular ungated cavity volume and the transient ischemic dilatation (TID) ratio for both the uncorrected and MC data.

Results: The mean changes in average counts in each of the 20 segments and the 3 major coronary artery territories are shown in the diagram. There was not statistically significant difference in average counts after MC in any of the 20 segments. There was also no statistically significant difference in average counts after MC when segments were grouped into the 3 major coronary artery territories. The mean left ventricle (LV) TID ratio was unchanged after MC ($p=0.98$). The LV ungated cavity volume decreased after MC by a mean of 0.53 ± 0.02 ml ($p = 0.08$).

Conclusions: MC does not seem to have a significant impact on data with no inherent motion. Hence, routine MC could be applied to all studies with no impact on clinical interpretation. Larger studies are needed to comfirm our findings.