

reconstruction (4 sub-sets, 8 iterations and Gaussian filter FWHM = 10mm) resulted to CoV of 8.4% and contrast recovery coefficient (CRC) of 138% and 57% for 16 ml hot and cold spheres respectively. The use of LEAP collimators with the same FLASH reconstruction did not improve contrast (CRC of 76% and 61% for the 16ml hot and cold spheres respectively) and produce similar non-uniformity (CoV of 7.9%) results. Alternative scatter correction with a TEW (159 keV \pm 7.5% photopeak and scatter windows at 174 keV \pm 3% and 138 keV \pm 3.5%) with MELP collimators resulted to significant contrast recovery of both hot and cold spheres (CRC of 110% and 59% for the 16ml hot and cold spheres respectively) and CoV = 7.9%. As expected volume sensitivity was higher (49cps/kBq/m³) with the use of LEAP compared to MELP (35cps/kBq/m³) collimators or MELP with TEW (33cps/kBq/m³) scatter correction. OSEM reconstructions for all collimators and scatter corrections resulted in poor contrast recovery (34, 43 and 51% for LEAP, MELP and MELP with TEW scatter correction respectively). Varying FLASH reconstruction parameters for images obtained using current acquisition protocol showed a significant improvement in uniformity with the use of 2 sub-sets and 8 iterations (CoV = 6.0%). **Conclusion:** This investigation has demonstrated that the use of MELP collimators with either scatter correction method resulted in good contrast recovery and non-uniformity. Increased contrast above 100% for FLASH reconstructions indicates the possible introduction of artefacts. This is to be investigated further for protocol optimisation. Further studies should be undertaken to assess how these findings can be transferred into clinical practice.

P0207

Comparison of the image quality of multi-focus fan beam collimator vs. parallel whole collimator SPECT/CT system in myocardial perfusion image: Phantom studies

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Objectives: The aim of this study was to evaluate image quality IQ-SPECT system compared with conventional (180° apart) and L-mode (90° apart) system in myocardial perfusion imaging (MPI). We focus mainly to evaluate on spatial resolution, image reproducibility, and image quantitative with use of various physical phantom. **Method:** Imaging was performed with both standard parallel hole collimation (LEHR) using a Siemens Symbia T16 SPECT/CT and the same system with the IQ-SPECT modification employing SMARTZOOM collimators. Conventional (conv.) and L-mode were performed over 180°contoured orbits with 30 and 34 views per detector for 12.5 sec into 64x64 matrices and 4.8 mm pixels. IQ-SPECT images were acquired over 208° cardio-centric orbits with 17 views per detector for 6.25 sec per view to 128x128 matrices and 4.80 mm pixels. Both images were attenuation corrected using CT images acquired immediately before SPECT with the integrated CT. The reconstruction soft-ware was used of Flash3D. Spatial resolution was to evaluate FWHM obtained the point source phantom (in house) that were arranged 11 point sources (12 mm ϕ) every 4cm from the center in the UFOV. Image quantitative was to validate cross-calibrated SPECT values against the radioactivity of pai-phantom that were enclosed different radioactivity concentration with 6 separate spaces in the cylindrical tube. The myocardial torso phantom was used to evaluate the image reproducibility and total image quality **Results:** FWHM value (radial) of IQ-SPECT at the point source in the central was increased 11% as compared with conv. and FWHM in the periphery was increased 41% with central FWHM. The aspect ratio (radial/tangential of FWHM): ASR) of IQ-SPECT was shown 0.6-1.4. However, the phantom's myocardial wall thickness from short axis images resulted in significant correlation ($p < 0.001$) between the conv. (25.1 \pm 1.1 mm), L-mode (24.7 \pm 0.97 mm) and IQ-SPECT (18.2 \pm 1.2 mm). Image distortion was occurred L-mode system. As function radioactivity and cross-calibrated SPECT values were fitted to a straight line (Conv.; $y=0.98x+0.03$ R²=0.98, L-mode; $y=0.89x+0.06$ R²=0.98, IQ; $y=0.98x-0.01$ R²=0.99). The data implied that quantitatively the use of IQ-SPECT improved for in the myocardial perfusion imaging. **Conclusions:** IQ-SPECT provided myocardial perfusion SPECT imaging comparable to conventional and L-mode SPECT, and improved significant image resolution and quality. Our result suggests that IQ-SPECT is the most beneficial technology for MPI SPECT.

P0208

Accuracy of attenuation and scatter corrections in SPECT-CT Myocardial Imaging.

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Aim of the study: Myocardial studies with integrated SPECT-CT systems can be corrected not only for scatter but also for attenuation: we have evaluated the accuracy of these corrections with a dedicated phantom. **Materials and methods:** We used a SPECT-PET/CT thorax water phantom (Data Spectrum) to mimic a clinical condition of attenuation and scatter, the phantom is provided with two cylinders

that were filled with the same radioactive solution, one positioned inside and the other outside the phantom. The phantom was scanned with Siemens Symbia T6 SPECT-CT using the clinical acquisition protocol for myocardial studies. SPECT was performed with a 90°detectors configuration, non circular orbit, 32 views, 64x64 matrix, 25 sec/view. CT scan was acquired with 130 kVp, 60 mAs, pitch 0.5, 4 mm slice thickness. The radionuclides used for this investigation were Tc-99m (396 MBq/l) and I-123 (162 MBq/l), commonly used in our Department to study myocardial perfusion and cardiac autonomic innervation. In order to perform scatter correction the clinical protocols employ a two-window and a three-window method for Tc-99m and I-123 respectively. Images were reconstructed using Siemens Flash 3D, an OSEM-3D algorithm, which provides corrections of nuclear data for attenuation using CT mu-maps and applies an additive correction for scatter. We have performed three different reconstructions: without corrections, applying the attenuation correction only and applying both the corrections for attenuation and scatter. On the transverse images the percentage difference of the mean counts between the inner cylinder and the outer was evaluated. Since in both cylinders the radioactive concentration is the same and the only difference is the attenuation and scatter due to the water surrounding the inner cylinder, with all the corrections performed this percentage should be ideally zero. Furthermore, reconstructions were performed using different combinations of iterations and subsets to evaluate their effect on image corrections. **Results:** Without corrections, only with attenuation correction, and with both attenuation and scatter corrections applied, the percentage differences were respectively -77%, -27%, -10% for Tc-99m and -75%, -21% and -8% for I-123 with 8 iteration/4 subset. Increasing the number of iterations and subsets (8i/8s, 16i/8s, 16i/16s, 24i/16s) the corrections were more accurate with a percentage difference ranging from -10% to -1% (24i/16s) for Tc-99m and from -8% to -1.6% (16i/16s) for I-123. **Conclusions:** Myocardial images are slightly under-corrected for attenuation and scatter, using the standard settings, however good results can be obtained increasing the number of iterations/subsets.

P0209

Evaluation of the clinical impact of Time-Of-Flight (TOF) PET/CT-scans for F18-FDG whole body protocol on a Siemens Biograph mCT

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Many technological improvements in hardware and software lead to the latest generation of PET/CT scanners. The comparison and transferability of scanner's clinical routine from different vendors and generations is demanding. The aim is to prove an acquisition protocol for whole body FDG-PET-CT and the clinical impact value of TOF-technology. The mCT-PET-Scanner (Siemens Medical Solutions USA, Inc., Malvern, PA) is equipped with four rings of 48 detector-blocks (13x13LSOcrystals, 4mmx4mmx20mm) with an axialfield-of-view of 21.8cm. Images from 37 oncologic patients (non-diabetic) were reconstructed, using iterative, iterative plus TOF, HD-PET (jitter correction for line-of-response) and HD-PET plus TOF in comparison. The differences between these protocols are discussed quantitatively and qualitatively for malignant lesions (>1cm diameter) and non-pathologic regions as a reference. For attenuation correction a low-dose-CT (40-slice-configuration, 120keV, 18mA-effective) was exposed in expiration. The limited statistic of the firmer generation of PET scanners requires postfiltering to make the images more presentable therefore the lesion detection on clinical images was limited. The latest generation diminishes this lag between statistics and spatial resolution. Powerful computers and optimized algorithms results to improved image quality using TOF without postfiltering, increased number of iterations from 2 to 4 (21 subsets) and the matrix from 128/256 to 400. TOF improves the contrast and shows smaller anatomical and pathological structures also in patients with normal BMI (Body Mass Index).The most stable SUV (standardized uptake value based on body weight) as a reference regions was from the liver parenchyma 2.9 \pm 0.5 (parotid 1.9 \pm 0.6, lung 0.6 \pm 0.3). Using iterative reconstruction relative to HD-PET and TOF the SUV-max in the liver parenchyma raises a factor of 2.0 \pm 0.4 including TOF a factor of 1.9 \pm 0.3, in the lung SUV-max raises a factor of 1.8 \pm 0.6 including TOF a factor of 2.0 \pm 0.5, for parotid parenchyma SUV-max raises a factor of 1.5 \pm 0.3 including TOF a factor of 1.4 \pm 0.2, for malignant lesions SUV-max varies depending on the structure of the lesion within 21% including TOF 20%. The mean-SUV within the parenchyma regions does not change significantly. Based on the hardware configuration, HD-PET and TOF shows a significant quality improvement. SUV is used as an indicator for malignancy versus benignancy, as a prognostic value, to quantify spatial concentrations for dosimetry and radiopharmaceutical studies. Non-pathologic parenchyma can be used as a reference-region where liver-parenchyma is varying 16%, alternatively parotid-parenchyma 29% and lung-parenchyma 46%. Using HD-PET and TOF protocol exploits the whole available technology to utilize best diagnostic and interventional and scientific benefit.

P0210

An Innovative Rotation-Based Iterative Resolution Recovery for HiReSPECT™: a Dedicated Small Animal SPECT System

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A novel rotation algorithm was developed to speed up the application of rotation-based MLEM image reconstruction and to perform resolution recovery by rendering feasible Collimator-Detector Response Function(CDRF) compensation in the HiReSPECT™ camera. HiReSPECT™ is a dedicated dual head SPECT system for imaging of murine models. Each detector is composed of an array of 1x1 mm² pixelated Cs(Na) crystals. We derived the CDRFs via fitted Gaussian functions at multiple distances from the head. The CDRFs were applied within the forward and backward projection processes in every sub-iteration. To achieve very efficient yet accurate rotation operations, noting that the default acquisition protocol includes 60 views covering 360 degrees with angular view-to-view steps of 6 degrees, we utilized a 12-step jump (78 degrees) for each new subiteration within the reconstruction. It can be shown that for the proposed 78-degree rotation, each pixel in the source image intersects with only 5 pixels in the target image, and vice versa. In our approach, the 5 pixels of the target image corresponding to each source pixel, and the fraction of counts assigned to each, were pre-computed analytically and stored in a N×N×2×5 look-up table, in which, N×N is the matrix size, and factors 2 and 5 respectively correspond to the Cartesian coordinates of the pixel centers prior to the rotation and the abovementioned fractional contributions from the 5 target pixels. To evaluate the implemented rotation approach, a 128×128 Shepp-Logan phantom image was rotated 60 times progressively with 78-degree steps via (i) our algorithm and (ii) the standard bilinear algorithm. Quantifying rotational accuracy using the bilinear method vs. our proposed algorithm, Normalized Square Error values of 0.3738 and 0.3740 were obtained, respectively, showing the same quantitative performance for the two methods. At the same time, the proposed rotational algorithm has improved computational efficiency as it requires N×N×5 multiplications utilizing the **pre-generated** LUTs, while N×N×8 multiplications are needed via the conventional approach. While the radial and tangential resolution of the system without resolution recovery is over 2 mm at nearly all positions within the FOV, reaching 2.5 mm at the edges, it did not exceed 1.8 mm anywhere within the FOV using the proposed approach. The proposed rotational approach to resolution modeling exhibited favorable computational efficiency compared to conventional bilinear approach, while depicting matched quantitative accuracy. Meanwhile, the code has a high convergence rate due to appropriately long angular steps of the sub-iterations and good resolution recovery power.

P0211

Experimental evaluation of the impact of Time-of-Flight (TOF) on edge definition of cold spots or cavities in a body phantom

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Aim: There is a theoretical spatial resolution limit to which TOF can improve the reconstruction accuracy. It is minimum detectable range of incorporating TOF imaging and radial distance of the cold spots in practice which we try to determine through this study. **Materials and Methods:** TOF-PET imaging improves the localisation of radionuclides by measuring the time difference between coincident annihilation photons to aid in the reconstruction process. Sharper images, with clearer hot and cold spot definition are expected. The improvement in reproducing hot spots within a homogeneous background has been well documented, but the improvement to cold regions is not as well known. For this experiment the analysis was performed with a Siemens Biograph mCT(TOF-PET/CT Camera), which has a time resolution of 0.5 ns (spatial resolution of 7.5 cm). A CT scan of the phantom was acquired for attenuation correction of PET data. Reconstructed diameters were measured from the FWHM of line profile across the cold lesions. The gain by using TOF was determined by comparing the line profile across the different cold lesions in the images reconstructed using TOF to that without TOF. The experiment used F18 with 88.3MBq of activity to surround cold spots spheres of diameters: 9.5–31.8mm and cold spot rods of diameters: 4.8 – 12.7mm. **Results:** From the initial results it was found that even though increasing the number of iterations with HD-TOF improves the contrast and edge definition, this did not produce a discernible increase in accuracy of reconstructed cold spot diameter. It was also found that there is a limit to the improvement in reconstructed cold spot diameter from the inclusion of TOF data, and that it is dependent the location of the cold spot. For cold spots found in isolation, TOF with High Definition (HD) iterative

improves cold spot diameters < 20mm, with FBP there is no discernible improvement. For cold spots located in a region of cold spots, TOF improvement with HD was only appreciable for the 9.5mm diameter rod (the smallest measurable), with FBP the accuracy was improved for rod diameters:9.5 – 12.7mm. **Conclusions:** Any contrast improvement is shared between all the cold spots, limiting the effect of TOF. There is a limit to the improvement in reconstructed cold spot diameter from the inclusion of TOF data, and that it is dependent on the location of the cold spot.

P0212

Preconditioned Alternating Projection Algorithms for Maximum a Posteriori ECT Reconstruction

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Aim: To reduce radiation dose to the patients undergoing emission computed tomography (ECT) examinations. **Materials and methods:** We propose to lower the total amount of activity in the radiotracer administered. However, it would lead to very high Poisson noise in the raw ECT data. Consequently, such very noisy data if treated by conventional techniques, such as expectation maximization with total variation regularizer (EM-TV) or ordered subset EM (OSEM), would lead to very noisy and clinically unacceptable reconstructed images. To accomplish good quality ECT reconstructions from low-dose ECT examinations, we introduce a generalized fixed-point formulation of the total variation (TV) regularized maximum a posteriori (MAP) ECT reconstruction problem. Based on this formulation, we propose preconditioned alternating projection proximity (PAPP) algorithm for computing the fixed point. We theoretically prove the convergence for the special case of our proposed algorithm. To investigate performance of our PAPP algorithm, we performed numerical experiments on simulated SPECT data with low (15%) and high (56%) Poisson noise content. The data were simulated for a cylindrical uniform phantom containing hot and cold spheres with various diameters. The PAPP was compared with conventional MAP expectation maximization (MAP-EM) algorithm with TV regularizer (EM-TV) and with the recently developed nested EM-TV algorithm for ECT reconstruction. **Results:** We observe that our PAPP algorithm with the EM-preconditioner very significantly outperforms the benchmark EM-TV in both the convergence speed, the noise in the reconstructed images and the image quality. It outperforms the nested EM-TV in the convergence speed while achieving comparable image quality. **Conclusion:** The developed PAPP algorithm with the EM preconditioner might allow very significant reduction in the radiation dose to the patients imaged using ECT by providing the same contrast-to-noise ratio for hot and cold lesions as conventional EM-TV but with the total administered radiotracer activity 2 to 6 times lower than presently used in standard-of-care ECT examinations.

P0213

Combined fan- and cone-beam collimators with circular orbit acquisition for brain SPECT imaging: optimization studies

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Aim: To optimize acquisition and reconstruction of brain SPECT by means of combined fan- and cone-beam collimators using triple-head camera and circular orbit under the constraints of fixed total acquisition time and radiopharmaceutical dose. **Methods:** Performance of a triple-head SPECT camera with combinations of low-energy ultrahigh-resolution fan-beam collimators (F) and cone-beam collimators (C) with focal length equal to 43.1 cm were investigated. The radius-of-rotation was fixed at 14 cm. The angular sampling was 120 views over 360 degrees rotation (i.e. 40 views per detector head). The following combinations of collimators were studied: CCC, CCF, CFF and FFF. Uniform cylindrical phantom with 7 hot and 7 cold spheres (0.64 - 3.2 cm diameter) simulating hot and cold lesions was used. One noiseless and 4 noisy datasets were investigated. The noisy datasets were simulated using the Monte Carlo SIMIND software. An ordered-subset EM (OSEM) algorithm was used for combined reconstruction. Attenuation, system resolution and sensitivity were modeled. No scatter correction, post smoothing nor regularization was applied. **Results:** For noiseless datasets a triple-cone-beam system resulted in axial distortion artifacts and diminished transaxial resolution away from central slice. A triple-fan-beam system resulted in the best-reconstructed image quality in terms of bias, noise, contrast and artifacts. For noisy data a cone-fan-fan beam system resulted in best-reconstructed image quality for detection of small lesions. **Conclusions:** A cone-fan-fan-beam system is most promising for detection of small lesions using triple-head gamma camera with combined cone- and fan-beam collimators and circular orbit acquisition in brain SPECT imaging.