
Magnetic resonance imaging yields excellent quality images of the cardiovascular system utilizing the inherent natural contrast between flowing blood and the surrounding anatomic structures. To evaluate the clinical usefulness of MRI in the noninvasive diagnosis of large vessel disorders, we have performed MRI on 40 patients with either aortic or pulmonary artery abnormalities (18 thoracic or abdominal aortic aneurysms, eight aorto-occlusive disease, six dissecting aneurysms, four Marfan's syndrome, two pulmonary artery aneurysms, one pulmonary artery occlusion, one aortic coarctation). Images were obtained in the transverse, coronal and sagittal body planes utilizing a 0.6T superconductive magnet. Cardiac and/or respiratory gating was employed in most cases. Correlation was made for all studies with conventional or digital subtraction angiography, computed tomography and/or ultrasound.

The diagnostic information obtained by MRI equaled or exceeded that obtained by other imaging techniques except for the few cases where cardiac arrhythmias precluded adequate gated acquisition. All aneurysms and their relationships to adjacent structures were readily demonstrated as were the presence or absence of mural thrombi and dissecting intimal flaps. Angiographically demonstrated atherosclerotic plaques and luminal stenoses were seen by MRI in all patients without arrhythmias.

We conclude that MRI is a powerful noninvasive diagnostic aid in the delineation of large vessel disorders, especially where knowledge of anatomic interrelationships can guide surgical or other interventional planning.


Thirty patients (pts) with suspected spinal infection (ages 22–82; 17 males, 13 females) were evaluated radiographically (6/30 tomographically) and with MRI. Twenty-nine of these pts had planar radionuclide bone scans (PRB) using 20 mCi technetium-99m HDP and 14 had gallium scans using 6 mCi gallium-67 citrate. Twelve of twenty-nine had bone single photon emission computed tomography (SPECT) and 6/14 had gallium SPECT. Twenty-one of thirty pts had positive microbiological, surgical, or clinical diagnostic criteria for infection. MRI was performed on a 0.6T superconductive magnet in a 50 cm body coil with sagittal 1 cm contiguous slices using spin-echo T1 weighted images (TE 30 msec/TR 0.5 sec) and T2 weighted images (TE 120 msec/TR 2.5 sec). Ten of thirty pts had TE 60 msec/TR 1 or 2 sec. imaging. Of the 21 pts with proven infection MRI was positive in 20/21 (95%); plain radiography in 12/31 (62%), PRB in 14/19 (74%) and gallium 9/13 (69%). Four PRB were suspicious and confirmed with SPECT giving a SPECT bone scan sensitivity of 95% and SPECT gallium sensitivity of 92%. MRI findings in infection showed decreased signal intensity of the disk and adjacent vertebral bodies on T1 weighting while increased signal intensity of the disk without evidence of an intranuclear cleft was evident on T2 weighting. 11 pts were followed up with repeat imaging in a 6-wk to 15-mo period, during and after antibiotic therapy. On review MR is more sensitive and specific than plain films. MR (particularly T2 images) is as sensitive as radionuclide studies and has greater anatomic specificity. Gallium imaging may show changes prior to MRI or PRB and reverts to normality more quickly but is influenced by antibiotic therapy. SPECT imaging is more sensitive than planar imaging.

Image Artifacts in Nuclear Magnetic Resonance Scanning: A New Frontier. R.J. Fischer and T.P. Callahan. The New York Hospital, Cornell University Medical Center, New York, NY.

Magnetic Resonance Imaging has produced a new set of image artifacts unique to this modality. The recognition of these abnormalities as artificial, rather than pathological, is essential for proper diagnostic interpretation. Artifacts can be divided into two broad categories—those due to the patient, and those due to the imaging system. Physiologic motion (respiration, cardiac pulsation, peristalsis) is the most common cause of image degradation, viewed as slight image blurring with slight concentric ringing around the image. Random spontaneous motion causes severe blurring of the image. Cardiac and respiratory gating markedly improve image quality. Foreign bodies, either on or within a patient, will usually produce no detectable signal, or, if magnetic, distort the image in the adjacent area.

The appearance of artifacts due to problems within the system can be highly varied. Continuous geometric patterns, geometric or irregular contours overlying part of an image, or irregular image distortions are the most common abnormalities in this group. The patterns produced are quite specific to the malfunction and can be attributed to problems with the shims, gradients, RF system, or computer hardware.

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Forty-eight subjects (18 normals; 30 abnormals, 22 with ventricular septal defects [VSDs] and nine with atrial septal defects [ASDs]) were examined with EKG-gated NMRI. The images were randomly presented to two independent observers who blindly interpreted them, using a five-category rating scale to indicate their confidence that ASDs and/or VSDs were present. After a 2-wk interval the images were reordered and again blindly interpreted using a two-category scale (present or absent). True- and false-positive fractions were calculated for each decision criterion level implied by the five-category scale and the resulting operating points plotted in a receiver operating characteristic (ROC) space. Single ROC curves were fit to the points of both observers for each type of defect, using a maximum likelihood estimation program. Operating points for VSD and ASD were calculated for echocardiography (EC) from sensitivities and specificities recently reported in the literature and plotted in the ROC space. Operating points generated in the two alternative experiments were also plotted. The detectability of VSDs by EKG-gated NMRI is comparable to that reported for EC, but that of ASDs appears far less. Because of its relatively low cost, simplicity, and accuracy, EC is superior to NMRI as a noninvasive method of detecting ASDs and VSDs.

**Validation of Dynamic Arrhythmia Filtration Compared with Serial Mode Technique for Gated Blood-Pool Imaging.** L. Wu-Konnelly, J.E. Juni, and J. Botti. *University of Michigan Medical Center, Ann Arbor, MI.*

Heart rate variability is an ever-present source of error in gated blood-pool imaging, especially when diastolic function (DF) is of interest. This study was undertaken to compare two methods of arrhythmia rejection, dynamic arrhythmia filtration (DAF) and serial mode (SM).

SM allows selection of the desired cycle length, eliminating beats of unusual length. SM has limited clinical use due to large disk storage requirements and time for postprocessing of data. DAF allows similar data to be obtained without the above restrictions. Cycles are selected and stored in memory during the acquisition based on predetermined parameters. Patients were imaged supine using standard in vivo labeling techniques. The computer set-up was an MDS A3 system for DAF and an MDS A2 system for SM. Signals from a standard gamma camera and EKG gate were split and interfaced to the two systems providing exact duplication of data input and simultaneous acquisitions.

Reformatted SM data and DAF data with a 5–6% window centered about the normal cycle length were analyzed using a previously validated semi-automatic ejection fraction (EF) routine. DF parameters such as peak filling rate (PFR), time to peak filling rate (TPFR), and time to end-systole (TES) were calculated using a multi-harmonic analysis of the time-volume curves. EF, PFR, TPFR, and TES for each patient were compared. Results showed a highly significant correlation with R values as follows: EF r = 0.99, PFR r = 0.94, TPFR r = 0.86, and TES r = 0.97.

We conclude that DAF is a valid alternative method to SM in the evaluation of DF from gated blood-pool imaging.

**Stippled Ribs—A Potential Pitfall in Bone Scan Interpretation.** D. Fink-Bennett and J. Johnson. *William Beaumont Hospital, Royal Oak, MI.*

A retrospective evaluation of 100 consecutive bone scans was performed to determine the incidence and clinical importance, if any, of increased uptake at the insertion of the iliocostalis thoracis portion of the erector spinae muscle group (rib stippling).

The scans were performed 2–3 hr after the intravenous injection of 15 mCi of technetium-99m methylene diphosphonate (\[^{99m}\text{Tc}\]MDP). Each patient had a standard whole-body scan (scintillation camera with whole-body imaging table) or a whole-body tomographic scan (PhoCon). Rib stippling was deemed present if a focal area of increased \[^{99m}\text{Tc}\]MDP was identified within the posterior angle of three or more consecutive ribs.

Seven of 100 (three bilateral, four unilateral) patients demonstrated rib stippling. Foci intensity was less than the scapular tips, but greater than the adjacent ribs. No patient had a history of chest trauma, pain and/or an abnormal radiograph.

Even though increased uptake within the posterior angle of the ribs is an uncommon finding (7%), its recognition as a normal bone scan finding is important to prevent bone scan misinterpretations. Its characteristic scintigraphic appearance and location should serve to differentiate it from the increased uptake of trauma and/or tumor.
Higher Order Statistical Scintigraphic Phase Analysis in Cardiac Conduction Diseases. D.A. Schultz, R.L. Wahl, J.E. Juni, J.D. McMeekin, and M. Tuscan. Cornell Medical Center, New York, NY, and the University of Michigan, Ann Arbor, MI.

Phase analysis (first order harmonic phase generation creating images reflecting cardiac contraction and conduction) is a relatively new nuclear cardiologic method shown to be of significant value in conduction and coronary arterial diseases.

In trying to detect more subtle disease, statistical parameters of phase analysis have been used. Standard deviation and skewness (s.d. and sk) have been shown to be of value in separating coronary arterial diseased (CAD) patients from normal (N) patients.

In this study, six N patients were compared to five patients with left anterior hemiblock and four patients with exercise-induced left bundle branch block (and no CAD). Although visual phase analysis and mean phase angle analysis showed significant differences in the conductive diseased patients from N patients, s.d., sk, and kurtosis (KU) analysis showed no significant differences, in opposition to higher statistical parameters when comparing CAD to N patients where there is a difference.

Higher statistical order analysis in other conductive diseases may be normal as well. If so, higher order analysis might differentiate patients with superimposed conductive and coronary disease from "pure" conduction diseased patients.

Dual Head HIPDM SPECT Imaging in the Differential Diagnosis of Dementia with MR and CT Correlation. H.N. Wellman, R. Gilmor, H. Hendrie, B. Mock, A. Kapuscinski, C.R. Appledorn, and J. Krepshaw. Indiana University School of Medicine, Indianapolis, IN.

Dual head single photon emission computed tomography (SPECT) brain imaging was performed in 20 patients with a clinical diagnosis of dementia approximately one-half hour after a 5 mCi dose of high purity (p,5n) iodine-123 HIPDM (N,N',N'-Trimethyl-N'-{(2-hydroxy-3-methyl-5-iodobenzyl)-1,3-propanediamine). Tomographic reconstruction used a 30th order, moderate cutoff (0.2) Butterworth filter found previously to optimize low noise and conspicuity. Most patients had computed tomography (CT) and magnetic resonance (MR) imaging and some patients were studied more than once.

In approximately one-half of patients referred with a diagnosis of dementia of the Alzheimer's type, SPECT results were consistent with multiple infarct dementia (MID). MR studies in most of these patients with MID demonstrated multiple white matter defects correlating with multiple gray matter defects seen with SPECT and consistent with angiogenic disease of theBinswanger's type. While CT demonstrated cortical abnormalities in some patients, the findings were often non-specific with enlarged ventricles and widened sulci.

Alzheimer's patients, both of the senile and presenile types, have been found with HIPDM to have largely symmetrical lesions in the parietal regions similar to those reported with PET imaging and neuropathology studies. Two patients with pseudodementia were found normal with all studies. Thus, SPECT HIPDM imaging appears to have a significantly complementary imaging role, especially with MR, in the objective differential diagnosis of dementias.

Sequential Vertebral Bone Scintigraphy in Osteoporotic Patients Treated with NaF. J. Ferguson, J.W. Froelich, M. Kleerekoper, and L. Shaw. Henry Ford Hospital, Detroit, MI.

Twenty-three white females with postmenopausal osteoporosis and vertebral compression fractures were chosen for a study utilizing sodium fluoride (NaF) therapy and quantitative bone scintigraphy. These patients were then placed into a randomized clinical study (NaF = 14, placebo = 9) with repeat bone scans every 6 mo.

Two hours after an injection of technetium-99m methylene diphosphonate scintigraphic images were obtained on a wide field of view gamma camera with 50K computer images over the lumbar and thoracic spine. With the use of controlled equal regions of interest, activity ratios were obtained comparing selected abnormal vertebra to the two closest normal vertebrae above or below.

Analysis of the data showed significant reduction in the activity ratios of abnormal to normal vertebra in the NaF treated patients (paired t-test p = 0.0095). No significant change was observed in the control group (p = 0.142). Analysis between the NaF and control groups indicated a significant difference in the change in ratio between the two groups (two sample t-test p = 0.087).

These results strongly suggest that NaF therapy aids in more rapid healing of osteoporotic vertebral fractures.

Differential First Transit Technetium-99m Recordings for Predicting Renovascular Disease. C. Wesołowski, G. Conrad, P.T. Kirchner, R.L. Meng, K.C. Jensen. University of Iowa, Iowa City, IA.

The initial rise rate of the renal time-activity recording has been previously examined, and the left-to-right ratio of these rates has been shown to correlate with differential renal blood flow in a canine model of renal arterial stenosis. Expected left-to-right ratios were determined from a population of 20 individuals. The mean normal left-to-right ratio was 1.31 ± 0.20 (1 s.d.) from non-normalized curves and 1.24 ± 0.11 from renal area normalized curves. To test the clinical efficacy of the left to right ratios for predicting renovascular disease, we analyzed the first transit recordings of technetium-99m DTPA/GHA in 19 hypertensive patients. Angiography and renal sampling were performed on all patients. 17/38 kidneys had significant renal artery stenosis (≥75%) or fibromuscular dysplasia. For predicting that a patient would have a significant angiographic abnormality, a left/right ratio <1.11 or >1.51 from non-normalized curves had a sensitivity of 93%, a positive predictive value of 87%, a negative predictive value of 75%, and a specificity of 60%. A positive renin was defined as (vein-artery)/(artery) ≥ 0.5 for both kidneys or (V-A)/A ≥ 0.5 for one kidney and (V-A)/A < 0.19 for the contralateral kidney.
For predicting that a patient would have abnormal renin(s), a left/right ratio < 1.01 or > 1.47 from area normalized curves had a sensitivity of 80%, a positive predictive value of 73%, a negative predictive value of 75% and a specificity of 67%.

Thus, an abnormal L/R ratio indicates a high likelihood of positive results from angiography and selective renin analysis.


This study evaluates single photon emission computed tomography (SPECT) in renal tomoscintigraphy in the evaluation of renal masses and correlates this modality, where indicated, with computed tomography (CT), ultrasonography (US), angiography (ANGI0) and nuclear magnetic resonance imaging (NMR).

Eight patients with renal cortical lesions detected on intravenous urography (IVP) were evaluated by SPECT and planar nuclear imaging using technetium-99m glucoheptonate (GH). Three of these patients were felt particularly likely to have renal tumors and were additionally evaluated with US, CT, ANGIO and NMR.

The five patients with relatively low-suspicion nodules on IVP had functioning, benign renal tissue accounting for their IVP lesions. Four of five were found by planar-GH nuclear imaging, 5/5 by SPECT-GH. In addition, SPECT-GH allowed better "confidence" in the normal renal tissue diagnosis in 3/5 cases. Of the three high suspicion renal lesions, two were hypernephromas; one was hyperfunctioning cortical tissue. All three were correctly identified prospectively on SPECT-GH. However, one hypernepoma was missed on planar-GH. NMR, CT, and ANGIO detected only one of two hypernephromas prospectively (US detected both); all four modalities incorrectly diagnosed the hyperfunctioned tissue suspicious for malignancy. All modalities detected a simple 2-cm cyst.


Monoclonal antibody (MCA) 443B6, an IgG1 isotype, was produced in our facility and reacted with several human lung AC cell lines and biopsy samples but not with several human small cell lung cancer (SCLC) cell lines and biopsy samples. Radiolabeling was achieved using a solid phase iodogen system (30–60 μCi/μg). After radiolabeling, protein purification was accomplished by gel exclusion chromatography and radioimmunoreactivity was determined using a solid phase radioimmunoassay procedure. Athymic nude mice, each bearing either a right thigh AC (A549) or SCLC (NCI-H69) tumor, were injected with 50–100 μCi of I-131 level MCA and imaged up to 7 days after injection. The animals were then sacrificed and organ biodistribution determined. Results of the study demonstrated optimal AC tumor visualization occurred from 3 to 7 days after injection with tumor concentrations as high as 4.7% of the initial injected dose. At 7 days postinjection, high organ concentrations were also observed in liver (1.83%/g of injected dose) and in blood (6.19%/g of injected dose). Tumor concentrations in nude mice bearing human SCLC tumor were less than 1% of the injected dose (0.30% of injected dose at 7 days postinjection). At 7 days postinjection, the highest remaining concentration was observed in blood (2.35%/g of injected dose). The results of the study demonstrated that radioimmunoscintigraphy of human AC was feasible with the radioiodinated MCA 443B6.


A computer-assisted curve stripping technique was used to derive renal transit times and flow fractions from the first transit aortic and renal recordings of technetium-99m radioactive (diethylentriamine acid, GHA, methylene diphotonate) following peripheral bolus injection. Mean values ± 1 s.d. for 40 normal kidneys: first and second component transit times: T1 = 6.8 ± 2.4 sec., T2 = 12.8 ± 3.2 sec.; flow fractions: f1 = 67 ± 9%, f2 = 17 ± 10%; residual fraction (slower components + filtration): Rf = 16 ± 9%. A tumor population of 11 patients without known renal disease was studied prior to chemotherapy. Mean f1 was diminished, and mean f2, T1, and Rf were elevated (p < 0.05). 18 hypertensive patients evaluated with angiography, renal vein renins, and scintigraphy were also reviewed. The mean f1 was decreased and the mean f2, T1, T2, and Rf were increased in this population (p < 0.01). The f1:T1 ratio proved to be a sensitive indicator of asymmetric renal disease. The mean left-to-right ratio (L/R) of f1/T1 in normals was 1.02 ± 0.10 (r = 0.93) and 1.6 ± 1.5 (r = 0.50) in the hypertensives. An L/R f1/T1 <0.82 or >1.22 had a sensitivity of 85%, specificity of 80%, and positive predictive value of 92% for the presence of an arterial lesion (stenosis of ≥70%). The sensitivity, specificity, and predictive value for lateralized or bilaterally elevated renins were 73%, 50%, and 73%, respectively.

The authors conclude that intrarenal blood flow distributions can be derived noninvasively and simultaneously for both kidneys, that the results obtained are similar to those previously reported with the invasive xenon washout technique, and that disease tends to produce intrarenal flow shifts and prolongation of transit times.

Technical Considerations of Dual Isotope Subtraction. S. Spaulding, J. Juni, and M. Tuscan. University of Michigan Medical Center, Ann Arbor, MI.

Computer image subtraction of two images which have been
acquired simultaneously using different energy photopeaks has become an integral element of several recently introduced imaging procedures. Correct analysis of the data from each photopeak involves using a computer subtraction process which considers several parameters. These include the relative contribution from each photopeak, scatter correction, image normalization, the response of the computer to negative pixel values, and careful attention to display technique.

Downscatter causes artificially high counts to be included in one of the images used in the subtraction procedure. Without correction for downscatter, inaccurate subtraction will result. Differences in relative count rates from the two energies may require normalization of the data prior to subtraction. The adjustment of the computer display hardware is critical for proper interpretation of the post subtraction image. Negative pixel values may cause subtle but significant errors in the displayed image. Once these factors are considered, an image which reflects the accurate count distribution may be produced.

We have developed a processing protocol which considers the above variables and accounts for them prior to the actual performance of image subtraction. Our protocol has proven accurate and beneficial in the analysis of 30 images that were acquired using IN-111 labeled platelets and Tc-99m labeled red blood cells and in parathyroid imaging. Careful consideration of downscatter correction, image normalization, and image display parameters is critical to meaningful dual isotope subtraction imaging.

Preparation of Indium-111 Human Albumin Microspheres for Intracoronary Injection Using Indium-111 Oxine. N.A. Petry, J.A. Ponto, H.L. Glass, W.O'Neill, and J.E. Juni. University of Michigan, Ann Arbor, MI; and University of Iowa, Iowa City, IA.

The impetus for development of a new approach to indium-111 (111In) human albumin microspheres (HAM) preparation resulted from our desire to employ dual isotope tomographic scintigraphy, in conjunction with technetium-99m HAM, to investigate the significance of coronary collateral circulation in preserving myocardial mass and function in acute myocardial infarction.

Previous methods of labeling HAM with 111In have used acidic solutions of indium chloride. Disadvantages of these methods include availability and chemical purity of the indium chloride and the required addition of weak chelating/buffering agents. In this new approach, a preparation method for 111In HAM using 111In oxine and HAM kits was investigated. Briefly, HAM kits were reconstructed with saline, mixed ultrasonically, subdivided into aliquots and 111In oxine/saline was added. Labelling efficiencies were determined at 10, 20, and 30 min at incubation temperatures of 22, 37, and 100°C. Transferrin was added to several preparations as competing ligand to separate free and weakly bound 111In from 111In HAM. Labeling efficiencies of ~90% were obtained with transferrin added and further in vitro incubation of 111In HAM at 37°C in the saline/transferrin solution demonstrated virtually complete stability over a period of 2 hr. ITLC-SG/0.05N HCl was in close agreement with the transferrin technique and indicated that optimal labeling efficiency was ~95% within 20 min at 100°C. Preparation stability at 2–8°C was evaluated by radiochromatography at various time intervals and greater than 90% radiochemical purity was consistently found up to 72 hr after preparation.

This preparation method requires much less time than previous methods, employs readily available radiopharmaceuticals, and is the most practical means to routinely prepare 111In HAM for clinical imaging procedures.

Should Selective Spleen Scans be the Test of Choice for Diagnosing Asplenia in Pediatric Patients? D.S. Lahti, J.E. Juni, S. Bank. University of Michigan Medical Center, Ann Arbor, MI.

Pediatric patients with severe congenital cardiac abnormalities have a high incidence of asplenia. Because of the problems associated with asplenia (high susceptibility to infection and cardiac abnormalities) it is important to diagnose these patients as soon as possible so that proper therapy can be started. A number of diagnostic tests have been applied to asplenia; however, the results frequently disagree. We have found selective spleen scans (SSS) using technetium-99m (99mTc) heat damaged red blood cells (DRBC) to be the optimal test to identify asplenia, polysplenia, and to localize splenic tissue.

Seventeen pediatric patients (all being treated for cardiac abnormalities) were evaluated for possible asplenia. We injected 1 cc of pyrophosphate in saline and withdrew 3–5 cc of blood after waiting 25 min. The DRBC were labeled with 99mTc and heat damaged in a water bath at 45°C for 25 min. The plasma and cells were assayed for labeling efficiency (≥90%) before reinjection. After 15–20 min, an ant. marker, ant., post., and both lateral views were obtained using a CAP collimator.

The SSS were compared with previous [99mTc]sulfur colloid (SC) liver-spleen scans (L/S), ultrasound (US), and Howell-Jolly body (H-Jb) blood test results. 5/6 (83%) of the [99mTc]SC L/S, 12 of 20 (60%) of the US, and four of 14 (28%) of the H-Jb tests did not correspond to the final diagnosis as established by SSS.

SSS are easily performed and interpreted and provide more accuracy in diagnosing asplenia and polysplenia than other techniques.


A monoclonal antibody raised against testicular embryonal carcinoma (5F9.3), with cross-reactivity with some choriocarcinomas, was radiolabeled with iodine-131 and evaluated in detecting occult choriocarcinoma in a 29-yr-old female.

The patient had a 4-yr history of choriocarcinoma, which originally had presented as a uterine rupture. She had had pulmonary and abdominal metastases resected, pelvic radiation, and 45 courses of chemotherapy. At the time of presentation she had a rising human chorionic gonadotropin (HCG) level, but no obvious macroscopic foci of disease, with three chest computed tomographic scans prior to admission read as scarring in the upper lung fields.

The patient received 1.25 mCi of 56F.3 MoAb i.v. She tol-
erated the injection well and scans were obtained at daily intervals to 6 days postinjection. Images showed increased uptake in the left chest and midabdomen. Close examination of the chest radiograph showed a small nodule in the left lung. This was needle-biopsied and confirmed to be choriocarcinoma with \( \sim 10 \times \) more radioactivity in the lesion than in normal cells from this aspirate. Pathologic confirmation of the abdominal lesion has not yet been obtained.

Radioimmunodetection of choriocarcinoma appears possible with this reagent. This holds forth promise for evaluating choriocarcinoma patients with rising HCG's but no obvious foci of metastatic disease.