between the area of the hot rectangle in the HR image and the same area in the phantom (object). We estimated uniformity by taking the quotient between the standard deviation in the hot rectangle area and the mean of counts in the same area. All the calculations were performed for each iteration of the algorithm. Conclusions: Positioning errors have consequences both on blurring and uniformity in a nonlinear form. Small levels of error can be compensated with more iterations, however high frequencies are increased. For large positioning errors unpredictable artifacts can arise.

P506

Evaluation of a SPECT collimator-detector response (CDR) software in phantom and ^{99m}Tc-labeled WBC

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Objectives: The diagnostic accuracy of SPECT reconstructed images is influenced by several factors that degrade image quality: attenuation, scatter and collimator detector response(CDR). 3D models for CDR geometric component degrading effects compensation are commercially available. We evaluated on a phantom study and clinical applications the "Evolution for Bone" software, developed by GE Healthcare for Bone Scintigraphy and the possibility of acquisition time reduction. **Methods**: Tomographic spatial resolution was evaluated using three linear sources of Tc-99m parallel to the axis of rotation and at radial distance of ± 7.5 cm. Noise and contrast were evaluated with a Jaszczak phantom respectively without and with hot sphere (concentration ratio 6:1). On a second time 17 patients were evaluated: 14 with bone disease (9 symptomatic prosthesis, 5 suspected osteomyelitis) and 3 vascular prosthesis. Two tomographic acquisitions were acquired, each of 15 seconds/projection, to create standard 30 seconds/projection acquisition as sum of them. 5 sets of reconstruction were compared (see the table for description). Images along all axis were analyzed by visual inspection by use of a 3-point scoring system. Lesion dimensions were evaluated as horizontal and vertical FWHM. Target-background ratio TBR was calculated in the most representative image of each lesion. **Results:**We measured a better resolution using iterative reconstruction OSEM vs FBP both in phantom and in patients (t-student FBPvsOSEM test p<0.0001); we didn't find any change using resolution recovery or half time acquisition vs OSEM**.** Image noise didn't change using OSEM instead of FBP, while it was improved by Evolution: in particular Evolution permitted a reduction of time per projection without lost of image quality vs standard FBP. The same considerations were possible for TBR evaluation. At visual inspection we registered an improvement using OSEM and RR (Fisher's exact test p<0.0001) .

	Phantom study			Patient study		
	Resolution Mean±SD	Noise %	Contrast %	Lesion Dimension Mean±SD (10 lesions)	Visual Inspection N° patients with maximum score	TBR Median (range) (18 lesions)
FBP *FullTime*	17.6±0.4	2.50	41	22±5.8	0	6.70 (1.50-19.32)
OSEM *FullTime*	14.1±0.3	2.35	44	18.4±4.9	6	6.10 (1.63-31.22)
Evolution *FullTime*	13.2±0.6	1.86	42	18.0±5.0	11	7.46 (46.55-1.86)
OSEM *HalfTime*	14.1±0.4	3.26	44	18.3±4.8	3	5.99 (1.69-40.16)
Evolution *HalfTime*	13.1±0.6	2.37	42	18.2±5.0	10	6.75 (1.93-55.26)

Conclusions: Evolution for bone software allows reduction of acquisition time in clinical applications without compromising image quality. Our results also confirmed a resolution improvement using an OSEM reconstruction instead of FBP.

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Digital measurements on 3D scintigraphic cardiac studies improve visualization and diagnosis of heart disease

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Aim Heart scintigraphy provides information with respect to the detection of myocardial perfusion defects, the assessment of the pattern of defect reversibility and the overall detection of CAD. We aim to define the relationship between the location and the degree of the stenosis in coronary arteries with the observed perfusion on the myocardial scintigraphy, using data of 3D images of myocardium This allows us to predict the impact evolution of these stenoses to justify a coronarography or to avoid it . The benefit of High Performance Computing in Software Aided Diagnostics can be also applied to the 3-Dimensional visualization and measurements on the 3D cardiac scintigraphic images; and defects of the cardiac structure can be emerged. **Method**: 120 cardiac patients had completed stress (Tc99m tetrofosmin at stress peak) and rest SPECT test by a GE Starcam 4000 tomographic gamma camera. We used the data of the 2 sets (stress-rest) of slices to produce couples of polar maps for all the patients. Our approach consists in using the myocardial scintigraphic data of the left ventricle at stress and at rest in topographic matrices. For each scintigraphic image set, regional myocardial tracer uptake was obtained by polar map analysis. Co-identification of myocardial perfusion images data was performed to eliminate normal morphological variances such as variances in orientation, size and shape, so that the remaining differences represent important functional differences. 3D data obtained at stress and at rest respectively are used to analyse and quantify left ventricle deformation between both images and the boundary of the analysis of spatial derivatives of the count density.A numerical distance is calculated.A significant difference is obtained between distances relating to the rest and stress data. This software tool permits to superpose the result of scintigraphic analyses to precise the location and the impact of the pathology. **Conclusion**: It is noticed that significant improvement in image quality increase the confidence of image data interpretation. The development of algorithms for analysis of myocardial images allows better evaluation of small and nontransmural myocardial defects.This method decreases the effects of operator variability and increases the reliability of diagnoses of organ irregularities. The best visualisation of the spatial heart shape, 3D volume of the left ventricle, and the accurate measurements of heart wall perfusion, play a crucial role for the diagnosis and treatment of heart diseases.

P508

Assessment of the wavelet transform in reduction of noise from the simulated PET images

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Aim: Positron Emission Tomography is an efficient method for tomographic imaging. PET provides images of high sensitivity, good spatial resolution for accurate quantification. However the high level of noise in the image limits its diagnostic utility. The noise removal in nuclear medicine is traditionally based on the Fourier decomposition of the images. However, this method is exclusively based on frequency components; irrespective of the spatial location of the noise or signal. The wavelet transform presents a solution by providing information on frequency contents while retaining spatial information. This alleviates the shortcoming of FT and thus, wavelet transform has been extensive used for noise reduction, edge detection and compression. **Materials & Methods:** The NCAT phantom was used to generate the digital phantom of a typical human torso. The activity distribution was adjusted based on the FDG uptakes of the organs in a normal human. The SimSET simulator was used to image the torso phantoms. The images were acquired at 8 level of signal-to-noise ratio. Four methods of wavelet de-noising: a) Single-level discrete wavelet transform b) Single-level discrete stationary wavelet transform, c) Global thresholding and d) Level dependent thresholding were examined to remove the noise from data using different base wavelet. The test images were decomposed into the approximation, horizontal, vertical and diagonal details and then were reconstructed using the different combinations of the approximation and details. All calculations were performed using software developed in MATLAB 7.1. **Results:** The best result in SWT is relative to "only approximation" reconstruction procedure and Global thresholding. **Conclusion:** Our results indicate Global (uniform) thresholding is more successful than Level dependent thresholding in de-noising nuclear medicine images. Using these methods noise reduction is more than 80%.

P509

Effect of Butterworth and Metz reconstruction filters on calculation of ejection fraction and stroke volume in 99m-Tc-MIBI gated myocardial SPECT imaging.

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Introduction:The use of reconstruction filters(Metz and Butterworth) on the calculation of left ventricular end- diastolic volumes,end-systolic volumes,stroke volumes and left ventricular ejection fractions from Tc-99m MIBI gatd myocardial perfusion SPECT studies has been made by various centres conducting Tc-99m MIBI gated myocardial SPECT studies.The criteria for selecting appropriate filter remains a subjective choice rather than depending on the defined parameters.The present study was therefore undertaken to see the effect of Butterworth and Metz reconstruction filters on calculation of ejection fraction and stroke volume in Tc-99m MIBI gated myocardial SPECT studies. Materials and Methods: The rest and gated myocardial studies in 90 patients were performed.Acquired projections were reconstructed separately using two different filters,a low pass filter(Butterworth) and an edge- enhancement filter(Metz) and thereafter the left- ventricular end diastolic volume,end -systolic volume,stroke volume and ejection fraction were calculated using dedicated software.The results of two filters for each patient were compared. Results and Conclusions: The mean End diastolic volume using Butterworth filter(BWEDV) and Metz filter(MEDV) was respectively observed to be 77.23±52.56 and 78.50±56.63 with a p-value of 0.610. The mean values of stroke volume using butterworth filter (BWSV) was found to be 41.54±12.86 wereas that using Metz filter (MSV) was observed to be 42.04±12.8 with p-value of 0.342. Similarly the mean values of left ventricular ejection fraction using butterworth filter (BWEF)was found to be 64.32±19.77 whereas that obtained with Metz filter (MEF) was observed to be 64.20±19.04 with a p-value of 0.821. As regards end systolic volume its mean value using butterworth filter (BWESV) was found to be 36.49±52.38 and that using Metz filter (MSEV) was observed to be 36.63±51.18 with a p-value of 0.809. It was evident that these parameters demonstrate no significant variation with change in filter. It can therefore be concluded that change in reconstruction filter does not significantly affect the calculation of left-ventricular end-diastolic volume, end-systolic volume, stroke volume and ejection fraction. However this observation is in variance with earlier studies which have reported significant variation in the value of these parameters with change in reconstruction filters.

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The Influence of Crystal Depth on Position Detection Accuracy and Detection Efficiency in PET Block Detector: A Monte Carlo Study

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It is well known that increasing the crystal depth in PET scanners effectively increases the system sensitivity at the expense of decreasing position detection accuracy. In this study we utilized the MCNP4C Monte Carlo code to quantitatively evaluate the influence of crystal depth on detection efficiency and position detection accuracy (PDA). The MCNP4C Monte Carlo code was used to study the detailed transport of 511keV photons originated as pencil beam from a point source toward the central crystal of a block detector consist of a 13×13 crystal array with 4mm×4mm cross section dimension. Three different crystal depths (10, 20 and 30mm) for BGO, LSO and LYSO were investigated. The code was validated through comparison with simulated data published by Shao et al. The analysis of photon history files showed that when crystal depth changes from 10 mm to 30mm, PDA in BGO decreased from 89.7% to 79.2%, while detector efficiency increased from 59.6% to 93.4%. Similarly the PDA in LSO and LYSO decreased from 87.1 to 73.6% and from 86.9 to 72.8%, respectively, while detection efficiency increased from 56.5 to 91.7% in LSO and from 53.7 to 90% in LYSO. The results thus quantified the trade-off between changes in detection efficiency and in PDA. With increasing crystal depths, higher rates of inter-crystal scattering and penetration were observed, thus explaining the losses in PDA. Although BGO has a slightly higher PDA than LSO and LYSO, the higher light output and lower decay time of LSO and LYSO continue to make them as crystals of choice for manufactures. The present context consisted of investigating the aforementioned effects at 511keV photon irradiation, as is relevant for PET studies. The data provide detailed information about photons' interactions within the crystal. The results indicate that the MCNP4C code with some small adjustment in the appropriate MCNP cards is a useful tool for investigation of photons interaction in PET block detectors in order to accurately model the photon behavior for such purposes as that of optimizing detector design or appropriate resolution modeling within image reconstruction tasks.

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compensation of cross-contamination in simultaneous Tl-201/Tc-99m myocardial perfusion SPECT imaging

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Aim: Theoretically both ^{201}Tl and ^{99m}Tc imaging may be performed simultaneously using different energy windows for each radionuclide. However, a potential limitation is the cross-contamination of scattered photons from ^{99m}Tc and collimator X-rays into the thallium-201 energy window. We used a middle energy window method to correct this cross-contamination. **Material and Methods:** Using the NCAT phantom simulator a typical torso phantom was generated. An extremely thin line source of ^{99m}Tc activity was placed inside cardiac region of the phantom and no activity in other parts. SimSET Monte Carlo simulator was used to image the scattered photons emerged from the phantom in different energy windows (140±10% for ^{99m}Tc, 100±10% as middle window and 77±15% for ^{201}Tl). X-rays distribution in ^{201}Tl window were also modeled as the ^{99m}Tc photopeak image, convolved by a Gaussian function. Different curves were fitted to the line-spread function obtained in each energy window. Absolute exponential curves were found to be the most simple and suitable functions to model the down scatter from the ^{99m}Tc in both the middle and ^{201}Tl energy windows. Deconvolution was used to find a suitable kernel for modeling the down scatter in ^{201}Tl energy window from image acquired in middle energy window. To examine the derived model a Plexiglas phantom (resembling the cardiac region) filed with ^{99m}Tc and ^{201}Tl activity was imaged in different energy windows. The cross contamination of ^{99m}Tc in ^{201}Tl were corrected and the contrast to defect ratio were calculated. Eleven patients who had angiographically confirmed myocardial defect were enrolled in study. The ^{201}Tl was injected at rest and after 10 minutes patients were imaged in 77±30% energy window. These images were used as the references. Immediately after, the patient exercised on a treadmill and ^{99m}Tc was administered at peak-stress. Simultaneous dual-isotope SPECT acquisitions were performed within 10 minutes of the ^{99m}Tc injection. ^{201}Tl images after correction were compared to the corresponding reference images and improvement in the defect-to-myocardium and the left ventricle cavity-to-myocardium contrast were determined. **Results:** RMS between real and modeled down scatter photons reduced from 3.95 ± 0.57 for previously suggested functions (Gaussian) to 3.76 ± 0.42 for our suggested functions in each projection. Significant improvement in contrasts was also observed in ^{201}Tl images acquired using simultaneous dual isotope protocol. **Conclusion:** Our results showed contrast improvement in thallium images after correction, however many other parameters should be evaluated for clinical approaches.

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Monte Carlo simulation for Ga-67 imaging using a low-medium energy collimator

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Gallium-67 (Ga-67) decays by electron capture and emits multiple energy gamma rays. For Ga-67 imaging, the use of a medium-energy (ME) collimator is suitable due to photons higher than 300 keV. In Japan, however, the combination of a low-medium energy (LME) collimator and the TEW scatter correction method is employed to improve spatial resolution and contrast for Ga-67 imaging. The aim of this study is to validate a Monte Carle simulator to optimize and evaluate Ga-67 imaging with an LME collimator and the TEW method. Material and Methods: In order to simulate a commercially available scintillation camera, we developed a realistic in-house Monte Carlo program (MCEP code). In this MCEP code, interactions of photons in the scattering medium, the camera collimator, the NaI crystal, and the back-compartment (including the light guide, photomultipliers, and electronics located behind the NaI crystal) were accounted for. Furthermore, special attention was paid to collimator penetration. Simulations were carried out for some Ga-67 sources in air and in water. Energy spectra in an energy range 50- 500 keV and images with three 20% energy windows set at the 93, 185, and 300 keV photopeaks were calculated for LME general purpose (LMEGP) and ME low-penetration (LP) collimators. Planar images were separately calculated for unscatter, scatter in water, scatter or penetration in the collimator, and Pb-X rays produced in the collimator. In order to validate the MCEP program, data acquisitions were performed using a scintillation camera (e.cam, Siemens, USA) equipped with the LMEGP or MEGP collimators under the same condition as the calculations. Results: The energy spectra calculated for both the LMEGP and MELP collimators were in good agreement with the measured ones. The simulated planar images for the Ga-67 sources also agreed well with the experimental measurements in spatial resolution and the count profiles. The images simulated for the LMEGP collimator's septal penetration of the 300 keV gamma rays were very similar to the acquired images. The effect of down scatter from higher energy photons on imaging with the lower energy (93 and 185 keV) photopeaks and the Pb-X rays included within the 93 keV photopeak were characterized better. Conclusion: The MCEP program for Ga-67 imaging was validated through comparison with experimental data measured on the real scintillation camera. Since this program allows a reliable simulation of Ga-67 gamma rays for the LMEGP collimator, it is very useful for studying and optimizing TEW scatter correction setting.

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Physics/Instrumentation: Emission Tomography Instrumentation & Integrated Multi-Modality Systems

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Position Reconstruction from Multi-Anode Photomultiplier Charge Signals

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Aim: A new position reconstruction method for position sensitive photomultiplier tubes is proposed in this work. The algorithm is based on a mathematical model operating on the charge signals recorded from the anode wires of a multi-wired anode system. This method overcomes the usual irregularities produced by the center of gravity algorithm near the edges of the field of view especially when a homogeneous scintillation crystal is used. Material and Methods: The amount of the charge detected from a multi-wired anode system is expressed in terms of superimposed analytically defined gauss distributions. The parameters of this expression are experimentally defined on an event-by-event analysis by performing all required transformations of the originally on the cathode produced photo-electron distribution. Data are obtained from a small field, high resolution gamma-Camera system with a 16X+16Y multi-wired crossed anode using the Position Sensitive Photomultiplier Tube (R2486, HAMAMATSU). The optical photon distribution for each type of the scintillation crystal used in the experiment is calculated with the photon transport system DETECT-2000. Results: Systematic studies for a group of inorganic scintillations crystals of CsI(Tl) with 2mm-4mm-8mm-12mm in thickness, as well as of BGO with 2mm-4mm-8mm in thickness, have been performed for different phantom geometries using small capillaries of 99mTc. Planar images have been reconstructed with the new method and compared to the traditional center of gravity technique. The experimentally obtained parameters for the produced light distribution inside the various crystals are expressed and categorized according to their geometrical characteristics. Conclusion: The developed method seems to drastically improve the resolution of the reconstructed planar information, even when homogeneous scintillation crystals are used.

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Analysis of the minimum detectable activitiy in the Gemini TF PET scanner

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Aim: Lesion detectability in PET investigations is limited by a number of physical and scanning constraints. The aim of this work is to characterize the minimum detectable activity level for the Gemini TF PET scanner by varying the parameters such as scan duration, injected activity, target-to-background ratio and object size. Materials & methods: We used the IEC body phantom set with the six fillable spheres with inner diameters of 10,13,17,22,28 and 37 mm. The four smaller spheres were filled with F18 activity so that the target to background ratio (T/B) were 16, 8, 4 and 2. The cavity of the IEC phantom was filled with F18 water of 12, 4.9 and 2.1 kBq/ml activity concentration for three different acquisition sets. The duration of the PET scans were 10 min in all cases. In the Gemini TF the data are acquired in list-mode enabling the user to define any frame length for the image reconstruction. We set the frame length to 1, 3, 6 and 9 min. The images were reconstructed with the manufacturer supplied 3D listmode iterative algorithm with and without TOF kernel. ROIs were drawn on the spheres of the central slices and the contrast recovery coefficients (CRC) and the contrast to noise ratio (CNR) parameters were calculated for any reconstructed images. Results: With T/B ratios of 4, 8, 16 the 13, 17, 22 mm spheres were detectable for any frame length and background concentration activity level. When we set the T/B ratio to 2 the number of detectable spheres depended respectively on the scan duration and background activity. At the lowest background activity (2.1 kBq/ml) only the 22 mm sphere was realized for scan length of at least 3 min. The 13 and 17 mm spheres were identified at the highest background activity (12 kBq/ml) and for at least 3 min scan duration. In this background level the 22 mm sphere was easily detectable for any scan duration. We also found that the CNR depends less on the total injected activity than on scan duration and the weight between them is sensitive to the applied reconstruction kernel (TOF or non-TOF). Conclusion: It is possible to visualize sources with T/B ratio of 2 in the case of Gemini TF PET scanner. Acknowledgement: This work was supported by the National Fund for Research and Development tender NKFP-A1-2006-0017.