POSTER SESSION I
Thursday, September 11, 2008, 5:30 p.m. – 7:00 p.m.
Emerging Applications and Technologies

2.01

QUARTER-TIME MYOCARDIAL PERFUSION SPECT WIDE BEAM RECONSTRUCTION

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Background: Compared to filtered backprojection (FBP) and iterative reconstruction with ordered subset expectation maximization (OSEM), wide beam reconstruction (WBR), which incorporates resolution recovery and models noise during reconstruction without applying a post-processing filter, has been reported to allow half-time gated myocardial perfusion single-photon emission computed tomography (SPECT) acquisition with preserved diagnostic quality. We postulated that with further noise modeling even shorter acquisition times would be possible.

Methods: The half-time WBR algorithm was modified for "quarter-time" acquisitions based upon anthropomorphic cardiac phantom data and a pilot group of 48 patients (pts). Pilot pts underwent 180-degree, 64-stop, full-time single-day rest (R) (25 second-per-stop [sps]) and stress (S) (20sps), and then "quarter-time" either R (6sps) (n=27 pts) or S (4 sps) (n = 21pts) 9 mCi/32 mCi R/S ^{99m}Tc-sestamibi SPECT. A 90°-angled dual-headed camera with high resolution parallel-hole collimators was used. Subsequently, using the same protocol, 134 consecutive pts (61 men, 73 women, mean weight = 182 lbs., mean chest circumference = 41 in.) were imaged both at R and S with full-time FBP and OSEM and also quarter-time WBR using the modified algorithm. Anticipating reconstruction artifacts in low count density R 6sps scans, a R 10sps acquisition was simulated by randomly dropping counts from each stop of the full time R acquisition while maintaining Poisson statistics, and the WBR algorithm was separately optimized for R 10sps SPECT. Blinded observers graded perfusion scans for quality (1=poor to 5=excellent) based on myocardial uniformity, endocardial/epicardial edge definition, and background noise. Perfusion defects were scored using a 17-segment model.

Results: For the 134 prospective pts mean image quality for R full-time OSEM and quarter-time WBR was equivalent (3.5) and superior to FBP (3.1) ($p < 0.0001$). For S, quarter-time WBR quality (4.2) was superior to both full-time OSEM (3.8) and FBP (3.4) (p's < 0.0001). Reconstruction artifacts (myocardial "streaks" or clustered hot pixels) were more frequent with quarter-time WBR than with full-time OSEM (14 R, 5 S vs. 1 R, 0 S), but did not confound interpretation. For R WBR, 10sps acquisitions were superior to 6sps (quality 3.7 vs. 3.5, p = .003) and artifacts were less frequent (8 vs.14). In pts with chest circumferences ≥ 44 in. (n=15), R image quality was better for 10sps than for 6sps (3.6 vs. 3.2, p = 0.03). Of the 19 patients with abnormal scans (summed stress scores [SSSs] > 2 by OSEM), mean SSSs, summed rest scores, and summed difference scores were not significantly different with quarter-time WBR vs. full-time OSEM (8.6 vs 9.3), (6.9 vs. 8.0), (1.9 vs. 1.3) (p's NS). Only 1 patient with normal full-time OSEM had abnormal quarter-time WBR (SSS = 3).

Conclusions: For perfusion SPECT quarter-time WBR affords image quality and defect characterization equivalent to full-time OSEM. Lengthening WBR R acquisitions to 10sps may be advantageous for larger patients.

2.02

SIMULTANEOUS DUAL ISOTOPE MYOCARDIAL PERFUSION IMAGING (DI-MPI) WITH D-SPECT

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Background: D-SPECT (Spectrum-Dynamics, Israel), a novel cadmium zinc telluride (CZT) cardiac camera with improved energy resolution, offers the potential for simultaneous acquisition of multiple radionuclides. Since simultaneous dual radionuclide (DR) stress and rest myocardial perfusion imaging (MPI) with its intrinsic exact image registration is of great clinical interest, we explored the accuracy and image quality of DR MPI using ^{201}Tl and ^{99m}Tc-MIBI with D-SPECT and compared to conventional MPI (C-MPI) with separate stress and rest acquisitions.

Methods: Eighteen consecutive patients (median age = 63 years, 11 men) were evaluated. Fifteen of 18 pts had known coronary artery disease and 8 had previous myocardial infarction (MI). Patients were injected with 74 MBq ^{201}Tl (rest) and 250 MBq ^{99m}Tc-MIBI (stress). C-MPI acquisition times for stress and rest images were 21 min and 16 min, respectively. The D-SPECT DR data were processed using the 70 and 167 keV ^{201}Tl photopeaks (15% window) and the 140 keV ^{99m}Tc (20% window) photopeak. We compared ^{201}Tl images obtained using gated D-SPECT acquired for 6 min at rest (Tl-R) and simultaneous gated DR acquisition of 15 min after stress (Tl-DR). Tl-R and Tl-DR images were also compared with ^{201}Tl rest C-MPI images. Visual analysis employed a 17-segment model of the left ventricle and a 5-point scale (0=normal, 4=absent) was used to calculate the summed stress scores (SSS), summed rest scores (SRS), and summed difference (SDS) scores. SSS ≥ 4 and SRS ≥ 2 were deemed abnormal, SDS ≥ 2 was defined as ischemia, and SDS ≥ 9 as severe ischemia. Image quality was graded on a 4-point scale (1 = poor, 4 = very good). Abnormal segment = score >1.

Results: C-MPI was abnormal at stress in 12 patients and at rest in 6 patients. By C-MPI, 3 had evidence of transmural and 3 of nontransmural MI. In the 12 abnormal studies, stress DR MPI was abnormal in 75 vs. 67 abnormal segments by stress C-MPI, and was normal in 129 of 137 segments normal by C-MPI. Rest DR-MPI was abnormal in 35 vs. 34 segments abnormal by rest C-MPI, and was normal in 169 of 170 segments normal by rest C-MPI. SSS and SRS on C-MPI and DR MPI highly correlated (r = 0.894 and r = 0.850, respectively; $p < 0.0001$ for both). A high correlation was also noted between Tl-R and Tl-DR SRS scores (r = 0.989, $p < 0.0001$) by D-SPECT. Mean image quality score was 2.94 and 3.78 for C-MPI and DR D-SPECT stress images, respectively ($p < 0.001$) and 2.94 and 3.72 for C-MPI and DR D-SPECT rest images ($p < 0.0001$). There was no significant difference in image quality between D-SPECT Tl-R and Tl-DR images (3.50 and 3.72, p = 0.16).

Conclusions: Perfusion abnormality shown by rest DR MPI highly correlated to rest C-MPI. DR MPI with D-SPECT offered significantly reduced imaging time, improved image quality and enabled fast, high quality simultaneous DR MPI in one imaging session. Pending further validation, these findings may represent a breakthrough in the quest for efficient and accurate MPI studies.

2.03

ASSESSMENT OF MYOCARDIAL ISCHEMIA IN AREAS OF ABNORMAL BLOOD FLOW DISTRIBUTION WITH DOBUTAMINE STRESS AND MULTI-PINHOLE (MP)-SPECT

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Background: Coronary obstruction as manifested by myocardial blood flow maldistribution can be detected by gated myocardial perfusion imaging (GMPI) even in the absence of myocardial ischemia. Echocardiography (echo) is able to measure the consequences of myocardial ischemia on left ventricular (LV) contraction and has the advantage of increased specificity. We present a protocol using concomitant Multi-Pinhole-single-photon emission computed tomography (MP-SPECT) imaging during dobutamine stress infusion that provides both pieces of diagnostic information simultaneously — stress/rest myocardial flow differences and LV contractile performance.

Methods: A group of 17 patients with established coronary artery disease (CAD) and normal resting LV contraction was studied following resting injection of 9.0 mCi of Tc-99m MIBI, we measured LV ejection fraction, segmental motion, and segmental thickening at rest and during each 8 min stage of dobutamine stress. Images were acquired on an Argus SPECT

camera equipped with a stationary 9-pinhole collimator. LV contraction was also measured by echo at the completion of each dobutamine stress stage. At peak dobutamine stress, 4.0 mCi of Tl-201 was injected one minute prior to cessation of infusion and a GMPI was acquired in list-mode with both Tc-99m and Tl-201 present simultaneously. Gated studies were evaluated visually in terms of segmental motion and segmental thickening and mapping of the onset of contraction using phase analysis. Myocardial perfusion imaging in terms of flow differences were interpreted using circumferential profile curve analysis.
Results: Patients with abnormal GMPI during dobutamine stress had either a stepwise increase in LVEF, segmental motion, and segmental thickening, or had an initial increase followed by a decrease in segmental thickening in the region of abnormal flow. The findings with echo were identical and simultaneous GMPI of both Tc-99m and Tl-201 following dobutamine stress (that is during recovery) mirrored the results obtained during initiation of dobutamine stress.
Conclusions: MP-SPECT during dobutamine stress allows myocardial ischemia to be detected in areas of abnormal myocardial blood flow, adding an echo dimension to GMPI. Since this data can be detected by GMPI during recovery from stress, this approach can be applied to GMPI performed following physiologic stress studies as well.

2.04
MULTICENTER INVESTIGATION COMPARING A HIGHLY EFFICIENT HALF-TIME STRESS-ONLY ATTENUATION CORRECTION APPROACH AGAINST STANDARD REST-STRESS TC-99M SPECT IMAGING
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Background: New iterative algorithms for scatter compensation (SC), noise suppression, and depth-dependent collimator resolution (RR) can shorten single-photon emission computed tomography (SPECT) acquisition by 50% with quality and accuracy equivalent to conventional scans. Stress-only myocardial perfusion SPECT is accurate and efficient when combined with line-source attenuation correction (LSAC). We investigated the potential for half-time stress-only LSAC-SPECT by comparing this to conventional rest/stress SPECT in patients imaged for suspected coronary artery disease (CAD) at 3 different centers.
Methods: One hundred ten patients (58% men, 53% exercise) had 64 projection rest/stress Tc-99m electrocardiography (ECG)-gated SPECT with simultaneous Gd-153 LSAC: 18 had $\leq$ 5% CAD likelihood and 92 had coronary angiography. The stress scans were retrospectively 'stripped' to create equally spaced 32 projection "half-time" (HT) scans for the emission and transmision (TX) projections. Astonish (Philips, Milpitas, CA) processing with attenuation correction (AC), SC, and RR was applied to the HT data with the HT TX maps reconstructed using a Bayesian iterative method. The conventional rest/stress image sets processed using filtered back projection (FBP) and without AC and the HT-AC stress only images were interpreted in random sequence by consensus of 2 readers blinded to clinical information in separate reading sessions.
Results: Comparing rest/stress FBP and HT-LSAC, stress perfusion quality was excellent/good in 82% and 89% ($p = 0.13$); interpretive certainty (definitely normal or abnormal) was 88% and 95% ($p = 0.14$); sensitivity was 77% and 83% ($p = 0.38$); specificity was 67% and 71% ($p = 0.65$); normalcy was 94% and 100% ($p = 1.0$); Summed stress score for CAD pts was 7.4 vs 7.8 and for non-CAD pts was 0.7 vs 0 ($p = 0.44$ and 0.16 respectively). Mean stress left ventricular ejection fraction was 60% in both groups.
Conclusions: Stress-only imaging with LSAC using the Astonish half-time acquisition/processing method provides results equivalent to conventional rest/stress scanning. This new approach has the potential to significantly improve operational efficiency without sacrificing accuracy.

2.05
A NEW SOLID STATE, ULTRA FAST CARDIAC MULTI-DETECTOR SPECT SYSTEM
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Objectives: To determine the improvements in cardiac imaging performance of a revolutionary single-photon emission computed tomography (SPECT) system design over state-of-the-art, but conventional SPECT dual detector system (Ventri, GE Healthcare).
Methods: The revolutionary design of an Ultra Fast Cardiac (UFC) system (GE Healthcare) uses an array of Cadmium Zinc Telluride (CZT) pixilated detectors simultaneously imaging all cardiac views with no moving parts during data acquisition. Maximum likelihood expected maximization (MLEM)-based iterative reconstruction adapted to the UFC geometry is used to create transaxial slices of the heart. The use of CZT improves the energy and spatial (contrast) resolution while the use of simultaneously acquired views improves the overall sensitivity and gives complete and consistent angular data needed for both dynamic studies and for the reduction of motion artifacts. For both UFC and Ventri systems: 1) energy resolution was measured using a Tc-99m point source, 2) SPECT resolution with scattering was measured by scanning 3 Tc-99m point sources positioned inside a cylindrical water phantom 3) Sensitivity was measured with Tc-99m by summing counts from all projections in 3 ways, a) using a 2.66 mCi point source 15 cm above the patient table, b) using a .63 mCi cardiac phantom placed on the table, and c) using regions of interest placed over the left ventricle from 10 clinical perfusion studies.

Table of Results:

	Energy resolution FWHM (%140 keV)	Central (mm)	Spatial resolution tangential (mm)	Radial (mm)	Point Kcts/sec/ mCi	Sensitivity phantom Kcts/sec/ mCi	Patients Kcts/sec Range
UFC	5.7%	4.9	4.3	4.3	41.24	35.34	2.2-4.7
Ventri	9.4%	10.9	7.5	10.9	5.71	5.57	.53-.67
Ratio	1.65	2.22	1.74	2.53	7.22	6.34	4.1-7.0

Conclusions: Compared to the Ventri, the UFC demonstrated improvements of 1.65 fold for energy resolution, 1.7-2.5 fold in spatial resolution and 5-7 fold for sensitivity. These significant improvements will allow shorter acquisition times and improved patient throughput and/or lower patient radiation doses. The overall UFC design promises to usher in a new era of dynamic SPECT imaging and flow quantification.

2.06
VALUE OF 18F-FDG POSITRON EMISSION TOMOGRAPHY IN THE ASSESSMENT OF INFLAMMATORY ACTIVITY IN TAKAYASU'S ARTERITIS
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Background: Takayasu's arteritis (TA) is a vasculitis that affects primarily large vessels. The progression of TA is characterized by inflammatory activity. Traditionally, the assessment of inflammatory activity is made indirectly by clinical evaluation. With 18F-FDG positron emission tomography (PET) it is possible to quantify inflammation in the arterial wall. This study presents one of the largest reported series of patients with TA and 18F-FDG PET. Its aim is to determine the usefulness of this method in the identification of inflammatory activity in patients with TA.
Methods: Thirty-five patients diagnosed with TA were studied. A clinical evaluation of activity using the criteria described by Dabague was performed on every patient by two experienced rheumatologists. Clinical active patients are defined as having 5 or more points in the Dabague criteria. A 15mCi dose of 18F-FDG was injected intravenously to all patients. Image acquisition was performed for 40 minutes, with transmission for attenuation correction followed by emission. 18F-FDG uptake was analyzed in the aorta and carotid arteries. 18F-FDG uptake was quantified using the standard uptake value (SUV) defined as a tissue activity concentration divided by the total activity injected per body weight. SUV of less than 1.2 was considered as inactive while higher values were considered as active.
Results: There were studied 35 patients with TA with mean age 31 $\pm$ 11. The mean value for activity measured with PET was SUV 1.2 (0 min and

4.5 max). The mean value of points for the Dabague clinical assessment criteria activity was 3.94 (0 min and 8 max). For the number of patients with active or inactive inflammation by PET and clinical assessment, see Table 1.
Conclusions: 18F-FDG PET detects inflammatory activity in patients who appear to be clinically inactive. 18F-FDG PET can help identify activity in a non-invasive approach so the treatment can be correctly given to patients with TA and inflammatory activity.

Table 1. Number of patients with active or inactive inflammation by PET and clinical assessment

	Active inflammation by PET analysis	Inactive inflamation by PET analysis
Active Inflammation by Clinical Assessment	15 patients	1 patient
Inactive Inflammation by Clinical Assessment	9 patients	10 patients

2.07

ENHANCING NUCLEAR CARDIAC LABORATORY EFFICIENCY: MULTICENTER EVALUATION OF A NEW POST-PROCESSING METHOD WITH DEPTH-DEPENDENT COLLIMATOR RESOLUTION APPLIED TO FULL- AND HALF-TIME ACQUISITIONS WITH SIMULTANEOUSLY ACQUIRED GD-153 LINE SOURCE ATTENUATION CORRECTION

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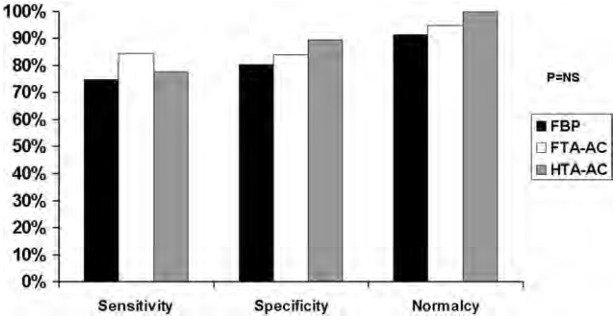
Background: A recently developed iterative reconstruction algorithm with depth-dependent resolution recovery (Astonish, Philips Medical System), performed without attenuation correction (AC), demonstrated improved image quality with full-time (FTA) and half-time (HTA) acquisition but revealed a trend for lower specificity and normalcy when compared with traditional filtered backprojection (FBP). This study evaluated the impact of simultaneously acquired Gd-153 line source AC with FTA and HTA with regard to image quality, interpretative certainty and diagnostic accuracy.
Methods: We studied 190 patients (132 with cardiac catheterization and 58 with low likelihood for CAD) from 3 nuclear cardiology laboratories having clinically indicated rest/stress Tc-99m sestamibi or tetrofosmin single-photon emission computed tomography (SPECT). Acquisition followed American Society of Nuclear Cardiology guidelines (64 projections, 20-25 seconds). Processing of the full data set included (FBP) and Astonish (FTA). Thirty-two projection data sets were created by full data set stripping and processed with Astonish (HTA). AC was applied to Astonish processed images (FTA-AC and HTA-AC). A consensus interpretation of 3 blinded readers was performed for image quality, interpretative certainty, and diagnostic accuracy.
Results: Image Qualities (excellent/good) for stress and rest perfusion were 84.7%/80% (FBP), 92.6/90% (FTA-AC) and 91.1/84.2% (HTA-AC), respectively ($p = 0.03$ for stress and $p = 0.025$ for rest comparisons). FTA-AC and HTA-AC improved significantly interpretative certainty ($p = 0.003$) with a marked reduction in the combined category of probably normal, equivocal, or probably abnormal interpretations (FBP 11.1%, FTA-AC 3.2% and HTA-AC 3.2%) In comparison with FBP, AC preserved diagnostic accuracy with trends for higher sensitivity with FTA-AC and higher specificity and normalcy with HTA-AC. (Figure 1)

Figure 1.



Conclusions: Full-time and half-time acquisition Astonish with simultaneously acquired line source AC improved image quality and interpretative certainty while preserved sensitivity, specificity, and normalcy rates. Therefore, half-time acquisition with AC may enhance laboratory efficiency without sacrificing image quality or diagnostic accuracy.

2.08

VALIDATION OF PROMPT GAMMA CORRECTION FOR 3D RB-82 MYOCARDIAL PERFUSION PET/CT IMAGING

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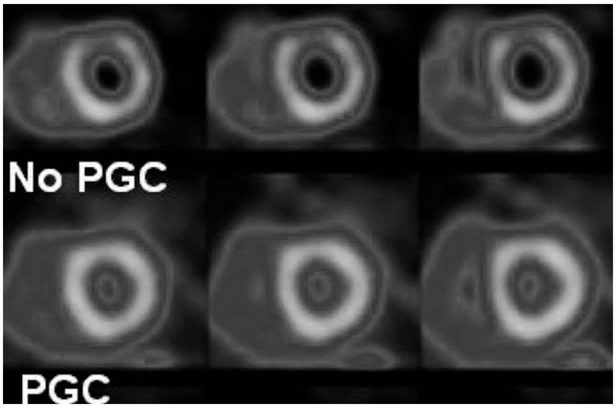
Background: Accurately correcting for the scatter component in 3D Rb-82 myocardial perfusion positron emission tomography (PET) images can be challenging because of contamination from the high-energy gamma photon emission (13%, $E = 776.5$ keV). This prompt gamma produces an additional background that can result in overcorrection for scatter, causing exaggerated defects and artifacts. We validated a new scatter correction method that incorporates prompt gamma correction (PGC) to compensate for the contamination.
Methods: Forty patients with a clinically indicated electrocardiography (ECG)-gated rest/dipyridamole-stress Rb-82 scan on a Biograph-16 PET/CT (Siemens, Knoxville, TN) were reprocessed with and without the PGC technique. PGC was performed by fitting and normalizing the background activity in the simulated scatter sinogram from single scatter simulation (SSS) before subtraction. Relative perfusion (pixel/max pixel*100) was measured with quantitative perfusion single-photon emission computed tomography (SPECT) by vascular territories, and left ventricular ejection fraction (LVEF) was measured by quantitative gated SPECT. Image contrast (IC) defined as $(C_{normal\ wall}\text{-}C_{blood\ pool})/\ C_{normal\ wall}$ was analyzed using manually drawn regions of interest (ROI).
Results: Visual inspection of the scatter corrected sinogram with PGC from 40 patients demonstrated higher count density in regions of high attenuation presented in anterior and lateral views. The difference of count density was more prominent in patients with large breasts ($n=12$) or large diaphragm ($n=9$). Quantitative analysis of relative perfusion overall showed that PGC increased uniformity by 4.57% LAD, 6.43% RCX, and 4.71% LCX ($p<0.001$). IC was also recovered by 19.8% for stress and rest=15.3% ($p<0.001$). LVEF did not significantly change ($\Delta = (4.1 \pm 2.8)\%$ stress and $(4.5 \pm 3.5)\%$ rest). In a limited subset of 9 patients with angiography and referred to CATH based on PGC results, 8 (88%) had true positive angiographic results ($\geq$ 50% coronary artery stenosis).
Conclusions: Prompt gamma correction improves the accuracy of the PET images. This correction likely will result in reducing false positive findings while still preserving true positive findings in 3D Rb-82 images.



2.09

VALIDATION OF QUANTITATIVE ANALYSIS OF HIGH-SPEED MYOCARDIAL PERFUSION IMAGING: COMPARISON TO CONVENTIONAL SPECT IMAGING

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Background: A novel high-speed single-photon emission computed tomography (SPECT) technology (D-SPECT), employing cadmium zinc telluride (CZT) crystal arrays, has been shown to detect a similar amount of perfusion abnormality by visual analysis of myocardial perfusion imaging (MPI) compared to conventional Anger SPECT camera (A-SPECT), in one fifth the acquisition time. This study validates normal limits for quantitative analysis of D-SPECT, defines criteria for abnormality, and compares quantitative results to A-SPECT in a pilot patient sample.
Methods: Normal limits were obtained from 59 patients (pts) with low prescan likelihood of CAD, who underwent A-SPECT and D-SPECT rest/stress Tc-99m sestamibi ($n = 40$) or tetrofosmin ($n = 19$) MPI at four U.S. centers (Cedars Sinai Medical Center, Baptist Hospital of Miami, Brigham and Women's Hospital, and Vanderbilt University Medical Center) as part of a multicenter clinical trial designed to validate the D-SPECT camera. Rest and stress imaging times for D-SPECT were 4 and 2 minutes, respectively. These normal limits were validated in 54 pts with intermediate-high likelihood of CAD, who underwent stress/rest Tc-99m sestamibi A-SPECT and D-SPECT MPI at University College London Hospitals (London, UK). Images were analyzed using quantitative perfusion SPECT (QPS, CSMC), and total perfusion defect (TPD) was calculated for D-SPECT and A-SPECT. In addition, images were visually scored (conventional 17-segment, 5-point scale). Visual % perfusion abnormality was calculated as summed stress or rest score divided by 68 (maximal score). Quantitative TPD by D-SPECT was compared to visual % perfusion abnormality, and criteria for defining abnormal TPD for stress and rest were obtained by Receiver Operator Characterisics (ROC) curve analysis.
Results: Quantitative TPD (%) for D-SPECT correlated linearly to visual % perfusion abnormality over a wide rage of perfusion abnormality at stress and rest ($r = 0.91$, 0.92, repectively, $p < 0.0001$). D-SPECT TPD also correlated excellently to A-SPECT TPD at stress and rest ($r = 0.92$, $r = 0.97$, respectively, $p < 0.0001$). Bland Altman analysis demonstrated that most differences between quantitative and visual D-SPECT measurements were between the mean $\pm$ 2 standard deviations for stress and rest (1.22% $\pm$ 9.93% and -0.64% $\pm$ 9.21%, respectively). ROC analysis for quantitative D-SPECT TPD with the visual % perfusion abnormality as the gold standard generated an area under the curve of 0.91 for stress and 0.92 for rest ($p < 0.001$ vs 0.5). A threshold of TPD 3.5% for D-SPECT, provided sensitivity and specificity of 82% and 85 %, respectively for detecting visual perfusion abnormality at stress, and 85% and 90%, respectively for detecting visual perfusion abnormality at rest.
Conclusions: Quantitative analysis of high-speed MPI, using specifically developed normal limits is highly sensitive and specific for detecting perfusion abnormality, and correlates excellently to quantitative analysis of conventional SPECT MPI.

2.10
LOW VOLTAGE, LOW TUBE CURRENT COMPUTED TOMOGRAPHY ANGIOGRAPHY IS DIAGNOSTICALLY FEASIBLE IN OVERWEIGHT, BUT NOT OBESE, INDIVIDUALS
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Background: Computed tomography angiography (CTA) of the coronary arteries is proving to be an exciting imaging technique. Its promise, however, is somewhat limited by significant radiation exposure. There has been some recent success with a low voltage, low tube current protocol to reduce radiation exposure. It is unclear whether this low voltage, low tube current protocol can be performed on all patients.
Methods: In this study, 235 patients underwent CTA with a tube voltage of 100 kV, a tube current of 300-450 mA, and a stringent electrocardiography (ECG)-dose modulation program (whereby the systolic current was decreased to 20% of the diastolic current). Radiation dose estimates and indices of image quality were calculated. We also evaluated the effect of coronary artery calcium (CAC) and body mass index (BMI) on image quality with this low voltage, low tube current protocol.
Results: The low voltage, low tube current protocol was associated with an estimated radiation dose of 5.1 $\pm$ 0.8 mSv. No significant effect upon image quality was noted with the extent of CAC (Table 1). On the other hand, image quality degraded with increasing BMI (Table 2). A semi-quantitative analysis revealed satisfactory and diagnostic image indices to a threshold BMI $\leq$ 30 kg/m2.
Conclusion: In conjunction with ECG-dose modulation and a lowered tube voltage, decreasing tube currents is diagnostically feasible and lowers radiation exposure significantly in non-obese patients.

Table 1. Impact of coronary artery calcium on image quality

	CAC 0 n=22	CAC 1-399 n=88	CAC ≥ 400 n=143
Image Noise, HU	54.2 ± 19.3	56.5 ± 18.4	57.7 ± 19.5
Signal-to-Noise Ratio	10.1 ± 3.2	9.3 ± 3.7	10.1 ± 4.1
Dose Estimate, mSv	4.5 ± 0.55	4.8 ± 0.90	4.9 ± 0.69

Table 2. Impact of BMI on image quality

	BMI 18-24.9 n=73	BMI 25-29 n=134	BMI ≥ 30 n=46
Image Noise, HU	49.3 ± 16.8	56.2 ± 18.4	71.0 ± 17.9
Signal-to-Noise Ratio	11.8 ± 4.5	9.7 ± 3.2	6.9 ± 2.6
Dose Estimate, mSv	4.6 ± 0.77	4.8 ± 0.64	5.1 ± 0.99

2.11
D-SPECT MYOCARDIAL PERFUSION IMAGING PROVIDES BETTER IMAGE QUALITY IN OBESE PATIENTS — RESULT OF A MULTICENTER TRIAL
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Background: D-SPECT, a novel high-speed single-photon emission computed tomography (SPECT) myocardial perfusion imaging (MPI) camera, has recently been shown to provide fast MPI with high image quality in a nonselected population. Image quality in obese patients tends to be degraded. Therefore, we aimed to compare the results of D-SPECT vs. conventional Anger camera SPECT (A-SPECT) MPI studies in obese patients.
Methods: Forty two patients (age $= 54 \pm 14$, M 45%, weight $= 118 \pm 24$ kg, body mass index $= 42 \pm 6$) underwent same-day Tc-99m sestamibi rest / stress MPI. D-SPECT images acquisition was performed within 30 min after A-SPECT. Images were visually analyzed on separate occasions by consensus of two independent experienced nuclear cardiologists blinded to the scores given for the other imaging modality. Summed stress score (SSS) and summed rest score (SRS) were calculated. Images were qualitatively assessed with a 5-point scale. SSS 1-3 was considered equivocal.
Results: SSS and SRS were 1.3 $\pm$ 3.2 vs. 3.5 $\pm$ 3.8 and 0.8 $\pm$ 2.7 vs. 1.9 $\pm$ 3.1 for D-SPECT and A-SPECT, respectively, $p < 0.01$ for both comparisons. The rate of good or excellent image quality was 97% vs. 77% for D-SPECT and A-SPECT respectively, $p < 0.01$. Grade 1 segmental perfusion defect (equivocal) was considered present in 15 of 714 (2%) vs. 101 (14%) of the D-SPECT and A-SPECT studies, respectively, $p < 0.05$. On a patient basis, the rate of equivocal studies was 6 of 42 (14%) vs. 22 of 42 (52%) for D-SPECT and A-SPECT, respectively, $p = 0.01$. SSS=1 was found in 1 vs. 8, SSS=2 in 3 vs. 8, and SSS=3 in 2 vs. 6 for D-SPECT and A-SPECT equivocal studies, respectively.
Conclusions: In obese patients, D-SPECT provided better image quality than A-SPECT and reduced the rate of equivocal segments and studies.

2.12
INITIAL PERFORMANCE EVALUATION OF AN ULTRA-FAST CARDIAC SPECT CAMERA — A PHANTOM STUDY
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Background: Myocardial perfusion imaging (MPI) with single-photon emission computed tomography (SPECT) remains critically important for assessing and managing patients at risk for coronary artery disease and cardiac events. However conventional methods of MPI SPECT involve long procedure times which compromises cost-effectiveness and overall diagnostic quality. For this reason, a novel cardiac imaging system has been

developed to significantly improve sensitivity versus that for conventional SPECT, thereby decreasing acquisition time and improving patient throughput without compromising image quality. We compare image characteristics from the new system with a five-fold reduction in acquisition time, to those obtained from conventional SPECT.
Methods: The new "ultra-fast cardiac" (UFC) system (GE Healthcare) incorporates a multi-detector array of Cadmium Zinc Telluride (CZT) detector modules simultaneously imaging all cardiac views with no moving parts during data acquisition. Transaxial slices of patient heart are reconstructed from the projection views using MAP iterative algorithm adapted to model UFC system. Image data were acquired experimentally using a Data Spectrum anthropomorphic torso phantom and simulating realistic male and female anatomy, uptake and perfusion defect variations typical for perfusion imaging. Scans were repeated with the novel and conventional SPECT (Ventri) cameras, resulting in a total of 21 scans on each system. Post-reconstruction, estimated count values on the mid-myocardial surface were assessed to calculate the normalized standard deviation (NSD) for the uniform (healthy) myocardium and the normalized contrast (NC) for known defect volumes. Segmental uptake for a 17-segment heart model was used to calculate agreement between reconstructed distributions obtained with the novel and conventional systems.
Results: UFC data exhibits better uniformity and similar defect contrast. (Table 1)
Conclusions: The new cardiac SPECT camera provides myocardial perfusion images with characteristics similar to those obtained with a conventional camera with a 5-fold reduction in the acquisition time.

Table 1.

Phantom type	Linear correlation coefficient of UFC and Ventri mean segment scores over 8 phantom uptake and anatomy variations	% scores differences between UFC and Ventri within 2SD
Uniform	0.93	87
Defects in septal and lateral walls	0.94	92
Defects in anterior and inferior walls	0.84	96

2.13
SIGNIFICANCE OF THE UNCERTAIN GROUP IN THE APPROPRIATENESS CRITERIA: TREATED AS APPROPRIATE OR INAPPROPRIATE IN A CONSECUTIVE PRE-REFERRED OUT-PATIENT POPULATION

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Background: The Appropriateness Criteria (AC) for single-photon emission computed tomography myocardial perfusion imaging (SPECT MPI) was established to improve the effective use of imaging. However, how to handle the Uncertain group for appropriate use in real world practice is still unclear and not well studied. In addition, most studies use patients after referral to the nuclear lab and thus do not adequately address the utilization in the general patient population seen in clinical practice. Analysis of appropriate MPI use before referral to the nuclear lab is critical to assess the potential impact of AC on MPI utilization patterns in the real world.
Methods: Consecutive 656 outpatients from cardiology and primary care clinics were selected for analysis. They were first categorized based on the presently used Clinical Practice Guidelines (CPG) and Medicare Reimbursement Guidelines (MRG) as Indicated or Not-Indicated for MPI. The same patients were then re-categorized as Appropriate, Inappropriate, or Uncertain based on the AC. Statistical analysis was performed with the chi-squared test.
Results: Out of the 656 patients, 175 (27%) were Indicated for MPI based on the CPG/MRG while only 123 (19%) patients were Appropriate based on AC. This results in a 30% relative *decrease* in MPI. The Uncertain group consisted of 135 patients accounting for 20% of the total population. Treating the Uncertain group as Appropriate would lead to a relative *increase* of 47% (258 vs. 175 patients).
Conclusion: This is the first study analyzing the potential impact of the Uncertain group on MPI utilization using the AC. Our study suggests that MPI utilization may *decrease* by ~30% if the Uncertain group is not treated as Appropriate; while on the other hand it may *increase* by 47% if treated as Appropriate. How to handle the Uncertain group is clearly the key to optimizing the effective use of MPI. Further study of the Uncertain group is warranted.

CPG/MRG	Appropriateness criteria		
Indicated	Appropriate	Uncertain	Uncertain + Appropriate
175 27%	123* 19%*	135 20%	258# 39%#

2.14
AN OPTIMIZED ITERATIVE RECONSTRUCTION AND PROCESSING PROTOCOL FOR 'HALF-TIME' (32 PROJECTION) REST/STRESS TC-99M-SESTAMIBI MYOCARDIAL PERFUSION SPECT

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Background: New reconstruction methods modeling the physics of single-photon emission computed tomography (SPECT) can theoretically reduce study acquisition time by one-half compared with conventional protocols. The goal was to determine optimal reconstruction parameters for rest/stress Tc-99m-sestamibi (mibi) studies for 32 and 64 projections with the ordered subset expectation maximization (OSEM)-based Astonish™ software (Philips Medical Systems) as a basis for clinical validation studies.
Methods: The strategy investigated a range of parameters in phantom experiments for subsequent evaluation on a limited group of patient studies. An anthropomorphic cardiac phantom depicting stress Tc-99m-mibi uptake and a 'cold' (0 activity), 45^0 transmural defect was imaged with 32 and 64 projections, 180º RAO-LPO orbit 8 frames/cycle, low-energy high-resolution collimation, 10, 20 and 30s/projection on a CardioMD™ dual 90º system. OSEM parameters were varied; iterations (IT) 3-8 ($\Delta = 1$), subsets (SS) 4-12 ($\Delta = 1$), and an algorithm-specific matched filter parameter (F) from 0.6-1.5 ($\Delta = 1$). Defect-to-normal contrast (DC) and normal short axis wall uniformity (U) were evaluated. Twenty (20) clinically-indicated 64 projection rest/stress Tc-99m-mibi SPECT studies (10 mCi rest/30 mCi stress) were studied in two groups: 1) 10 (5M) with < 5% likelihood (LL) for coronary artery disease (CAD), body mass index (BMI) 29.6 ± 4.6 kg/m^2 and 2) 10 (5M) with cath-confirmed CAD, BMI 30.3 ± 4.1 kg/m^2. All studies were 'stripped' generating 32 projections for analysis. Summed stress, difference, and rest scores (SSS, SDS, SRS), and stress left ventricular ejection fraction (LVEF) were compared.
Results: *Cardiac Phantom*: Median values (IT = 4, SS = 8, F = 1.0) yielded U (mean ± SD) of 0.76 ± 0.17 (64), 0.72 ± 0.18 (32) and 0.69 ± 0.20 (FBP). DC values were 0.48 (64), 0.53 (32) and 0.54 (FBP). Unacceptable image degradation occurred when IT was < 3 or > 6, SS was < 4 or F was < 0.8 or > 1.3, thereby defining a 'neighborhood' of acceptable values. *Patient Studies*: Processing using IT = 4, SS = 8, F = 1.0, scoring for the LL group was SSS: 1.0 ± 3.2 (64), 1.6 ± 5.0 (32) and 1.1 ± 4.0 (FBP). SDS was 1.0 ± 3.2 (64), 1.6 ± 5.0 (32), and 0.5 ± 3.0 (FBP); SRS was 0.0 ± 0.0 (64), 0.2 ± 0.6 (32), and 0.0 ± 0.0 (FBP) (p = NS). For the CAD group, SSS was 20.7 ± 8.4 (64), 19.6 ± 9.6 (32) and 19.0 ± 7.0 (FBP) (p = NS), SDS was 12.0 ± 6.8 (64) 12.1 ± 7.5 (32) and 11.8 ± 4.0 (FBP) (p = 0.48). SRS was 7.8 ± 9.9 (64), 8.0 ± 9.5 (32) and 7.0 ± 7.1 (FBP) (p = NS). An F value of 0.8 was selected for electrocardiography-gating reconstruction. Stress LL LVEF was 71% ± 10% (64), 70% ± 11% (32) and 67% ± 9% (FBP) (p < 0.5). Stress CAD LVEF was 53% ± 10% (64), 53% ± 10% (32) and 52% ± 9.6% (FBP) (p = NS).
Conclusions: Thirty-two and 64 projection Astonish™ images reconstructed using 4 iterations, 8 subsets and 1.0 filtering (perfusion) and 0.8 (gated) gating provide equivalent and high quality studies and are recommended for subsequent clinical validation studies.

2.15
REPEAT STRESS MYOCARDIAL PERFUSION IMAGING AFTER A NORMAL RESULT: WHICH PATIENTS ARE AT HIGHER RISK FOR CARDIAC EVENTS?

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Background: The temporal characteristics of risk after a normal myocardial perfusion imaging study (MPI) have been described in the literature, but the value of repeat testing in groups predisposed to coronary events is unknown.
Methods: We studied 1,160 patients from 1996 to 2003 with previous normal studies, no history of CAD, and who underwent clinically indicated repeat MPI. The mean time between tests was 3.1 ± 1.8 years. Sub-groups were evaluated by age (< 75 vs. ≥ 75), gender, chest pain (presence vs. absence), diabetic status, type of stress (pharmacologic vs. exercise), and resting electrocardiogram (ECG) interpretation (normal vs. abnormal). Patients were followed for increased clinical risk of cardiac death/non-fatal myocardial infarction (CD/NFMI). Cox Regression (CR) analysis was performed to determine independent predictors of adverse cardiac outcome.
Results: In follow-up, 80 patients suffered CD/NFMI. The annualized event rate was 2.2%, with a mean follow-up of 3.1 ± 1.8 years. Repeat testing revealed 222 patients (19.0%) had abnormal MPI while 938 (81.0%) remained normal, with annualized CD/NFMI event rates of 6.3% and 1.3%, respectively ($p < 0.001$). Annualized event rates were significantly higher for subjects exhibiting abnormal vs. normal repeat MPI in all sub-groups (4.7-8.1% vs. 0.6-3.0%, respectively; p = 0.025 to < 0.001). CR identified, in order of significance, abnormal repeat MPI, pharmacologic stress, male gender, and age ≥ 75 as independent predictors of CD/NFMI (Table 1). Referral for evaluation of chest pain was not an independent predictor in multivariate analysis. An abnormal resting ECG and the presence of diabetes were not found to be statistically significant predictors of CD/NFMI in either univariate or multivariate analyses. The addition of repeat MPI data to clinical variables resulted in a significant increase in the global chi-square (47.9 to 99.4, $p < 0.001$).

Table 1.

Sub-group	Wald	*P*	Odds ratio (95% confidence interval)
Abnormal Repeat MPI	35.5	<0.001	3.95 (2.51-6.21)
Pharmacologic Stress	21.3	<0.001	3.20 (1.95-5.25)
Male Gender	15.1	<0.001	2.44 (1.56-3.82)
Age >=75	8.2	0.004	1.97 (1.24-3.14)
Chest Pain	4.4	0.036	0.62 (0.39-0.97)

Conclusion: Repeat MPI is a valuable tool in identifying patient sub-groups at increased risk of CD/NFMI. An abnormal repeat MPI significantly increases the likelihood of an adverse cardiac event despite a previously normal study, while a normal repeat study conveys an ongoing excellent prognosis.

2.16

A METHODOLOGY FOR CHARACTERIZATION OF CORONARY ATHEROSCLEROSIS USING DUAL-SOURCE COMPUTED TOMOGRAPHIC CORONARY ANGIOGRAPHY

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Introduction: Computed tomographic coronary angiography (CTCA) offers the opportunity for evaluating both the lumen of coronary arteries and also the vessel wall, including the characteristics of plaques contained within the wall. We describe a methodology for characterizing coronary atherosclerosis using CTCA.
Methods: CTCAs from consecutive patients were evaluated independent of clinical information. Data were acquired on a dual-source Siemens Definition CT scanner using our clinical imaging protocol (120 kVp, 450 equivalent mAs (8 mSv), pitch=0.6 and 0.75 mm3 voxel) with Optiray 350. Final image data were filtered using a 0.3/Nyquist low pass filter. For each CTCA, the three major coronary arteries were evaluated for the number of plaques (NUM). Each plaque was evaluated for degree of occlusiveness (OCC: 1 = 1-10%, 2 = 11%-50%, 3 = 51%-90%, 4 = > 90%), remodeling (REM: 1 = 1-10%, 2 = 11%-50%, 3 = 51%-90%, 4 = > 90%), calcification (CAL: 1 = lipid, 2 = mostly lipid, 3 = mostly calcium, 4 = calcium), length (LEN: mm), and location within the coronary artery (LOC: 100% most proximal to 0% most distal). A coronary artery calcium score (CACS) was also generated for each patient.
Results: Sixty-seven patients (pts) were evaluated (35 were female; mean age = 59 +13 yrs; mean CACS = 113 + 218). A total of 416 plaques were evaluated through a univariate comparison of LEN, CAL, REM, OCC, CACS, and NUM according to gender, age and presence of risk factors (age, smoking, hypertension, diabetes mellitus, family history, hypercholesterolemia). Age > 60 yrs was associated with a greater number of plaques, 7 vs 5, p = 0.012; higher total lipid content, 146.6 vs 33.3, p = 0.03; and higher CACS, 99.7 vs 33.3, p = 0.006 but no significant differences were observed in the other measured indices. The age-related differences in plaque morphology were confined to women: number of plaques, 6.5 vs 5.0, p = 0.032; total lipid content, 172.9 vs 29.9, p = 0.003, and CACS 99.6 vs 25.4, p = 0.017 with no significant age-related differences being observed in men. Differences in plaque morphology were also seen in pts with a greater number of risk factors. Patients with > 3 risk factors had more plaques 6 vs 5, p = 0.029; higher total lipid content 122.1 vs 36.4, p = 0.023; higher CACS 89.5 vs 33.3, p = 0.056, and more evidence of remodeling 1.6 vs 1.4, p = 0.049.
Conclusions: In this preliminary study, we were able to successfully characterize plaque morphology using dual-source CTCA. In addition, we identified significant differences in plaque morphology in the different sub-groups studied, including age, gender, and number of coronary risk factors.

2.17

VISCERAL FAT VOLUME IS UNRELATED TO ADIPOSE TISSUE INFLAMMATION

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Background: Inflammatory cytokines released from white blood cells in visceral adipose tissue may contribute to the metabolic syndrome. Computed tomography (CT)-derived values of visceral adipose mass have been proposed to quantitate the severity of this process. We hypothesized that patients (pts) with whole body positron emission tomography (PET)/CT imaging in the fasting state with FDG for benign causes would exhibit a relationship between the CT volume of abdominal visceral adipose tissue and inflammation within the tissue, as assessed by standardized FDG uptake (SUV) PET measurements.
Methods: A review of pts with whole body PET/CT imaging was performed to identify individuals without a malignant or systemic inflammatory process. In 41 pts, a benign process was confirmed by serial CT exams or by tissue biopsy. Fifteen pts had untreated hyperlipidemia, 20 pts with hyperlipidemia were on statins, while 6 controls did not have hyperlipidemia and were not on statin therapy. Volumetric measurements of abdominal visceral adipose tissue were obtained directly from the CT scans by an observer unaware of the patient's clinical status. SUV measurements of the visceral adipose tissue were obtained in right and left upper and lower quadrants and averaged. An index of the total inflammatory burden was derived by multiplying the average adipose tissue SUV by its volume.
Results:

	Visceral fat volume (ml)	Visceral fat SUV	Product SUV x volume
Hyperlipidemia - no Rx (n=15)	5697 ± 3370	0.58 ± 0.14	2983 ± 1557
Hyperlipidemia-statins (n=20)	4857 ± 2435	0.64 ± 0.13	3025 ± 1477
Controls (n=6)	3722 ± 2123	0.65 ± 0.12	2386 ± 1345

On ANOVA, P = NS for fat volumes, SUVs and SUV-volume products.

No relationship was noted between visceral fat volumes and SUV values for the statin-treated pts and controls. An inverse linear relationship was noted between visceral fat volumes and SUV values in the untreated pts ($SUV = -2.78 \times 10^{-5} \times Volume + 0.73$, $r = -0.652$, $p < 0.01$)
Conclusions: PET FDG SUV measurements of visceral fat inflammation are unrelated to visceral abdominal fat volume in statin treated pts and controls. An *inverse* relationship between visceral adipose volume and the degree of inflammation exists in untreated pts. This suggests that volume measurements alone incompletely characterize the severity of the inflammatory process. Further studies are warranted to ascertain if simultaneous anatomic (volume) and physiologic (SUV's) measurments provide more accurate characterization of the state of inflammation in visceral adipose tissue.

2.18

ARE THE APPROPRIATENESS CRITERIA FOR CARDIAC COMPUTED TOMOGRAPHY REALLY "APPROPRIATE": A SINGLE CENTER CROSS-SECTIONAL REVIEW

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Background: Cardiac computed tomographic angiography (CTA) has evolved into a robust non-invasive technique to evaluate coronary artery disease (CAD). The American College of Cardiology Foundation/American Society of Nuclear Cardiology/Society for Cardiovascular Computed Tomography published appropriateness criteria for CTA in 2006. We intend to assess the distribution of CAD amongst patients (pts) with appropriate, uncertain, and inappropriate criteria for CTA. The study also examines the current utilization pattern of CTA in a large community-based cardiology practice.

Methods: We performed a single center cross-sectional review of pts referred for CTA in this practice from November 2007 to March 2008. Data was collected on 69 consecutive pts. Pts were divided into three categories based on the guidelines: appropriate, uncertain, or inappropriate. CTA results were further divided into three groups: obstructive CAD (defined as at least one lesion with stenosis $> 50\%$), non-obstructive CAD, and normal. Chi-square and Student t-tests were used to compare categorical and continuous variables respectively.

Results: Sixty-nine CTA studies were examined. The average age of the group was 64 years and 55% were males. Hypertension, hyperlipidemia, diabetes, smoking, and h/o CAD was found in 44 (64%), 53 (77%), 6 (9%), 9 (13%), and 18 (26%) pts respectively. Symptomatic (chest pain) and asymptomatic CAD was the indication in 45% and 28% of pts, respectively. According to the appropriateness criteria for CTA, 20 (29%) pts had appropriate, 13 (19%) had uncertain, and 36 (52%) had inappropriate indications. Sixteen pts (23%) had significant CAD, 24 (35%) had non-obstructive CAD and 23 (33%) had no CAD while 5 CTA studies were non-diagnostic. Distribution of CAD in pts without known CAD (n = 46) in the three categories is shown in Table 1.

Table 1. Distribution of CAD in pts without known CAD (n=46) in the three pre-defined categories

Indication	Obstructive CAD n(% of row total)	Non-obstructive CAD n(% of row total)	Normal n(% of row total)	Total n(% of column total)
Appropriate	4 (25)	7 (44)	5 (31)	16 (35)
Uncertain	2 (33)	1 (17)	3 (50)	6 (13)
Inappropriate	3 (13)	9 (38)	12 (50)	24 (52)
Total	9 (20)	17 (37)	20 (43)	46 (100)

Conclusions: Chest pain evaluation is the most common indication for CTA in our study while 52% of the tests performed would be considered "inappropriate" according to the published guidelines. Although, we studied a small group of pts, frequency and severity of CAD was not significantly different among the three pre-defined categories.