No. 325

QUANTITATION OF INDIUM-111 ACTIVITY IN SPECT.
T.G. Turkington, R.J. Jaszczak, D.R. Gilland, K.L. Greer, and R.E. Coleman. Duke University Medical Center, Durham, NC.

The ability to quantitate activity and volumes using In-111 and standard reconstruction techniques is studied for its relevence to monoclonal antibody imaging and subsequent therapy. We acquired data using a water-filled torso-shaped phantom with a 32 ml sphere, 95 ml sphere, 570 ml cylindrical bottle, and 1500 ml liver-shaped insert all positioned closely and with activity concentrations of 1.5, 1.5, 0.92 and 0.64μCi/ml. In addition, a 37 ml reference bottle at 1.5μCi/ml was placed outside the phantom for normalization. Separate windows were set and acquired for the 172 and 247 keV photopeaks and for scatter windows below each.

The data were reconstructed by adding both photopeak windows together before filtered backprojection and subtracting the lower scatter window (k=.4) and attenuation correction (Chang) using an "average" narrow beam factor 0.135/cm, with the attenuation map determined by outlining reconstructed scatter data. In a second method, the higher-energy window was also reconstructed separately with no scatter subtraction and attenuation constant selected to give a flat profile in the "liver".

Counts were summed from regions of interest set manually for each slicefor each object. Volumes were determined by measuring the activity concentration at the middle of each object and dividing into the total activity determined. Correcting the count sums in each object by the ratio of known activity in the ref. bottle to total counts measured in projection data, errors were 4% - 43% for the four objects, and volume determinations gave errors of 3%-7% for the first method. The second method gave act. errors of 6%-15% and vol. errors 4%-7%

The study indicates that reasonable quantitation may be done using I-111. The use of only 247 keV photons has the advantage that scatter subtraction is not required in selected situations. Further optimization of k-value and attenuation correction will improve both methods.

No. 326

AN ARTIFICIAL NEURAL NETWORK FOR LESION DETECTION FROM SPECT IMAGES.
C.E. Floyd Jr., G.D.Tourassi, S. Garg, M.T. Munley, J.E. Bowsher, R.E. Coleman, Duke University Medical Center, Durham, NC.

An artificial neural network has been developed to detect non-active lesions in reconstructed SPECT images.

Projection data were simulated using a Monte Carlo model of SPECT acquisition from a cylinder of activity containing 30,000 counts and a 2cm defect lesion. Images were reconstructed using filtered backprojection. A single layer perceptron neural network was trained by supervised learning with a modified delta rule for 100 iterations on 400 examples. Perceptron network topology forms a non-linear output as a function of a weighted neighborhood sum which is compared to a threshold to determine presence of a lesion. Network weights were adjusted to minimize the mean squared error for detection using a gradient decent. The trained network was then applied to a set of 120 images (60 containing lesions). True positive and false positive detection ratios were formed from the network response for a Receiver Operating Characteristic (ROC) study. The same images were used in a human observer ROC ranking study.

The trained neural network performed significantly better than the human observers with an area of 0.86 (network) compared 0.68 (human). Training time for 100 iterations on 400 examples was less than 2 min.

This study demonstrates that lesion detection in noisy SPECT images is a suitable task for a simple neural network architecture when the background is uniform.

No. 327

OBJECT AND ALGORITHM DEPENDENCE OF BIAS AND VARIANCE FOR ART, MULTIPLICATIVE ART, AND THE E-M ALGORITHM.
J.A. Stamos, N.H. Clinthorne, W.L. Rogers. Division of Nuclear Medicine, University of Michigan, Ann Arbor, MI.

J.A. Fessler

Although iterative reconstruction algorithms are advantageous for non-standard imaging geometries, for spatially variant imaging systems, and for attenuation and scatter correction, the criteria for terminating iterations are poorly understood.

We have examined object-and-algorithm-dependence upon iteration for the well-defined task of quantifying the activity in known regions of interest. Bias in the estimate was evaluated from noise-free simulated data for an imaging system with 10 mm FWHM Gaussian response. Variance was determined from 50 noisy realizations of the data.

Plots of bias versus variance and of RMS error demonstrate extreme differences in the convergence trajectory for the 3 algorithms and for different regions of the object.

The number of iterations to reach a minimum RMS error depends upon region size. For ART, minimum error in a 14 mm diameter region is reached at 12 iterations, while for a 10.5 mm diameter region, the error is still decreasing at 50 iterations.

This regional dependence in stopping point suggests that global error criteria are less than optimal and that spatially-dependent regularization methods should be investigated in lieu of a stopping criterion.

No. 328

OPTIMIZATION OF TRANSMISSION SOURCE COLLIMATION FOR SPECT AND PLANAR IMAGING ATTENUATION MEASUREMENTS.
A.N. Bice, L.D. Durack, J.F. Eary. University of Washington Medical Center, Seattle, WA.

Transmission measurements are one method of estimating single photon attenuation for quantitative rotating gamma camera SPECT and conjugate-view planar imaging. Often these transmission measurements are performed without source collimation. Consequently, corrections for the inclusion of large numbers of scattered events are necessary before determination of attenuation coefficients. Alternatively, available gamma camera parallel hole collimators can be used to collimate sheet source photons, thereby suppressing the scatter problem, but at a cost of significantly reduced transmission counting rates. Because optimal parameters for transmission source collimator design have not been reported we performed experimental measurements and detailed Monte Carlo simulations of I-131 and Tc-99m transmission measurements of tissue (water) to examine the relationship between source collimation, source energy, % scatter in the transmission measurement and transmission source collimator sensitivity. For transmission measurements we find: 1) most recorded scatter events come from source photons emitted >10 degrees from the desired transmission direction, 2) nearly all recorded unscattered transmission events come from source photons emitted < 7 degrees (primarily within 2-6 degrees) from the desired transmission direction, and 3) transmission collimator sensitivity increases with increasing parallel hole width. These results indicate: a) that for transmission source collimation, currently available parallel hole collimators are geometrically suboptimal (i.e., hole-widths too small and angular restriction too severe), and b) with the correct design, up to four-fold improvements in source collimator sensitivity may be achievable while maintaining low % scatter in transmission estimates of tissue attenuation.

Instrumentation and Data Analysis: General: Computer Modeling, Image Processing and Detection

10:30–12:00 **Session 56** **Rooms 222–232**

No. 329

PLANAR IMAGING AT 511keV WITH A GAMMA CAMERA AND HIGH-ENERGY COLLIMATOR.
A van Lingen, PC Huijgens, FC Visser, OS Hoekstra, JD Herscheid, GJJ Teule. Free University Hospital, Amsterdam, The Netherlands.

A special high energy all purpose (SHEAP) collimator was designed for imaging positron emitters (e.g. F-18). Bore length, hole diameter and septum thickness were 100, 4.6, 2.0mm respectively. The performance of this collimator for F-18 was compared to imaging of routinely used isotopes and collimators: Tl-201, Tc-99m (LEAP), and Ga-67 (MEAP). The 20% windows were centered at 84 (Tl), 142 (Tc), and 93, 184, and 296keV (Ga).
Linesources were applied in air and in water at distances from 2.5 to 20cm from the collimator to assess spatial resolution and the effect of scatter. Resolution was measured by the full width at half maximum (FWHM) of the line spread function, and the effect of scatter by the full width at tenth maximum (FWTM).
The FWHM in air for F-18 was worse than that of each of the other collimator/isotope combinations at every distance. In water at distances of 5cm and more the FWHM of SHEAP/F-18 was comparable to that of the LEAP/Tc-99m and appreciably better than with the LEAP/Tl-201 or MEAP/Ga-67. These differences were even more pronounced for the FWTM and can be attributed to the scatter.
These observations can be explained by the relative deterioration in the ability of the camera to reject scattered radiation at low energies.
The performance of the 511keV collimator was also tested under realistic conditions. We investigated the quality of planar F-18-deoxyglucose images in patients with a myocardial infarction and patients with a malignant lymphoma during treatment. In both situations clinically relevant information on tissue viability could be obtained.
It is concluded that positron emitters can be effectively imaged with generally available gamma cameras. The results of the present study indicate that some of the benefits of PET radiopharmaceuticals may find a place in the practice of conventional nuclear medicine.

No. 330

HIGH RESOLUTION PINHOLE SEQUENCE IMAGING OF SMALL LABORATORY ANIMALS. R.H. Moore, H. Ohtani, B.A. Khaw, H.W. Strauss. Massachusetts General Hospital, Boston, MA.

Small pinhole imaging at high magnification permits the use of normal and large-field-of-view cameras to image 1-5 cm fields of view in a reasonable time. Because pinhole sensitivity rises dramatically as object distance decreases, one-mm pinhole collimators can be used for small-animal gated blood pool or thallium planar imaging in a 15 minute timeframe. The geometry of high-magnification pinhole imaging also fits the assumptions of cone-beam reconstruction. A pilot study was performed to determine the feasibility of high resolution sequential pinhole imaging in rats. Following acute coronary ligation and injections of 3.5 mCi of Tl-201 and 18.2 mCi Tc-glucarate, the animal was sacrificed by ether overdose. A cylindrical lexan rat-restrainer was mounted on an indexed turntable to permit manual rotation of the animal about a vertical axis. Sixty one-minute images were collected by rotating the turntable in 6-degree increments, using Tl (25%) and Tc(20%) windows. Cine-loop presentation of these images provides a strong sense of depth based on cues of varying size and brightness with rotation. The data sets were merged for presentation by alternate-pixel color coding of the Tl distribution, in blue and the Glucarate, in yellow. In each of sixty frames the data were merged so that odd-numbered pixels were Tl data and even-numbered data were Glucarate data. This allows visual tracking of the two distributions for their spatial context. Cone beam back-projection should permit the standard slice-wise tomo-graphic presentation of data, but requires increased computer time and resources. The rotating presentation highlights the specific "distortions" introduced by the pinhole geometry, allowing the viewer to appreciate them, and factor them into interpretation of the data set.

No. 331

TECHNICAL AND CLINICAL ASPECTS OF AN INTRAOPERATIVE PROBE. L.A. Wilson, J.A. Kuhn, L.E. Williams, R.M. Corbisiero, R.L. Kondo, and J.D. Beatty. City of Hope National Medical Center, Duarte, CA.

The purpose of this study was to technically and clinically evaluate an intraoperative CsI radiation detection probe, the OncoProbe™ (Model #68750, Care Wise Medical Products Corp.).
Several experiments were conducted using In-111 and Tc-99m point sources at contact to determine the optimal settings and physical characteristics:

Characteristic	In-111	Tc-99m
Threshold/Window (keV)	90/270	60/190
Sensitivity (cts/sec/μCi at photopeak)	1136	626
Energy Resolution (ΔE/E % at photopeak)	25	34

The detector dead time was 21.2 μsec and the activity response for both radionuclides was linear with an average correlation of 0.99 with and without collimation. The probe had difficulty resolving the high energy peak (247 keV) of In-111, which was probably due to the minute size of the detector crystal.
In a clinical study, the OncoProbe was used in 12 patients following the infusion of In-111 anti-carcinoembryonic antigen monoclonal antibodies. In 3 of the 10 patients who underwent laparotomy, clinical management was affected by the probe findings: 1) new lesion identification, 2) localization of lesions seen by radioimmunoscintigraphy (RIS), 3) confirmation of complete lesion resection. Also, the probe was useful in confirming appropriate biopsy in 4 of 5 mediastinal and supraclavicular lesions seen by RIS.
We conclude that the OncoProbe has energy resolution that, while significantly worse than a gamma camera (15%), is sufficient to detect In-111 during surgery and affect patient care. The OncoProbe performed well clinically and technically offering an intraoperative adjunct to complement RIS.

No. 332

SIMPLE: A SYMBOLIC INTERACTIVE MODELING PACKAGE & LEARNING ENVIRONMENT. S.S. Gambhir, D.K. Mahoney, S.C. Huang, M.E. Phelps. UCLA School of Medicine, Los Angeles, CA.

We have developed a simple, yet powerful, tracer kinetic modeling package for the Apple Macintosh™. This symbolic interactive modeling package and learning environment (SIMPLE), which overlays the simulation tool Extend™ and was developed with the ModL and C languages, allows for the graphical construction of linear compartmental models with icons that the user places and connects on a worksheet. The user selects model elements from a comprehensive library of icons, such as a compartment with influxes and outfluxes, a compartment with distribution volume, a compartment with flow, an observer (including a PET scanner icon), an input-function compartment (one with a pre-specified time-activity curve), and data plotters. The user then graphically connects these icons to specify a compartmental model with first-order rate constants. SIMPLE empowers the user to experiment easily with the effects on the observation of varying the input function, the rate constants, and the number of compartments. These model simulation features allow for quick model testing, and they act as an exploratory learning environment for the user unfamiliar with compartmental modeling.
SIMPLE also includes a structural analysis feature that can be used to generate the state equations which govern linear compartmental models. With this information and SIMPLE's nonlinear regression support, it is simple for the user to estimate model parameters, with the option of parameter constraints, from fits to real data. The package already contains many models encountered in PET, including blood-flow models and the FDG model, and one can quickly use SIMPLE to construct models for many other fields and applications. There is also full on-line help available regarding the meaning and use of any of the symbolic icons, as well as many tutorial compartmental models for the new user. This package forms the basis for a flexible modeling tool and learning environment, and future enhancements to the package are planned.
SIMPLE is unique among compartmental modeling software now available: it is extremely powerful, yet it is usable by even the most mathematically naïve scientist.

No. 333

FILTERS FOR NOISE SUPPRESSION IN IMAGE SEQUENCES
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We have developed two filters for suppressing noise in images that are correlated with other members of the image set (as opposed to the image filtering techniques that are used to suppress noise in an image without considering other available images that contain in part the same information, and result in a loss of information by spatial smoothing). Examples of applicable image sets are radionuclide image time sequences used for generation of functional images, and MR images of the same tomographic plane based on different PS parameters. The first filter is based on multivariate statistics techniques and includes linear and non-linear principal component