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Effect of Intermittent pneumatic compression on the lower limb bone uptake of Tc99m MDP.

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Introduction: Venous compression of the lower limbs obstructs outflow through deep and superficial veins. It is hypothesized that venous channels in the long bones will act as collateral channels to restore outflow, and therefore general blood flow through bone will increase. Such a hemodynamic change should affect the uptake of radiopharmaceuticals by the bone. The purpose of this study therefore was to determine whether bone uptake in the lower limb would be affected by intermittent venous compression. **Materials and Methods** The effect of intermittent pneumatic compression of the distal thigh and calf on uptake of $^{99}Tc^{m}$ methylene diphosphonate (MDP) was studied in twenty-four patients. All were undergoing routine bone imaging for medical conditions that did not involve their lower limbs. Patients received 1 hour of 60 second on and 60 second compression at 60 mmHg on one limb only, after injection of the radiopharmaceutical. Three hours post-injection the relative difference in uptake (net counts per pixel) between the treated and coresponding area of the two limbs was calculated. **Results** The median differences in uptake in the intermittently compressed limb, compared to the contralateral limb, were +7.6% (interquartile range +3.9% to +16.0%, $p<0.0005$ [Wilcoxon]) for the anterior aspect of the femur; +11.7% (interquartile range +4.3% to +22.2%, $p<0.0005$) posterior, femur; +10.5% (interquartile range +6.5% to +13.8%, $p<0.0005$) anterior, tibia; +10.6% (interquartile range +5.5% to +17.6%, $p<0.0005$) posterior, tibia. **Conclusions** Intermittent pneumatic compression increased significantly the uptake of $^{99}Tc^{m}$ MDP in long bones by probably affected the blood flowing through the bones. This has potential clinical applications in the areas of fracture healing, managing diabetic patients and drug delivery.

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Treatment of idiopathic osteoarthritis of the knee joint by Yttrium-90 radiochemical synovectomy

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Aim: Yttrium-90 colloid synovectomy in idiopathic osteoarthritis (grade I) of the knee is applied as an alternative treatment to conventional non-steroid anti-inflammatory drugs or arthroscopic synovectomy and lavage.Material and Methods: Seventy-two (72) patients (91 knees), mean age 59 years (range 46-71 years) with idiopathic osteoarthritis (grade I - minor radiological changes) were prospectively followed, after yttrium-90 synovectomy (injection of 5 mCi yttrium-90 citrate per joint). The knee joint was immobilized for 48 hours following the injection. All patients were clinically and radiologically evaluated before, and 1, 3, 6 and 12 months after the intra-articular injection. Patients were evaluated using modified WOMAC scale (score 0-182 points, results classified as very good when score is 140-160 points and excellent when score is higher than 160). Modified WOMAC scale assesses pain, joint stiffness, function, patient's sociality and emotional background, clinical and radiological findings from the knee compartments.Results: All patients had minimum 2 years follow-up (range 2 - 4 years). Findings of the 1st and 2nd post-injection year are presented. Mean pre-injection WOMAC score was 115, rising to 147 and 139 on the 1st and 2nd year, respectively. Pain and patient's emotional background are the parameters mainly improved. No re-injections were needed. Neither joint infections, nor radiation necrosis around the puncture were noticed. One patient presented inflammatory-like symptoms, mainly joint effusion, after the injection, which subsided after local ice application. Three patients complained for worsening of their symptoms after the procedure and were finally treated by total knee replacement.Conclusions: Radiosynovectomy with yttrium-90 citrate for idiopathic knee osteoarthritis seems to offer a safe and valuable treatment option, alternative to drug administration or surgical treatment. Results are reproducible and stable during the first 2 years.

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Reconstruction & Simulation

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Implementation of respiratory motion correction in PET using list mode data

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Objectives: Respiratory motion leads to a reduction in PET image contrast and lesion detectability, degrading the accuracy of recovered activity concentrations and functional volumes. Although respiratory gating may account for respiration the reduced statistics in individual gated images reduce dramatically the impact of such an approach. The objectives of this work were to investigate the impact of respiratory motion correction based on the acquisition of list mode data. **Materials and Methods:** List mode data based PET simulated datasets were derived using the NCAT anthropomorphic phantom in combination with a GATE simulation of the Philips Allegro PET scanner. A set of eight NCAT emission images were produced corresponding to 625ms/frame. Different size spherical lesions (7, 11, 15 and 21mm in diameter) were added in the lower, middle and upper lobe of the left and right lungs of the NCAT emission and transmission frames. The generated NCAT attenuation frames without any blurring effects were used in combination with an affine and an elastic registration to define the transformation parameters to be used with the simulated list mode data. The objective was for the data of the last 7 frames to match the first NCAT frame corresponding to full exhalation. In our implementation of the affine transformation, the list mode datasets corresponding to frames 2 to 7 were shifted according to the transformation parameters. The overall corrected list mode dataset was finally reconstructed using the OPLEM (one pass list mode EM) algorithm. In the case of the elastic transformation the contribution of each line of response to a particular voxel (in its original detected position) was shifted during the reconstruction to a new location defined by the elastic deformation matrix between the specific frame and frame 1. A region of interest analysis was performed in the reconstructed images (with and without motion correction) in order to assess the improvement in lesion's contrast and activity concentration, while line profiles were used to assess the effects on lesion location. **Results:** The use of the affine transformation can lead to >55% and >90% improvement in lesion contrast and location accuracy respectively, depending on lesion location and size. In the case of the elastic transformations a larger and more uniform improvement was observed independently of lesion location. **Conclusions:** The application of an affine or elastic transformation before or during the reconstruction of list mode PET datasets respectively, can accurately compensate for the effects of respiratory motion.

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Comparing NEC-based OSEM with other weighted OSEM approaches for 3D whole-body PET imaging

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Aim: In this work we compare different weighted OSEM (Ordered Subsets Expectation Maximization) approaches for the reconstruction of 3D clinical whole-body PET data. Weighting is a procedure for making the statistical model for the data as realistic as possible. The NEC (Noise Equivalent Count) transformation method proposed by Nuyts et al. partially restores the Poisson characteristics of data assumed by OSEM. Former results from simulation have shown improvements in tumour detectability when a realistic model is used. This is the case when comparing NEC-weighted OSEM (NEC-OSEM) reconstructed images with those obtained with AW-OSEM (Attenuation Weighted), in widespread usage on clinical routine. We describe an implementation of NEC-OSEM for clinical data and we discuss some practical problems as well as limitations associated with the experimental determination of the weights.**Methods**: Clinical data were acquired in 3D mode on the HR+ scanner and corrected for physical and geometrical effects. They were then rebinned into 2D data, using the Fourier-rebinning (FORE) algorithm. Rebinned data were reconstructed using two different versions of OSEM: NEC-OSEM and AW-OSEM. In AW-OSEM, each rebinned bin is multiplied (weighted) by the reciprocal of the corresponding attenuation correction factor; in NEC-OSEM, the multiplicative weight is given by the quotient of the mean over the variance values in the same sinogram bin. Since there is no direct access to the mean or the variance, these moments should be estimated. The mean value in one bin of the raw data is assumed to be the value of that bin after spatial smoothing; using this mean value and the corrections applied to the data, the variance and the mean value in each point of the corrected and rebinned data are obtained. In addition to FORE+2D, two fully 3D OSEM reconstructions were performed: ANW-OSEM3D (normalization and attenuation Weighted), and Ordinary Poison (OP-OSEM3D), where the raw data are directly reconstructed and all corrections are applied during the reconstruction.**Results**: NEC weights were determined for clinical data. Reconstructed images were obtained for FORE+NEC-OSEM2D, FORE+AW-OSEM2D, and for ANW-OSEM3D and OP-OSEM3D. The quality of the FORE+NEC-OSEM2D reconstructed images are very sensitive to a misestimation of the weights and fully 3D OSEM reconstructions tend to show a bigger improvement in quality over FORE+AWOSEM2D. **Discussion**: The experimental determination of the NEC weight is quite complex for a clinical use and fully 3D OSEM reconstructions show more promising results in term of image quality.

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Monte Carlo simulations of a coded aperture using GATE

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Aim: Coded aperture imaging is widely used in x-ray astronomy. This multiplexing technique is the ideal alternative to focusing techniques in order to achieve high sensitivity and high spatial resolution. The direct application of coded aperture imaging technique from x-ray astronomy (far-field imaging) to nuclear medicine (near-field imaging) produces specific artifacts on reconstructed images. Monte Carlo simulations can provide useful informations on artifacts formation mask pattern optimization and coded aperture imaging limitations in planar and tomographic scintigraphy. We study the feasibility of modelling and simulating a coded aperture mounted on a conventional gamma camera with the GATE platform, based on the GEANT4 Monte Carlo code.**Material and Methods:**Firstly the gamma camera DST-XL (General Electric Medical Systems) and its LEUHR collimator (Low Energy Ultra High Resolution) were modelled. Simulated and measured energy spectra of a ^{99m}Tc point source in air were compared. The system sensitivity was simulated and evaluated for a ^{99m}Tc point source in air at different distances from the collimator. The simulated and measured spatial resolution were compared in the same way as sensitivity for ^{99m}Tc line sources. Secondly we modelled a coded aperture based on a Singer sequence and mounted on the gamma camera DST-XL. This coded aperture is composed of 196 conic holes (diameter: 3.1 mm) drilled, according to the special pattern, in a lead plate of 3.5 mm thickness. The reconstruction technique was cross correlation. Simulated and measured energy spectra, sensitivity and spatial resolution were evaluated, of a ^{99m}Tc point source in air, at the focal plane of the coded aperture system.**Results:**A good agreement between the simulated and measured data was found for the gamma camera DST-XL equipped with the LEUHR collimator and the coded aperture. The maximal difference between the measured and simulated spatial resolution was 2.5 % for both collimators. The 196 conic holes of the coded aperture were modelled thanks to GATE by creating and repeating, by symmetries and tanslation, 26 conic holes.**Conclusion:**The flexibility of GATE in creating and repeating conical or cylindrical volumes allows to model a particular apertures based on pseudo-random patterns. Further simulations will deal with new mask pattern, hole geometry, focal length and reconstruction optimization.