

Abstracts in this section pertain to papers presented at the Proceedings of the Spring Meeting of the Central Chapter of the Society of Nuclear Medicine, "Nuclear Medicine in Clinical Oncology: Current Status and Future Aspects," March 19-21, 1987, Chicago, IL. Program Chairman: Carlos Bekerman, MD.

Quality Control Techniques and Artifacts in Dual-Photon Absorptiometry. M. Costanza, K. Patel, and E. Turbiner. *Wheeling (Jesus) College, Wheeling, WV; and Mercy Hospital, Pittsburgh, PA.*

Three factors which can affect the final diagnostic quality of dual-photon densitometry images have been examined. They are: (a) the effects of attenuating materials found on or within the patient; (b) the consequences of marginal quality control parameters on subsequent data; and (c) the value of accurate history taking.

An x-ray phantom with various artifact-producing devices was imaged by a Lunar DP3 Dual-Photon Densitometer with IBM PC-AT computer.

The study provided an understanding of how numerous artifacts can be produced by the three factors. We were able to generate, reproduce, and catalog a series of artifact images which serve as a useful reference.

Nuclear Medicine Guided Aspiration Bone Biopsy. B.P. Mullan, F.T. Lovegrove, V.F. Antico, and G. Sterrett. *Sir Charles Gairdner Hospital, Perth, Australia.*

Differentiation of benign from malignant osseous lesions in a patient with known or suspected malignancy is of considerable importance. Solitary bone lesions are especially difficult and a tissue diagnosis has traditionally been by fluoroscopic needle biopsy or by open biopsy. Nuclear medicine bone scintigraphy with lead ring localization, provides a simple, physiological approach with less radiation exposure. Localizing accessible safe biopsy sites in patients with multiple secondaries from an unknown primary tumor is also achieved with ease.

Two to four hours following i.v. injection of technetium-99m methylene diphosphonate, the patient is scanned, the lesion localized and positioned for biopsy. Rib and sternal lesions were aspirated with either a sternal aspiration needle or a 19-gauge lumbar puncture needle, and a Jamashidi needle was used for pelvic sites, allowing biopsy and aspiration of marrow contents.

Thirty patients have been biopsied in this manner. Approximately 10% of rib lesions were shown to contain tumor, whereas pelvic sites yielded a higher incidence depending on whether single or multiple lesions were present.

Nuclear medicine guided bone biopsy would appear to be a very useful physiological technique to refute or confirm secondary bony malignancy, especially when radiologically normal lesions are present. Positive biopsies occur more frequently with pelvic biopsy sites than with rib biopsy sites.

Preoperative Pulmonary Scintigraphy as a Predictor of Respiratory Function Following Lung Resection. B.P. Mullan, J. Markos, F.T. Lovegrove, V. Antico. *Sir Charles Gairdner Hospital, Perth, Australia.*

The prediction of postoperative lung function following lung resection in bronchogenic carcinoma has traditionally been based on the Forced Expiratory Volume in 1 sec (FEV1); Forced Vital Capacity (FVC); Maximum Ventilatory Volume (MVV), and probe or single view lung perfusion. In this study, spirometry was used in conjunction with computer analysis of ventilation/perfusion (V/Q) pulmonary scintigraphy to predict postoperative lung function. Methods were as follows. (a) Pulmonary function was assessed by measuring FEV1 and FVC pre and postoperatively by routine spirometry, (b) Pulmonary scintigraphy (1) Differential and regional ventilation was assessed posteriorly by the computer analysis of a standard xenon-133 ventilation study. (2) Differential and regional perfusion was assessed by the computer analysis of anterior, posterior and appropriate oblique views, following i.v. technetium-labeled macroaggregates of albumin, thus giving lung and lobar perfusion.

Thirty-seven patients have been studied and followed up. There is a close correlation between the predicted and observed postoperative FEV1 and FVC for both lung and lobar resections. The perfusion derived FEV1 and FVC correlation coefficients are 0.82 and 0.84 for lobar resections. Similar results were obtained for ventilation analysis.

Computer analysis of pulmonary scintigraphy with preoperative spirometry provides a simple noninvasive method of predicting postoperative lung function following lobar or lung resection.

Scintigraphic Balloon Proctography for Dynamic Assessment of Anorectal Angle. W.M. Oswald, M.E. Pezim, D.A. Barkel, J.H. Pemberton, and M.L. Brown. *Mayo Clinic and Foundation, Rochester, MN.*

An increasing body of evidence suggests that the angulation between the anal canal and rectum is critical to fecal continence. Loss of this angle results in incontinence, while excessive angulation may lead to constipation. Previous methods of visualizing the anorectal angle have relied upon contrast medium, necessitating the delivery of significant doses of radiation. Scintigraphic balloon proctography was developed to allow measurement of the anorectal angle with a reduced radiation requirement. A cylindrical balloon is placed into the anal canal and rectum, and filled with a solution of 5 mCi of $^{99m}\text{TcO}_4^-$ in 70 ml of water. Imaging is performed in a variety of positions during various physiological maneuvers. Mean angles (degrees) in 23 normal volunteers are 105.4 \pm 14.6 rest, 87.7 \pm 14.7 squeeze ($p < .007$)*, 97.3 \pm 8.3 valsalva maneuver ($p < .008$)*, and 117.1 during attempted defecation. Assuming 30 min of exposure from 5 mCi of ^{99m}Tc , the patient receives less radiation in this method (bone marrow 12 mrad, testis 4 mrad, and ovaries 45 mrad), than he would using conventional x-ray, assuming 1 min of fluoroscopy and a lateral pelvic film

* (Relative to rest).

(bone marrow 121 mrad, testis 212 mrad, and ovaries 583 mrad). We are continuing to utilize this technique, accumulating normal values in healthy volunteers, to further delineate the role of the anorectal angle in patients with incontinence, constipation, and other anorectal disorders.

Indium-111 WBC Scintigraphy Versus Other Imaging Tests in Suspected Orthopedic Prosthesis Infection: A Comparison. J. Magnuson, M. Brown, M. Hauser, R. Fitzgerald, and G. Klee. *Mayo Clinic/Foundation, Rochester, MN.*

Optimal management of patients with suspected infection of prosthetic implants requires accurate confirmation or exclusion of periprosthetic infection. Ninety-eight patients were retrospectively studied who were sent for Indium-111 (¹¹¹In) WBC imaging for the determination of septic prosthesis and subsequently underwent surgery within 14 days (mean 3.9 days). There were 65 total hip arthroplasties, 18 total knee arthroplasties, ten femoral endoprostheses, and five other prosthetic devices. At surgery, half (49) of the patients were infected as determined by culture or histology.

The results of the following were analyzed for sensitivity, specificity, and accuracy in the diagnosis of prosthesis infection: [¹¹¹In]WBC scans, plain film radiographs (x-ray), three-phase bone scan (3P-BS) and arthrograms (Arth). Each imaging test was graded as positive, intermediate, or negative for infection; positive and intermediate test results were considered as positive for statistical analysis.

	Three-phase			
	[¹¹¹ In]WBC	bone scan	X-ray	Arth
No. Studies	(98)	(48)	(96)	(24)
Sensitivity	89.7	100	57.1	90.0
Specificity	73.4	17.2	36.1	38.4
Accuracy	81.6	60.4	46.8	62.5

The study demonstrates that the best imaging modality for the diagnosis of prosthetic infection is [¹¹¹In]WBC.

The Use of Profile Analysis for the Assessment of Organ Dimensions. M.K. O'Connor, B. Oswald, M.L. Brown, P. Kamath, and S. Phillips. *Mayo Clinic, Rochester, MN.*

In gastric emptying or colonic motility studies, total counts within an organ is not an indicator of organ size. We have developed a method for measurement of organ dimensions based on the use of the full width half maximum (FWHM) of profiles taken through these organs. In vitro studies were performed using a large rectangular Lucite box filled with water. Four circular Lucite phantoms with internal diameters of 3.2–10.2 cm were constructed together with an elliptical phantom of dimensions 9.6 × 4.0 cm. All phantoms were filled with water containing various concentrations of technetium-99m (^{99m}Tc). Phantoms were placed at depths ranging from 5–25 cm from the surface of the water-filled box. Gamma camera images were obtained and the FWHM calculated from horizontal profiles taken across the cylinders. The FWHM showed no variation with ^{99m}Tc concentration in the same cylinder. Over the range of cylinder depths, the FWHM for all cylinders increased by 0.5–0.7 cm. This was due to the increase in collimator FWHM as a function of distance rather than due to the presence of scatter. At a depth of 10 cm,

correction factors of 1.05 (3.2 cm cylinder) to 1.22 (10.2 cm cylinder) were required to convert FWHM to true diameter. For cylinder diameters <3 cm, this technique did not work as the FWHM was determined primarily by the collimator.

Use of the FWHM together with a correction factor of ~1.1 allows accurate estimation of the diameter of elliptical or cylindrical organs in the body, irrespective of their depth or the activity within them.

Measurement of Arterial to Total Hepatic Blood Flow by Radionuclide Angiography. M.K. O'Connor, P. Mac Mathuna, and P. Keeling. *Mayo Clinic, Rochester, MN and St. James Hospital, Dublin, Ireland.*

Assessment of liver hemodynamics was obtained by analysis of first pass flow studies through the liver and spleen using Tc-99m compounds not actively trapped by these organs. This study examined existing and new methods for the determination of % arterial flow from these studies. Eighty-two studies were performed in 56 patients with both normal and abnormal liver function. Using region of interest analysis, time-activity curves were obtained for the lungs, liver, and spleen. These curves were analyzed by four different methods. Methods 1 and 2 analyze the early and late phases of the liver flow curve using techniques described by Sarpar et al. (Sarpar R, Tarcan YA. *Radiology* 1983; 147:559–562). Method 3 employs deconvolution analysis of the liver and spleen curves with the lung curve. The areas under the deconvolved curves are proportioned to blood flow. Method 4 uses a refinement of Method 3 as described by Juni et al. (Juni et al. *Eur J Nucl Med* 1985; 11:A9). All methods showed an intraobserver variation of 3.2–5.1% in % arterial flow after reanalysis. In 11 patients who underwent repeat studies, the correlation between the two studies was r = 0.58, 0.55, 0.89, and 0.79 for Methods 1–4, respectively. Methods 3 and 4 provided the most significant separation between normals and patients with mild cirrhosis (p < 0.02 and 0.01, respectively). Method 4 underestimated true % arterial flow in patients with portal vein thrombosis (PVT). Method 3 was the most reproducible and the most suitable for the detection of PVT.

Response of the Visual Cortex with Iodine-123 HIPDM: Eyes Open Versus Eyes Closed at time of Injection. J.D. Krepshaw, C.R. Appledorn, H.N. Wellman, B.M. Mock, and R. Tangerman. *Indiana University Medical Center, Indianapolis, IN.*

To determine the effect of environmental stimuli upon the uptake of I-123 HIPDM with the brain, we examined regional cerebral uptake levels depending upon eyes open (EO)/eyes closed (EC) at the time of tracer injection. Five clinically normal subjects, providing informed consent, were examined twice (EO and EC). For the EC study, the subjects were blindfolded five minutes prior to injection and remained so throughout the SPECT acquisition. The EO study was performed in an identical manner, without the blindfold. Fourteen days separated the two studies in each subject.

Injected doses were similar (5.2–5.4 mCi). Data acquisition was performed 25 min postinjection using a dual detector SPECT system. Data were collected at 15 sec/image, 120 images/360°, times two detectors. Approximately 5.5 million counts/study were collected. Twelve millimeters transaxial slices (6 mm overlap) were reconstructed parallel to the O.M. line and study slices (EO and EC) were registered. Circumfer-

ential profiles at the level of the visual cortex were generated and EO and EC curves were compared for five regions: L and R frontal, L and R parietal, and occipital.

We observed a dramatic increase in relative activity in the occipital region for EO compared to EC. This increase was not observed in the other regions. The best homogeneous distribution of the tracer was obtained for EC. We conclude that environmental (visual) stimuli do influence HIPDM tracer uptake and efforts should be made to control them.

Detecting Bile Leaks: Tips for Technologists on Hepatobiliary Imaging. S.L. Carichner and C.E. Nagle. *William Beaumont Hospital, Troy, MI.*

The occurrence of iatrogenic leaks in the biliary tree following hepatic or biliary surgery is well documented in the literature. In addition, abdominal trauma is sometimes responsible for bile leaks. Patients with a bile leak may complain of pain, tenderness, swelling, nausea, or low-grade fever. The nonspecificity of these symptoms makes a bile leak very difficult to diagnose solely on a clinical basis. The technetium-99m IDA scan has been shown to be of value in detecting bile leaks, especially postsurgery, where distortion of anatomical landmarks can interfere with evaluation through a ultrasound or computed tomography.

The authors present an imaging protocol for hepatobiliary scintigraphy for patients suspected of having a bile leak. Case examples are used in discussing how the technologist can improve the biliary scan information. Special attention is given to the patient history and clinical setting, acquisition of special images to enhance the detection of aberrant radiotracer, and ways to assist the nuclear physician in the performance of further supplemental scan procedures, i.e., paracentesis.

Although bile leaks are relatively uncommon, the frequency with which cholecystectomies are performed dictates that nuclear medicine personnel become familiar with the clinical signs of these leaks and special imaging procedures that aid in making the diagnosis.

Specific Localization of Native and DTPA Conjugated Monoclonal Antibodies by the Hepatocyte. B. Kasabali, M.J. Blend, S.M. Pinsky, L. Ghosh, and R. Prasad. *Michael Reese Hospital, and University of Illinois at Chicago, IL.*

An avidin biotin immunoperoxidase staining technique (AB-P) using antimouse monoclonal antibody (MoAb) as a secondary anti-body and a standard autoradiography procedure (Au-P) were applied to normal rat liver frozen sections. The aim of this study was to gain a better understanding of the mechanism of MoAb-liver binding. One of our iodinated MoAbs (P3) served as an excellent blood pool agent and was not bound to liver. All other MoAbs whether labeled with iodine-125 or indium-111 were avidly taken up by hepatic tissues. Specific MoAbs directed against human isoferritins, rat liver histocompatibility antigens (MAS-101) and nonspecific MoAbs (anti-human albumin MoAb and human IgG) were used. There was hepatic binding of all antibodies tested as demonstrated by AB-IP and Au-P. A variety of different cellular binding patterns were found depending on the specificity of the MoAb. While anti-basic isoferritin MoAb (LF01) showed plasma membrane binding, anti-acidic isoferritin MoAb (2A-4) accumulated in the nucleus. Native and DTPA-

conjugated MAS-101 and anti-human albumin MoAb localized in the sinusoids, P-3 showed diffusely reduced binding. These in vitro data suggest that there is specific binding of MoAb based on the particular antigens present in the cell and the specificity of the antibody. Multiple mechanisms such as RES uptake. Increased blood flow and FC-receptor binding may be operative in the in vivo situation.

Detection of Culture Proven Acute and Chronic Osteomyelitis: Comparison of Indium-111-Labeled Leukocytes and Triple Phase Bone Scans. M.J. Blend and H.L. Kahen. *Michael Reese Hospital and Medical Center, and University of Illinois. Chicago, IL.*

The diagnosis of chronic and/or acute musculoskeletal infection in the orthopedic patient can often be difficult. A prospective study was conducted in order to determine the sensitivity (sen.) and specificity (spec.) of the indium-111-labeled leukocyte scan [¹¹¹In]WBC) and triple phase technetium-99m (^{99m}Tc) methylene diphosphonate bone scans in culture proven (C-P) bone infections. Thirty-nine patients with suspected osteomyelitis were imaged at 24 and (for 36) 48 hr postinfusion of [¹¹¹In]WBC. Autologous leukocytes were labeled using a slight modification of the method of Thakur et al. (*Ex Hematol* (suppl 5): 1977). All patients were evaluated with plain radiographs and 23 bone cultures were obtained. Symptoms for 6 wk or greater were considered chronic. The sen. of [¹¹¹In]WBC scan for C-P acute osteomyelitis was 100% (6/6) and was comparable to that of the triple phase bone scan (5/5). The spec. for [¹¹¹In]WBC scans for C-P acute infections was 75% whereas ^{99m}Tc bone was significantly lower (<50%). In C-P chronic infections the sens. of [¹¹¹In]WBC scans was 60% with a spec. of 50% and the ^{99m}Tc bone scan had a sen. of 100% with a spec. of 83%. These data suggest that [¹¹¹In]WBC scans are extremely sensitive and slightly more spec. when compared to triple phase bone scans in acute infections of bone. Indium-111 WBC scans may be an excellent follow-up scan when the bone scan is questionable. However, both the sensitivity and spec. of the [¹¹¹In]WBC scan are of questionable value for chronic bone infections. The use of bone scan with a follow-up gallium scan may be more informative in cases of chronic infection.

Accurate and Reproducible Attenuation-Corrected Radionuclide Left Ventricular Volumes Obtained by a Technologist. S.A. Squicciarini and M.R. Starling. *Department of Internal Medicine, University of Michigan and VA Medical Center, Ann Arbor, MI.*

Accurate radionuclide angiographic (RNA) left ventricular (LV) volumes are necessary to evaluate LV contractility. A trained technologist can play an important role in obtaining LV volumes through the use of a simple geometric method to correct for attenuation. To determine the accuracy and reproducibility of this method, we studied eight patients using LV biplane contrast cineangiography (CINE) and RNA on two separate occasions, one simultaneous with (Day 1) and one within 48 hr of (Day 2) CINE. To obtain an attenuation correction factor (A) for RNA LV volumes, the distance from the gamma scintillation camera to the LV center of mass (d') was determined by the technologist using anatomic landmarks in the LAO and anterior projections on Day 1 and Day 2. LV

end-diastolic (ED) and end-systolic (ES) volumes were calculated using hand-drawn, background subtracted regions-of-interest, plasma blood sample counts, and A. The d' values on Day 1 and Day 2 correlated ($r = 0.96$) as did the values for A ($r = 0.95$). The mean CINE LVED volume was 327 ± 214 ml, while the average RNA LVED volumes were 280 ± 250 ml on Day 1 and 275 ± 230 ml on Day 2 ($p = \text{NS}$). The mean CINE LVES volume was 184 ± 212 ml, while the average RNA LVES volumes were 152 ± 193 ml on Day 1 and 154 ± 167 ml on Day 2 ($p = \text{NS}$). We conclude that a trained technologist can reproducibly obtain distances to the LV center of mass for attenuation correction using anatomic landmarks that yield RNA LV volumes which do not differ significantly from those obtained by biplane CINE.

Pharmacokinetics of High Activity Iodine-131 T-101 Monoclonal Antibody. J.M. Kazikiewicz, A.M. Zimmer, D. Robinson, R.E. Goldman-Leiken, S.T. Rosen, and S.M. Spies. *Northwestern University Medical Center and Veterans Administration Hospital Lakeside, Chicago, Ill.*

Currently, our laboratory has treated seven patients and retreated three patients with cutaneous T-cell lymphoma using 100–200 mCi iodine-131 (^{131}I) T-101. Plasma clearance studies and radioactive component analysis of plasma and urine samples were performed. Blood samples were collected up to 7 days following antibody infusion. Urine was collected daily up to 6 days postinfusion. Aliquots of plasma and urine were counted for radioactivity in a multichannel analyzer. Clearance and excretion curves were generated and $T_{1/2}$ calculated. Plasma samples were analyzed using size exclusion high pressure liquid chromatography (HPLC), while urine samples were analyzed using HPLC, gel exclusion, and anion exchange chromatography. Diagnostic plasma activity for five of six patients showed biexponential clearances with an initial $T_{1/2}$ from 0.9 to 1.5 hr and a prolonged $T_{1/2}$ from 14.8 to 25.0 hr. Therapeutic plasma activity for five of six patients showed monoexponential clearances with a $T_{1/2}$ from 11.6 to 24.6 hr. Urinary excretion $T_{1/2}$ was 2.3 ± 0.9 days. Analysis of plasma showed predominant activity associated with intact ^{131}I T-101 (80% up to 40 hr postinfusion). Urine activity was associated with uncomplexed “free” ^{131}I .

Radioimmunotherapy Retreatment of Cutaneous T-cell Lymphoma: Effect of Plasmapheresis on Human Antimurine Antibody Titers. A.M. Zimmer, R.E. Goldman-Leiken, J.M. Kazikiewicz, S.T. Rosen, and S.M. Spies. *Northwestern University Medical Center and Veterans Administration Hospital Lakeside, Chicago, IL.*

Radioimmunotherapy retreatment of patients with murine monoclonal antibodies is difficult due to human antimurine

antibodies (HAMA). We investigated the effect of plasmapheresis on HAMA titers in three patients, who were then retreated with 100 mCi to iodine-131 T-101 (10 mg). Plasma samples, obtained pre- and postplasmapheresis, were incubated with known amounts of radioiodinated T-101 for 30 min and immune complex formation quantified using size exclusion high performance liquid chromatography (Bio-Sil TSK 250 sizing column). In addition, solid-phase RIA was performed to quantitate specific immunoglobulins. Results of the study showed significant reductions in HAMA titers (61%, 56%, and 28%) after plasmapheresis. The greatest reduction appeared to be in the IgM component. After plasmapheresis, in two patients, the amount of T-101 involved in immune complex formation ($0.7 \mu\text{g}$ and $1.9 \mu\text{g}$ T-101/ml plasma) was less than the administered monoclonal antibody ($\sim 3.3 \mu\text{g}$ T-101/ml plasma) and clinical responses were observed after retreatment. In the other patient, complexed T-101 ($13.3 \mu\text{g}/\text{ml}$ plasma) was greater than the administered dose and no clinical response was observed after retreatment.

Treatment of Metastatic Bone Pain with Strontium-89. R.C. Robinson, J.A. Spicer, D.F. Preston, A.V. Wegst, and N.L. Martin. *Kansas University Medical Center, Kansas City, KS.*

We have investigated strontium-89 (^{89}Sr) as palliative therapy for the bone pain of metastatic cancer.

We have treated 204 patients, with 20 receiving ^{89}Sr chloride intravenously in a dose of $30 \mu\text{Ci}/\text{kg}$, while all subsequent patients received $40 \mu\text{Ci}/\text{kg}$. The patients were followed with pain diaries, pain medication taken, sleep patterns and Karnofsky Index. There were 137 patients with adequate follow-up who survived at least 3 mo. Patients included 100 with prostate carcinoma, 28 with breast carcinoma and nine with miscellaneous carcinomas metastatic to bone.

Eighty/100 patients with prostate carcinoma showed clinical response and 25/28 breast Ca patients noted improvement. Four of nine with miscellaneous carcinomas responded. No patients with prostate or breast carcinoma noted a worsening of symptoms; two of nine in the miscellaneous category had no clinical response. Ten prostate and five breast cancer patients became pain-free. The overall response rate in the 137 patients was 80%. Little hematological depression was noted. The platelet count usually decreased an average of 20% at 4–5 wk following treatment. Serious marrow toxicity occurred in 4% of patients, and was always associated with marrow invasion and extensive previous beam radiation and chemotherapy. Multiple doses of strontium at 10–12-wk time intervals resulted in continued palliation in $\sim 50\%$ of patients.

Strontium-89 shows great promise in controlling pain of metastatic cancer to bone, particularly in breast and prostate carcinoma.