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BOOK OF ABSTRACTS

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001

WHOLE BODY HYBRID PET/MR DETECTS MORE NEOPLASTIC LESIONS THAN PET/CT IN METASTATIC LUNG CANCER

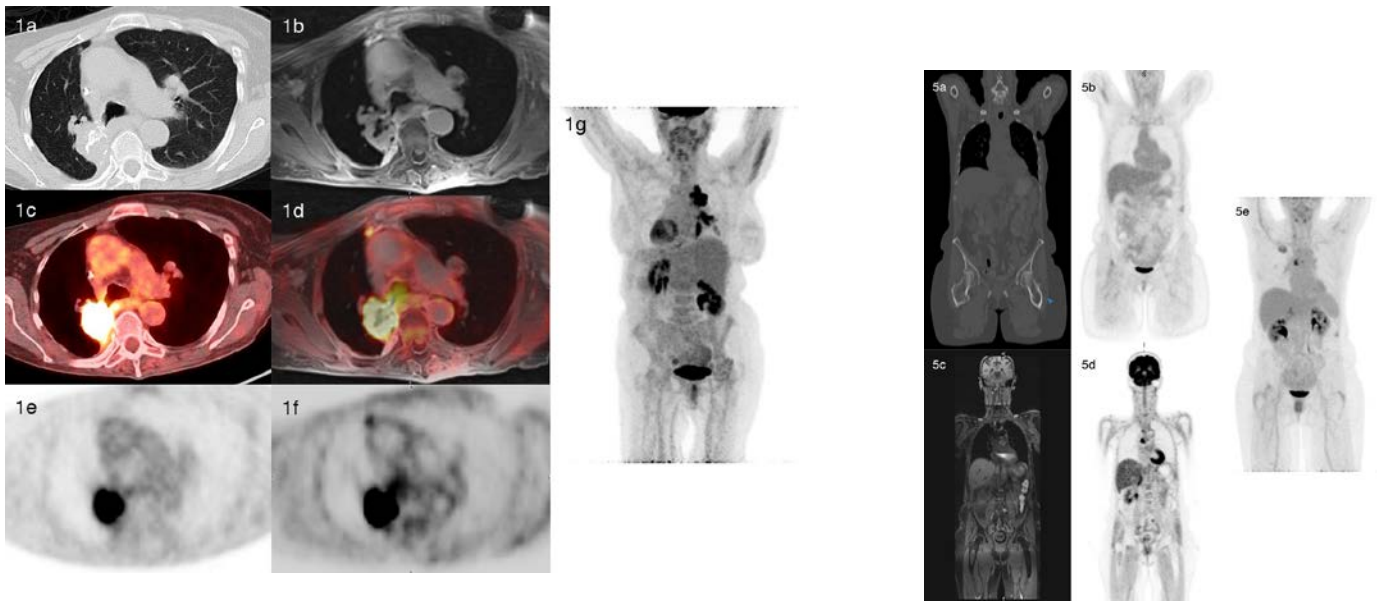
Rajan Rakheja, Linda DeMello, Hersh Chandarana and Kent Friedma, Division of Nuclear Medicine, Department of Radiology, New York University School of Medicine, New York, NY

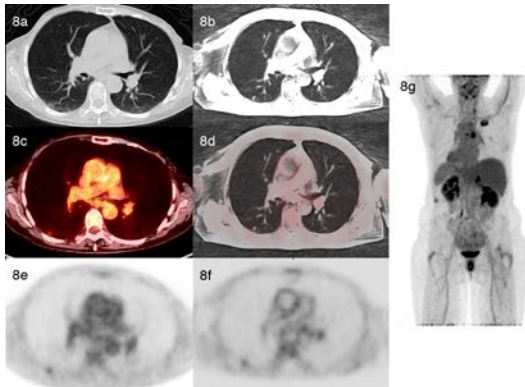
Purposes: To compare the ability to detect neoplastic disease using positron emission tomography (PET)/magnetic resonance (MR) imaging in metastatic lung cancer with that of PET/computed tomography (CT).

Methods: Institutional review board approval and informed consent were obtained. Six patients with proven stage IV lung cancer underwent fluorine 18 fluorodeoxyglucose FDG-PET/CT. Directly after, these patients underwent a whole-body PET/MR scan with our new hybrid whole-body system (MR with integrated PET system, Siemens, mMR). The PET/CT was read independently by a Nuclear Physician trained in PET/CT. The PET/MR study was jointly read by a Nuclear Physician with extensive experience in PET/CT and a Radiologist with vast experience in MR. Location and number of neoplastic lesions were documented. Tumor-to-liver ratios were calculated and compared between PET/CT and PET/MR imaging. Spearman rank correlation was used for comparison of data.

Results: All neoplastic lesions described on PET/CT were identified on PET/MR (23/23 lesions). PET/MR detected additional osseous metastases in one patient and better delineated size and extent of bone metastases in two patients. In addition, PET/MR demonstrated brain metastases in one patient, an area not imaged on routine PET/CT. A pancreatic lesion not seen on the CT portion of the PET/CT was effortlessly identified on PET/MR. A strong Spearman correlation was found between the tumour -to-liver ratios at PET/CT and those at PET/MR ($p = 0.86$). The mean tumour-to-liver SUV ratio was 2.32 for PET/CT and 4.39 for PET/MR.

Conclusion: Simultaneous PET/MR is a promising new technology for detection metastatic disease in patients with lung cancer. There were no FDG-avid metastases identified on PET/CT that could not be identified on PET/MR. In addition to significantly decreasing radiation exposure, PET/MR better defined osseous and pancreatic metastases.





002

WHOLE BODY HYBRID PET/MR DETECTS MORE OSSEOUS METASTASES THAN PET/CT

Rajan Rakheja¹, Linda DeMello¹, Hersh Chandarana¹, Sarah Palestrant, Amy Melsaether, Kent Friedman¹

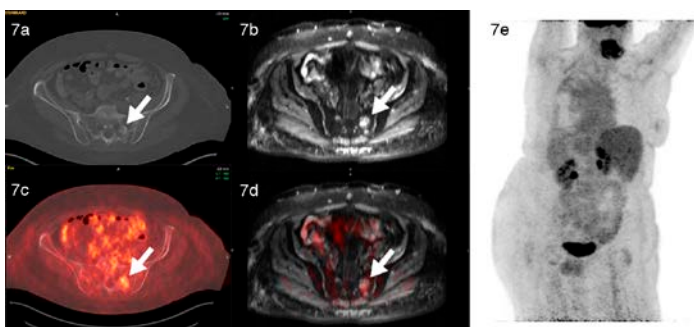
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Purposes: To compare the ability to detect osseous metastases using positron emission tomography (PET)/magnetic resonance (MR) imaging in patients with known bone metastases with that of PET/computed tomography (CT).

Methods: Institutional review board approval and informed consent were obtained. Twelve patients with known bone metastases underwent fluorine 18 fluorodeoxyglucose FDG-PET/CT. Directly after, these patients underwent a whole-body PET/MR scan with our new hybrid whole-body system (MR with integrated PET system, Siemens, mMR). The PET/CT was read independently by a Nuclear Physician trained in PET/CT. The PET/MR study was jointly read by a Nuclear Physician with extensive experience in PET/CT and a Radiologist with vast experience in MR. Another blinded Radiologist read the PET/MRI for osseous metastases confidence scoring. Location and number of bone metastases were documented, along with reader confidence scores. Tumor-to-liver ratios were calculated and compared between PET/CT and PET/MR imaging. Pearson’s correlation was used for comparison of data.

Results: PET/MR detected 45/45 bone metastases, PET/CT detected only 36/45 (80%) metastases. PET/MR detected several additional osseous metastases and better delineated size and extent of metastases. Reader confidence scores were higher for PET/MR than PET/CT (pair t-test, $p < 0.05$). A strong Pearson’s correlation was found between the tumor-to-liver ratios from PET/CT and those from PET/MR ($r = 0.96$, $p < 0.05$).

Conclusion: Simultaneous PET/MR is a promising new technology for detection osseous metastases. PET/MR detects more bone metastases than PET/CT, while the superior anatomical resolution also contributes to higher reader confidence scores.



003

CORRELATION BETWEEN SUV AND ADC OF NEOPLASTIC LESIONS ON WHOLE-BODY SIMULTANEOUS HYBRID PET/MR*Rajan Rakheja¹, Linda DeMello¹, Hersh Chandarana¹, Kent Friedman¹*

Purpose: To assess the correlation between SUV and ADC of neoplastic lesions using simultaneous positron emission tomography (PET)/magnetic resonance (MR) hybrid camera

Methods: Institutional review board approval and informed consent were obtained. Twenty four patients with known primary malignancies underwent fluorine 18 fluorodeoxyglucose (FDG)-PET/CT. Subsequently, these patients underwent a whole-body PET/MR examination with a recently introduced hybrid whole-body system (MR with integrated PET system, Siemens, mMR). Diffusion imaging was acquired using a single shot spin echo EPI sequence with parameters as follows: slice thickness 6 mm, TR/TE 5900/54 milliseconds, 30 axial slices, BW 1628 Hz/pix, voxel size 2.6 x 2.1 x 6 mm, parallel imaging GRAPPA factor of 2, fat-saturation mode, b-values of 0, 350 and 750 s/mm². The PET/CT was interpreted independently by nuclear physicians trained in PET/CT. The PET/MR study was jointly read by a nuclear physician with experience in PET/CT and a radiologist with experience in MR. ROIs were manually drawn along contours of the neoplastic lesions that were clearly identified on PET and DWIs. ADC_{mean} was defined as average ADC value for all voxels in each lesion, and ADC_{min} as the lowest ADC value among all voxels in each lesion. SUV_{max} (on PET/MR and on PET/CT), SUV_{mean}, ADC_{min}, and ADC_{mean} were recorded on PET/MR for each FDG-avid neoplastic soft tissue lesion, for a maximum of three lesions per patient. Relationship between SUV_{max} vs ADC_{min} (on PET/MR and PET/CT), SUV_{mean} vs ADC_{mean}, SUV_{max}/liver mean vs ADC_{min} were assessed using Pearson's correlation coefficient.

Results: Sixty nine neoplastic lesions (52 non-osseous lesions, 17 bone metastases) were evaluated. The mean SUV_{max} from PET/MR was 7.0±6.0, mean SUV_{mean} was 5.6±4.6, mean ADC_{min} was 1.10±0.58 and mean ADC_{mean} was 1.48±0.72. A significant inverse Pearson's correlation coefficient was found between the PET/MR SUV_{max} and ADC_{min} (r= - 0.21, p=0.04), between SUV_{mean} and ADC_{mean} (r= -0.18, p=0.07), and between SUV_{max}/liver mean and ADC_{min} (r= - 0.27, p=0.01). A similar inverse Pearson's correlation coefficient was found between the PET/CT SUV_{max} and ADC_{min} (r= - 0.29, p=0.01) and between PET/CT SUV_{max}/liver mean and ADC_{min} (r= - 0.25, p=0.02).

Conclusion: Simultaneous PET/MR is a promising technology for detection of neoplastic disease. Given the significant inverse correlation between SUV_{max} with ADC_{min}, and SUV_{mean} with ADC_{mean}, ADC values may offer complimentary information about tumor cellularity. Correlation coefficients between SUV_{max} and ADC_{min} from PET/MR were similar to values obtained from same day earlier PET/CT. There is future potential to utilize both tumoral quantitative markers to assess aggressiveness and treatment response.

004

[¹⁸F]FLUOROETHOXYBENZOVESAMICOL (¹⁸FEOBV) RELIABLY DEPICTS ALZHEIMER'S DISEASE-LINKED CHANGES IN CHOLINERGIC SYSTEMS IN THE HUMAN BRAIN

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Objectives: Early alterations of basal forebrain cholinergic systems are a well know part Alzheimer disease (AD), and correlate with its clinical manifestations. The PET radiotracer [¹⁸F]Fluoroethoxybenzovesamicol ([¹⁸F]FEOBV)

has been proposed as a tool to evaluate the state of those systems *in vivo* on the basis of thorough validations in rodents and primates. Recent results suggest that cholinergic anomalies in AD might be linked to morphological alterations of cholinergic fibers, rather than to a decrease in their number. We investigated whether [¹⁸F]FEOBV can, *in vitro*, detect differences between postmortem brain samples from AD subjects and controls.

Methods: Frozen samples from 13 AD subjects and 23 matched normal controls were obtained from the Douglas-Bell Canada Brain Bank. Tissue sections from the striatum, prefrontal cortex and hippocampus were incubated for 60 min. in [¹⁸F]FEOBV (>1100 Ci/mmol), washed in cold buffer, dried and imaged with phosphor plates (20 minutes). Seven sub-regions were analyzed on digitized sections: neocortical gray and white matter (the latter used as non-specific binding reference area), caudate, putamen, and 3 hippocampal sectors (CA1, CA3, dentate gyrus). Averaged normalized binding values for each region were compared (Controls vs AD) by one-way ANOVA.

Results: Significant binding reductions were found in AD subjects in CA1 (20.13%; F = 13.39, p = 0.001), CA3 (25.16%; F = 7.15, p = 0.014), and in the PFC (24.5%; F = 22.07, p < 0.0005). Other areas evaluated presented no significant anomaly.

Conclusions: Decreased [¹⁸F]FEOBV binding in CA1, CA3 and PFC agrees with reported degeneration of septohippocampal and innominatocortical cholinergic systems in AD. Maintained binding in the dentate gyrus might be explained by reactive sprouting of remaining cholinergic fibers or primary resistance of those fibers to degeneration. [¹⁸F]FEOBV is a promising marker for the detection of alterations in brain cholinergic systems, whether those are linked to changes in innervation density or to reversible structural or molecular modifications of cholinergic fibers.

005

COMBINED RADIONUCLIDE MYOCARDIAL PERFUSION STUDIES AND STRESS ECHOCARDIOGRAPHY MAY PROVIDE THE MOST ACCURATE PHYSIOLOGICAL STUDY OF THE HEART, ELIMINATING UNNECESSARY CARDIAC CATHETERIZATIONS.

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PURPOSE: Myocardial Perfusion Study (MPS) is considered to be one of the best physiological tests for diagnosis of ischemic heart disease. However, it has a number of problems such as diaphragmatic attenuation in men, breast attenuation in women, lateral attenuation in obese patients, fictitious abnormalities from radioactivity from the adjacent organs, and falsely negative studies due to balanced severe triple vessel disease. Our hypothesis was if adding stress echocardiogram (SECHO) will help resolve these issues.

METHODS: A series of patients with clinical suspicion of ischemic heart disease had history and physical examination, stress ECG test (SET), MPS, echocardiogram and SECHO. On the basis of this combination, ischemic heart disease was suspected in certain patients who were sent for cardiac catheterization.

RESULTS: We have full reports of 64 consecutive such patients. 62 patients were noted to have significant coronary artery disease defined as minimum of 70% blockage of one of the 4 major coronary arteries. Therefore 97% of the patients who were sent for angiography deserved this to be done. A similar figure in the literature appears to be about 70%. Therefore these results indicate that addition of SECHO to MPS increased the accuracy of the diagnosis of cardiac ischemia. Also, the combined studies dramatically improved identification of the abnormal segments of the heart. Attempts were made to have a follow up of the patients who were not sent for catheterization. In this group, one patient suffered from myocardial infarction several months after the procedure but is well now. 55 patients were fully re-evaluated and showed no significant abnormalities. This may indicate that in the original studies, good prognosis could be given to the patients who were not deemed to be abnormal.

CONCLUSION: Here we report a dual modality imaging system using radioisotopes and sound waves. We believe that this combination may give the most accurate physiological study that has been available up to date. There may be two objections to our proposed approach: 1) Addition of SE increases the cost. We believe this is much

more compensated by doing fewer unnecessary angiograms; 2) Two stress tests on the same day are dangerous. There is vast literature on this subject referred to as the 'warm up phenomenon' which indicates it may even be beneficial. Also we have reduced risk to patients by avoiding unnecessary angiograms. Our findings require to be confirmed by a controlled clinical trial.

006

STRESS ECG TEST CANNOT BE USED AS A SOLE TEST TO EXCLUDE SIGNIFICANT CORONARY ARTERY DISEASE REQUIRING INTERVENTION

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PURPOSE: Much is written about problems with using stress ECG test (SET) as a sole test for exclusion of significant coronary artery disease. However, in guidelines of various countries SET (as a sole test) is recommended as capable of excluding significant ischemic heart disease. For the present study, our hypothesis was that it cannot be used as such.

METHODS: A series of patients with clinical suspicion of ischemic heart disease had: (1) their medical history taken and subjected to physical examination, (2) SET, (3) radionuclide myocardial perfusion studies (MPS), (4) echocardiogram and stress echocardiogram (SECHO). On the basis of this combination, ischemic heart disease was suspected in a number of patients who were sent for cardiac catheterization. We have complete results of 64 such patients, 62 of whom had significant ischemic heart disease on angiography. Our current study is on the basis of these 62 extensively studied patients. In all patients ST segment depression (STD) were measured and recorded as 0-5 mm; or it was indicated that because of bundle branch block no significance can be placed on STD.

RESULTS: *Single vessel disease:* Left anterior descending coronary artery: out of a total of 21 patients, 11 had no STD, 4 had 1-1.9 mm STD and 5 had STD of 2 mm or more. One had bundle branch block. There was no correlation between degree of STD versus severity of blockage ($p=0.175$). Right coronary artery: out of 8 patients, 2 had no STD, 2 had 1-1.9 mm STD, 4 had STD of 2 mm or above. There was significant correlation between extent of STD and severity of blockage ($p=0.025$). Left main coronary artery: out of 3 patients 1 had STD of 1.5 mm, 1 had STD of 2 mm and one had STD of 3.5 mm. Left circumflex coronary artery: only one patient who had no STD. *Multiple vessel disease:* out of 15 patients with 3 vessel disease, one had no STD, one had 1 mm and 13 had 2-5 mm STD. There was significant correlation between STD and number of vessels involved ($p=0.014$).

CONCLUSION: Statistical analysis showed the more extensive coronary artery disease, the more pronounced STD on SET. The current study shows that SET is of no help whatsoever in case of the single blockage (70-100%) of the left anterior descending coronary artery. We believe that a patient with 70% or more blockage of LAD should be considered for angioplasty and this was successfully done for our patients. According to our results, using SET, as the sole investigation, is not reliable for exclusion of ischemic heart disease.

007

AN EVALUATION OF THE MEASUREMENT OF THE TRANSIENT ISCHEMIC DILATATION RATIO IN ISCHEMIC HEART DISEASE

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PURPOSE: In radionuclide myocardial perfusion studies (MPS) the average volume of the left ventricle (LV) is measured at rest (LVR) and when post-exercise (LVPE) studies are done (usually 30 minutes after exercise). LVPE is divided by LVR to obtain what really is persistent ischemic dilatation ratio, but is by tradition, called Transient

Ischemic Dilatation ratio (TID ratio). It is reported in the literature that when the value is 1.21 or more, it signifies significant ischemia. TID ratio is now routinely measured and reported in nuclear cardiology studies. We investigated the value of this ratio in clinical practice in ambulatory patients who had their TID ratio calculated before and after intervention. Also we compared this to the actual visualization of segmental or global cardiac ischemic dilatation as visualized by stress echocardiography.

METHODS: A series of patients with clinical suspicion of ischemic heart disease had history and physical examination, stress ECG test (SET), MPS, echocardiogram and stress echocardiogram (SECHO). On the basis of this combination, ischemic heart disease was suspected in certain patients who were sent for cardiac catheterization. They had angioplasty or bypass surgery and were again scanned by the aforementioned non-invasive physiological tests.

RESULTS: Fifty four patients were noted to be normal and their average TID ratio was 0.93. Nine patients had single vessel disease and their average TID ratio was 1.04 before and 0.97 after intervention. Nine patients were noted to have two vessel disease and their average TID ratio was 1.01 before and 0.97 after intervention. Six patients were noted to have three vessel disease and their average TID ratio was 1.00 before and 0.97 after intervention. The patients were observed with echocardiogram during exercise (SECHO) and in 10 patients, all or part of the left ventricle dilated during exercise. In these patients, the TID ratio was 1.35, 1.04, 1.28, 0.9, 1.29, 1.07, 0.9, 1.17, 1.03 and 1.01.

CONCLUSION: Very few patients had elevation of TID ratio. Statistical analysis revealed TID ratio was not related to the extent of coronary artery disease. Intervention, which was shown by physiological studies to have been beneficial in most patients, made no difference to the ratio. Therefore, in the context of ambulatory patients with ischemic heart disease, calculation of TID ratio does not give any extra information. In contrast, stress echo clearly demonstrated transient ischemic cardiac dilation.

008

A FEASIBILITY STUDY OF THE USE OF GAMMA CAMERAS IN CANADIAN HOSPITALS AS WHOLE BODY COUNTERS FOR PEOPLE IN AN EMERGENCY, INTERNALLY CONTAMINATED BY RADIONUCLIDES

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OBJECTIVE: In a nuclear accident, a large number of people may be contaminated by gamma ray-emitting radionuclides such as ⁶⁰Co, ⁹⁰Sr, ¹³¹I, ¹³⁷Cs, ¹⁹²Ir and ²⁴¹Am. Many may require assessment of their contamination levels using various devices including portal monitors, hand-held detectors, and whole body counters (WBC). Canada has a limited number of such equipment, but most of its hospitals have gamma cameras for nuclear diagnostics. Therefore, the objective of this work was to determine the feasibility of using gamma cameras in hospitals as whole body counting devices,

MATERIALS AND METHODS: A literature search and a telephone survey of hospitals in Canada were conducted. In order to understand more about the potential of gamma cameras in Canada in a nuclear accident, the Radiation Protection Bureau (RPB) raised the question at a 2012 face-to-face meeting with the Federal/Provincial/Territorial Radiation Protection Committee (FPTRPC) in Ottawa.

RESULTS: The literature search showed no Canadian publication on the topic. The telephone survey revealed poor cooperation from hospitals. A face-to-face meeting with the FPTRPC in Ottawa, showed support for establishing networks with hospitals and other centres that have gamma cameras, and for developing appropriate protocols. If properly modified and operated, gamma cameras can augment the Canadian equipment capacity for emergency response.

CONCLUSION: Gamma cameras in hospitals can augment the equipment capacity for nuclear emergencies in Canada. Improvement of RPB's communication with hospitals will strengthen its plans to conduct research into developing protocols that will make gamma cameras suitable for assessment of people who may be internally contaminated. So far however, no country has successfully used a gamma camera as a WBC for emergency response, but the Centre for Disease Control (CDC) in the USA suggests that gamma cameras should be used only after patients have been adequately externally decontaminated.

009

OVERSIMPLIFICATION IN BASIC NUCLEAR MEDICINE TEXTBOOKS HAS INTRODUCED CONCEPTUAL AND MATHEMATICAL ERRORS.

Matthieu Pelletier-Galarneau, Lionel S. Zuckier

Objective: In the effort to simplify physiologic and epidemiologic concepts, we note that basic textbooks have promulgated 2 mathematical non sequiturs which often have become standard teaching. We therefore wish to review the mathematical underpinnings of the interpretation of diuretic renography and V/Q lung scanning and contrast them to the simplified rules of interpretation.

Findings: Published interpretation of obstruction on diuretic renography relies on fixed washout cutoff times (typically <10, 10-20 and > 20 min) to differentiate obstructed from non-obstructed renal units. We note that half-time of washout is actually dependent on the ratio of renal flow to renal pelvic volume; use of a fixed cutoff in the case of severe collecting system dilation vs. a more modestly dilated system ignores the mathematical underpinnings of the study and will overdiagnose obstruction in the former case and underdiagnose in the latter. Our second example addresses the typical reporting of V/Q scans, as high, intermediate and low probability. This unfortunate labeling nomenclature relies solely on the scan finding and does not take into account the pretest probability, which is inconsistent with Bayes' theorem and can lead to erroneous clinical conclusions.

Conclusion: Review of mathematical underpinnings of diuretic renography and lung scanning will grant the nuclear medicine physician with a superior understanding of these examinations.

010

¹²³I-NAI IMAGING CAN BE ELIMINATED FROM EARLY/LATE MIBI IMAGING WITH ONLY MINIMAL EFFECT ON FINAL IMAGING DIAGNOSIS.

Matthieu Pelletier-Galarneau, Lionel S. Zuckier

Objectives: Of the multiple components comprising our standard parathyroid imaging, ¹²³I-NaI imaging is decidedly the most costly. We analyzed effect of eliminating this imaging phase on final diagnoses.

Material and Methods: We retrospectively analyzed 44 consecutive parathyroid studies of patients with primary hyperparathyroidism acquired over 1 year. Acquisition protocol comprises dual-energy ^{99m}Tc-MIBI/¹²³I-NaI planar images (at 15 min and 3 hrs) and subsequent ^{99m}Tc-MIBI SPECT-CT. Three sets of images were interpreted: 1. Early/late MIBI alone 2. Former plus late MIBI SPECT-CT 3. Former plus ¹²³I-NaI comparison. The constrained sets 1 and 2 were compared to consensus diagnosis based on total information (set 3).

Results: By removing the ¹²³I comparison, interpretation of only 2/44 patients was altered (1 each positive or equivocal to negative). By also eliminating SPECT-CT, interpretation of another 6 studies was altered; 3 positive to negative, 2 positive to equivocal and 1 negative to positive.

Conclusion: Comparison with ^{123}I , added to base early/late MIBI imaging, was necessary to reach final diagnosis in only 2/44 patients (4.5%) suggesting that in our era of constrained resources, this radiopharmaceutical can be eliminated with savings of over \$52,000 in 44 patients and only minimal effect on accuracy. In this scenario, SPECT-CT remained a necessary component of diagnostic testing, necessary for final diagnosis in 6/44 cases. In selected cases, $^{99\text{m}}\text{TcO}_4^-$ imaging could potentially be subsequently performed to replace ^{123}I -imaging.

011

^{51}Cr -EDTA VOLUME OF DISTRIBUTION AS A FUNCTION OF TIME AND ITS IMPLICATIONS FOR EXPONENTIAL AND ADAPTIVE GAMMA VARIATE PLASMA-CLEARANCE MODELS.

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Objectives: Time varying volume models, $V(t)$, are developed and tested for Sums of Exponential term (SET) models with one (E1), two (E2) and n (En) exponential terms and for adapted GV functions.

Methods: Plasma clearance (CL) and $V(t)$ models were validated using ^{51}Cr -EDTA from patients with liver failure ($n = 13$, $t = 5, 1440$ min).

Results: Gamma variate (GV) models obtained by adaptive Tikhonov regularization (Tk-GV) are consistent with V being zero at $t = 0$. E1 models produce both CL - and V -values that approach infinity at late times, as measured from E1 solutions for CL and V using temporally adjacent plasma samples. CL -values from E1 models applied to temporally adjacent samples are always larger than their corresponding $CL(\text{Tk-GV})$ values. From Tk-GV model predictions, the least inflated $CL(\text{E1})$ -values still average 15% too large. This explains the empirically observed Chantler constant. When the E1 and GV functions agree at two points, the Chantler type correction factor varies with 1) sampling times, 2) level of renal function, and 3) ratio between the inhomogeneous and homogeneous volumes of distribution of the system, the latter of which is difficult to calculate from an E1 model. E2 models also had significantly inflated CL -values. The E1 and E2 models have significantly more negative curvature than C_{obs} . Even En models incorporating $V(t)$ have $V > 0$ at $t = 0$ and convergence to E1 for t large, Thus, En has inflated CL -values from underestimation of AUC .

Conclusions: GV functions from Tk-GV models exhibit $V = 0$ at $t = 0$, do not converge to E1 for t large, had the least root mean square error relative to C_{obs} (rRMS = 7.7%) and were the best concentration models tested. The SET functions used had rRMS > 10%, underestimated AUC , overestimated CL , and did not estimate CL as well as adapted GV models for ^{51}Cr -EDTA.

012

DUAL PHASE TC-99M MIBI IMAGING WITH SPECT/CT IN THE EVALUATION OF PRIMARY HYPERPARATHYROIDISM: EVALUATION OF THE LOCALIZATION ACCURACY

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Objectives: Assess the accuracy of dual phase Tc-99m MIBI with SPECT/CT for localization of parathyroid adenomas in the setting of primary hyperparathyroidism.

Methods: Retrospective evaluation of 400 consecutive patients who had a Tc-99m MIBI SPECT/CT study for hyperparathyroidism between Mar 2007 and June 2009. 87 patients met our study criteria which included

surgical intervention within one year of the SPECT/CT, the absence of chronic end-stage renal failure or dialysis, and previous parathyroid surgery or total thyroidectomy. Surgical findings were used as the reference standard and were categorized as conventional left, conventional right, or ectopic in location. The pre-operative SPECT/CT findings were then compared with surgery to determine the accuracy of the pre-operative localization.

Results: 86 of the 87 patients were found to have a parathyroid adenoma at the time of surgery while one patient was diagnosed with a parathyroid carcinoma. No patients were diagnosed with parathyroid hyperplasia. 26 of the implicated parathyroid glands were ectopically positioned and 61 glands were conventionally located at surgery. Accuracy indices for the localization of ectopic parathyroid adenomas were as follows: sensitivity 80.8%, specificity 100%, positive predictive value 100%, negative predictive value 92.4% and overall accuracy 94.3%. Accuracy indices for the conventional location and correct side were as follows: sensitivity 86.7%, specificity 96.3%, positive predictive value 98.1%, negative predictive value 76.5% and overall accuracy 87.4%. Overall, the accuracy indices were as follows: sensitivity 83.9%, positive predictive value 100% and overall accuracy 83.9%. The specificity and negative predictive value could not be calculated for the overall data set as an adenoma or carcinoma was detected at surgery in every case.

Conclusions: Dual phase Tc-99m MIBI with SPECT/CT is a very accurate and reliable means to correctly localize parathyroid adenomas for the purpose of surgical planning.

013

RECENT ADVANCES IN MULTIMODAL NUCLEAR IMAGING AND VISUALIZATION: DUAL TRACER PET/SPECT IMAGING AND 3D PRINTING

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Traditional invasive studies can readily produce high quality cross sectional studies of biological processes in pre-clinical models of disease. However, the true power of *in vivo* molecular imaging can be demonstrated through non-invasive longitudinal studies. The information content gleaned from such studies is multiplied by the number of modalities that may be applied in a reasonable fashion. To this end, we will present a new and robust method for full trimodal imaging of animals in SPECT, PET, and CT modes in which data fusion is conserved using an integrated nuclear imaging platform. This work demonstrates that combinations of ^{99m}Tc (sPECT) and ¹⁸F (PET) probes may indeed be used within individual animals in a practical experimental manner. In addition, we will present a 3D printing technique for the enhanced visualization of these tomographic data sets. In essence, this strategy takes data off of the computer screen and puts it in the palm of the viewer's hand in the form of an anatomical model object in which the complexity of the specimen is conserved. In summary, these protocols highlight the use and integration of multimodal imaging for longitudinal studies with a focus on technology and visualization.

014

REVIEW OF RADIATION EXPOSURE FROM CT SCANS PERFORMED IN WHOLE BODY PET/CT SCANS FOR ONCOLOGIC INDICATIONS IN A COMMUNITY BASED CLINIC- A MEDICAL QUALITY ASSURANCE REPORT

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Objectives: To review the radiation exposure from the CT scan portion of the PET/CT studies performed at our laboratory to confirm that our procedure is keeping with the current standard of practice.

Method: We have performed a retrospective review of all patients coming to our laboratory for PET/CT for oncologic indications from February 2011 to October 2012. The dose reports generated by the CT scanner for all these patients were tabulated and the corresponding effective doses calculated. Averages and ranges of effective dose were calculated for the whole group and subgroups of body weight.

Results: 415 PET/CT were performed from February 2011-October 2012. The dose report was not available in 4 patients and therefore not included in this analysis. The average effective dose (range) for the whole group of patients, the weight categories of <120lb, 121-150lb, 151-175lb, 176-200lb and >200lb were: 6.9mSv(1.9-11.6mSv), 3.9mSv(1.9-8.4mSv), 5.5mSv(3.7-7.9mSv), 6.9mSv(3.5-8.6mSv), 8mSv(6.6-10.2mSv) and 9.5mSv(5.7-11.6mSv) respectively.

Conclusion: CT scans have increasingly been used for diagnostic purposes over the past few decades. A number of reports have examined the associated radiation induced cancer risk from CT scan. Although the risk appears to be low, there is increasing awareness in the medical community for the need to minimize the radiation dose to patients undergoing CT scans. We have confirmed that the effective dose to patients in our CT procedure is in line with the effective dose of combined CT neck, chest, abdomen and pelvis scans quoted by other centres in the literature. Furthermore, our protocol minimizes radiation dose to smaller size patients who require lower mA to produce an adequate scan.

015

RENAL CORTICAL IMAGING IN CHILDREN: 99mTc MAG3 VERSUS 99mTc DMSA.

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OBJECTIVE: To determine the potentials of technitium-99m mercaptoacetyltriglycine (99mTc MAG3) to replace technitium-99m dimercaptosuccinic acid (99mTc DMSA) in assessment of renal cortex and split renal function (SRF).

MATERIAL AND METHODS: This a retrospective study in which we reviewed the scintigraphic results of 52 patients with age range of 7 days-10 years (mean, 5.3 years). A total of 104 studies (1 99mTc MAG3 and 1 99mTc DMSA per patient) were performed between 1 January, 2009 and 31 December, 2010 because of various renal disorders. Both studies were performed within 24 hours of each other, starting with 99mTc MAG3.

RESULTS: Twenty patients had normal SRF, and 26 patients had abnormal SRF (6 with solitary kidney, 4 with 1 kidney SRF <10%, and 16 with 1 kidney SRF >10%). In all 46 patients, SRF assessed by 99mTc MAG3 correlated with that by 99mTc DMSA (P = 0.0001). In remaining 6 patients, the correlation was less optimal, and the diseased kidney had overestimation of SRF by 99mTc MAG3. Nonvisualized kidneys and cortical defects were observed equally on both studies.

CONCLUSION: 99mTc MAG3 provides adequate images for assessment of renal cortex and accurate measurement of SRF comparable with 99mTc DMSA results. In addition, it provides important information on the

urodynamics of both kidneys, avoids unnecessary radiation to the children, as well as is time saving. We consider it is time to replace the ^{99m}Tc DMSA with ^{99m}Tc MAG3 in most nephrourologic disorders in pediatric patients and to keep the former to doubtful cases obtained using the latter.

016

METASTATIC OVARIAN CARCINOMA SHOWING SURPRISINGLY WIDESPREAD SUBCUTANEOUS ^{99m}Tc-MDP SOFT-TISSUE UPTAKE

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Objective: We report the rare observance of subcutaneous lesions from an ovarian primary and there unusual uptake of ^{99m}Tc-MDP on whole body bone scan.

Materials and Methods: 26.7 mCi of ^{99m}Tc-MDP (methylene diphosphonate) was administered intravenously in the left antecubital fossa. Tomographic whole body images from head to mid-thigh and planar images of the lower extremities were obtained 2.5 hours after the radiotracer was injected. For the computed tomographic (CT) studies, selected CT thorax, abdomen and pelvis with oral contrast were obtained showing multiple subcutaneous and intramuscular lesions. An excision of the skin measuring 1.4 x 1.3 by 0.9 cm with the resection margin inked green was analyzed histologically. The cut sections showed homogeneous pale tan tissue and within the dermis there was a deposit of adenocarcinoma. The tumor was also noted to form cysts and there were numerous psammoma bodies. Similar samples analyzed previously and found elsewhere within this patient were shown representing metastatic adenocarcinoma.

Descriptions: A patient with primary ovarian carcinoma was evaluated for skeletal metastases with a routine whole body bone scan. Metastases to bone was not visualized, however multiple foci of soft-tissue uptake were noted including several subcutaneous lesions. Correlating CT and excision biopsy confirmed calcified soft tissue metastases. Cutaneous involvement is unusual during metastases in a variety of primary malignancies but is even more so at presentation. Epithelial ovarian Ca accounts for 90% of ovarian tumours with other types including sex-cord-stromal tumours, germ cell tumours, and extra-ovarian primary peritoneal cancer (1-4). The intraperitoneal route of dissemination is thought to be the most common but there is evidence for metastasis through lymphatic channels, hematogenously or accidental implantation following surgical debulking (5). Distant metastasis, including cutaneous manifestations, occurs more frequently at late stages of the disease (stage IV) and can reflect widespread dissemination. Survival in these circumstances is generally poor (6,7).

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Eric Lepp Clinical Vignettes

EL-001

ROLE OF GA-68 DOTANOC PET/CT IN THE DETECTION OF CANCER OF UNKNOWN PRIMARY

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An 84 year old male was admitted to the hospital for investigation of hematuria, weakness and dizziness. He had a history of BPH, CABG, HTN, and multinodular thyroid goiter. He was also known for Type II diabetes, well controlled by diet alone. A non-contrast CT urography was performed to investigate the hematuria, which did not demonstrate urinary tract abnormalities but there were incidental hypodense liver lesions. A repeat abdominopelvic CT with contrast as well as an US showed the liver findings but no primary lesions. Biopsy results were solid poorly differentiated carcinoma with foci of anaplasia. Gastroscopy was normal. Colonoscopy demonstrated several polyps which were resected, with pathology of tubular adenomas. After recurrent bouts of symptomatic hypoglycemia with tremors, sweating, weakness, the pathology results from the community hospital where he was hospitalized prior to transfer were revised. Chromogranin staining was positive. The liver biopsy was compatible with metastatic neuro-endocrine tumor. Endoscopic US did not demonstrate and pancreatic finding. A Ga-68 DOTANOC was performed to search for the primary lesion. Increased uptake was seen in the large liver metastases as well as in several smaller, additional liver metastases in both lobes. Focal, intense uptake in the pancreatic tail was seen. Final diagnosis was therefore metastatic insulinoma. The Ga-68 DOTANOC PET/CT revealed the origin of the metastatic NET, was started on Everolimus treatment after failure of somatostatin therapy and is a candidate for peptide receptor radionuclide therapy if he remains symptomatic.

EL-002

FDG PET/CT: A SENSITIVE IMAGING MODALITY FOR BISPHOSPHONATE RELATED OSTEONECROSIS OF THE JAW

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We present a 83 year old women who was known for metastatic renal cell cancer and was treated with curative nephrectomy. While on bisphosphonates, she was referred to a maxillofacial surgeon for suspected osteonecrosis of the left jaw, who ordered a bone scan with SPECT. The bone scan showed intense Tc-MDP uptake in the left mandible, in keeping with clinically suspected stage I osteonecrosis of the jaw (ONJ). At the same time, an oncologist ordered a 18F-FDG PET/CT scan to assess renal cell staging, which demonstrated intense focal FDG uptake in the left mandible (SUVmax 6.9) and moderate focal FDG uptake in the right mandible (SUVmax 5.4). In addition to confirming the suspected ONJ on the left side, we suggested underlying osteonecrosis of the jaw in the right mandible. While clinically there were no symptoms in the right mandible, consultation between our Nuclear Medicine team and the maxillofacial surgeon lead to the patient being alerted to carefully monitoring the right mandible and to return to the clinic in the presence of any new symptomatology. Two weeks later, the patient developed pain in the right mandible, and was diagnosed with early ONJ, correlating to the site described by the PET scan two weeks earlier. Both sites were resected and the patient is disease free in the mandible. This was an example of how FDG PET/CT is more sensitive than bone scintigraphy and can detect subclinical disease to help guide surgical treatment.

Figure 1 is an example of the enhanced sensitivity of FDG PET/CT (Fig 4a transaxial fused and 4c coronal fused) compared to Tc-MDP bone scanning (4b SPECT transaxial fused); PET/CT detected a second sub-clinical site of ONJ in the contralateral right mandible, in addition to the clinical area of exposed bone in the left mandible.

In addition to presenting this fascinating case where our Nuclear Medicine team was able to help the patient and the maxillofacial surgical team, while illustrating a novel use of PET/CT, I will also incorporate our broader research on this subject to make this talk more interesting to the Canadian Nuclear Medicine community. We have looked at 24 patients with ONJ and their PET/CT scans of the mandible and abstract is below

Purpose: To evaluate the diagnostic sensitivity of FDG PET/CT for the evaluation of Bisphosphonate Related Osteonecrosis of the Jaw (BRONJ)

Methods: Institutional review board approval was obtained. Twenty-four patients on bisphosphonates referred for suspected osteonecrosis of the jaw, later pathological proven, underwent fluorine 18 fluorodeoxyglucose FDG-PET/CT. The PET/CT was read by a board certified Nuclear Physician trained in PET/CT. Location and SUVmax of abnormal jaw uptake were recorded, along with mean SUV of contralateral normal mandible. Target-to-background ratios were calculated.

Results: PET/CT detected hypermetabolism in the mandible at the site of osteonecrosis in all twenty-four patients. Mean SUVmax was 8.67 ± 3.84 , while mean target-to-background ratio was 5.93. In one patient, PET predicted an additional area of osteonecrosis that only became clinically apparent weeks after the scan. In other patients, PET accurately delineated more extensive underlying osteonecrosis than was evident by clinical examination/radiographs.

Conclusion: FDG PET/CT is an extremely sensitive imaging modality for BRONJ. Our study suggest PET findings can be used to diagnose clinically suspected osteonecrosis and more accurately guide surgical resection.

EL-003

IATROGENIC HYPERTHYROIDISM INDUCED BY IODINATED CT INTRAVENOUS CONTRAST MATERIAL.

Ashley Mummery, Christopher Winter

Case: An 80-year-old man with a history of chronic renal failure on enoxaparin therapy for a prior deep vein thrombosis was assessed using IV contrast enhanced CT of the abdomen and an abdominal aortogram for hemodynamic instability secondary to a left rectus sheath hematoma. In the weeks following these imaging studies the patient showed increasing clinical signs of thyrotoxicosis with development of tremor, restlessness, insomnia, and hypotension. His blood work showed decreased TSH levels with progressively increasing free T3 and free T4. Thyroid ultrasound showed bulky multinodular disease. A thyroid scan performed using Tc-99 pertechnetate showed diffusely decreased uptake - a thyroiditis pattern. The patient was treated with prednisone but his thyrotoxicosis continued to progress. His tachycardia was treated with propranolol, however, this medication had to be held due to symptomatic hypotension. It was suspected the patient might have iodine-induced thyrotoxicosis (Jod-Basedow) due to the iodinated intravenous contrast from his previous imaging studies therefore tapazole therapy was initiated. The patient failed medical management was treated with a total thyroidectomy. Pathological examination of the excised thyroid revealed a multinodular thyroid with no evidence of thyroiditis or Grave's disease. Following this, thyrotoxicosis clinically resolved and his free T3 and T4 levels fell.

Conclusion: Given: 1) the patient's medical history of a contrast enhanced CT with renal failure; 2) decreased iodine uptake on Tc-99 thyroid scans; and 3) lack of pathological evidence of thyroiditis or Grave's disease; the most likely cause for the patient's thyrotoxicosis was iatrogenic iodine overload. This case is presented to demonstrate the importance of considering iatrogenic administration of iodine as a possible cause of

hyperthyroidism, particularly in elderly patients. Nuclear medicine thyroid scintigraphy contributed to the differential diagnosis for hyperthyroidism. Correlation of this result and the recent iodine load were suggestive of the final diagnosis.

EL-004**UN CAS DE DÉMENCE RENVERSANT**

Cette vignette clinique exprime bien l'important rôle que jouent les études cérébrale TEP dans les cas atypiques de démence et l'importance des images anatomiques obtenues simultanément.

Il s'agit d'une patiente de 59 ans présentant un tableau de démence avec éléments frontaux et changement de la personnalité. Le diagnostic de démence demeure au premier plan. Aucun symptôme neurologique focal mis en évidence. Aucune anomalies biochimiques.

Étant donné le jeune âge de la patiente et le tableau atypique, une étude cérébrale TEP au FDG avec TDM faible dose est exécutée dans le but de corréler le tableau clinique à un patron métabolique afin d'orienter le diagnostic et la prise en charge du patient. Aucun examen anatomique n'avait été effectué préalablement.

L'étude TEP démontre un hypométabolisme modéré symétrique impliquant les noyaux gris centraux, le thalamus et le cervelet ainsi qu'un hypométabolisme au pourtour des ventricules qui sont dilatés. La TDM faible dose obtenue lors de la TEP met en évidence une importante hydrocéphalie des ventricules latéraux et du troisième ventricule qui semble en relation avec une importante masse calcifiée à la portion supérieure du foramen de Monroe avec extension filiforme au troisième ventricule. On fait donc, grâce à la portion TDM de la TEP, le diagnostic d'une hydrocéphalie sur une probable obstruction. La résonance magnétique a corroboré les trouvailles de la TEP.

La patiente a par la suite bénéficié d'une résection partielle de la masse et ensuite l'installation d'une dérivation ventriculopéritonéale. Tous ses symptômes de démences se sont amendés. La pathologie finale a statué en faveur d'un méningiome bénin. L'évolution de la patiente est favorable.

Message à emporter : - La TEP-TDM cérébrale est un outil important pour les cas de démences atypiques afin d'orienter adéquatement le diagnostic clinique et le traitement du patient.

-La corrélation anatomique lors d'une étude métabolique permet dans certain cas de préciser le diagnostic.

- Il est primordial d'investiguer les causes réversibles de démence précoce.

IS THIS DEMENTIA?

This vignette expresses the important role of PET-scan in atypical cases of dementia and the importance of anatomic images acquired at the time of the metabolic studies.

I present the case of a 59-year-old woman with clinical features of dementia including behavioural symptoms and personality disorder. Dementia was the first diagnostic hypothesis. The physical exam didn't show any focal neurological symptoms. Blood tests were normal.

Due to the atypical presentation, the clinician decided to proceed with a PET-CT scan study to find a metabolic pattern of dementia to fit the clinical findings. The study showed a symmetrical moderate hypometabolism implicating basal ganglia, thalamus and cerebellum. There was hypometabolism around the ventricles which were dilated. The CT part of the study showed an important hydrocephalus of lateral ventricles and third ventricle with an important partly calcified mass in the superior Monroe foramen with spindly extension to the third ventricle.

The low dose CT scan allowed the diagnosis of hydrocephalus on blockage. Magnetic resonance imaging supported the findings of the pet-scan study.

The mass was resected and the patient benefited from installation of a derivation shunt. All symptoms disappeared after the intervention. The final pathology revealed a benign meningioma. The patient clinical features evolved in a favourable way.

Take home messages: - Cerebral PET study is an important tool for atypical cases of dementia to clarify diagnosis and choose the appropriate treatment. - Anatomic correlation during a metabolic study allows in certain cases to specify the diagnosis. - It is important to investigate reversible causes of early dementia.

EL-005

MICROCATHETER INJECTION CEREBRAL PERFUSION SPECT WITH MRI CO-REGISTRATION FOR NEUROINTERVENTIONAL APPROACH PLANNING

Fung, Christopher, Hung, Ryan W.†, Koberstein, Wadet, O'Kelly, Cian‡, Rempel, Jeremy†, Ashforth, Robert†, Abele, Jonathan† and Warshawski, Robert†.*

This case study illustrates the utility of microcatheter-directed intra-arterial injection of ^{99m}Tc-HMPAO for determining cerebral territory at risk, in the setting of a planned neurointerventional approach to an intracranial aneurysm. A 31 year old female patient, presenting initially with headaches and papilledema, was discovered on CT angiography to have a 1.6 cm diameter distal left posterior cerebral artery (PCA) aneurysm. The aneurysm was considered inaccessible for surgical clipping due to its location. An interventional approach for aneurysm coiling was thought optimal, but had a fair probability of flow occlusion distally. Some uncertainty existed as to whether eloquent visual areas were supplied by the distal PCA, so simultaneous Wada testing using etomidate and cerebral perfusion SPECT via intra-arterial radiotracer injection were undertaken to characterize the at-risk territory. A microcatheter was directed via a right femoral artery approach into the aneurysm. ^{99m}Tc-HMPAO was selected for its high expected cerebral first pass extraction (~80%). The involved territory was estimated to comprise less than a tenth of total brain tissue, so the dose was reduced to 200 MBq. Unstabilized ^{99m}Tc-HMPAO (injected <30 minutes after preparation) was used to avoid unnecessary toxicity risks associated with direct intra-arterial methylene blue injection. SPECT data was acquired with fiducial markers, reconstructed using iterative reconstruction, and co-registered to a Gadolinium-enhanced 3D GRE T1-weighted MRI dataset. This demonstrated localization of activity to the left precuneus and cuneus, along the parietooccipital sulcus, but sparing the occipital gyri. Wada testing was concordant, showing no visual field defects. After aneurysm coiling and parent vessel occlusion, follow-up whole brain perfusion SPECT demonstrated no significant perfusion defects, suggesting sufficient prior arterial collateralization to this territory. Intra-arterial injection SPECT brain perfusion may therefore prove helpful in guiding clinical decision making with regard to interventional procedures, where eloquent areas of cerebral cortex may potentially be at risk.

EL-006

PET/FDG DIAGNOSIS OF SARCOIDOSIS SECONDARY TO INTERFERON TREATMENT OF MELANOMA

by Etienne Rousseau, MD, R3, Nuclear Medicine, Université de Sherbrooke

Interferon alpha, among a few other chemotherapy agents, is increasingly known to induce secondary sarcoidosis.

Thus, findings of hypermetabolic enlarged lymph nodes on PET-CT/FDG scans, in the context of neoplastic disease in patients under such therapy presents a unique challenge in that sarcoid disease must be differentiated from metastatic nodal involvement.

Such a case of secondary sarcoidosis of a melanoma patient treated with interferon alpha who presented at our institution for follow-up PET-CT/FDG scan will be presented along with a review of pertinent literature relating to sarcoid disease secondary to chemotherapy.

The patient, a 52 years old male, presented with a hypermetabolic enlarged right cervical lymph node that was revealed to be a unique melanoma metastasis on histopathology. On follow-up PET imaging, multiple mediastinal hypermetabolic lymph nodes appeared under interferon treatment along with a left axillary adenopathy. The mediastinal nodes regressed after cessation of interferon while the axillary metastasis remained, thus confirming suspicion of a sarcoid-like reaction for the mediastinal nodes.

Take Home Message: When interpreting PET/FDG scans of patients presenting with multiple hypermetabolic enlarged lymph nodes currently undergoing interferon alpha therapy for metastatic neoplastic disease (for instance, melanoma), sarcoid-like reactions to chemotherapy must be included in the differential diagnosis.

DIAGNOSTIC AU TEP/FDG DE LA SARCOÏDOSE SECONDAIRE AU TRAITEMENT DU MÉLANOME PAR INTERFÉRON

Etienne Rousseau, MD, R3, Médecine nucléaire, Université de Sherbrooke

L'interféron alpha, comme certains autres agents de chimiothérapie, a récemment acquis une notoriété pour induire des sarcoïdoses secondaires. La trouvaille d'adénopathies hypermétaboliques au TEP-CT/FDG, dans le contexte de maladie néoplasique chez des patients sous de telles thérapies, présente donc un défi unique car la réaction sarcoïde doit être différenciée d'une maladie ganglionnaire métastatique.

Un tel cas de sarcoïdose secondaire au traitement par interféron-alpha d'un patient atteint de mélanome, vu à notre institution pour TEP/FDG de contrôle sera présenté avec une revue de la littérature pertinente.

Le patient, un homme de 52 ans, s'est présenté avec un ganglion cervical droit hypermétabolique augmenté en taille qui s'est révélé être une métastase unique de mélanome à l'histopathologie. Sur le TEP de suivi, sous traitement à interféron, il y eut apparition de multiples ganglions médiastinaux hypermétaboliques et d'une adénopathie axillaire gauche. Les ganglions médiastinaux ont régressé suite à la fin du traitement à l'interféron, mais pas la lésion axillaire, ce qui confirma la suspicion de réaction sarcoïde pour expliquer les ganglions médiastinaux.

La conclusion: Lors de l'interprétation de TEP/FDG de patients avec de multiples adénopathies sous traitement à interféron pour une maladie néoplasique (par exemple, le mélanome), les réactions sarcoïdes doivent être incluses au même titre que les métastases ganglionnaires dans le diagnostic différentiel.
