POSTER SESSIONS

MONDAY DR. THEO LAWLESS ROOM
10:45 a.m.-12:15 p.m.

RADIOPHARMACEUTICAL 1 POSTER SESSION: PREPARATION AND CONTROL

Chairman: Kenneth A. Krohn
Co-Chairman: Gerald A. Bruno

TECHNICAL PARAMETERS INVOLVED IN THE IN-VIVO RED BLOOD CELL LABELING TECHNIQUE. A. Michael Zimmer and Dan G. Pavel. University of Illinois Medical Center, Chicago, Illinois.

In-vivo red cell labeling using consecutive injections of "cold" stannous pyrophosphate (Mallinckrodt) and Tc-99m pertechnetate has been previously initiated in our laboratory. The purpose of this study was to investigate specific parameters of RBC labeling including the minimum concentration of stannous pyrophosphate needed for highest red cell labeling, the maximum in-vivo activity, and the effect of additional pertechnetate on RBC labeling.

Selected volunteers were injected with stannous pyrophosphate concentrations ranging from 0.3-2.9 mg/1000 ml whole blood. Following a 30 minute lag time, whole blood samples were obtained, immediately incubated with Tc-99m pertechnetate, and the labeling efficiency and chemical state of plasma Tc-99m determined. An additional blood sample was obtained 30 minutes after pertechnetate injection and compared to the total activity injected. At various time intervals, up to 8 days after in-vivo RBC labeling, the RBC labeling capacity was tested with Tc-99m pertechnetate as described above.

Results of the study showed that in order to obtain the highest RBC labeling, a minimum 1.4 mg stannous pyrophosphate/1000 ml blood must be used. The in-vivo activity at 30 minutes post-pertechnetate injection was 90.5±12.0 (s.d.) of the initial injected activity. The RBC labeling efficiency, after a second pertechnetate addition, initially decreased rapidly ($T_{\frac{1}{2}}$ = 6 hours) followed by a longer phase ($T_{\frac{1}{2}}$ = 5 days). Background RBC labeling was achieved approximately 8 days after initial RBC labeling.

RADIOCHEMICAL ANALYSIS OF RADIOPHARMACEUTICALS. THE TECHNETIUM-99m PHOSPHORUS COMPOUNDS. Azu Owunwanne, David A. Weber and Robert E. O'Mara. University of Rochester Medical Center, Rochester NY

Any quality control program designed to evaluate the radiochemical purity of Tc-99m radiopharmaceuticals should be able to identify at least three Tc-99m compounds. These include the Tc-99m labeled radiopharmaceutical, Tc-99m pertechnetate and Tc-99m dioxide. A single paper chromatographic system capable of resolving these three compounds has been developed. The system requires the Tc-99m compound to be soluble in the developing solvent to obtain migration. Factors influencing the extent of migration of each compound are the nature of the paper and the concentration of the developing solvent.

The best separations are obtained with carboxymethyl cellulose ion exchange paper CM82 developed in 0.5M NaCl and Whatman paper No. 3MM or Whatman ashless paper No. 40 developed in 1M sodium acetate buffer. Tc-99m dioxide remains at the origin; the Tc-99m pertechnetate and Tc-99m phosphorus compounds move with Rf values of 0.56-0.75 and 0.82-1.0 respectively. A major advantage of this system is its ability to separate Tc-99m phosphorus compounds from Tc-99m pertechnetate and Tc-99m dioxide. This has not been possible with the standard assay using 3MM paper and 85% methanol, acetone or methylethyl ketone as the developing solvents. The described method can be adapted to the study of the chemical problems associated with the formulation of Tc-99m radiopharmaceuticals, as well as to some of their subsequent reactions. These include, for example, the in-vitro stability of Tc-99m phosphorus compounds and their reactions with oxygen. This simple system offers wider application to quality control of Tc-99m labeled radiopharmaceuticals than those presently in use.

IN VIVO RED CELL LABELING WITH TC-99m. Alun G. Jones, Michael A. Davis, Roger F. Uren and Peter Shulkin, Department of Radiology, Harvard Medical School, Boston, MA.

Radionuclide studies of blood flow in the heart are an important segment of clinical nuclear medicine. The only agent which has been widely available, however, has been Tc-99m labeled HSA, which suffers from several disadvantages including that it is a marker for albumin space and not vascular space. Recent literature reports have indicated an alternative: the in vivo labeling of red blood cells by sequential intravenous administration of a stannous tin compound and Tc-99m as pertechnetate. This phenomenon has been studied in dogs with four radiopharmaceuticals at different dose levels and at different intervals between the injections. These agents included pyrophosphate (PPi), methylene diphosphonate (MDP), glucoheptonate (GH) and DTPA. The blood clearance of radioactivity was measured in 26 dogs following administration of pyrophosphate at stannous tin levels of 0.01 - 160µg/Kg, and compared to the clearance of pertechnetate and Tc-99m-HSA. Changes from pure pertechnetate behavior became evident at approximately 1µg/Kg, with a plateau beginning in the region of 10µg/Kg. Little variation was obtained using time intervals between injection ranging from 5-30 minutes. The average labeling levels were 75% ID immediately after mixing occured down to 55% at 2 hours. The balance of the activity is excreted via the kidneys; no activity concentrations were observed in bone, thyroid, intestine or salivary glands. The data indicates that labeling efficiency may be highest with DTPA, next PPi, followed by MDP and GH. These results compare favorably with clinical PPi studies in 27 patients in which average % ID in red cells was estimated at 68% (range 55-95%), at dose levels of 33µg/Kg and at 10µg/Kg (averaged for a 70 Kg human).

NEW REACTIONS FOR PRODUCTION OF RHODIUM-101m. Kenneth L. Scholz, Vincent J. Sodd, Nuclear Medicine Laboratory, FDA, BRH, Cincinnati, Ohio and James W. Blue, Lewis Research Center, NASA, Cleveland, Ohio.

The purpose of the work was to determine the feasibility of producing high-purity Rh-101m from the He-3 particle irradiation of rhodium and palladium targets. Rhodium-101m exhibits good decay characteristics for use in nuclear medicine. It emits 307-keV photons with an 88% abundance, and decays by electron capture and isomeric transition with a 4.3 day half-life. Rhodium-101m is produced in high-purity form through its precursor palladium-101, which has an 8.4 hour half-life. Recent studies with platinum metals such as rhodium have shown that they can be complexed with organic compounds to form stable products useful for cancer chemotherapy. This work evaluated the Rh-103(He-3,5n) and the natural Pd(He-3,xn) reactions that resulted in Pd-101. The yield of Pd-101 was 5 mCi/µA-hr from both reactions using He-3 irradiation energies of 60 to 68 MeV on targets about 30-MeV thick. Previous work showed that the yield using 40-MeV protons on rhodium and palladium targets was about 50 and 0.5 mCi/µA-hr of Pd-101, respectively. Chemical considerations indicate that palladium is better than rhodium as a target material because palladium metal is easily dissolved in acid, while rhodium metal is nearly impervious to chemical attack. The chemical procedure used, isolated the Pd-101 free from all rhodium isotopes and, after a suitable decay time, allowed

collection of carrier-free Rh-101m. It is concluded that useful amounts of Rh-101m can be produced from He-3 particle irradiations and that if palladium is used as target material a significant increase in yield over the previously reported proton yield is obtainable.

RAPID, QUANTITATIVE RADIOIODINATION OF O-IODO-HIPPURIC ACID. P. M. Wanek, H. B. Hupf, and H. A. O'Brien, Jr. Los Alamos Scientific Laboratory, Los Alamos, NM

As a part of a new research effort to study chemical reaction mechanisms associated with radioactive labeling of biological compounds, an investigation of radioiodination of o-iodo-hippuric acid (OIH) was performed, principally because of the importance of this agent in the non-invasive assessment of individual kidney function. In addition, a need exists for rapid, quantitative radioiodination procedures, particularly those readily adaptable to cold kit preparations, to facilitate the utilization of I-123 in clinical nuclear medicine.

The extent of labeling OIH with I-125 was studied as a function of: (1) solvent used; (2) addition of various inorganic cations; (3) cupric ion concentration; (4) temperature; and (5) reaction time. Labeling yields were evaluated with ascending paper chromatography employing both n-butanol-acetic acid-water (4:1:1 v/v) and benzene-acetic acid-water (2:2:1 v/v) solvents.

The results obtained demonstrate that rapid, quantitative radioiodination of OIH can be achieved by mixing purified OIH (5 mg) with aqueous $CuSO_4$ (0.5 mg) and 0.3 ml reductant-free NaI-125 solution (2 mCi/ml). The mixture is autoclaved for 15 min., cooled, diluted with phosphate buffer solution, and filtered to remove excess copper. The average yield of labeled OIH is 98%, with 2% of the organic-bound activity being associated with o-iodobenzoic acid (OIB). Less than 2% of the initial activity is lost in the copper precipitate. This method offers decided advantages over previously-reported procedures, and appears readily adaptable to a cold kit preparation.

THE LOCALIZATION OF CARBON-11 LABELED HEXAMETHONIUM IN CARTILAGE. M. Anwar, B. Mock, K.A. Lathrop and P.V. Harper. The University of Chicago, Chicago, IL.

The rapid localization of carbon-14 labeled hexamethonium in cartilage has been demonstrated by radioautography in the mouse using a dose of 10 mg/kg. We have synthesized hexamethonium with a ^{11}C-methyl label. Carbon 11, produced by the (p,α) reaction on N_2, is passed over CuO at 850°C to produce $^{11}CO_2$ which is absorbed in lithium aluminum hydride. The latter is decomposed with a high boiling alcohol to yield $^{11}CH_3OH$ which is converted to $^{11}CH_3I$ with HI and reacted with 1.6(Bis-di-methyl amino) hexane to produce hexamethonium. Current efforts are directed toward perfection of the synthesis to produce better yields and higher specific activity so that animal distributing studies can be carried out. This agent may have great potential in evaluation of the destroyed cartilage in various forms of arthritis, particularly since quantitative positron imaging methods may be used under conditions which are close to ideal, i.e., in the extremities.

N-13 AMMONIA OXIDATION TO MOLECULAR NITROGEN FOR PULMONARY FUNCTION STUDIES. W. Vaalburg, S. Reiffers, A. Paans, E. Beerling. University of Groningen, Netherlands. R.J. Nickles. University of Wisconsin, Madison, WI. H. Krizek, P.V. Harper. Franklin McLean Memorial Institute, University of Chicago, Chicago, IL.

Gaseous and dissolved nitrogen offers several distinct advantages over Xe-133 in the assessment of regional ventilation and perfusion. First, the lower tissue solubility abbreviates the tracer kinetics by restricting the label to the alveolar gas. Second, the positron decay permits tomographic isolation by coincidence imaging devices currently attracting attention in nuclear medicine. Difficulties inherent to the ten minute physical decay have been overcome in preclinical trials conducted at the three institutions above, characterized by diverse accelerator-hospital logistics. With minor variations, the procedure starts with proton irradiation of water, followed by reduction of the labelled nitrate to carrier-free ammonia by steam distillation from basic solution. Next, oxidation with aqueous hypobromite is performed and excess OBr^- is removed by an ion retardation resin. Gas radiochromatography verifies that all activity is present as injectable, molecular nitrogen. When gas is desired, it is quantitatively evolved by performing the oxidation step with carrier ammonium chloride. Activities of 40-50 mCi remain in several ml at 20 minutes EOB, and is transported to the Groningen Academic Hospital by car. Current measurements on patients and normal volunteers center on probe-based studies monitoring activity in twelve lung regions during conventional respiratory maneuvers. Maintenance of N-13 in solution considerably simplifies transport and handling.

C-11-DL-TRYPTOPHAN, A POTENTIAL PANCREAS-IMAGING AGENT FOR POSITRON TOMOGRAPHY. Lee C. Washburn, Tan Tan Sun, Bruce W. Wieland, and Raymond L. Hayes. Oak Ridge Associated Universities, Oak Ridge, Tenn.

Because tryptophan has the greatest pancreatic uptake of the naturally occurring amino acids, we have synthesized C-11-labeled DL-tryptophan and evaluated it preclinically as a potential agent for pancreatic imaging.

Studies with the C-14-carboxyl-labeled amino acid corroborated previously reported high pancreatic specificities of DL-tryptophan in three animal species examined. Tissue distribution was complete by 30 min after intravenous administration, and only a slight carrier effect was seen through 5 mg/kg. The pancreas-to-liver ratio was 11:1 at 30 min in the rat. Loss of radiolabel by decarboxylation and urinary excretion was low (total of 17% in 2 hr).

We have synthesized 55 mCi of DL-tryptophan [side chain-3-C-11] (C-11-DL-tryptophan) from 1 Ci of C-11-cyanide by our rapid (20 min), high-temperature, high-pressure modification of the Bücherer-Strecker amino acid synthesis, using 3-indoleacetaldehyde bisulfite addition compound as a precursor. (3-Indoleacetaldehyde itself is quite unstable.) The amino acid was purified using a column of Porapak Q followed by cation exchange chromatography. C-11-DL-Tryptophan was obtained in ∿30% chemical yield in a total synthesis and purification time of 55 min. Similar procedures can be used for the synthesis of several other C-11-labeled amino acids.

Preclinical studies in animals have demonstrated that C-11-DL-tryptophan is a potentially useful new agent for pancreatic imaging in man, especially in view of its applicability to imaging by positron computerized axial tomography. (Supported by US ERDA and NCI Grant Number CA-14669.)

CLINICAL STUDIES OF C-11-LABELED AMINO ACIDS. Gould A. Andrews, Karl F. Hübner, Lee C. Washburn, Bruce W. Wieland, William D. Gibbs, Raymond L. Hayes, Thomas A. Butler, and I. Reid Collmann. Oak Ridge Associated Universities (ORAU), Oak Ridge National Laboratory (ORNL), Oak Ridge, TN, and The University of Tennessee Memorial Research Center and Hospital, Knoxville, TN.

We are evaluating C-11-labeled natural and unnatural amino acids as agents for tumor localization and pancreatic imaging. High specific activity C-11-Carboxyl-labeled 1-aminocyclopentanecarboxylic acid (C-11-ACPC) and C-11-carboxyl-labeled DL-valine have been tested. The compounds were administered intravenously without reaction, and, preliminary to the availability of advanced imaging equipment, were studied with a rectilinear scanner. Both agents were rapidly removed from the blood stream (ACPC >90% in 45 min, DL-valine >85% in 60 min). C-11-ACPC is seen in cancer tissue, liver, and sometimes heart and spleen. After doses of 12-45 mCi, tumor was demonstrated by scanning in 18 of 24 patients with five dif-

ferent types of cancer. In three lesions, there was uptake of C-11-ACPC but not of Ga-67-citrate, although the latter was usually more informative. Among nine patients given C-11-DL-valine in doses of 26 to 45 mCi, six showed the pancreas clearly, two questionably, and one not at all. Renal activity sometimes interfered with interpretation. Clinical correlations in this series are incomplete.

We conclude that with tomographic positron imaging equipment soon to be available, C-11-ACPC offers promise as a general tumor-scanning agent and C-11-DL-valine as a pancreas-imaging pharmaceutical. (USERDA and NCI Grant Number CA-14669.)

CARBOXYL-LABELED C-11-ACBC, A POSSIBLE NEW RADIOPHARMACEUTICAL FOR DETECTION OF CANCER USING POSITRON TOMOGRAPHY. Raymond L. Hayes, Lee C. Washburn, Bruce W. Wieland, and Tan Tan Sun. Oak Ridge Associated Universities, Oak Ridge, Tenn.

Since C-11-carboxyl-labeled 1-aminocyclopentanecarboxylic acid (ACPC) has been used successfully in animals and man for the detection of malignancy, studies have been made of the tissue distribution characteristics of the alicyclic cyclohexane (ACHC) and cyclobutane (ACBC) analogs of ACPC to test their affinities for tumor tissue.

We prepared C-14- and C-11-carboxyl-labeled ACHC and ACBC by our modified rapid, high-temperature, high-pressure Bücherer-Strecker method for synthesis of C-14- and C-11-ACPC. Purifications were by ion exchange. In rats ACHC gave much poorer tumor-to-nontumor ratios than ACPC and further study of it was discontinued. ACBC, on the other hand, distributed in vivo as rapidly as ACPC and gave better tumor-to-nontumor ratios (5:1-15:1), particularly for the muscle and blood (~2X that of ACPC). Urinary excretion of ACBC was low and, as with ACPC there was no carrier effect or apparent decarboxylation. The toxicity of ACBC in the mouse was found to be extremely low compared to that reported for ACPC. C-11-ACBC has been prepared in batch amounts of up to 135 mCi using the Oak Ridge National Laboratory's 86-Inch Cyclotron.

We conclude that C-11-ACBC may be superior to C-11-ACPC for detection of cancer in man by positron tomography, since it distributes in vivo as rapidly as does C-11-ACPC, appears to be less toxic, and shows greater tumor-to-nontumor ratios, particularly for muscle and blood which generally make up approximately 60% of the body weight. (Supported by US ERDA and NCI, DHEW Grant Number CA-14669.)

TUESDAY DR. THEO LAWLESS ROOM
4:00 p.m.-5:30 p.m.

INSTRUMENTATION 2: POSTER SESSION

Chairman: Robert R. Anger, Jr.
Co-Chairman: K. William Logan

A NUCLEAR CARDIOLOGY MODULE FOR ANGER CAMERAS. R. M. Sano, B. Ioannou, D. Kearns, and E. K. Prokop. Picker Corp. and Hospital of St. Raphael, New Haven, Conn.

A clinical accessory for Anger cameras has been designed to perform specific diagnostic real time routines for nuclear cardiology; ejection fraction calculation (LVEF), left ventricular ejection time, left ventricle integrated gated time activity curve, and on 8" x 10" film, gated multi-images demonstrating 12,24, or 48 time integrated frames from R to R for heart wall motion visualization. Presently, expensive general purpose nuclear computer systems are required to perform these tests.

In contrast, this dedicated nuclear cardiology module derives inputs from an Anger camera and ECG during the Tc-99m H.S.A. (L.A.O.) study. Positioning of an elipitcal region (L.V.) and its associated horseshoe background area (bkg.) is accomplished with a joystick. Size, shape, and angle of the major axis are all variable. Simultaneously in real time, gated multi-images are accumulated on film and a L.V. - bkg. gated time activity curve is being stored in 256 channels of memory. After sufficient statistical criteria have been met (average 5 min.), the module automatically interrogates its memory and calculates L.V.E.F. and prints the L.V. time activity curve plus its associated ECG and time ref. markers on a strip chart recorder. A mechanical aperture on the camera collimator significantly increases the maximum counting rate from the L.V. to 8K cts./sec./cm^2.

The nuclear cardiology module is an economical addition to an Anger camera that has the potential to perform most of the cardiac protocols presently done by nuclear medicine computer systems.

DEAD-TIME AND UNIFORMITY CORRECTIONS OF STUDIES PERFORMED WITH AN ANGER AND A MULTI-CRYSTAL CAMERA. Frank S. Prato and Lionel Reese, St. Joseph's Hospital, University of Western Ontario, London, Ont.

Parameters needed for dead-time corrections can be obtained by measuring the relationship between count rate and activity. It is usually assumed that only one such relationship is required for the entire detection surface. This is only valid if the uniformity pattern is independent of count rate. The Anger camera (Picker Dynacamera 3C) showed a significant change in uniformity as the count rate was increased from 9000 to 20,500 c.p.s. The multi-crystal camera (Baird System 70) did not show such a dependence.

Uniformity corrections are valid only if non-uniformity is related to differences in sensitivity. Two different measurements of sensitivity were compared to the uniformity pattern of the Anger camera. In one, a point source of radiation was collimated by a 1/8 inch hole in a ¼ inch thick lead sheet. The count rate was measured for different positions of the hole on the detector surface. Similarly, sensitivity was measured using a collimated pencil beam of radiation. These two measurements were similar to each other, but differed from the uniformity pattern. Therefore, much of the non-uniformity is related to improper positioning of events. In contrast the uniformity pattern of the multi-crystal camera was entirely related to difference in sensitivity.

Dynamic Anger camera studies should not be corrected for non-uniformity, and the use of a single dead-time correction curve can easily result in a 10% error in the relative corrected count rates. However, such correction can be applied with greater confidence to studies produced with our mutli-crystal camera.

CAMERA COLLIMATORS: COMPARISON AND PERFORMANCE INDEPENDENT OF INTRINSIC CAMERA PROPERTIES. J.M. Cuevas, J.C. Ehrhardt, and L.W. Oberley. The University of Iowa, Iowa City, Ia.

Imaging characteristics were measured in 30 (10-, 12- and 15-inch) camera collimators representing 3 manufacturers. Three identical collimators from each manufacturer were also measured to test quality control. Line spread functions were obtained by moving a line source across a collimator positioned above a slit detector. The collimator was rotated to average out any septal effects. This method has significant advantages over other methods because the results are dependent only on collimator performance, allowing comparison between collimators that is dependent only on their individual properties. Previous methods have used a camera as the detector and include effects of the intrinsic camera resolution and sensitivity.

The modulation transfer function full width at half maximum (FWHM) and sensitivity were calculated. Sensitivities were found by two methods, integration of the line spread function and response to a disc source. The two methods measure separate physical quantities which differ for nonparallel hole collimators.

Because the FWHM varies linearly with source to collimator distance, the FWHM at all distances is specified by two parameters, the FWHM at a single distance and the resolution gradient (RG), i.e., the rate of change of the FWHM with distance. RG is an important characteristic of collimator performance. The sensitivity is proportional to the square of RG but less well correlated to the FWHM.

The various collimators represent design choices between FWHM, RG and sensitivity. However, collimators with similar names from different manufacturers may have quite different characteristics.

A NEW APPARATUS FOR FLUORESCENT SCANNING: A MOVING X-RAY TUBE. Peter D. Esser, College of Physicians and Surgeons, Columbia University, New York City, and Daniel B. Lister, Princeton Gamma-Tech, Princeton, N.J.

A departure has been made from the traditional design of scanning fluorescent systems: a scanning head assembly has been constructed which contains an x-ray tube and an 80 x 5 mm Si(Li) detector mounted at a 30 degree angle. The detector resolution at the iodine K-alpha peak, 28.6 keV, is 0.58 keV. The assembly is mounted on the arm of a commercial single-probe scanner. Signals from the x-ray detector are routed to a single channel analyzer (1 keV window) whose output is applied to the inputs of the display devices.

A DC power supply provides an accelerating potential of 80 kV to a tungsten target at 0.5 mA. The beam exits through a 1.6 mm diameter channel in a removable lead collimator. At the scanning distance of 7.6 cm, the FWHM of the line-spread function is 0.46 cm. A scan speed of 30 cm/sec and 2 mm line spacing are used. For a thyroid phantom filled with 16 mg stable iodine in 32 ml of water the integral counting rate is 5800 cps and at the K-alpha peak, 66 cps including 16 cps background.

The images obtained with this apparatus are comparable in quality and information content to those obtained by conventional radionuclide imaging, with a significant reduction in dose: 40 mr for a typical 20 min fluorescent scan. Furthermore, the use of an x-ray generator system offers certain advantages over radionuclide sources for this purpose: a high photon flux, easily adjustable in intensity, with an effective energy closer to the K-absorption edge than the 60 keV photons from Am-241, and no potential problems in shielding a long-lived radionuclide source.

COMPARISON OF DUAL PROBE AND TOMOGRAPHIC SCANNING USING GALLIUM-67 CITRATE. Neal L. Horn and Leslie R. Bennett. UCLA Medical Center, Los Angeles, Ca.

Gallium-67 Citrate (Ga) has been shown to concentrate in a wide range of tumor types and inflammatory conditions. This prospective study was undertaken to determine whether tomographic scanning could enhance the diagnostic capability of the conventional anterior and posterior views when using Ga.

Both 5-inch diameter dual probe (Ohio Nuclear) and tomographic scintigraphy (Pho-Con by Searle) using Ga were performed within 24 hours of each other in 67 patients referred to the UCLA Nuclear Medicine Clinic. Forty-nine patients had malignancies while eighteen had benign disease. Scintigraphic findings were correlated with histopathologic data, roentgenographic studies, other radionuclide studies, as well as the physical and laboratory findings.

A total of 85 paired studies using both the dual probe and tomographic scanners were performed on these 67 patients. Forty-five of the studies were of equal diagnostic value while the tomographic scan was superior in 19 cases and the dual probe scan in 21. Ninety-five foci of abnormal isotope deposition were demonstrated by the tomoscanner while 91 abnormal foci were demonstrated with the dual probe instrument.

Although the overall quality of the images was about equal, the tomographic scanner was able to detect 4 abnormal collections and 1 physiologic isotope collection not seen with the dual probe scanner. We conclude that with the isotope Ga, tomographic scintigraphy is a useful adjunct to the conventional anterior and posterior views. (Supported by USPHS Grant GM01920-08).

ZONE PLATE IMAGING WITH A GERMANIUM CAMERA. Kevin A. Kelly, Robert F. Redmond. Nuclear Engineering Department, The Ohio State University, Columbus, Ohio.

The usefulness of the high-purity germanium gamma camera under development here will be greater if an optional Fresnel zone plate aperture is used in addition to conventional multihole collimators. The zone plate would provide high resolution images of small structures detected with a conventional aperture having less resolving power.

A zone plate imaging system was designed for eventual use with a square array of detectors, measuring 15.3 cm on a side and containing 64 x 64 resolution elements. The images obtainable were simulated by computer studies. Shadowgrams were obtained initially by optical simulation, and later by digital simulation of shadowcasting. Images were reconstructed by computer processing, and image quality was improved by digital image enhancement. Image printout was on a standard line printer.

This paper describes the system and presents samples of the dozens of simulated images obtained. Images of small sources were excellent, but images of large sources were poor. The system has a limited tomographic imaging capability.

The theoretical spatial resolution of the system, 1.7 mm, is better than that assumed for the germanium camera, 2.4 mm. Because the camera contains a small germanium detector, the size of sources imageable is small. The largest imageable source is one with a frontal area of 12 sq cm.

The zone plate-germanium camera system would be useful for the imaging of small intracranial lesions, the location of myocardial infarcts, and the identification of tumors in the skeletal system.

THALLIUM-201 IMAGING CAPABILITIES OF SCINTILLATION CAMERAS IN COMMUNITY HOSPITALS. Dennis Hoogland, Lee Forstrom, Richard Ponto, and Merle Loken. Universtiy of Minnesota Hospitals, Minneapolis, Minnesota 55455.

Recent reports suggest that only cameras with unusual resolution characteristics are suitable for use in Tl-201 imaging. To evaluate this concept, Tl-201 resolution capability was tested in 15 cameras in use at various community hospitals served by our Nuclear Pharmacy. A New England Nuclear Au-195 phantom was imaged at the collimator face, and at a three inch distance(2 inches air, 1 inch leucite). The phantom contained elements measuring 1x1, 1x2, 1x3, 2x2, 2x3, and 3x3 cm. The cameras ranged in age from one month to approximately seven years. Low energy general purpose collimators were used in most cases; images with converging collimators were also obtained when possible. The resultant images were then independently rated by four Nuclear Medicine physicians on a blind basis for ability of each camera to resolve each element (scored 0 to 10, with 0 = no resolution). As expected, significant degradation of image quality was observed when the phantom was moved three inches away from the collimator face. Even in these images, however, partial resolution of 1x3 cm elements was commonly seen (8 of 15), although only three cameras were able to resolve the 1x1 element. All 15 cameras were able to resolve 2x2 cm elements. Converging collimators (N = 4) were not associated with a significant change in image scores. Overall, images from the cameras tested were comparable in quality with those obtained from a camera (with computer enhancement) used at our hospital. This camera has been used successfully for two years in clinical and animal Tl-201 imaging. From these data, it appears that many cameras in clinical use have resolution capabilities adequate for Tl-201 imaging.

INTERFACING A PHO/CON TOMOGRAPHIC SCANNER TO A DIGITAL COMPUTER. E.A. Silverstein, E.W.

Fordham, D.A. Turner, A.A. Ali and A. Chung-Bin. Rush Medical College, Chicago, Ill.

Following extensive clinical experience with the Anger tomographic scanner (Pho/Con) a phased program has been undertaken to augment the capability of this device by interfacing it to a digital computer. The first phase (completed) consisted of design of the interface and development of Fortran reconstruction programs to display raw image data by back-projection. By use of a PDP-11/45 computer, image data from three dimensional arrays of point sources of radioactivity were simulated with a random number generator to test the reconstruction software. In the present phase, a dedicated Pho/Con scanner has been interfaced to a data acquisition system consisting of a PDP-11/20 computer with 24K of memory, an analog to digital converter, a digital input-output and a data storage disc. The system was designed to allow great flexibility in data collection formats. Programs are currently being written and tested to realize features such as: A. Continuously variable choice of image planes; parallel or tilted with respect to the horizontal. B. Variable depth of field in any plane. C. Stereoscopic views. D. Better image quality from improvements in image reconstruction algorithms and use of enhancement techniques.

Data acquisition and processing by means of a digital computer should permit optimal use of the tomographic capability of the Pho/Con scanner.

WEDNESDAY DR. THEO LAWLESS ROOM
10:45 a.m.-12:15 p.m.

CARDIOVASCULAR 5: POSTER SESSION

Chairman: Ralph Gorten
Co-Chairman: Marvin I. Friedman

A METHOD FOR INCREASING THE ACCURACY OF THE RADIONUCLIDE MEASUREMENTS OF THE EJECTION FRACTION AND LEFT VENTRICULAR VOLUME CURVE. D.G. Pavel, E. Byrom, J.A. Bianco, A.M. Zimmer. University of Illinois Medical Center, Chicago, Illinois.

The methods presently published have a tendency, in practice, to underestimate the Ejection Fraction (EF) as well as the slope of the Left Ventricular Volume Curve (LVVC). The main reason for this is that usually only one region of interest (ROI) is used for the computations, which is a considerable approximation of the spatial changes that occur during a cardiac cycle. By using the computer capabilities and combining the data obtained from two ROIs these drawbacks can be avoided. The protocol presently tested in our institution starts by a simultaneous delineation of the systolic and diastolic images on the computer's TV monitor. By trial and error, an isocontour (expressed in # of cts/pixel) is displayed successively in time, but simultaneously on both images, until a good match with the outer borders of both images is accomplished. The boundaries are then completed manually, separately for each image, and the upper background limits are then determined on the systolic frame only (the rest of the horseshoe background area is determined automatically by the program). The LVVCs obtained separately from the diastolic and systolic ROIs are corrected for background and a weighted interpolation is performed resulting in the corrected LVVC. From this curve the EF and any parameter related to the LVVC can now be calculated without systematic underevaluation. The correlation with angiography data is in progress, and the first 9 cases confirm these facts. This procedure can be applied with both gated and single pass techniques.

NUCLEAR KYMOGRAPHY: A NEW METHOD FOR ASSESSING REGIONAL MYOCARDIAL WALL MOTION. Mark W. Groch, George K. Lewis, Paul Murphy, E. Gordon DePuey, and John A. Burdine. Group Research, Searle Diagnostics Inc., Des Plaines, Ill. and Baylor College of Medicine, St. Luke's Episcopal/Texas Children's Hospital, Houston, Tx.

Regional myocardial wall motion is usually subjectively evaluated from gated end systolic and end diastolic blood pool images. Nuclear kymography, which displays a one dimensional image in time, synchronous with the electrocardiogram, provides a method to quantitate this motion. This technique is analogous to M-mode ultrasound in that one dimension is displayed as a function of time, however, the activity distribution is displayed in place of acoustic interfaces. The motion of regional myocardial segments is measured from the kymogram at multiple projections across the cardiac blood pool, after equilibrium of Tc-99m-human serum albumin. Nuclear kymography is more quantitative than gated blood pool imaging and is not hindered by viewing windows as is single and multiple transducer ultrasonography.

Motion as measured by nuclear kymography agreed with that obtained from cineangiography in a series of patients with varying wall motion abnormalities. Also, regional myocardial wall motion was studied by nuclear kymography in a series of patients under the conditions of stress and rest. To illustrate the quantitative ability of nuclear kymography, displacement towards the apex of the aortic and mitral valves was found to be 2.3 and 1.8 cm respectively, in one normal patient. Since the kymogram sweep is initiated by the R-wave of the ECG, the rate of contraction of myocardial segments can be related to corresponding portions of the ECG.

CORONARY FLOW AND VOLUME AFFECTS GATED IMAGES AND EJECTION FRACTION IN QUANTITATIVE RADIOCARDIOGRAPHY. R.N. Pierson, Jr., A.V. Prabhu, M.I. Friedman, S. Shimomura, M. Shimomura, R. Roberts, J. Spencer and S. Alam, St. Luke's Hospital Center, Columbia University, New York City, N.Y. 10025.

Coronary blood flow (CBF) and myocardial blood volume (MBV) represent a conceptually ignored but definable blood pool which contributes a rim of counts to blood pool images, and a delayed transit time component to the left ventricular (LV) time activity curve (TAC). Furthermore, MBV counts are part of the background for which ejection fraction (EF) algorithms provide correction.

To quantify the spatial and volume components contributed by MBV, Tc-99m filled spheres simulating actual LV volumes were imaged with a surrounding sphere containing 15% of ventricular concentration to simulate MBV.

Spatial images of cardiac blood pool were apparently increased 1.0 $\pm$ 0.2 cm, or 16% of LV diameter. At diastole, increase was only .4 $\pm$ 0.1 cm, 6% of LV diameter. Counts contributed to "background" for TAC EF measurements were 17% of total at end diastole, and 27% at end systole, due to thicker end systolic myocardium. Thus myocardial counts alone reduce measured EF significantly, actual degree dependent on actual EF, ranging from 8 to 25%.

To quantify effect of CBF on TAC, green dye curves sampled from LV simultaneously with precordial radiocardiography were deconvoluted for catheter transit by Fourier analysis to reconstitute the true LV TAC in 12 patients studied at cardiac catheterization.

Prolongation of LV mean transit time averaged 1.2 seconds, 37% of true transit time. Correction for the CBF component, by CBF = .05xLV stroke volume counts, time delayed by 1 stroke, accounts for about 1/3 of this prolongation.

LOCALIZATION OF LEFT TO RIGHT SHUNT LESIONS BY CO-2 INHALATION AND IMAGING. Noel R. Zusmer, Denny D. Watson, Peter J. Kenny, Frank J. Hildner and Albert J. Gilson. Mount Sinai Medical Center, Miami Beach, FL.

A method for the detection and localization of left-to-right cardiac shunts has been developed which utilizes inhalation of 40 mCi. of oxygen-15 labeled carbon dioxide and imaging of the heart with a standard commercially available scintilation camera-computer system equipped with a special high energy collimator.

The inhaled tracer rapidly labels the water fraction of the lung capillary blood which flows directly into the left heart. Serial quantitative anterior images of the heart are recorded every 0.2 sec. for a ten second period following a single breath inhalation. Localization of the shunt can be obtained by direct visualization of the images which show the indicator flow through the shunt path following its introduction into the left heart; in addition, with the aid of an on line computer, indicator dilution curves can be obtained from a region of interest over the lungs to quantify the pulmonary to systemic flow ratio by methods previously described (Watson, et al. Radiology 119, 615, 1976). This method can reliably detect and localize shunts with pulmonary to systemic flow ratios of 1.2 or greater. Atrial and ventricular septal defects, patent ductus arteriosus and anomalous pulmonary venous return have been visually identified by this imaging method.

The technique provides a simple and inexpensive method for locating and classifying shunt lesions following the direct left side introduction of radionuclide through gas inhalation. Because of the short half life of O-15, the absorbed radiation dose to the lungs from this procedure is less than 200 mRad.

TOMOGRAPHIC SCINTIGRAPHY OF REGIONAL MYOCARDIAL PERFUSION. B. Leonard Holman, John D. Idoine, Thomas A. Sos, Roger Tancrell and Gordon DeMeester. Harvard Medical School and Peter Bent Brigham Hospital, Boston, MA, and Raytheon Company, Waltham, MA

Estimation of the extent of decreased perfusion by scintigraphic methods has been hampered by the geometric constraints of two-dimensional imaging. Myocardial perfusion scintigraphy was performed using the Fresnel zone plate tomographic camera after the coronary artery injection of Tc-99m microspheres (20-40 microns). Coronary artery occlusion was performed in six dogs by embolization via a catheter guidewire system. Twenty mCi of Tc-99m microspheres were injected into the left main coronary artery in these six dogs and in three additional unoccluded dogs. Scintigraphy was performed in multiple projections in the live animal. Optical reconstruction of the holographic image provided tomographic scintiscans of the heart. Perfusion defects were detected with the Fresnel zone camera tomographic images in all four dogs with left anterior descending artery embolization and in two dogs with embolization of the circumflex artery. Perfusion defects could be easily distinguished from the left ventricular cavity. Scintigraphy was also performed with an Anger-type gamma camera for comparison. The extent of the perfusion defect was measured by planimetry and expressed as a percentage of the ventricular area in that projection. The average of the right anterior and left anterior oblique projections provided the most accurate estimate of the size of the perfusion defect (average error: 13.2 percent; range: 0-38.2 percent). Fresnel zone plate imaging provided an accurate in vivo assessment of the extent of altered myocardial perfusion.

TOMOGRAPHY IN CARDIAC IMAGING. S. Cantez, P.V. Harper, F. Atkins, J. Sbarboro, and H. Karunaratne. University of Chicago, Chicago, IL.

Accurate delineation of uptake defects in the heart and estimation of their size is difficult even from multiple projections using conventional imaging methods because of the three-dimensional configuration of the myocardial activity distribution. In principle, tomographic imaging should permit a more accurate estimate of the fraction of the myocardium involved by an uptake defect since each slice can be measured separately and the results summed. Back-projection longitudinal tomographic images produced using a prototype positron camera with rubidium-81 have been compared with conventional camera images using thallium-201 in the same patients with healing myocardial infarctions. Phocon images of the thallium-201 distribution in patients imaged during stress testing have also been compared to conventional thallium images obtained in the same studies. Comparison has likewise been made in the same subjects with ^{13}N-ammonia between longitudinal positron tomograms processed to remove out-of-focus data and Pho/Gamma IV images using conventional projection and tungsten collimation. It appears clear that back-projection tomograms add only slightly to the information obtained from conventional images. Processing to remove the out-of-focus data appears to give markedly improved contrast and delineation. Thus in using tomography, processed longitudinal tomograms show a distinct improvement, and multiple transaxial tomograms with any of the available instruments should probably give the best possible results. (Supported by SCOR Grant HL-17648, ERDA Contract EY-76-C-02-0069 and USPHS Center for Imaging Research Grant GM-18940.)

MYOCARDIAL IMAGING WITH THALLIUM-201 AT REST AND EXERCISE - A MULTICENTER STUDY: CORONARY ANGIOGRAPHIC AND ELECTROCARDIOGRAPHIC CORRELATIONS. James L. Ritchie, Barry L. Zaret, H. William Strauss, Bert Pitt, Daniel S. Berman, Heinrich R. Schelbert, William L. Ashburn, and Glen W. Hamilton. VA Hospital, Seattle, Wa.

A multicenter study of rest and exercise Thallium-201 (^{201}Tl) myocardial imaging, including 190 patients (pts) from 5 institutions, was performed. All pts had coronary angiography for proven or suspected coronary artery disease. Exercise images were obtained following graded treadmill or bicycle stress. Images were performed on 4 different gamma camera models and interpreted by the originating investigator without knowledge of other clinical or angiographic data. Among those 148 pts with angiographic coronary stenosis > 50%, image defects were present in the rest study in 78 (53%) pts; new or increased defects following exercise were present in 90 (61%) pts; and rest and/or exercise defects were present in 115 (78%). Image defects in the rest study were more common than ECG Q waves (78 vs. 68; $p < .03$). New exercise image defects were more common than exercise ST depression (77/132 [58%] vs. 62/132 [47%], $p=.06$). Among 42 pts with < 50% coronary stenosis, 4 (10%) had a rest, 1 (2%) a new exercise, and 5 (12%) either a rest and/or exercise image defect. One of these 42 (2%) had an ECG Q wave, and 5/37 (12%) had exercise ST depression.

We conclude that myocardial imaging enhances diagnostic sensitivity in the noninvasive evaluation of coronary artery disease. These findings apply to most available gamma cameras and to a broad spectrum of image readers.

RADIOACTIVE MANGANESE: ITS POTENTIAL AS A MYOCARDIAL IMAGING AGENT. Heinrich Schelbert, Depew Chauncey, Samuel Halpern, Phillip Hagan, Frank DeLano and Martha McKegney. VA Hospital and University of California, San Diego, CA.

Manganese (Mn) is primarily an intracellular ion and localizes in mitochondria. Because of the abundance of mitochondria in myocardium, Mn-54 was examined for its possible utility as a myocardial (M) imaging agent and compared to Tl-201. Tissue distribution studies of both carrier-free Mn-54 and Tl-201 were performed in 58 rats at 0.5, 1, 2, 4, and 6 hrs. following I.V. administration, and in 6 dogs at 30 min. and 4 hrs. after Mn-54 administration. In 2 of the dogs, the anterior descending coronary artery was ligated 3 days prior to study. In the rats, myocardial Mn-54 concentration was highest at 1 hr. (1.92% dose/gm) after injection with a decrease of 47% over the next 5 hrs. Mn-54 blood (B) levels were 0.02% dose/ml at 1 hr. and fell by 70% during the next 5 hrs. M/B ratios for Mn-54 reached a peak value of 294:1 at 4 hrs. after injection. By contrast, Tl-201 reached its highest M/B ratios of 48:1 at 30 min. after injection, M concentrations at that time being 1.43% dose/gm. In 2 dogs sacrificed at 30 min., 2.43% of the Mn-54 was present in the heart, and in 4 dogs, sacrificed at 4 hrs., the heart contained 2.07% of the dose; 2.1% was present in the lungs, 41.4% in the liver, and 17.0% in the kidneys. M/B ratios averaged 74:1. In the 2 dogs with experimental myocardial infarcts, Mn-54 concentrations in infarcted M were reduced by 13 to 75% (mean 47%) when compared to normal myocardium. The results of these studies suggest that isotopes of Mn (Mn-52 or Mn-52m) may be useful for myocardial imaging, especially by computerized emission tomography; furthermore, due to its unique location within mitochondria, Mn compounds may be of interest for evaluating specific aspects of myocardial ischemia.