Physics/Instrumentation - Quantitative Imaging: Data Analysis

24

Monte Carlo Modeling of the Effects of Cascade Gamma Photons in 2D PET Images Obtained With the Isotopes: Br^{76}, Y^{86}, I^{124}

P. A. Santos, M. V. Martins, P. Almeida; Instituto de Biofísica e Engenharia Biomédica, Lisboa, PORTUGAL.

Aim: The aim of this work was to determine by Monte Carlo Modeling (MCM) the effects of including gamma photons (γ), emitted in cascade with positrons, in 2D PET images of isotopes that decay both by Positron Emission (PE) and Electronic Capture. These isotopes have the advantage of having longer half-lives than conventional PET imaging isotopes, allowing for PET diagnostic and therapeutic applications where imaging over a period of several days is necessary. **Materials and Methods**: For this study we have considered the decay by PE, in which the positrons and the cascade γ-photons are emitted by the same nucleus. The isotopes considered were the Br^{76}, the Y^{86} and the I^{124}. For the MCM we have altered SimSET in order to simulate a simplified PE decay scheme of these isotopes; considering only positrons with relative abundances >0.5%, but still accounting for more than 95% of the positrons emitted by each isotope (Br^{76}:97.9%, Y^{86}:96.2%, I^{124}:98.7%). Also, only γ-photons with abundances >1.0% were considered. The coincidences between the two positron annihilation photons (511C) and the γ-γ and γ-511 coincidences (Cascade Coincidences, CC) were binned into different sinograms, as were the scattered-511C and scattered-CC. To simulate 2D PET images of a cylindrical phantom filled with water and 5 linear inserts containing radioactivity, we have used scanner geometry parameters corresponding to the GE DST PET/CT. **Results**: For this simulation geometry we have found that, for the three isotopes considered, the CC contribution to the image is spatially uniformly distributed. We have found that for Br^{76} the total number of true-coincidences in the images consisted of 7.9% of true-CC and 92.1% true-511C. The number of counts in the scatter images was composed of 36.2% scattered-CC and 63.9% of scattered-511C. The corresponding percentages for Y^{86} were: true-CC=6.6%, true-511C=93.5%, scattered-CC=48.7% and scattered-511C=51.4%. For I^{124} we found the respective values: true-CC=2.8%, true-511C=97.2%, scattered-CC=16.3% and scattered-511C=83.7%. **Conclusions**: Hence, MCM of CC originated from PE decay shows that the percentage of scattered-CC included in the images is significantly high and its correction is crucial to attain image quantitative accuracy. Although the results show that the percentage of true-CC included in the images is <10%, this component of the CC must also be corrected to achieve image quality. The MCM work in progress includes the assessment of the impact of CC in image spatial resolution, signal-to-noise ratio, contrast and radioactivity recovery factors, both in 2D and 3D PET images.

25

Use of Wavelet based Thresholding in Iterative Deconvolution for Partial Volume Correction in Emission Tomography

N. Boussion[1], C. Cheze Le Rest[1], F. Turkheimer[2], A. Reilhac[3], **D. Visvikis**[1]; [1]INSERM U650, Brest, FRANCE, [2]Imperial College, London, UNITED KINGDOM, [3]CERMEP, Lyon, FRANCE.

Objectives: One of the parameters greatly affecting quantification in emission tomography is the reduced spatial resolution resulting in partial volume effects (PVE). These effects lead to increased apparent volume and decreased activity intensity in small structures. Most current PVE correction methodologies are based on the use of CT or MRI images and are characterised by assumptions regarding correlations between anatomical and functional information as well as uptake homogeneity within structures of interest. The deconvolution of a system's point spread function (PSF) to correct for PVE can overcome such assumptions but its utilisation has been limited as a result of increased noise in the whole image. In this study we are introducing and assess the performance of a new regularisation step in iterative deconvolution for PVE correction in ET in order to improve its noise performance. **Methods**: Wavelet thresholding was implemented at each iteration of an iterative deconvolution algorithm. The dependence of the correction to the PSF size was evaluated, while the approach was compared with classical anatomy-based PVE correction methods. The modified methodology was evaluated and its performance compared on both simulated (brain) and clinical (brain and whole body) PET images. Simulated datasets of a hot spheres phantom (diameters from 8-37mm, contrast 8:1) were produced using GATE. In terms of performance under clinical imaging conditions, FDG PET brain images (16 patients) and 11C-Raclopride (5 patients) simulated with SORTEO as well as clinical brain images were used in the evaluation. Finally, the algorithm was evaluated on clinical FDG whole body studies. **Results**: The new algorithm provided a level of correction similar to standard methodologies making use of anatomical information. On the other hand, in comparison to standard iterative deconvolution noise propagation was significantly reduced (> an order of magnitude), while the improvements were dependent on the statistical image quality. In the clinical evaluation the recovered activity concentration increased by >20% in the striatum of the 11C-raclopride brain images while an increase of 40-75% was observed in small lung lesions of clinical whole body FDG scans. Finally small differences (<5%) were found through the variation of the PSF size. **Conclusions**: A new regularisation step in iterative deconvolution for PVE correction was developed and evaluated. The wavelet-based denoising was effective in significantly reducing noise in the deconvolved images with the same level of PVE correction in the structures of interest.

26

Continuous leakage monitoring with radioactive ^{99m}Tc-PYP during hyperthermic isolated limb perfusion with tumor necrosis factor and Melphalan

M. Ferrari, G. Trifirò, L. L. Travaini, A. Rossi, J. Soteldo, M. Cremonesi, L. Zorzino, A. Cascio, G. Paganelli; European Institute of Oncology, Milano, ITALY.

Background: Hyperthermic isolated limb perfusion (HILP) with tumour necrosis factor-α (TNF) and Melphalan is applied for the palliative treatment of advanced melanoma and soft tissue sarcoma of the extremities. Being TNF levels in the perfusion circuit ~10 times more than the maximally tolerated systemic levels, monitoring of leakage from the isolated circuit into the systemic circulation is mandatory. Generally, ^{131}I-HSA and/or ^{99m}Tc-HSA are used as tracers for leakage monitoring. As an alternative, the blood pool tracer ^{99m}Tc-pyrophosphate(PYP) was considered. The aim of this study was to validate the new method and to verify whether the leakage quantified by ^{99m}Tc-PYP is able to guarantee the safety of the procedure. **Methods:** Twenty consecutive patients (3 superior, 17 inferior arms) underwent HILP. Before surgery patients were injected with PYP (2ml). Once the surgical isolation of the extremity was accomplished, 0.05MBq/kg of ^{99m}Tc was injected systemically, and the count-rate on the pre-cordial level measured by a scintillation probe (2x2"-NaI(Tl)). This was the reference count-rate. Subsequently, 0.5 MBq/kg of ^{99m}Tc was injected into the perfusion circuit. Leakage was associated to an increase of the reference count-rate. A leakage(%) curve was registered during HILP, taking into account the physical decay, the volume and radioactivity ratio between the systemic and isolated circuits. 10% leakage was considered as threshold limit to interrupt HILP. If the two circuits are balanced (no leakage), 1 mg of TNF was injected into the limb at 38°C. After ~30', Melphalan was injected with the limb reaching >39°C. Melphalan perfusion lasted 1h before the washout procedure. In the first 5 patients serial blood samples were drown during surgery to evaluate TNF concentration. The TNF measured in blood and TNF the extrapolated from the leakage curve (^{99m}Tc-PYP) were compared. **Results:** Only in 2 out of 20 patients, HILP was not performed because of leakage >10%. The results of TNF concentration in blood are consistent with ^{99m}Tc-PYP evaluations. In 3 patients, the duration of perfusion was shortened due to high increase of leakage (>8%). In 3 patients, negative values of leakage were registered after 10', because of an inverse pressure occurred between systemic (higher pressure) and isolated (lower pressure) circuits, thus increasing the perfused circuit volume. **Conclusions:** ^{99m}Tc-PYP is able to accurately quantify the value of leakage with the advantage of a continuos, easy, recordable and real-time monitoring. Moreover, risks from radiation protection perspective are negligible. These characteristics optimise and guarantee the safety of the procedure.

27

Model Selection for Blood Time-Activity Curves using the F-test and Akaike's Information Criterion

P. Kletting[1], K. Hohl[2], S. N. Reske[1], G. Glatting[1]; [1]Universität Ulm, Klinik für Nuklearmedizin, Ulm, GERMANY, [2]Universität Ulm , Biometrie und Medizinische Dokumentation, Ulm, GERMANY.

Objectives: Different criteria exist to choose the best model among a set of alternative models. A commonly used model selection method is the F-test. Another appropriate method is the Akaike's information criterion (AIC) which can be interpreted intuitively and is not restricted to compare nested models. Thus, both methods were applied to determine the best model describing the blood biokinetics of In-111-labeled anti-CD66 antibody and then compared in terms of robustness, user-interaction and applicability. In addition, pharmacokinetic parameters of all patients were investigated with respect to their equality. **Methods:** In 11 patients (6 male and 5 female, age: median 47 years, range 12-66 years) with AML or ALL, the blood serum activity of In-111-labeled anti-CD66 was measured in preparation for conditioning prior to allogeneic stem cell transplantation. A set of 5 models (sums of exponentials) was chosen to identify the model fitting the data best. The F-test and the AIC were conducted. The fit parameters were calculated using a minimum sum of squares algorithm with two weighting methods (1/y2, no weighting). **Results:** The AIC approach leads to the selection of the same model (sum of two exponentials) for all patients choosing 1/y2 as weighting method. Using no weighting, for all but one patient the same model was preferred. The results of the F-test were much more inhomogeneous and sensible to the chosen weighting method. In addition, we found that the time activity curves differ between patients although there are common properties. **Conclusions:** General advantages of the AIC over the F-test are confirmed in the study, especially the more intuitive user interaction , which is helpful for an effective and efficient fitting process. For the investigated data the AIC is demonstrated to be the more robust approach, since the sensitivity of the AIC to the chosen weights model of the data seems to be smaller.

28

Wide Beam Reconstruction Technology - Does It Respect Myocardial Perfusion SPECT Functional Parameters?

H. Pena[1], **G. G. Cantinho**[1], S. C. Shwartz[2], S. Figueiredo[1], D. Marona[1], J. Monteiro[1], F. Godinho[1]; [1]Atomedical & IMN-FML, Lisboa, PORTUGAL, [2]UltraSPECT, Ltd, Haifa, ISRAEL.

Background: Wide Beam Reconstruction (WBR™) technology (UltraSPECT, Israel) is a resolution recovery method, designed to simultaneously suppress noise and improve image resolution and is optimised specifically for short gated cardiac stress perfusion scans without applying any post-filter. The aim of our study was to compare the quantitative myocardial perfusion(MP) SPECT functional parameters based on the image obtained by this new methodology with the values obtained through our usual protocol. **Methods:** 100 patients were studied: 29 women and 71 men, 62±11 years old and weight: 75±12 kg. 51 had history of AMI. After pharmacological stress, patients went through a double stress MP SPECT scan, on the same occasion and gamma camera. The first acquisition used 30 views, 40 sec/view (2 detectors at 90º). Images were reconstructed by filtered back projection(FBP). The second protocol used 60 views, 10 sec/view. Images were treated by WBR. The 200 acquired studies were processed by the same operator with Cedars-Sinai software. LVEF, EDV, ESV, SMS and STS were determined. Paired Student t test and correlation coefficient(CC) was calculated. **Results:** The sample size of 200 studies presents a statistical power of 0.99 (effect size: 0.3; alpha-level: 0.05). LVEF and volumes of the two paired groups show no statistically significant difference (SSD) and a very strong correlation. Summed scores show a SSD in Student t test, but with a strong CC (see tables below). **Conclusions:** The very good results obtained confirm that this new technology with half of the scan time doesn't influence the main functional parameters obtained in MP SPECT scans (LVEF and volumes). Motion and thickening scores are strongly