ABSTRACTS FOR SCIENTIFIC PROGRAM:

TO BE PRESENTED BY TITLE ONLY

Computer Processing of Image Data with Color-Coded Isocount Contour Display BY RALPH ADAMS, ERNEST J. BRAUN, CHARLES FINNEY AND CARL JANSEN, White Memorial Medical Center, Los Angeles, Calif. and Loma Linda Univ. Hospital, Loma Linda, Calif.

Computer-processed image data are often displayed as a series of isocount contours, each identified by typewritten symbols. Such a presentation cannot be ideally adapted for rapid or accurate interpretation since it requires excessive time for analysis by the physician. Indeed, other authors have found it desirable to color code their isocontours by hand before projecting or publishing them. The purpose of this project is to produce such color-coded scintigrams rapidly and automatically.

A series of color filters mounted on a wheel in front of the lens of the camera photographing the cathode-ray tube is driven from color to color by a mechanism controlled by the computer. A program has been written to automatically open or close the camera shutter and to display a number of isocount contours in sequence through pre-selected combinations of color filters and exposure times. The operator may vary color shading or sequencing as well as select linear, logarithmic or other mathematical scales by typing appropriate prescribed commands into the program.

The authors present a number of color-coded scintigrams together with corresponding black and white ones demonstrating the value of such a system.

The authors show how these color-coded scintigrams enhance contrast, extend dynamic range and provide quantitative information at a glance.

Nature of the Mechanisms Responsible for the Concentration of ^{51}Cr-Complexes by Tumors BY L. J. ANGHILERI, Univ. of Colorado Medical Center, Denver, Colo.

Studies carried out on five different types of animal tumors (Ehrlich carcinoma, lymphosarcoma 6C3HED, melanoma B16, lymphatic leukemia BW5147 and hepatoma BW7756) have shown a considerable concentration of radioactivity when animals were injected with ^{51}Cr-alloxantin complex. The highest radioactivity is observed in bone, followed by kidneys, tumor and liver. In preliminary studies it was observed that these types of chromium complexes (where chromium still retains some of its cationic properties) are bound to insoluble calcium compounds (as phosphates, carbonates, etc.) as well as to bone mineral tissue in a process of combined ion exchange and complex formation. To investigate whether this mechanism is also responsible for the high kidney, tumor and liver uptakes, a fractionation of the different calcium compounds (alcohol soluble, ether soluble, water soluble, acetic acid soluble and hydrochloric acid soluble) was performed on tissues from animals previously injected with $^{45}CaCl_2$. Considering the fact that hydroxyapatite has been identified in many tumors, a similar fractionation on animals previously injected with ^{32}P-sodium orthophosphate was done. The experimental results show a similar pattern for all the three tissues: a high proportion of acetic acid soluble fraction (normally insoluble), while the calcium uptake is much higher in tumor than in the other tissues. On the other hand, the ^{32}P distribution does not follow the ^{45}Ca pattern, which is an indication that insoluble calcium compounds other than hydroxyapatite may be present. Furthermore, there is a defined relationship between the calcium uptake and the chromium concentration in all the tumors, which is an indication that the interaction of calcium com-

pounds with chromium complex is the main process involved. These experimental results, besides clarifying the process of chromium concentration, open the possibility of further studies on the influence of calcium metabolism in tumor development.

Comparative Study of the Value of Sodium Polyphosphates and Orthophosphate for Localized Beta Irradiation of Tissues BY L. J. ANGHILERI AND ESTHER S. MILLER, Univ. of Colorado Medical Center, Denver, Colo.

Through the study of the body distribution of ^{32}P-sodium polyphosphates (lineal and cross-linked) and ^{32}P-sodium orthophosphate (with carrier and carrier-free) in normal and in tumor-bearing animals, an evaluation of their usefulness as a local beta-irradiation source for the various tissues and at different times after their administration was performed. The presence of carrier in a range of 0–20 mg of phosphorus per kg does not affect significantly the orthophosphate distribution. When injected intravenously, both lineal and cross-linked polyphosphates are taken up in lesser extent by all the tissues than the orthophosphate with the exception of bone, in which uptake is 30–40% higher. On the other hand the intraperitoneal administration of these condensed phosphates shows a lower value than orthophosphate in bone. This indicates that the way of administration is reflected in the final distribution. In general, the cross-linked form is taken up in a lesser extent than the lineal. *In vitro* assays of the action of acid and alkaline phosphatase on the polyphosphates have shown a high rate of hydrolysis by the acid phosphatase, while the alkaline shows a little action. The incorporation in experimental tumors (melanoma B16 and Ehrlich carcinoma) which possess a low acid phosphatase activity shows a higher concentration of orthophosphate. The overall pattern of distribution indicates that while orthophosphate is immediately incorporated into tissues with a high phosphorous turnover (as tumor, spleen, kidneys, etc.), the polyphosphates need to be previously hydrolyzed by acid phosphatase. This points out the usefulness of these radiocompounds only in the case of tumors with a high acid phosphatase activity.

Effect of Initial Radioiodide Therapy on Thyroid Scan Length, Surface Area and Uptake BY MOHAMED A. ANTAR, ALI ANTAR AND RICHARD P. SPENCER, Yale Univ. School of Medicine, New Haven, Conn.

To document the effects of radioiodide therapy on the size and function of the adult thyroid, 35 patients with hyperthyroidism were studied. Criteria for inclusion were: (1) clinical and laboratory evidence of hyperthyroidism in a person over age 35; (2) diffuse enlargement or a normal-sized thyroid (thus excluding the gross multinodular goiters); (3) this was the initial treatment with radioiodide in each case (80 μCi/gm); (4) the patients returned 3 months after therapy and had good quality scans before and after treatment; (5) there had to be a decrease in radioiodide uptake at the 3 months followup compared with the initial values. There were seven males (average age 49), and 28 females (average age 47). The male-to-female ratio of 1:4 is equivalent to that seen in our general thyroid studies. The mean thyroid length prior to therapy was 5.7 cm (4.2–8.7 cm) while 3 months after treatment the mean value was 4.7 cm (2.8–7.9 cm). In two cases there was no change in thyroid scan length ($\pm$0.1 cm measurement). For all 35 cases, there was a highly significant relationship between the thyroid length after therapy (L_A) and that before (L_B) treatment ($\sigma = 0.80$, $L_A = 0.25 + 0.78\ L_B$). There was an even better correlation between the scan surface area (S) of the thyroid after therapy and that before ($\sigma = 0.87$, $S_A = 1.18 + 0.62\ S_B$). In terms of the percentage alteration in thyroid length, the least change (9%) was seen in the largest gland while the greatest (44%) was observed in one of the smallest thyroids. The mean value of the 24-hr radioiodide uptake prior to treatment was 59%, while 3 months after therapy it was 23%. The initial surface area of the thyroid scan appeared to have a good predicting relationship to the fraction of patients developing thyroid underactivity at the 3 months followup. Of the glands with an initial surface area under 17 cm^2, eight out of 11 (73%) had 24-hr uptake values of 19% or less at 3 months, while only six out of 24 (25%) of the larger glands had low values at 3 months. Using the parameter of uptake-to-scan surface area, 32 out of the 35 patients had lower values after treatment. There was often a greater decrease in uptake than in the estimated mass change in the thyroid. Thus there is a highly significant relationship between the pretreatment and post-treatment thyroid scan sizes (length and surface area) in these cases, but little relationship between the pre- and post-therapy uptake values. Part of the beneficial effect of radioiodide therapy is probably due to a loss of thyroid mass, while part may be due to physiological alterations not apparent by external shrinkage. Potential criteria for predicting these two effects are available for discussion. (Supported by T-492 from the American Cancer Society and by USPHS CA06519.)

Intracardiac and Intravascular Deposition of Lung Scan Macroaggregates BY MOHAMED A. ANTAR,

GERALD S. FREEDMAN, EUGENE A. CORNELIUS AND RICHARD P. SPENCER, Yale Univ. School of Medicine, New Haven, Conn.

Unusual localization of ^{131}I-macroaggregated albumin had been known to occur in two situations: (1) when a shunt was present so that particles escaped before pulmonary entrapment; (2) when the particles clump together causing localized deposition in the lungs ("hot spots"). We have observed two further instances that deserve documentation since recognition of these occurrences may be helpful in establishing the diagnosis.

1. Deposition in a phlebitic vein. A 57-year-old male noted the sudden onset of shortness of breath, chest pain and diaphoresis 4 days postoperatively. A lung scan was performed after the intravenous injection of ^{131}I-macroaggregated albumin into the right antecubital vein through an in-dwelling catheter. The anterior scan showed a focal deposit of radioactivity in the region of the axilla. It evolved that the in-dwelling catheter had been in the right arm since his admission. Hence a phlebitis seemed likely with deposition of some of the radioactive material in an involved region. Eight days later, there was no retained radioactivity in the arm. A phlebogram at this time demonstrated the residual of a clot in the axillary vein. A repeat lung scan was not accompanied by localized collection of the particles. This finding is consistent with the observation by M. Webber and coworkers of the deposition of macroaggregated albumin in venous thromboses of the lower extremities.

2. Deposition within the heart. A 67-year-old male developed shortness of breath postoperatively. Intravenous injection of ^{131}I-macroaggregated albumin was not accompanied by any unusual difficulty. The lung scan showed two focal deposits of activity in the right lung (relatively anteriorly on the lateral view), one smaller deposit in the left lung and a major deposition in the midline. The latter collection appeared to be within the heart. The first evidence to favor this was the localization by anterior, oblique and lateral views. The second piece of data was that the radioactivity fluctuated with the heart beat. Third, a radioisotopic angiogram, following injection of a ^{99m}Tc-bolus was consistent with a right ventricular localization. Fourth, the patient's hospital course included an increasing systolic murmur and EKG changes. There was persistence of radioactivity in this intracardiac localization over several days (which may have been either entrapment or a clump of particles or deposition on a fresh intraluminal cardiac defect). A followup scan 3 days later (using the persisting activity in the lungs from the previous study) showed disappearance of the intracardiac activity with the appearance of a new "hot" spot in the right lung. This strongly suggested embolization of an intracardiac clot. In addition to clumping or the presence of a shunt, abnormal localization of macroaggregated albumin should suggest a phlebitic process or intracardiac defect. (Supported by T-492 from the American Cancer Society and by USPHS CA06519.)

Pertechnetate Uptake in Hashimoto's Thyroiditis BY H. L. ATKINS, W. C. ECKELMAN, W. HAUSER AND P. RICHARDS, Brookhaven National Laboratory, Upton, N.Y.

In routine examinations of the thyroid trapping function with ^{99m}Tc-pertechnetate, a new metabolic abnormality—high pertechnetate uptake by the thyroid gland—has been observed in some patients with Hashimoto's thyroiditis. In 12 out of 13 patients studied there have been discrepancies in the results of various thyroid function tests. In 10 patients the pertechnetate uptake was elevated while the blood levels of thyroid hormones were within or below the range of normal. Only two of these patients had an elevated 24-hr iodide uptake. The high pertechnetate uptake was found to be associated with a high ^{131}I-PBI. It is suggested that both the alteration of the trapping function and the rapid iodide turnover reflect the increase in TSH levels in the blood of patients with Hashimoto's thyroiditis described by others.

Treatment of Hyperthyroidism with Radioactive Iodine (^{131}I). Use of an Individually Calculated Dose in 241 Male Patients with Graves' Disease BY WILLIAM H. BLAHD, V.A. Center and UCLA School of Medicine, Los Angeles, Calif. AND MARGUERITE E. HAYS, V.A. Hospital and State Univ. of New York at Buffalo, Buffalo, N.Y.

This report encompasses a 20-year study of 241 male patients who received ^{131}I for the treatment of Graves' disease. All patients received a therapeutic dose of ^{131}I which was estimated to deliver 7,000 rads to the thyroid gland and was based on the assumption that 1 μCi ^{131}I/gm would deliver 160 rads. The therapy dose was calculated from the 24-hr thyroid uptake, the effective half-life of the retained ^{131}I tracer dose and the gland weight, the latter determined by an empirical weight formula from the thyroid scintigram. The actual number of millicuries required to deliver the calculated dose ranged from 0.4 to 20.8 mCi. The median followup period was 5 years.

Detailed comparisons were made between the group of patients who were controlled with single doses of ^{131}I and the group requiring multiple doses.

In this series 45% of the total patient group and 68% of the Negro patients required multiple doses in contrast to other series with primarily female populations in which there were substantially lower incidences of retreatment. Patients who required multiple doses had more severe laboratory abnormalities and had lost more weight. Only 25% were euthyroid within 10 months in contrast to 85% of the patients who received a single dose. These patients also became hypothyroid later but ultimately had a higher incidence of hypothyroidism.

The rate of appearance of hypothyroidism for the total series followed a consistent pattern. Approximately 10% developed hypothyroidism during the first year. An increment of 2.7%/year was observed in post-therapy Years 1–5, 3.7%/year during Years 5–10 and approximately 6.3%/year during Years 10–15. The mean incidence of hypothyroidism for the entire series was 27.8%. Hypothyroidism appeared to be related to the severity of disease, especially weight loss, and the need for multiple dose therapy. In contrast to the experience reported by others it would appear from the present data that when the radiation dose delivered to the thyroid is maintained constant, there is no correlation between the number of millicuries administered and the need for multiple doses, the time required to attain a euthyroid state, the incidence of hypothyroidism or the time interval preceding the development of hypothyroidism.

Since the actual number of millicuries of ^{131}I required to deliver the therapy dose has little or no relation to the ultimate therapeutic effect, a dose calculated to deliver a predetermined radiation dose to the thyroid can be expected to give a more predictable response than an arbitrary millicurie dose. The particular method of therapeutic dosimetry used in this series which included determination of gland weight by an empirical formula and the measurement of important parameters of thyroid physiology provides a more precise means of establishing the proper therapy dose. These data also suggest the value of tailoring the initial thyroid radiation dose to the severity of the patient's disease as well as to his sex and race.

New Solution to the Renography Problem BY K. E. BRITTON AND N. J. G. BROWN, Middlesex Hospital Medical School, London, England.

The technical problem of renography, that of providing a record of the variation with time of the quantity of Hippuran in each kidney, the "kidney" curve, has been solved by the use of digital or analog computer-assisted blood-background subtraction (CABBS). The purpose of this study is to tackle the three aspects of the clinical problem which arise because of the unsuitability of currently available apparatus in the clinical environment.

First, apparatus should be designed not only to meet the needs of outpatients but also to cope with the problems of seriously ill patients in the ward now that CABBS renography enables the assessment of individual renal function in patients with down to 4% of normal total renal function. A prototype, mobile, self-contained system incorporating an analog CABBS facility has been tested. The couch height is adjustable for ease of handling seriously ill patients. For example, a patient who had sustained a fractured spine and pelvis developed increasing uremia. In this patient, who was also on a respirator, renography using the mobile couch demonstrated normal renal function so operative intervention became unnecessary.

Second, to extend the technique to the general hospital or clinic, a doctor-orientated rather than physicist-orientated system is mandatory. Results on a series of patients will be presented.

Third, the clinical interpretation of the kidney curve depends on a knowledge of the handling of Hippuran by the kidney in health and disease, which is still controversial. Using the mobile system, for example, studies on patients which measure their ureteric pressures during simultaneous renography have *not* confirmed the presence of "ureteric spasm" during irregularities of the third phase of the renogram. These irregularities appear to be due to fluctuations in renal perfusion. The system may be used for correcting renin release for relative renal plasma flow at renal vein catheterization.

In conclusion, the mobile system is demonstrated to be a clinically successful, purpose-built machine for standard and background-subtraction renography, meeting the needs of the general hospital and the specialist.

Simple, Low-cost Approach to Clinical Xenon Studies BY ROBERT G. CARROLL, Cincinnati General Hospital, Cincinnati, Ohio

Xenon-133 pulmonary perfusion and ventilation studies approach the ideal of nonintrusive physiological measurement; they are uniquely capable of documenting patterns of regional pulmonary function.

A major limitation in clinical xenon perfusion and ventilation studies has been their high cost. If the same xenon used for perfusion is saved by having the patient rebreathe, then both perfusion and ventilation can be evaluated with 8–20 mCi of injectable xenon in saline.

The basic cost of perfusion studies can be dras-

tically reduced by preparing injectable xenon from gaseous xenon obtained from Oak Ridge. The single vial cost of injectable xenon is $50 for 7.5–10 mCi and $70 for 18–25 mCi. The gaseous product can be obtained for $165 for the first curie. Thus a 7.5–10 mCi dose would cost $1.65.

The patient sits with his back resting against the gamma-camera diverging collimator. Approximately 20 mCi of ^{133}Xe dissolved in saline is injected in the arm opposite the lung of interest. The patient then takes a deep breath and holds while eight rapid sequence films are taken to visualize the heart and pulmonary vasculature. The patient then breathes back and forth into a 6-liter oxygen-filled weather balloon. Four films of 25,000 counts are accumulated during this rebreathing phase. The balloon is removed, and the patient then is allowed to breathe into an exhaust duct. Films are taken every 30 sec during normal washout.

The xenon-saline dispensing apparatus uses the Oak Ridge glass ampule as a mixing chamber and reservoir. A heavy rubber plug is inserted to seal the ampule neck. A 13-gage inlet needle and an 18-gage outlet needle with Millipore filter are then inserted and the available space completely filled with saline. The 13-gage needle is then thrust through the glass breakoff seal, and the inner chamber is flooded with cold saline from a 50-cc syringe while the three-way stop-cock on the exhaust needle is closed.

After the chamber is full of saline, the exhaust needle stop-cock is opened to a 10-cc Hamilton gas-tight syringe. Additional saline is forced through the 13-gage inlet needle, thereby forcing xenon saline into the Hamilton syringe, which thus becomes a high specific-activity reservoir. Dose syringes can be then filled by saline displacement from the ampule or directly from the high specific-activity Hamilton syringe. The xenon rebreathing apparatus is extremely simple. Minimum requirements are a 6-liter weather balloon and 10 in. of tubing. A mouthpiece and an on-off valve add elegance.

The exhaust system consists of a squirrel cage blower attached to a 4-in. flexible dryer ducting. The patient's exhaled breath during washout is thus ducted to an outside wall.

Methods for Correction of Time-Constant Distortion in Dynamic Studies and in Fast Scanning BY BENEDICT CASSEN, Univ. of California, Los Angeles, Calif.

In nuclear medicine instrumentation applications it is frequently necessary to record a time-varying signal which is modified by either an unavoidable time constant or one purposely added to smooth statistical fluctuations. As is well known, a long time constant will appreciably distort a rapidly changing signal. It is shown that methods exist to largely eliminate this distortion and recreate the original signal either graphically or by analog-computer circuitry.

In principle, the method consists of adding to the observed time curve a time-constant-determined fraction of its derivative rate of change. This method can also be applied to correcting for distortion and elimination of scalloping in fast scanning.

Various modifications and applications of this principle will be illustrated. The improvement of scanning resolution by preventing scalloping will be presented. As the integrated area under a time-constant distorted signal can be shown to be unchanged from that of the original signal, pulse-type flow measurements can be derived even when long time constants are involved.

In the rapidly evolving field of nuclear medical dynamic studies, computational methodology can be of great aid in improving quantitative significance.

Collimator Design for Quantitative Organ Measurement BY LAURENCE P. CLARKE, JOHN S. LAUGHLIN AND KLAUS MAYER, Sloan-Kettering Institute, New York, N.Y.

This study was undertaken to quantitize organ activity using the Institute's dual-detector rectilinear scanner. Quantitative results require that the detector response and resolution be uniform with depth through the patient. Considerable improvement in uniform resolution has recently been achieved for small detector size (2 × 2 in. crystal), the solid angle subtended at the focus being small (Genna, S., Farmelant, M. H. and Burrows, B. A.: Improved scintiscan resolution without sensitivity loss: "constant-resolution" collimator. In *Symposium on Nuclear Activation Techniques in the Life Sciences,* IAEA, Vienna, 1968). However, for crystals of larger diameter, the solid-angle variation along the detector axis is more acute.

Two collimators have been constructed for the 4 × 4-in. crystals of our scanner. The required uniform depth response and resolution were achieved with a 28-hole lead collimator having rings of 9 and 18 holes with corresponding focal lengths of 14 and 18 cm, respectively. Parameters of the holes were chosen to axially extend the foci of each ring. The focal lengths were determined theoretically by a collimator simulation program; they were also determined experimentally.

Measurements were taken for ^{51}Cr (320 keV) with detector separations of 20, 25 and 30 cm. Line-spread functions of both detectors were summed and

showed little variation with depth in tissue-equivalent material. With the 20-cm separation, resolution defined by full width at half maximum was 2.5 cm in tissue. For both resolution and plane sensitivity, the percentage deviation from the mean was within 5% for all depths. With the 25- and 30-cm positions, resolution and plane sensitivity remained within 10% and 15% of their mean values, respectively. This collimator system is being used to quantitate organ activity in liver and spleen in patient studies.

Portal Hypertension Caused by Inflow Overload Complicating Myelogenous Leukemia BY BERNARD CLOWDUS, CHARLES MARTINEZ AND ERVIN KAPLAN, Chicago Medical School and V.A. Hospital, Hines, Ill.

When cirrhosis and venous obstruction cannot be incriminated, the cause for portal hypertension may be obscure. Hemodynamic and histologic studies in a 45-year-old male with chronic myelogenous leukemia, esophageal varices and resistant ascites are therefore reported. Investigations in this case included transhepatic portal venography with intrasplenic manometry; estimated hepatic blood flow, occluded and free hepatic vein pressures and phlebography. Arterial catheterization (Seldinger technique) of the spleen with angiography and external scintigraphy using the Picker Dynacamera System was performed using serial injections of 2 mCi of ^{133}Xe on two occasions and a final 2 mCi of ^{99m}Tc-pertechnetate. Video recording of this information permitted subsequent determinations of splenic resistance, splenic and hepatic blood flow and circulation times. The non-recycling of ^{133}Xe revealed, in this patient, flow of blood through the spleen without subsequent flow through the liver, while ^{99m}Tc appeared in the spleen and flowed through the liver only at the time compatible with hepatic artery recycling. Post-splenectomy injection of the splenic vasculature (Liebow technique) permitted anatomical evaluation of the splenic circulation, while post-mortem anatomical examination revealed the patency of splenic venous drainage, the hepatic portal system and intrahepatic circulation.

Splenic resistance was decreased while total splenic and hepatic blood flows were increased. Portal and occluded hepatic venous pressures were increased before surgery returning to normal after splenectomy. Postoperatively ascites did not reform, even after sodium restriction in the diet and diuretic therapy had been discontinued.

Post-mortem examination of the liver with complete sectioning demonstrated no evidence for fibrosis or infiltration of leukemic cells causing outflow obstruction, and polymer injection of the splenic vasculature revealed no gross A-V shunts.

The data support the conclusion that the elevated portal pressure in this patient was entirely attributable to a decreased splenic resistance and increased splenic blood flow (inflow overload to portal system), and that this phenomenon was related to the increased vasculature of the enlarged leukemic spleen. The value of scintigraphy is emphasized in the understanding of difficult circulatory dynamics exemplified here.

Technique for the Rapid Preparation of Lung Scan Particles using ^{99m}Tc-Sulfur and Human Serum Albumin BY MICHAEL D. CRAGIN, MILO M. WEBBER, WINONA K. VICTERY AND DANIEL PINTAURO, Univ. of California Center for the Health Sciences, Los Angeles, Calif.

Technetium-99m-sulfur suspension with human serum albumin as a radio-diagnostic agent in lung scanning is prepared rapidly with greater efficiency than the traditional lung scanning agent. It also yields a more constant particle size when compared to commercial preparation. ^{99m}Tc-sulfur suspension is made after a modified Patton procedure. Dilute human serum albumin is added to the vial of sulfur particle preparation. Following the addition of a phosphate buffer and subsequent hot water bath treatment with agitation, the particles of Tc-S are incorporated into the forming aggregates of albumin. A test of tagging efficiency is made by comparing the activity of an aliquot of material before and after Millipore filtration. The lung-size particles are separated from the Tc-S particles in this manner. When compared with a commercial lung scanning agent, (Tc-S)MAA showed a slightly higher efficiency rate (99.7%) than did the commercial product (95.6%).

In vivo studies using mice were performed to compare the amount of injected material found in the lung with the material of insufficient particle size which would concentrate in the liver and the blood. These studies again showed the (Tc-S)MAA preparation to be slightly superior to that of the commercial product, concentrating 98.4% of the injected material in the lung in comparison to a 97.4% concentration of the other product. The scans obtained are of excellent quality because a dose of 1 mCi or more can be used. No accumulation is seen in the liver.

In vivo scans in patients have been made using this material. It has proven to be easy to prepare, and clinical results of consistently high quality have been obtained. (Supported by US AEC Contract AT (04-1) GEN-12.)

Solvent Extraction of ^{99m}Tc in the Clinical Laboratory BY M. C. CREWS, B. R. WESTERMAN AND J. L. QUINN, III, Chicago Wesley Memorial Hospital and Northwestern Univ. Medical School, Chicago, Ill.

The increasing use of ^{99m}Tc and its compounds and the introduction of routine isotope angiography have increased the amount required daily as well as imposed more stringent requirements on the eluate. Consideration of our needs in view of available generator systems decided us in favor of the solvent extraction separation of ^{99m}Tc from ^{99}Mo to supply our department.

The system we use consists of well-shielded glassware designed with ease of operation, minimization of radiation dose and future needs in mind. Separation is accomplished by mixing redistilled methyl ethyl ketone with ^{99}Mo in a basic solution. The layers are allowed to separate and the aqueous ^{99}Mo solution is drained off into a reservoir for use in later extractions. The methyl ethyl ketone layer is passed through an acid alumina column to remove traces of base and then evaporated to dryness. The ^{99m}Tc is taken up into normal saline, membrane filtered to sterilize, and assayed. The control over the specific activity that this system allows has many advantages. Low-volume doses make bolus injections possible for rapid studies, decrease the hand dose during injection and permit the preparation of high specific-activity compounds. Yields from this system average 90%, and the eluent is free from ^{99}Mo and alumina contamination.

Even with the greater complexity of this system compared to sterile generators, our total cost per millicurie of ^{99m}Tc and its compounds has decreased. This is due partially to the high yields and the fact that the ^{99}Mo solution is much cheaper than a sterile generator. Other factors that provide advantages in time and cost are the freedom from contamination, the necessity of preparing compounds only once daily and the fact that only one elution per day is necessary. Second elutions may be made without sacrifice of the high specific activity. Setting up a solvent-extraction system requires personnel with more chemical and health physics background than found in the average laboratory. These personnel must also be available to solve any problems that can and do occur. Once the system is in standard operation, daily extractions can be performed by a pharmacist or competent technician. The need for backup personnel, as well as the fact that a broad license is required for solvent extraction, will limit its use to large institutions.

After more than a year's experience with this system we feel that its advantages far outweigh its disadvantages and that it is the most practical solution to meet the increasing needs for ^{99m}Tc in larger institutions.

Optimizing Administered Dose in Radioisotope Diagnostic Studies BY CLAYTON DOUGLAS, EDGAR L. SURPRENANT AND L. ROBERT BENNETT, St. Mary's Hospital, Long Beach, Calif. and UCLA Center for the Health Sciences, Los Angeles, Calif.

The amount of radioisotope used in diagnostic procedures is limited by the quantity of radiation the patient absorbs. Permissible exposure is determined by the potential somatic and genetic effects. Two factors determining the detrimental effects of a given quantity of radioisotope are (1) the size of the body (or organ) in which the isotope is distributed (radiation absorbed/unit tissue) and (2) the susceptibility of the subject. Potential long-term somatic and genetic effects are more critical in children than in the aged; genetic considerations are of no concern in patients past the reproductive age. From these considerations, a practical schedule for optimizing the amount of radioisotope administered to each patient for imaging procedures has been formulated on the basis of their weight and age.

The dosimetry for a standard man (70 kg, 40 years old) was determined for several radiopharmaceuticals from published data, and acceptable radiation exposure was established for each. The "standard" dose was adjusted in proportion to body weight to produce a similar total-body and target-organ radiation exposure for all patients. The dose was further modified by the patient's age with a minimum of 0.67 $\times$ standard dose for subjects under 20 years and a maximum of 1.50 $\times$ standard dose for subjects over 65 years. Technetium-99m-pertechnetate, as used for brain imaging, is presented as a model. The schedule has been modified to limit the administered dose of radiopharmaceuticals that produce unusually high target-organ radiation, e.g. ^{203}Hg-chlormerodrin. The schedule was initially presented in tabular form for use by technicians. It has since been found more convenient to use a desk-top computer; the computer slip is made a permanent part of each patient's record.

This schedule has been used for all routine clinical studies in a community hospital for 18 months. The dose for "high-risk" individuals (children) has been minimized. The diagnostic quality of exams on heavier and older patients has been significantly improved, especially the dynamic studies. Since the time required to perform static exams is inversely proportional to the amount of radioisotope administered, the net effect of the schedule is to prolong the exam time for children while shortening it for patients over 40 years old. Most patients examined

in this facility are over 40, so total exam time has been decreased.

Optimizing the administered dose of radioisotopes on the basis of patient age and weight is theoretically sound and offers a practical method for controlling the radiation exposure of the population examined.

Three-Year Experience with ^{99m}Tc-Albumin Preparations in a Community Hospital BY CLAYTON H. DOUGLAS, EDGAR L. SURPRENANT, MARY A. GROSSNICK AND MILO M. WEBBER, St. Mary's Hospital, Long Beach, Calif. and UCLA Center for the Health Sciences, Los Angeles, Calif.

Technetium-99m has been shown to be a superior isotope for scintillation imaging when compared to previous commonly used materials, e.g. ^{131}I and ^{198}Au. Its short physical half-life (6 hr) and single emission (140 keV) permits administration of larger amounts of activity that produce higher quality exams while significantly reducing patient radiation exposure. Technetium-99m-tagged albumin preparations can be used for blood pool (heart, placental), reticuloendothelial structure (liver, spleen, bone marrow) and vascular bed (lung) studies. The short physical half-life requires that these materials be prepared at or near the site of use. To verify the safety of administering such radiopharmaceuticals, 3 years' experience in a community hospital with a program for preparing and administering radioalbumin has been reviewed.

The procedure for preparing radioalbumin is similar to that first suggested by Stern and modified by Larson and Griswald. Technetium-99m was eluted daily from commercially obtained ^{99}Mo generators. A 15-cc aliquot was added to 37.5-mg albumin. Other additives include dextrose, ferric chloride, ascorbic acid and acetate buffer. With proper pH and temperature adjustments, three preparations were obtained: ^{99m}Tc-albumin (TcA, nonaggregated), ^{99m}Tc-microalbumin (MiA, particle size about 0.5 micron) and ^{99m}Tc-macroalbumin (MaA, average particle size 50 micron). All equipment was sterile; pharmaceutical-grade materials were used. The radioalbumin was prepared daily by technologists under the direction of a physician. During the 3-year period ending December 1969, this material was administered intravenously 1,631 times, including 88 TcA, 1,011 MiA and 532 MaA administrations. Concurrently, $^{99m}TcO_4^-$ obtained from the same generators was administered 1,449 times (brain exams). The hospital charts of 144 patients who received radioalbumin and 86 who received pertechnetate were reviewed for any indication of adverse effects during the 24 hr following the administration.

No reactions were observed while the patients were in the nuclear medicine area. Review of the 230 hospital charts revealed no instance of temperature, pulse or respiratory rate elevation or gastrointestinal, respiratory or neurologic symptoms that were not directly attributable to the patients' preexisting condition. Chills were not observed.

Considering the excellent quality of exams obtained with ^{99m}Tc preparations and the low radiation hazard to the patient, some risk of morbidity would be entirely acceptable in selected patients. However, we have found no evidence of adverse effects. It is therefore recommended that for clinical radioisotope imaging, ^{99m}Tc-albumin (or similar preparations) be used in preference to materials that produce more patient radiation per millicurie administered or that result in poorer image quality. (Supported in part by US AEC Contract AR (04-1) GEN-12.)

Computer-Compatible Aperture Card Microfilming System for Nuclear Medicine BY GERALD S. FREEDMAN, SALVADOR TREVES AND RICHARD P. SPENCER, Yale Univ. School of Medicine, New Haven, Conn.

The rapid growth of nuclear medicine now results in more than 1 million examinations per year in the United States and is doubling every 4 years. This success has brought with it the problems of information storage and retrieval. A computer-compatible, analog and digital information-retrieval system is suggested as a means for handling this information storage and retrieval problem.

A commercially available, 35-mm direct positive microfilm processor camera capable of filming transparent (transilluminated) or opaque (reflected light) documents with a turret lens system of three different minifications was used. The documents to be microfilmed are placed in the processor camera which has a maximum area capacity of 24 $\times$ 36 in. The 35-mm microfilm chip produced by the camera occupies columns 53 thru 77 of the standard 80-column IBM card. A standard card punch is used to keypunch 56 columns of information; the completed cards can be processed by sorting, accounting and computer equipment. The microfilm can be viewed with a special reader printer or viewer projector. Duplicates can be inexpensively made by a diazo process.

Two direct positive films are available, each with a remarkable degree of resolution (capable of resolving 100 lines/mm). They both have a D_{max} of greater than 2 and a satisfactory H and D curve, the analysis of which will be presented. Our coding system for the first 56 columns for punched data include: hospital number, patient's name, birth date,

examination, examination date, isotope, interpretation and diagnosis. A slave deck containing all the punched information without the microfilm is used and suggested for record keeping and high-volume data processing. On this card, the area usually occupied by the microfilm is free for handwritten notations. All nuclear medicine results, including Polaroid scintigraphs, graphic presentation, typed reports, as well as transparent scans are easily microfilmed. Moreover, recent improvements now permit even low-contrast radiographs to be microfilmed with a high degree of precision and gray-scale reproducibility. (Supported by USPHS CA 06519.)

Comparative Dynamic Flow Studies with Sequential Use of ^{99m}Tc-Sulfur Colloid and ^{99m}Tc-Pertechnetate BY BEN I. FRIEDMAN, MURRAY FIELDS, MARCIA BOYD, ALLAN HARPER AND KENNETH E. AVIS, Univ. of Tennessee Medical Units, Memphis, Tenn.

For clinical human research rapidly repeated dynamic flow studies of the cardiac and cerebral systems have been needed. We have compared flow determined with ^{99m}Tc-sulfur colloid, prepared from a commercially supplied ^{99m}Mo generator and colloid kit, to flow using ^{99m}Tc-pertechnetate performed within 1 hr.

Various radionuclides have been used for intravascular flow studies but ^{99m}Tc is most valued because of its low radiation exposure, 6-hr half-life and easy detectability with the Anger scintillation camera. Indium-113m has been used, but its higher energy requires changing collimators.

Twenty to 30 min after initial cardiovascular and cerebrovascular flow studies with ^{99m}Tc-sulfur colloid, we performed a second flow using i.v. ^{99m}Tc-pertechnetate as the injectate. Volumes of material injected were less than 3 ml. Five to 7 mCi of ^{99m}Tc-sulfur colloid and 10–15 mCi of ^{99m}Tc-pertechnetate were used for cardiovascular evaluation.

Studies were compared for appearance time and reproducibility. Although the appearance time in the cerebral vessels varied by 3 sec, distribution of the radionuclide was the same on sequential studies.

Consecutive studies of vascular flow using two forms of ^{99m}Tc are similar. With this approach it is now possible to study cerebrovascular flow before and after acute short-term therapy or manipulation such as carotid angiography or hemodilution. Cardiovascular studies including anterior, right and left obliquities can be performed within 1 hr. These noninvasive techniques are considerably more valuable when a patient can be restudied so quickly.

^{111}In—A New Radiopharmaceutical for Extended Studies BY DAVID A. GOODWIN, PHILIP MATIN AND ROLAND A. FINSTON, V.A. Hospital and Stanford Univ., Palo Alto, Calif.

Indium-111 is a cyclotron-produced radioisotope with a half-life of 2.8 days. It decays without beta emission and emits two gamma photons which are acceptable for scanning. Both the 247 and 173-keV photons are emitted with each disintegration. Either photon can be used to produce a scan or, with minor adaptations of equipment, both can be used.

Since the radiochemistry of indium is well known, the absence of beta decay and 2.8 day half-life makes ^{111}In an excellent radioisotope for procedures requiring scanning at 24–72 hr. This paper presents the use of this radionuclide in new radiopharmaceuticals for extended procedures such as cerebrospinal fluid scanning, lymphangiography and other possible studies such as tumor localization and localization of blood clots. Examples of each type of study will be shown along with methodology.

Low-Molecular-Weight Dextran in the Treatment of Experimental Myocardial Infarction—Evaluation with Scanning and Computer Techniques BY RALPH J. GORTEN, C. ROBERT LINCOLN, KENNETH A. KRACKOW AND JACK K. GOODRICH, Duke Univ. Medical Center, Durham, N.C.

Low-molecular-weight dextran (LMWD) has been proposed as a beneficial adjunct to the clinical management of acute myocardial infarction. Infusion of LMWD has been observed to improve the microcirculation because of decreased cellular aggregation and to reduce cardiac work as a result of lowered blood viscosity. It has been anticipated therefore that the amount of hypoxic tissue damage consequent to coronary occlusion could thereby be diminished. A radionuclide scanning technic was applied for evaluation of this assumption.

Acute myocardial infarction was experimentally produced by complete ligation of the left circumflex artery in 30 anesthetized animals. In alternating fashion, half of these were infused with LMWD and half with Ringer's solution. Sham operations were performed in five other animals. Mercury-203-chlormerodrin, administered intravenously shortly after arterial ligation, and rectilinear scanning were used to delineate the areas of myocardial necrosis. In addition to visual inspection of the photoscans, digital-computer analysis of the scan information was found advantageous for objective, repeatable, statistically significant and quantitative comparisons of the series of heart scans.

No significant differences were found between the

LMWD- and the Ringer's solution-treated groups. Regions of increased tracer concentration could be identified in all heart scans of these two groups with considerable variation in size of the areas of infarction and in severity of damage. Computer programs compared these aspects first according to significant differences within each heart and then also by categorizing variations among all the hearts. The sham-operated animals were used as a basis for the normal distribution of tracer and its scan representation.

Thus, a theoretically beneficial clinical procedure was found to have no significant effect on the size and severity of acute myocardial infarcts when tested under controlled experimental conditions. Radionuclide scans and their computer analyses provided objective and expedient means of reaching this conclusion.

Circulation Time Studies Using Isotopic Methodology BY S. E. HALPERN, V. FICKEN AND C. SMITH, Univ. of Oklahoma School of Medicine, Oklahoma City, Okla.

The subjective circulation time is a valuable tool in evaluating the cardiovascular status of patients; yet by its subjective nature it is inaccurate and often dangerous. We have designed a method of performing circulation times using ^{99m}Tc-pertechnetate that is safe, reproducible and accurate.

One 2 × 2-in. heavily collimated NaI(Tl) crystal of a Baird-Atomic Renotron is localized over the patient's subclavian vein at the shoulders, and the second probe is placed over the femoral artery at the inguinal ligament. One millicurie of ^{99m}Tc-pertechnetate is then injected into the forearm of the side being monitored. When the subclavian crystal detects the photons, the signal is recorded by the servowriter. The same event occurs at the femoral region. The time constantly used is 0.3 sec, and the paper moves at the rate of 0.5 cm/sec. The time interval between the recorded events at the shoulder and the thigh is the circulation time.

The mean circulation time for normal patients is 13.7 sec with a range of 10–18.8 sec. Ten patients with congestive heart failure had mean circulation times of 32 sec with a range of 19.6–59.6 sec. Twenty-five thyrotoxic patients had mean circulation times of 9.2 sec with a range of 6.2–13.4 sec. The 11 people who have become euthyroid have increased their circulation times to an average of 17.4 sec with a range from 10.7 to 26.6 sec.

We feel that the isotope circulation time is reproducible, free of subjective errors, safe, provides a record for the clinical chart and may be of diagnostic value in heart disease and hyperthyroid states.

Arterial Disease and Hypermobility of the Kidney BY KEN HAMAMOTO, W. NEWLON TAUXE AND JAMES C. HUNT, Mayo Clinic, Rochester, Minn.

We have recently been engaged in a study of renal mobility. This has been based on estimations of kidney depth by double-isotope renography in sitting and prone positions. This method takes advantage of the differential tissue absorption of gamma rays emitted from ^{125}I and ^{131}I, both labeled to orthoiodohippurate.

Depth estimations in the prone position have been compared with the estimation of kidney depth derived from regression equations developed on the basis of height, weight, age and surface area against kidney depth measured at the time of renal biopsy.

This technique has been employed in 241 patients (138 females and 103 males) who were referred for routine orthoiodohippurate renography. Of these, 224 were sent for evaluation of arterial hypertension, 17 for other reasons.

Data on mobility, the difference between depth estimates derived from sitting and prone renograms were compared to the clinical diagnosis. It was found that patients with angiographically proved renovascular disease of the renal artery of the fibromuscular type had significantly greater degree of renal mobility than did those subjects who had atheromatous disease or those who were diagnosed as essential hypertension.

This was particularly true of the right kidney, where sitting-less-prone kidney depths indicated an increase of 10.4 mm in males with fibromuscular disease and of 10.3 mm in females.

In patients without fibromuscular disease this increase in right kidney depth was found to be 1.5 mm in males and 4.0 mm in females.

On the left side, increase in kidney depth (sitting-less-prone values) averaged 4.5 mm in males with fibromuscular disease and 3.5 mm in females.

In males without fibromuscular disease sitting-less-prone values average —2 mm and in females —1 mm.

Our data suggest that there is an associative relationship of fibromuscular disease of the renal arteries in both sexes, if not an etiologic one.

New Form of Clinically Oriented Phantom for Radionuclide Imaging BY C. CRAIG HARRIS, THOMAS S. BUFFALOE, JACK K. GOODRICH AND ROBERT H. WILKINSON, JR., Duke Univ. Medical Center, Durham, N.C.

We have found laboratory phantom imaging targets useful for several purposes. When these phantom targets successfully imitate the spatial counting rate distributions that present in clinical scan

images, they can have additional advantages. First of all, long-lived phantoms of this kind are useful in establishing standardized scan recording techniques. Second, they are useful for checking an allegedly malfunctioning instrument. Third, they allow the student a means of producing a clinical-like scan without the involvement of a human subject. Finally, they can serve to check the effectiveness of scan data-enhancement techniques.

The purpose of this study was to find a good and simple means of making a series of phantoms that successfully simulated a wide range of organ images. Various methods of achieving desired spatial variations of counting rate have been used before, such as radioactive blotting paper segments, ion-exchange resin beads, specially configured plastic vessel compartments, etc. Each of these materials and methods has disadvantages. Our purpose was to find a better way to make the desired phantoms.

The method that was finally chosen was to make a large-area source emitting photons with uniform flux density which is then covered with a laminate of lead foil contoured to match counting rate contours obtained from clinical scans. Thus by a spatial variation in attenuation, the uniform photon flux from the slab source is made to simulate the spatial variation of counting rates seen in clinical scan images.

Slab sources were made from plastic cells filled with radioactive liquid. For a long-lived phantom ^{57}Co was chosen. For a source that could be refilled from day to day, ^{99m}Tc was chosen. Lead foil in thicknesses 0.005 and 0.002 in. were obtained from the A. D. MacKay Co. in New York. The 5-mil foil is readily available; the 2-mil foil is more expensive and more difficult to obtain, but is sometimes available from stock. The transmissions of ^{57}Co photons from the slab sources through the 2-mil and 5-mil foils are 83% and 65%, respectively, and for ^{99m}Tc, 88% and 75%, respectively.

The result of this endeavor to date is a modest library of lead-foil attenuators in plastic jackets that are used with appropriate slab sources to simulate the spatial variations of counting rate obtained in normal and abnormal technetium brain scans. These phantoms have been found to be quite useful in our clinical and teaching efforts.

Suitable plastic cells can be constructed by anyone who can saw acrylic plastics and use ethylene dichloride for glue. The relatively large attenuation value for 0.005-in. foil does not preclude the use of it alone to make the attenuator laminates for brain phantoms. The smearing effects of collimator resolution tend to soften steps into gradients. Once the desired spatial variation of counting rate is decided upon, a simple contour map drawn on paper shows the builder where to place layers consisting of 0, 1, 2 or 3 thicknesses of lead foil. A library of such drawings will be published in the near future. (Supported by the US AEC under contract No. AT-(40-1)-3945.)

Correlations of Scans with Laboratory Data Following Canine Renal Allografting BY MICHAEL HAYES, THOMAS C. MOORE AND DENNIS P. THOMPSON, UCLA School of Medicine, Harbor General Hospital Campus, Torrance, Calif.

To study the specific value of sequential renal scanning in the management of renal allograft recipients, 88 scan examinations were performed on 20 dogs after renal allografting. The scan results were compared with daily laboratory data consisting of BUN, creatinine, urine volume, blood and urinary levels of histamine.

Sequential renal scans were performed on a nearly daily basis using a scintillation camera with ^{131}I-Hippurate. Three scan parameters were compared with laboratory data: the kidney-to-background brightness ratio during the first minute postinjection; the bladder entry time of activity; and the time at which the amount of activity in the bladder appeared equal to the amount in the kidney. In addition, a renal blood flow index was calculated from the heart blood pool clearance of Hippurate as monitored by an external probe. Fairly rapid changes in allograft status made daily scans necessary in these non-immunosuppressed dogs.

In about half the dogs, scan changes occurred 1 or 2 days before alterations in BUN and creatinine, while in the remainder, scan changes paralleled laboratory values. The brightness of the kidney scan image during the first minute correlated best with BUN and creatinine. Somewhat surprisingly, bladder entry time did not correlate very well with volume of urine output. The renal blood flow index correlated well with urine histamine levels and in four animals showed a paradoxical improvement just before rejection. This improvement coincided with a 7–10-fold increase in urinary histamine.

In conclusion, this study adds to existing evidence that sequential scanning is a safe, atraumatic examination which is more sensitive to daily changes in renal function than BUN and creatinine tests. However, scans and blood flow indices must be interpreted with caution because a misleading improvement may be observed immediately before rejection. The authors postulate that this is a period of transient renal hyperemia due in part to an increased histamine release during the inflammatory stage before rejection.

Radioactive Bromide in Diagnosis of Central Nervous System Disease BY MARTIN HEITZMAN, Walter Reed General Hospital, Washington, D.C. AND GERALD S. JOHNSTON, Letterman General Hospital, San Francisco, Calif.

Orally administered ^{82}Br-sodium bromide (100 μCi) was used to assist in the study of patients hospitalized with central nervous system disease. The ^{82}Br-sodium bromide was given in water 24 hr before a planned spinal tap. The radioactivity in 1 ml of serum and 1 ml of cerebrospinal fluid was determined in a well scintillation counter and the ratio between them was calculated. This bromide partition ratio was normal, ranging from 2.4 to 3.8, in 18 patients with conditions including head injury, herniated nucleus pulposus, multiple sclerosis, Guillain-Barre syndrome, organic brain syndrome, Charcot-Marie-Tooth disease, chromophobe adenoma of the pituitary, chorioretinitis and epilepsy. In five other patients with a history strongly suggesting neurosyphilis or neurotuberculosis, the bromide partition ratio was of help in ruling out these conditions and obtaining correct diagnoses. In one patient with essentially normal supporting diagnostic studies, this ratio was of primary aid in diagnosing active neurosyphilis. The abnormal ratio fell below 1.6. This level has been confirmed by previous studies. The bromide partition ratio was of help in diagnosing and, in a negative way, in helping to rule out the presence of tuberculous meningitis or of neurosyphilis in patients where either diagnosis was a consideration.

Phantom for the Calibration of Scintigraphic Instrumentation BY GERALD J. HINE AND BERTRAM J. L. SAUERBRUNN, V.A. Office and V.A. Hospital, Washington, D.C.

With the rapidly increasing number of different types of scintigraphic instruments, scanners as well as cameras, the need for a simple method for intercomparison of their performance becomes more urgent. Although several procedures have been suggested for this purpose, they are either too elaborate and time consuming or do not give all the necessary information such as relative sensitivity, uniformity of response with field size, depth response and spatial resolution for different gamma-ray energies. A phantom has been designed which allows one to obtain this information from a single scintigram for each instrument at the selected operating conditions for a chosen gamma-ray emitter.

The phantom is machined from a 3-in.-thick 10 $\times$ 10-in.-wide block of Lucite. Five concentric wells are provided for a 750-ml solution of radionuclides. Each well is 1 in. wide, and the depth of successive wells increases by ⅛ in. beyond that of the previous one. In the outer well of the phantom, with a 7–9-in. diameter, the height of the solution is ¼ in. The adjacent wells have a depth of ⅝, 1⅛ and 1¾ in., respectively. Finally the center well with a 1-in. diameter has a depth of 2½ in. The increase in depth of successive wells should compensate approximately for the increase in gamma-ray attenuation so that the number of primary gamma rays escaping from the phantom should increase in about five equal steps from the edge to the center of the phantom.

For different types of scintigraphic instruments and for each collimator for a particular instrument, the amount of radioactivity in the phantom and the exposure times are chosen so that the same number of total counts are accumulated in each case. The relative sensitivity of different instruments and their collimators becomes apparent from the required radioactivity and exposure times. The resolution and depth response are indicated by the ability to differentiate the five levels of radioactivity with the selected data readout system. Nonuniformity or nonlinearity of the device can be recognized by variations of counting rate for each circular level of radioactivity and a distortion of the appearance of successive circles. This is particularly useful when dealing with diverging collimators.

Finally, the phantom has been found suitable for the evaluation of different readout methods. In particular the effects of minification with a reduction of accumulated counts has been studied. The performance of a black and white to color conversion system (Scanavision from Baird-Atomic) has been investigated, and its calibration as a function of the five steps of the phantom has been attempted. The results obtained with the phantom for different types of scintigraphic instruments will be reported.

Scintiphotography in the Routine Use of Cerebral Blood Flow Studies BY OSCAR B. HUNTER, JR. AND NELLIE M. BERING, Oscar B. Hunter Memorial Laboratory, Washington, D.C.

The Anger camera provides an additional tool in diagnosis by making rapid blood flow studies possible. The purpose of this study is to demonstrate in 150 patients the value of rapid cerebral blood flow studies in conjunction with the static brain image.

Our procedure uses rapid-sequence pictures at 4-sec intervals following the rapid injection of 10 mCi ^{99m}Tc. The first picture is exposed for 8 sec with the subsequent pictures timed for 4 sec. The studies have been performed using Polaroid pack film and a team of two, one to inject and the other to work with the sequencing of the pictures. The

majority of the patients have been studied by imaging from the posterior view; the remainder have either had lateral or anterior views. In addition to correlating the flow studies with the static brain image, a correlation has been made of the age of the patient with the time of the "brightest" vascular sequence.

The flow study permits the identification of different functions of the vascular tree, vascular abnormalities and any major alterations, such as those produced by thrombosis or a space-occupying lesion. The flow studies show an arterial perfusion visualizing the carotid and cerebral artery patterns and the venous perfusion in later sequences.

The rapid-sequence images were studied and flow patterns established. The rapid-sequence images were studied with the static brain images. The vascular lesions showed during the arterial perfusion stage. The flow studies in patients admitted for cerebral vascular infarction showed decreased arterial perfusion and in a few cases showed filling in the venous phase. The rapid blood flow studies are an advantage in the study of patients with altered mental function which may be related to vascular changes as well as in the older patient.

The performance of the rapid cerebral blood flow study has been established as a part of the routine brain image study.

Stabilization of Particulate Suspensions with Nonantigenic Polyhydric Alcohols: A Comparison of Effectiveness with Other Stabilizers BY WILLIAM W. HUNTER, JR. AND GARY ALAN EDWARDS, Ohio State Univ. College of Medicine, Columbus, Ohio

Stabilizers play an important role in the successful preparation of radiolabeled particulate suspensions used as scanning agents. However, severe anaphylactoid reactions have been reported in preparations employing the common stabilizing agents.

The application of polyhydric alcohols for stabilization of particulate suspensions has been developed in our laboratories. A six-carbon polyhydric alcohol, mannitol, has been routinely used as a stabilizer in pharmaceutical preparations of ^{99m}Tc-sulfur colloid. More than 2,000 liver scans have been performed with a mannitol-stabilized product without a single incidence of any drug reaction.

Stabilization rendered by the polyhydric alcohols has been compared with the common stabilizers, gelatin, carboxymethylcellulose and low-molecular-weight dextran. Comparative studies on the effectiveness and duration of stabilization were conducted using macroaggregates prepared for pulmonary perfusion studies and particles less than 1 micron in dia intended primarily for liver and spleen scanning. Strontium carbonate aggregates, iron hydroxide aggregates and ^{99m}Tc-labeled sulfur colloid suspensions were used. The effect of the stabilizer on the physical nature of the particle was examined microscopically while the biological influence of the stabilizer was studied in laboratory animals.

Results of the studies have demonstrated the superior stabilizing qualities of the polyhydric alcohols in addition to the absence of anaphylactoid reactions in clinical utilization. Stabilization of these preparations does not deteriorate within the practicable shelf-life as dictated by their short-lived radiolabels.

Electron microscopy is being used to further study the influence of stabilizers on preparation of colloidal gold which might account for the reported differences in *in vivo* distribution of these preparations.

Total-Body and Renal Clearance of ^{203}Hg-Chlormerodrin. The Effect of Chelating Agents on Clearance BY G. T. KRISHNAMURTHY, MANUEL TUBIS, MARIANNE LEDERER AND WILLIAM H. BLAHD, V.A. Center, Univ. of California School of Medicine and Univ. of Southern California School of Pharmacy, Los Angeles, Calif.

The project was undertaken to study the normal total-body and renal clearance of ^{203}Hg-chlormerodrin and the effect of chelating agents on the clearance. The standard chair technique in a total-body counter was used. The total-body and renal clearance of 1 μCi of ^{203}Hg-chlormerodrin was studied in 19 subjects. The subjects were followed up to 6 weeks. In eight control subjects, 24, 48 and 72-hr total-body retention was 36 $\pm$ 7.34%, 29 $\pm$ 7.0%, and 27 $\pm$ 7.2%, respectively. At the end of 11 days, total-body retention was 19 $\pm$ 7.1%. Six weeks later the total-body retention was 7 $\pm$ 3.4%. During the first 24 hr, 52% of the administered dose was excreted in the urine. Of this, the first 8- and the first 16-hr urinary excretions were 27% and 42%, respectively. Probable stool and sweat excretions for the first 24 and 48 hr were 12% and 17%, respectively.

Six subjects were given L-cysteine orally: 500–1,000 mg at varying times after 1 μCi of ^{203}Hg-chlormerodrin. Five subjects were given D-penicillamine: 500 mg initial dose followed by 250 mg every 6 hr for 48 hr. Initial dose was given at varying times before or after ^{203}Hg-chlormerodrin administration. There was no statistical difference in total-body and renal excretion between the control subjects and the subjects given L-cysteine and D-penicillamine.

Even though chelating agents have been used successfully in the treatment of mercury poisoning, they seem to show no effect when the amount of mercury is very small as is the case in a renal scan dose.

Technically, ^{203}Hg is a good renal scanning agent. Its use, however, has been limited because it results in a large total-body and renal radiation dose. It is suggested that the search for a better and more convenient renal scanning agent be continued or that a better chelating agent be sought to enhance clearance of ^{203}Hg from the body.

Evaluation and Standardization Models in Clinical Dynamic Studies BY SIMON LAM, ISMAIL KAZEM, TAKASHI HONDA AND LUTHER W. BRADY, Hahnemann Medical College and Hospital of Philadelphia, Philadelphia, Pa.

Over the past few years, organ blood flow studies have been greatly simplified because of: (1) The availability of nondiffusible radiopharmaceutics labeled with short-lived isotopes; and (2) The availability and refinements of the scintillation cameras with fast-recording and memory-storage capability, and the ability of processing the data accumulated with both analog and digital display possibilities.

However, before one can obtain any meaningful conclusion from the clinical dynamic studies, one needs to fulfill the following: (1) Establish the validity of the clinical findings by direct measurements; (2) Standardize the factors involved in the study; and (3) Calibrate the equipment and test its stability.

To satisfy these criteria, a dynamic phantom was constructed, consisting of a central pumping system with different "organ" attachments. For cardiac studies a two-chambered plastic heart is used. The cerebral blood flow is simulated by two pools in a hemispherical plastic shell. The pulmonary trapping evaluation is determined using a filter arrangement. The specifications, design and construction procedures will be presented, and data obtained will be discussed.

Clinical Studies of Erythropoiesis using Simultaneous Iron Kinetics and Bone Marrow Scanning with Small Doses of ^{59}Fe BY S. A. LANDAW AND H. S. WINCHELL, Donner Laboratory, Univ. of California, Berkeley, Calif.

A protocol has been developed for rapid clinical evaluation of RBC disorders. Plasma iron turnover (PITR) is determined using 2–5 μCi of ^{59}Fe. Whole-body scans of ^{59}Fe distribution are performed using the Anger whole-body scanner (scan time: 22–44 min) within the first day and again at 7 and 14 days after injection of tracer iron. In addition to the usual information obtained from the PITR and incorporation of tracer iron into circulating RBC at 7 and 14 days, the whole-body scanning protocol gives valuable additional information, as follows. When erythropoietic rate is markedly increased, the initial (first day) scan may show extension of marrow into peripheral sites. When erythropoiesis is suppressed, no marrow uptake is seen, and ^{59}Fe accumulates in the liver as storage iron. In myeloid metaplasia loss of central marrow may be seen, with erythropoietic activity in splenic and/or hepatic areas, and in peripheral sites such as the knees and ankles. On the 7- and 14-day scans, the distribution of labeled RBC is visualized. Splenic sequestration is readily apparent as a progressive increase in isotope localized in the splenic area during this period of time. In the normals, on the other hand, only a constant activity in the blood pool is seen up to 60 days after isotope injection. This protocol has been demonstrated to be of considerable value in the clinical evaluation of patients with a wide variety of hematologic problems. The entire protocol takes less than 5 hr of patient time in three visits over a 14-day span of time, while yielding results qualitatively similar to those obtained using complete iron kinetics studies.

Pancreas Scanning—Is It Worth It? BY SILVIU LANDMAN, ROBERT J. POLCYN AND ALEXANDER GOTTSCHALK, Univ. of Chicago and the Argonne Cancer Research Hospital, Chicago, Ill.

In spite of the enthusiasm expressed by some, pancreatic scanning has *never* been eagerly championed in this institution. Nevertheless, we have managed to accumulate a series of 82 cases since 1966, and have analyzed these in retrospect to assess the clinical utility of the procedure.

No special meal or premedication was used in these patients. Immediately after i.v. administration of 250 μCi of ^{75}Se-selenomethionine, serial 10-min anterior views were taken with the Anger camera for up to 1 hr or longer. Almost all patients had liver scans with ^{99m}Tc-colloid in conjunction, and in 47 cases hepatic subtraction with a 1,600-channel analyzer was performed.

The scans were interpreted by one of us as normal, faintly or partially visualized or nonvisualized, without knowledge of either clinical data or the initial report. Clinical correlation was obtained from autopsy, surgery or clinical course. The pancreas was well visualized in 41 cases, not visualized in 22 and faintly or partially visualized in 19 cases. Eight cases had to be eliminated from the study because of lack of adequate followup (four were normally visualized, three not visualized and one was faint). In patients with good visualization, the diagnosis of normal pancreas could be confirmed in 32 of 37, the remaining five cases had chronic pancreatitis. In the 19 cases in which the pancreas was not visual-

ized—nine had carcinoma originating in or invading the pancreas, seven had chronic pancreatitis and three were considered normal. In the 18 cases in which the pancreas was visualized only partially or faintly—the majority (10) had chronic pancreatitis or pseudocysts, five had carcinoma and three were normal.

Analysis of the technique showed that the best visualization was most often obtained in the first 40 min, and even when the best view occurred later, earlier pictures would have been adequate for diagnosis.

The subtraction technique was also critically evaluated and found to be essential in only one case, and corroborative in 20 of the total of 47 subtractions performed.

In conclusion, a normal pancreas scan may provide valid diagnostic information (87%); in this series none of the 14 cases with carcinoma had a normal study. When the scan was abnormal, however, it was impossible to distinguish reliably between different pathologic entities—especially between carcinoma and pancreatitis. Finally, the lack of subtraction equipment should not deter an institution from using the procedure.

Radiation Dose to Human Beings from ^{75}Se-L-Selenomethionine BY KATHERINE A. LATHROP, Univ. of Chicago and Argonne Cancer Research Hospital, Chicago, Ill., R. EUGENE JOHNSTON, V.A. Hospital and Vanderbilt Univ., Nashville, Tenn. AND MONTE BLAU, Roswell Park Memorial Institute, Buffalo, N.Y.

Radiation absorbed dose to various organs from a single intravenous injection of ^{75}Se-L-selenomethionine based on the available human total-body retention, excretion and tissue concentration data has been calculated according to the schema devised by Loevinger and Berman using the nuclear parameters of Dillman and absorbed fractions of Snyder *et al.* Many of these data are previously unpublished and were obtained by several investigators expressly for the work of the Medical Internal Radiation Dose Committee of the Society of Nuclear Medicine. Total-body retention was observed for as long as 923 days at which time ~3% of the injected ^{75}Se remained. Compiled retention data on 24 subjects from four investigators are best fitted with three exponential components. The equation for this curve is:

$$A = 0.1308e^{-1.255t} + 0.443e^{-0.01512t} + 0.4194e^{-0.003146t},$$

where A is the retention fraction at t days. Loss of ^{75}Se from the body is approximately 80% in urine, 15% in feces and 5% in breath, hair, nails and skin. Concentration of ^{75}Se in organs was determined on surgical or autopsy samples taken at intervals from 0.02 to 361 days. Radiation absorbed-dose calculated from these data is 0.10 rads/μCi administered for blood, 0.03 for liver, 0.021 for kidney, 0.018 for spleen, 0.010 for pancreas, 0.0084 for total body, 0.0069 for testes, 0.0046 for thyroid and 0.0031 for ovary.

Computer Computation of Rectilinear Scanning Data BY SAMUEL R. LERNER, PHILIP H. COOPER AND FELIX J. PIRCHER, V.A. Hospital, Houston, Tex.

It would be important to use the output from a rectilinear scanner for quantitative scintigraphy. The convenient acquisition of counting data from a dual-head rectilinear scanner has made possible the manipulation of these data on large-scale digital computers since the counts collected over very small linear increments are preserved with full coordinate information. The counts recorded on magnetic tape can be used to derive tables, contour line maps and contour symbol maps for regions or the whole body. The contour maps can be expanded to examine regions of interest more fully. The program and subroutines were written in Fortran IV for the IBM 7094 computer.

The computer program provides an edit subroutine to read the magnetic tape into memory, check for certain man and machine errors and write a corrected tape for computation purposes. The data are arrayed and printed in a tabulation listing of 25 columns by 125 longitudinal intervals of ½ in. to present the total scanning table surface as approximately ½-in. squares, listing the number of counts accumulated in traversing each such square. Another subroutine calculates a contour line map by searching the array of data and tracing a linearly interpolated line between adjacent points of counts above and below the designated contour values, usually 20 fractions of the maximum count recorded. A contour symbol map is generated by a program subroutine which divides the maximum counting rate recorded into 40 levels and assigns character symbols to each. The map is printed on the line printer as lines of 110 spaces with the 40 contour intervals. Tag word information is preserved for patient identification and a summary table of total counts accumulated above each of the 40 contour levels is printed. About 0.3 min of computer time is consumed per patient whole-body scan, plus tape search time and peripheral equipment usage (plotter, line printer, etc.).

This method of analysis has been applied to data collected from a systematized phantom and from

patients. Quantitation of the data accumulated by means of a compartmentalized phantom with sources of known size and activity indicate the counting rate per microcurie for sources in the midline of the phantom is independent of the source volume or activity for a given depth of water in the phantom. Whole-body scans of patients studied in this way give relative counting rates in small areas and contour maps to supplement the diagnostic scan for definition of lesions.

Dynamic Autofluoroscopic Pulmonary Vascular Examination in Thromboembolism BY FABER F. MCMULLEN, JR., MIGUEL DIZON, PEDRO M. MONTOJO AND HERBERT C. ALLEN, Hermann Hospital, Univ. of Texas, Houston, Tex.

A rapid and safe dynamic examination of the pulmonary vasculature has been developed using the Autofluoroscope and ^{99m}Tc. This examination can be completed in less than 1 min which makes it suitable for the study of the gravely ill patient.

The patient remains supine and receives the isotope indicator by venipuncture in the antecubital fossa. The first pass of the indicator through the pulmonary vasculature is recorded on tape by the Autofluoroscope. The pulmonary vascular recording is then reviewed on the self-contained television screen. Based on the physical characteristics of the patient, the display is altered to demonstrate maximum clarity of the vasculature.

The dynamic scan concept was developed through experience by using the Autofluoroscope in a manner that was similar to the rectilinear device during the evaluation of 10 patients with acute pulmonary embolism. The patients were studied by pulmonary arteriography and by rectilinear and autofluoroscopic recordings using macroaggregated serum albumin. The macroaggregated albumin was later replaced with 15 mCi of ^{99m}Tc.

The dynamic autofluoroscopic scan recording of the pulmonary vasculature is a new, faster, safer method for the study of the severely ill patient with thromboembolism.

Body Composition *In Vivo* Using Radionuclide Photon Absorptiometry BY RICHARD B. MAZESS AND JOHN R. CAMERON, Univ. of Wisconsin Hospital, Madison, Wis.

The relative composition of soft tissue was determined both *in vitro* and *in vivo* using absorption measurements with one or more low-energy monochromatic radionuclides (^{109}Cd, ^{125}I, ^{153}Gd and ^{241}Am). These photon sources were used with a scintillation detector, pulse-height analyzer system to scan human limbs and also to measure the lipid content of subcutaneous adipose tissue. Because the fat and lean components of soft tissue have different absorption coefficients at low energies, the relative fat-lean composition can be determined from absorption measurements at two energies, or alternatively from determination of the linear absorption coefficient at low (15–30 keV) energies.

Experiments were done in a variety of samples *in vitro* and the accuracy of this new method was very high (1–3% error). The precision of the method was also high (1%) in measurements on standards and on humans over several months. Measurements were made on normal subjects and on subjects on altered diets and water balance. The composition changes in the upper arm of obese subjects undergoing weight loss were observed over an 8-week period of dieting.

Composition measurements obtained by radiation absorption observations were highly correlated with other indicators of body composition. Use of a scanning procedure permitted estimation of the total mass of each component in the beam path as well as the relative composition, and in some anatomical areas such as the upper arm the bone mineral mass can be measured simultaneously. Radiation absorptiometry appeared to be a simple and reliable index of body composition for both clinical and normative applications. (Supported in part by U.S. AEC AT-11-1-1422.)

Measurement of Gastric Emptying Rate with the Scintillation Camera BY ROBERT C. MEADE AND JOSEPH J. BARBORIAK, Marquette School of Medicine, Milwaukee, Wis.

A simple physiologic method for measuring gastric emptying rate is needed for clinical and research studies. The nonabsorbable isotope $^{51}CrCl_3$ with the scintillation camera and multichannel analyzer appears well suited for this purpose.

Following the ingestion of 300 μCi of $^{51}CrCl_3$, the patient is placed supine beneath the camera head. The activity in the stomach is visualized on the scope of a 1,600-channel analyzer and the region of interest set to include only this area. The total activity in this region is automatically printed every 10 min. The gastric emptying time is determined by regression analysis using a desk-top computer. Polaroid pictures are taken at comparable intervals.

The activity when plotted yields a single exponential decline. In a few individuals the small bowel activity interferes and an exponential plot is not obtained. The Polaroid pictures readily identify these cases.

The average emptying time of normal fasting individuals was found to be 30 min ranging from

15–50 min. There was no apparent correlation with age. The same individuals were studied fasting and with a meal. With a high-fat breakfast the average emptying time was 145 min. If alcohol was ingested with the meal, the emptying time was significantly prolonged, +87%. A very prolonged emptying time has been observed from a few days to 20 years after partial gastrectomy.

Although $^{51}CrCl_3$ is associated only with the solid contents of the gastrointestinal tract, it appears to be a useful marker for measuring gastric emptying with the scintillation camera.

Scintiscanning using ^{99m}Tc-Sulfur Colloid in the Evaluation of Abdominal Trauma BY R. E. O'MARA AND J. A. DANIGELIS, State Univ. of New York, Syracuse, N.Y.

At times, the diagnosis of splenic or hepatic rupture as a result of trauma is difficult. Prior to the introduction of ^{99m}Tc-sulfur colloid, splenic scans were frequently of poor quality due to erratic splenic sequestration as a result of poorly controlled red-cell damage and inadequate labeling associated with time-consuming preparation of labeled red blood cells. Colloidal ^{198}Au may be used to evaluate the liver and spleen, but it results in a high radiation dose and frequently gives poor splenic detail. The ^{99m}Tc-sulfur colloid is readily prepared as well as being commercially available and results in good visualization of the spleen and liver. Total-body and liver radiation dose estimates will be presented for the average 1-year-old, 5-year-old and adult humans.

We will present seven cases of abdominal trauma in which the definitive diagnosis was reached on the basis of scanning. These will be correlated with other radiographic and surgical diagnostic techniques as well as with the operative findings, surgical specimens and, in one case, scanning of the excised spleen.

Positive findings that may lead one to suspect organ trauma are: (1) filling defects secondary to laceration or hematoma; (2) organomegaly, (3) a diffusely mottled, unhomogeneous pattern of uptake; and (4) organ displacement.

In addition, we will use these cases to illustrate the following points: (1) that satisfactory studies can be obtained with either rectilinear scanning or rapid-imaging devices; (2) that multiple views are frequently necessary; (3) that this technique may be used as an emergency procedure; (4) that visualizing both liver and spleen is important; (5) that scanning may be used as a followup modality in those cases where operative intervention must be deferred; and (6) what the limitations of the procedure are.

We feel that with due awareness of its limitations and when it is properly applied to the clinical situation, scintiscanning is a safe, simple and rapid technique which can give evidence for the diagnosis of organ rupture or hematoma, whether it is of the overt or occult variety.

Simple Modification of Gamma Camera for Semiquantitative Flow Studies BY DENNIS D. PATTON AND RICHARD R. REED, Univ. of California, Irvine, Calif. and California College of Medicine, Orange County Medical Center, Orange, Calif.

Several techniques have been advanced recently for quantification of organ flow studies using the gamma camera. These tend to involve the use of large computers or complex accessories. While these new techniques offer a great improvement in the amount and quality of the information obtainable from radioisotope studies, their relatively high cost may delay the advent of new quantitative organ imaging studies at smaller nuclear medicine facilities. A simple technique is presented by which a nuclear medicine clinic can "go on the air" with materials likely to be at hand, while waiting for acquisition of more sophisticated systems.

A videotape recorder records the dynamic flow study from a gamma camera. At a convenient time the study is replayed on a TV monitor. Areas of interest are defined and marked. A suitably protected and adapted photomultiplier tube is placed against the TV screen over an area of interest. The videotape is played back and the photomultiplier tube relays the counts over the area of interest to a ratemeter and from there to a chart recorder which writes an analog display of the counting rate as a function of time. The sequence is a repeated over each area of interest. Finally the analog chart records are analyzed, using time-based parameters that are not so greatly affected by bolus shape and system nonlinearity. Slopes of activity curves and transit times have been found to be fairly reliable parameters.

Experience so far has shown the technique to be useful in comparing the relative blood flow to paired organs such as cerebral hemispheres and kidneys; it can show the transit time in cardiovascular flow studies; and it can show the time and rate of first appearance in dynamic studies whether rapid or slow. It is a valuable adjunct to the Polaroid films ordinarily obtained during the study. The system is simple to set up and operate. While lacking the sophistication of larger systems, it is capable of providing a semiquantitative evaluation of flow studies, using more readily obtainable components. It is suggested as a first step towards the more complex systems.

Dual-Head, Rectilinear Scanner for Quantitative Scanning BY FELIX J. PIRCHER, SAMUEL R. LER-

NER AND PHILIP H. COOPER, V.A. Hospital, Houston, Tex. AND GERALD J. HINE, V.A. Central Office, Washington, D.C.

Quantitative scintigraphy refers to the technique of measuring absolute or relative amounts of radioactivity within an organ by the use of a scanner or scintillation camera. It may be performed for the diagnosis of organ function and for dosimetry of diagnostic and therapeutic procedures. Several systems have been developed and tested in the past. The purpose of this study was to determine whether or not a commercially available, dual-head, rectilinear scanner could be modified and adapted for quantitative scanning.

A dual-head rectilinear scanner with two opposing scintillation crystals of 5-in. dia and 2-in. thickness was chosen. A multichannel analyzer was added to obtain the information in digital form—the most convenient form of recording for analysis. The analyzer is used as a buffer and records the pulses from both detectors in 100 channels while they traverse the table. A potentiometer driven by the worm screw assigns through its ramp voltage the incoming pulses to successive channels. A magnetic tape unit transfers the information from the buffer to the tape during the longitudinal travel of the detectors in ½-in. increments. The detectors are equipped with 43-hole collimators measuring 5 in. in dia, focused at 5 in.

The performance of the instrument was determined by measuring the line-spread functions summing the output from both detectors. The measurements were made for ^{57}Co at detector separations of 23, 24, 25 and 26 in. The optimal results were obtained at a detector separation of 26 in. The full width at half maximum was 0.81 in. ±5% (s.e.) over a distance of 9 in. centered between the two detectors. The relative sensitivity of the instrument to a source at different depths of water was determined by using a line source containing ^{57}Co. The results showed that the range of sensitivity variation of the system is ±12%.

From this we concluded that the instrument described here is acceptable for quantitative scanning with respect to resolution and sensitivity as well as through its relative independence of source depth. Quantitative measurements of the radioactivity present in an area were made using a compartmentalized phantom and computer analysis of data. The results of these studies are reported elsewhere.

Potpourri of Useful Operational Modifications to the Pho/Gamma III Gamma Camera BY JOHN R. PRINCE, LARRY COEN, WALTER G. DUKSTEIN AND JAMES S. ARNOLD, Kansas City General Hospital and Medical Center, Kansas City, Mo.

After several years of experience with the Pho/Gamma Camera we have made several simple but important changes in the instrument which provide for increased safety and efficiency of operation. The purpose of this report is to briefly describe these changes. Examples are:

1. A foot switch and contact relays have been installed for the remote operation of the 35-mm time-lapse camera. This allows dynamic function studies to be performed by one technician instead of two as before. Thus, remote control of the time-lapse camera is of significant economic importance.

2. The cord which operates the up and down motion of the scintillation head has been replaced by an ultrasonic remote control unit. The previous cord was an electrical hazard (several persons have been shocked) and had a consistent rate of failure. This change provides significant safety improvement as well as increased ease of operation.

3. A simple circuit with a thermistor has been attached to the gamma camera. The thermistor detects the temperature change in the airflow through the nasal passage and allows the breathing artifacts in liver/lung scans to be minimized by gating the camera to be on only during the end of expiration.

4. The split-crystal function has been slightly modified to switch off or on the black line in the scope display of the split crystal. This improves the ease of interpretation of the analog display.

These simple improvements can be incorporated for about $200 in parts and about 30 hr of an electronics technician's time.

Patterns of Abnormal Radioactivity in Brain Scan Interpretation BY J. L. QUINN, III, Chicago Wesley Memorial Hospital and Northwestern Univ. Medical School, Chicago, Ill.

Most large series of pertechnetate brain scans report 80–90% accuracy in diagnosing brain tumors. The list of non-neoplastic diseases which cause abnormal uptake continues to grow, making the positive brain scan even more nonspecific.

Our experience with over 700 abnormal brain scans has led us to establish certain confidence levels for the patterns of abnormal uptake. Of major consideration are: (1) anatomic location; (2) relationship to specific arterial distribution; (3) uniformity of radioactivity; (4) changes in activity with time (seconds, days, weeks, months); and (5) alteration with steroid therapy.

Some patterns have excellent confidence levels

such as the crossing over of distinct vessel distribution for tumor; invasion through the corpus callosum of both hemispheres for malignant glioma; multiple areas of uptake in the parietal lobe for metastases or emboli; and rapid changes in scan appearance or negative scan with abnormal cerebral radioangiogram in stroke. The ability of the scan to pinpoint the location of lesions in the posterior fossa to the cerebello-pontine angle, anterior or posterior cerebellum or vermis aids considerably in reducing the differential in these cases.

These and other patterns will be illustrated, discussed and assigned confidence levels.

Comparison of Radioisotope and Pyelographic Tests in Screening for Renovascular Hypertension BY JOSE D. QUINONES, VIJAY VARMA AND OSCAR MACAL, Univ. of Michigan Medical Center, Ann Arbor, Mich.

To estimate the role of the renogram and of the rapid sequence pyelogram (RSIVP) as screening tests in the detection of renovascular hypertension, pre-operative renograms and pyelograms were studied using objective arteriographic measurements and the surgical outcome as the criteria of significance.

Hypertensive patients who underwent isotope renography and scan, RSIVP and arteriography were divided into three categories based on the arteriogram: normal, unilaterally significant and borderline. Those who underwent surgery were evaluated as outpatients (OP) and classified as: cured (OP blood pressure below 150/95 on no drugs); improved (same results on diuretics alone plus a significant lowering from pre-operative levels); and unchanged (OP blood pressure not meeting the above criteria).

The ^{197}Hg-chlormerodrin (^{197}Hg-C) and ^{131}I-Hippuran (^{131}I-H) renograms were performed under the direct supervision of a physician with careful attention to hydration and kidney localization. Scans were performed with ^{197}Hg and a scanner. All isotope studies were later read by another physician without knowledge of the diagnosis. Six criteria of significance were applied in interpreting the ^{131}I-H results: Time to peak (T_{max}), time to 50% of peak ($T_{max} + T_{1/2}$), time from peak to 50% of peak ($T_{1/2_{max}}$), excretory segment shape (excretory contour), angle of accumulation phase (S2) and ratio r/l of S2. The r/l slope ratios and kidney size and maximum count differences were used to interpret the ^{197}Hg-C and the scan, respectively.

RSIVP was performed under dehydration with films taken at 2, 3, 5, 10, 15 and 30 min. A disparity in renal length in excess of 1.4 cm, late appearance and delayed disappearance of contrast material were taken as positive criteria. The arteriogram was performed by the transfemoral route.

Twenty-nine patients were studied. Ten had normal arteriograms, 13 had unilaterally significant lesions and six were borderline cases. Of the normal patients one had an abnormal ^{131}I-H and two others had abnormal RSIVP's based on size only. Scans and ^{197}Hg-C's were normal. Of 13 cases of unilateral lesions no false negative tests occurred with either the ^{131}I-H or the RSIVP. Two RSIVP's were positive on size disparity only. Two scans and three ^{197}Hg-C renograms were falsely negative. All patients underwent surgery. There were 10 cured, two improved and one unchanged. Of six cases considered borderline arteriographically, five had unilateral predominance and one bilateral segmental narrowing. Four underwent surgery with one operative death. In all the ^{131}I-H was abnormal in one side. In two the RSIVP was normal and in two others abnormal based on size only. Of the first two one was cured and the other improved following surgery. The scans and ^{197}Hg-C were each falsely negative once.

The Hippuran renogram when performed and analyzed in a standard fashion reflects few false positives and misses no cases of significant lesions. The ^{197}Hg renogram and scan are not as sensitive. Pyelography retains its value as a screening test although in this small series two false negatives would have been recorded.

Scanning Kidney Tumors in Children BY L. D. SAMUELS AND MARY EAGLE, Children's Hospital and Ohio State Univ., Columbus, Ohio

These studies were undertaken to improve preoperative diagnostic accuracy in abdominal tumors located in and around the kidneys. The ^{197}Hg-chlormerodrin kidney scans, frequently combined with ^{131}I rose bengal liver or ^{99m}Tc-sulfur colloid liver-spleen scans, were performed on an Ohio Nuclear Model 54F scanner equipped with a 5 in. crystal and 93-hole, 1-cm-resolution collimator. Compared to the IVP which sometimes cannot detect the minor calyceal distortion of a small intrarenal tumor or an extrarenal tumor impinging on kidney, in no case scanned was the distinction between intra- and extrarenal tumor missed and no tumors involving kidney either intrinsically or extrinsically were missed. A round cell carcinoma was correctly differentiated from a Wilm's tumor on scan; Wilm's tumors from 2–10 cm in dia have been diagnosed preoperatively and neuroblastomas have been diagnosed as extrarenal, extrahepatic tumors, probably neuroblastoma. In two cases, gastrointestinal tumors were correctly identified on scan. These studies suggest that kidney scans, preferably combined with liver or liver-spleen

scans, should be part of the routine workup of every pediatric abdominal mass.

Evaluation of a Diverging Collimator BY BERTRAM J. L. SAUERBRUNN, WILLIAM EDWARDS, EDWARD WINTERS, CHARLES TUCKER AND LOUISE WEST, V.A. Hospital, Washington, D.C.

The purpose of this communication is to report our experience in evaluating the uses of a commercially designed diverging-collimator attachment to a scintillation camera (Nuclear-Chicago).

Prior to clinical trial, studies using line-type sources containing ^{99m}Tc and ^{131}I as well as a phantom "tumor" study indicated a somewhat better resolution of images obtained with routine parallel-hole collimation compared to diverging collimation at close distances to the camera face. Images and "lesions" were more clearly depicted when viewed close to the camera with diverging collimation, but reasonably good resolution was maintained at distances up to 6 in. from the collimator face (field of view about 14 in.). It was also noted that tilting the collimator face from the perpendicular could produce some distortion of the image size and shape. This was more pronounced with divergent collimation.

In ^{131}I-MAA perfusion lung studies in 35 patients there were no significant differences in the display of abnormalities in a comparison study of right lateral and posterior views obtained with both the diverging collimator and 3- or 5-in. single probe scanner. In an additional 110 cases, a single posterior scan view and three diverging-collimator camera views was accomplished. In 30 severely dyspneic patients only camera views were done. From these studies, it was evident that the diverging-collimator camera system allowed shorter viewing times. This was especially valuable to the dyspneic patient who could be studied more rapidly and in a sitting position. Greater patient comfort also resulted in much less motion artifact.

In a ^{99m}Tc-sulfur colloid liver study involving 150 patients, the diverging-collimator camera viewing proved satisfactory in certain respects. In a comparison study with 150 anterior scanning views, there were fewer technically unsatisfactory scintiphoto studies, and liver outline appeared to be better delineated with the diverging camera system. However, in 25 lesions depicted by scanning there was one false negative and one equivocal scintiphoto noted in the camera study. The diverging-collimator camera system appeared to be of most value as an auxiliary in allowing rapid additional views of liver or spleen in the "large liver" group of patients. In such cases, in contrast to the regular low-energy collimator, the diverging collimation allowed easier positioning of the patient with a single view of the liver, a direct comparison of relative liver and spleen activity and liver/spleen size in most instances.

The diverging collimator is a valuable attachment for the scintillation camera permitting visualization of both lung fields as well as large organs in a single view. Perfusion abnormalities are readily and adequately detected. This device is also an important adjunct in liver scintigraphy.

Evaluation of Commercial ^{99m}Tc-Sulphur Colloid Kit BY BERTRAM J. L. SAUERBRUNN, CHARLES TUCKER AND WILLIAM EDWARDS, V.A. Hospital, Washington, D.C.

A commercially designed ^{99m}Tc-sulfur colloid kit (Squibb) was evaluated over a period of 10 months in our laboratory. Parameters tested included chromatographic analysis, particulate size, animal organ distribution studies and clinical scintigraphy in over 150 patients.

Colloid yields averaged 93% on 85% methanol chromatography remaining relatively stable when tested after a 24-hr period. With such preparations, organ distribution studies using rats revealed that 75–78% of the total radioactivity injected was retained in the liver, 1% in the spleen and 1½% in the lungs. Millipore filtration studies of colloid dispersed in a 0.1% Alconox solution using various-sized filter pores suggested a particulate range size from 220 to 800 millimicrons.

In 60 kit preparations there were two instances in which colloid formation was imperfect. These were manifested by the formation of a yellow gelatinous precipitate. One precipitation was noted immediately after the addition of buffer. One developed after a delay of 2 hr after apparent normal colloid formation. In the latter instance, colloid yield was only 72% on chromatography.

There were no adverse reactions observed in over 150 patients injected with ^{99m}Tc-sulfur colloid. Scintigraphic liver visualization was generally excellent particularly with Anger camera viewing.

Fifteen abnormal ^{99m}Tc-sulfur colloid scans were obtained in patients with biopsy-proven malignancy of the liver. Duplicate scans using radiogold resulted in 13 abnormal scans, one negative scan and one equivocal scan.

The commercial kit preparations of ^{99m}Tc-sulfur colloid are generally reliable and uniform, allowing excellent scanning studies. Occasional malformations of colloid can occur and may be self-evident on physical inspection. It is important to look for delayed colloid breakdown. However, breakdown would appear to be highly unlikely in those prepa-

rations which yield more than 90% colloid on chromatography.

Leukemia Following Cancericidal Doses of Radioiodine BY JAN K. SIEMSEN, Univ. of Southern California, Los Angeles, Calif.

Whole-body radiation from single cancericidal doses of ^{131}I in the treatment of differentiated thyroid cancer has been estimated at 20–70 rads and whole-blood radiation at 20–120 rads in athyroitic patients. These high radiation burdens are cause for concern and reappraisal of this treatment modality.

A 19-year-old girl developed acute myeloblastic leukemia following the administration of 230 mCi of ^{131}I over a 2-year period for papillary thyroid carcinoma. This tragic case prompted us to search the literature for evidence of the frequency of this complication.

Pochin observed four cases of acute leukemia in a series of 200 patients; that is an incidence of 2% or, extrapolated, 4,000 cases per million population per year. This extrapolation from a single series is probably invalid. In our own material of 160 patients treated over a 15-year period, we have seen no other cases and none were observed in other relatively large series such as that of Haynie and Beierwaltes.

We have found only 15 such cases reported in the literature. No reliable information is available on the total number of patients treated, but a reasonable conservative estimate places this figure at approximately 5,000. The leukemia incidence calculated from these data would be 150 per million population per year, or only slightly more than the expected natural incidence of 85 per million per year. Even allowing for unreported cases and for errors in these gross assumptions, this complication appears to be much less frequent than estimated by Pochin. Therefore, the risk of leukemia does not seem to be a contraindication against ^{131}I treatment of differentiated thyroid carcinoma. All cases of leukemia after radioiodine treatment should be reported to permit a more accurate estimation of its incidence.

"Paradoxical" Response of Hyperactive Thyroid to Suppression BY JAN K. SIEMSEN, NANCY TELFER, PETER A. LEINS AND GRETA WANYIK, Univ. of Southern California School of Medicine, Los Angeles, Calif. and V.A. Hospital, Long Beach, Calif.

We were impressed by the observation that the radioiodine uptake frequently rises rather than falls after T_3 administration in hyperthyroid patients.

To check on the validity of this impression, all T_3 suppression tests done at our institutions in the last 5 years were reviewed. All tests were done by giving 25 μg of T_3 q.i.d. for 8 days following a baseline uptake and by repeating the uptake on the seventh and eighth day.

Eighty-eight patients showed no suppressibility by standard criteria. In all of these the diagnosis of hyperthyroidism was established subsequently. In 53 out of the 88 cases the 24-hr uptake was higher after T_3 administration than before; in 27 of these the rise was more than 20% of the baseline value; in 17 it was more than 30%. Taking the group as a whole there was a mean rise of 13.2% of the original value. The difference between the second and first 24-hr uptake was significant ($p < 0.01$).

Only 40 out of 88 patients had an early (5 or 6 hr) uptake before and after T_3 administration. While statistically not significant, there also was a tendency to rise in these tests and the correlation between 24 hr and early uptakes was high ($r = 0.62$).

The reason for this phenomenon remains obscure. Artifacts such as incidental iodine contamination, inadequate hormone administration or technical errors were ruled out by meticulous technique. There was no correlation of the "paradoxical" response with the patients' age or sex or the type of their hyperthyroidism. Fifty-six patients had Graves' Disease, 27 multinodular toxic goiter and five single toxic nodules. All were untreated. One possible explanation for the rise in 24-hr counts, namely a moderate slowing of iodine transit through the gland in patients with originally rapid turnover, appears to be eliminated by the good correlation between 24-hr and early uptakes. To check on this facet further, six patients were studied with hourly uptakes following an intravenous tracer dose before and after T_3 administration. Three out of these six showed significant rise in all values of the curve.

Henneman *et al* suggested a spontaneous fluctuation of the LATS titer as an explanation for this phenomenon. This possibility was not investigated in our series.

Dissociation Between Thyroid Nonsuppressibility and Serum LATS Levels in Graves' Disease BY GERALD E. SILVERSTEIN AND GERALD BURKE, Michael Reese Hospital and Medical Center, Chicago, Ill.

Nonsuppressibility of thyroid ^{131}I uptake in Graves' disease has classically been related to the presence of circulating long-acting thyroid stimulator (LATS). During treatment of hyperthyroidism with antithyroid drugs, a proportion of patients regain normal suppressibility (Alexander *et al, J. Clin. Endocr.* **27**:1682, 1967). We examined the relationship of thyroid suppressibility to LATS levels

in 14 thyrotoxic patients on long-term treatment with antithyroid drugs (mean duration of treatment, 11.9 months, 13 patients followed for 6 months or more). Twenty-minute ^{131}I thyroid uptake and LATS levels (before and after triiodothyronine administration) were measured before and at 1–3-month intervals during antithyroid drug treatment. Eight patients developed thyroid suppressibility during treatment; of these, three had detectable LATS prior to treatment and there was no decline in LATS levels with treatment and restoration of suppressibility. Of six patients whose thyroid uptake remained nonsuppressible during long-term treatment (mean, 11.1 months), LATS was undetectable in both the serum and concentrated immunoglobulin G fraction of four.

Two patients who showed normal suppressibility during and/or following antithyroid drug treatment subsequently developed recurrent hyperthyroidism.

These studies suggest that in Graves' disease: (1) thyroid nonsuppressibility may reflect an intrinsic thyroid abnormality rather than the presence of circulating LATS, and (2) thyroid suppressibility during long-term antithyroid drug treatment of hyperthyroidism is not invariably associated with sustained remission.

Interfacing the Pho/Gamma Camera to a Digital Computer BY ROBERT O. SMITH AND WILLIAM M. FLOWERS, JR., Univ. of Mississippi Medical Center, Jackson, Miss.

There is much interest in computer analysis of isotope scan data. In order to use a digital computer for this purpose, the data of interest must be in a form suitable for input to the computer. Although several devices are commercially available for obtaining computer-compatible data from the Pho/Gamma camera, they are expensive because they either have some form of special purpose high-speed memory or a very small built-in digital computer. When a computer is already available, only the interface to the camera and some computer software are needed.

Because the duration of the camera to oscilloscope deflection pulses is 2.5 μsec, relatively high-speed analog-to-digital conversion techniques are required. A combination of simultaneous and successive approximation techniques was used to provide conversion to 5 bits (32 levels) in 1.5 μsec. The three most significant bits are obtained in > 0.5 μsec by the simultaneous method. Successive approximation resolves the two least significant bits in 0.5 μsec each. With addition of the sixth bit (for 64 levels), conversion time would be 2 μsec. This hybrid design allowed relatively inexpensive 2 mHz logic to be used in the A-D converters and the timing circuits controlling data transfer between the converters and the computer.

Nine-point averaging combined with a display in which density varies exponentially as the size of the number increases linearly has produced displays with better resolution than photo recordings made in real time. Excluding labor, the Pho/Gamma camera can now be interfaced to a laboratory digital computer for less than $2,000. This brings quantitative computer analysis closer for those who previously could not afford equipment for such studies. (Supported in part by USPHS Grant HE-07628.)

Quantitation of Radioactive Content *In Vivo* Using Combined Emission-Transmission Measurements BY JAMES A. SORENSON, Univ. of Wisconsin, Madison, Wis.

Estimates of the radioactive content of a patient or of an organ within a patient based on external counting measurements may be inaccurate if the distribution of radioactivity is not known. The principal source of error is the unknown amount by which the emitted radiation is attenuated within the patient. External transmission measurements may be used to determine body thickness and to obtain a correction to minimize this error. We have investigated this technique and have developed a generally applicable theory for combined emission-transmission measurements to accurately quantitate radioactive content, which will be described. This theory was tested using profile scanning techniques to study injected doses of ^{59}Fe and ^{99m}Tc-sulfur colloid. A linear scanning device having a single 8-in.-dia NaI(Tl) detector with a slit collimator of variable slit width was used for these studies. Doses were scanned before injection to determine the counts in the administered radioactivity. Subjects were scanned in the supine and prone positions 15 min after injection. These scans were corrected using data from a transmission profile scan obtained earlier. In both normal and diseased subjects, having a variety of radionuclide distributions, the total of transmission corrected counts was within 10% of the injected counts for both ^{59}Fe and ^{99m}Tc-sulfur colloid doses. It is concluded that transmission measurements provide an accurate absolute correction for body habitus in quantitative measurements of radioactive content.

Distribution Functions for Quantifications and Interlaboratory Comparison of Number of Radioiodide Drinks to Cure Hyperthyroidism BY RICHARD P. SPENCER, Yale Univ. School of Medicine, New Haven, Conn.

Instead of being frustrated by the fact that some

patients require two or more drinks of radioiodide to cure their hyperthyroidism we can use this to gain insight into the interaction between these individuals and the treatment regimen. A function can be constructed by examining the cumulative number of radioiodide drinks given to the population. By the total cumulative number of drinks (C_∞) is meant the sum of the number of drinks given to all patients. For example, 100 patients requiring one drink each, 45 patients requiring two drinks each and 10 patients requiring three drinks each would have $C_\infty = (100 \times 1) + (45 \times 2) + (10 \times 3) = 220$. When the cumulative number of drinks is plotted against the number of drinks per patient, a curve is obtained which rises rapidly and reaches a plateau. To an exceedingly close approximation, the actual distribution is described by: $C = C_\infty\ (1 - e^{-\lambda D})$; C is the cumulative number after D drinks per patient, and λ is the rate constant. From the data of Silver (1962) $\lambda = 0.217$, while for Maynard's data (1969) $\lambda = 0.294$, and for the values given by Nofal, Beierwaltes and Patno (1966) $\lambda = 0.334$. The correlation coefficients of the three lines were 0.99. If the populations were identical, this would indicate different vigorousness in approaching therapy at the three centers. In addition to the rate constants, different populations can be compared by means of the average number of drinks per patient, and the number of drinks per patient to achieve half of C_∞. Further, subgroups within a population can be studied separately and perhaps the effects of age or thyroid size separated. From the data of Nofal and coworkers, different rate constants can be shown between the results of treating hyperthyroid patients with normal-sized glands and patients having diffusely enlarged thyroids or multinodular goiters. A second function notes that when the cumulative percent of response to treatment (on a probability scale) is plotted against the logarithm of the number of drinks, a nearly straight line is obtained. The resultant plot gives a good description through the 99th cumulative percentage of the results of radioiodide therapy of hyperthyroidism described by Silver, Nofal, Beierwaltes and Patno and by Maynard. The plot is consistent with a log-normal distribution (such as found by the multiplicative effect of variables with a normal distribution). It can also be approximated, however, by the equations of "multitarget lethality" and by several other functions. Such approaches permit interlaboratory comparison and might permit separation of the variables contributing to the effects observed after radioiodide therapy of hyperthyroidism. (Supported by T-492 from the American Cancer Society and by USPHS CA 06519.)

Major Variants in the Liver and Spleen Scans of Children BY RICHARD P. SPENCER, HOWARD A. PEARSON, EUGENE A. CORNELIUS AND M. A. ANTAR, Yale Univ. School of Medicine, New Haven, Conn.

Utilization of short-lived radiopharmaceuticals has permitted more extensive study of the pediatric age group. As experience is gained with liver and spleen scans in children, a number of patterns begin to emerge. Recognition of these variants depends upon (1) appreciation of the change of organ size with age; (2) knowledge of the functional pattern of distribution of the scanning agent; (3) information as to the rate of change of the lesions with time. When using ^{99m}Tc-sulfur colloid in children, the liver-to-spleen ratio of counts per unit area is usually 2:1 to 6:1. Relatively larger values (less in the spleen) occur in cases of splenic disorders, including "functional asplenias." Lower values of the ratio (more in the spleen) occur in hepatic disorders, as relatively greater reticuloendothelial activity is shown by the spleen. Nearly all of the variants that will be encountered in children can be placed in the following categories. *Anatomic Variants:* (1) Situs inversus; (2) Congenital asplenia; (3) Eventrations; (4) Splenic cysts; (5) Surgically removed or transposed spleen; (6) Polycystic disease (and cysts from infestations). *Functional Variants:* (7) Localized defects following irradiation; (8) Functional asplenia; (9) Deformed liver or spleen of S-S disease; (10) Heterogenous combined structural and functional variants (principally the liver in congestive cardiac failure, and cirrhosis with or without biliary atresia); (11) Neoplastic changes, including metastases, lymphomas and deformation displacement by extrinsic tumors. To sort out these variations, we have found the following procedures to be helpful. (1) Whenever possible, the studies are done in the dynamic mode so that the colloid bolus can be followed through the heart, lungs and liver (especially important for the rapid diagnosis of hepatic eventrations). (2) The counting rates over several areas of the liver and spleen are marked on the scans. (3) Multiple views are taken, and the counting rates are also marked. (4) The scans are overlaid on nonmagnified radiographs of the chest and abdomen. (5) Attention is given to any past history of abdominal trauma, surgery, radiation or blood dyscrasias. (6) Serial scans are performed to follow regression or progression of lesions. (7) Blood pool scans may be done if angiomas are suspected. Key illustrative cases are available to point out the salient features. (Supported

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Gut Mucosa Blood Flow: Discrepancy Between Isotope Fractionation and Microsphere Methods BY RICHARD P. SPENCER, ROBERT J. TOULOUKIAN, EUGENE A. CORNELIUS AND SALVADOR TREVES, Yale Univ. School of Medicine, New Haven, Conn.

Scrapings of the intestinal mucosa and mucosal biopsies are of importance not only in histological studies but in estimating the presence of various enzymes and metabolites. It would be useful if these pieces of tissue could be used in the quantification of blood flow to the gut mucosa. Hence the mucosal to "submucosal" distribution of ^{86}Rb (Sapirstein's technique) and ^{169}Yb microspheres were compared in rats and other animals. Both techniques have been well validated in the past as measuring the fraction of cardiac output going to the gut. However, there have not been studies on the distribution of these radiolabels between the mucosa and underlying layers. Carbonized microspheres (low density in 10% dextran) of 25 ± 5 microns dia were injected into the left ventricle of anesthetized rats. One minute later ^{86}RbCl was injected, and the animals were sacrificed after another minute. The procedure was also reversed (^{86}RbCl injected first, then the microspheres), to insure that the results did not vary because of the small number of vessels occluded by the microspheres. (The mucosa was obtained by scraping the washed luminal surface with a glass slide.) With the 25-micron spheres, the ratio of counts/gm mucosa to counts/gm underlying tissues was 3:100. This means that there was an insignificant number of 25-micron direct shunt vessels going to the mucosal cells. Using ^{86}Rb, the ratio of counts/gm mucosa to counts/gm underlying tissues was 130:100. Hence there were discordant results between the two procedures. Going to a dog, the experiments were repeated with 15-micron ^{169}Yb spheres and soluble ^{86}Rb. The ratio of ^{86}Rb counts/gm mucosa to counts/gm underlying tissue was 130:100, while that of the ^{169}Yb microspheres was only 10 to 100. It is apparent that at the individual tissue layer, the definition of blood flow begins to become hazy. The diffusible indicators (such as ^{86}Rb) may be expected to give results higher than that of the microspheres for epithelial lining tissues away from major vessels. Flow fraction values are available for the whole tissue and its parts. Reports on the measurement of intestinal blood flow by radioisotopic techniques must be carefully reviewed as to the validity of the procedure for the region studied. (Supported by USPHS CA 06515 and by T-492 from the American Cancer Society.)

Thyroid Imaging with ^{99m}Tc-Pertechnetate and the Pinhole Camera BY H. WILLIAM STRAUSS, PETER J. HURLEY AND HENRY N. WAGNER, JR., The Johns Hopkins Medical Institutions, Baltimore, Md.

In euthyroid and hyperthyroid patients, ^{99m}Tc-pertechnetate has been shown to be comparable to ^{131}I-iodide for thyroid imaging. In the patient with a low thyroid uptake it may be of particular value. We have compared ^{99m}Tc-pertechnetate and ^{131}I-iodide scans in 56 patients whose 24-hr thyroid ^{131}I uptake was 15% or less. An 8-in. rectilinear scanner was used. Scans were interpreted independently by two observers, and the results in each patient were compared for image quality. The ^{99m}Tc-pertechnetate image was superior in 26 cases, markedly so in 14; the images were of equal value in 23 patients; and the ^{131}I-iodide image was better in seven, markedly so in only two.

We have also compared two different imaging instruments: the rectilinear scanner and the Anger scintillation camera with pinhole collimator. The pinhole collimator offers advantages in resolution, but its low sensitivity precludes its routine use with ^{131}I. We have used both instruments to produce thyroid images in 100 patients, comprising euthyroid, hypothyroid and hyperthyroid individuals. A dose of 5 mCi of ^{99m}Tc-pertechnetate was administered intravenously, and the study begun shortly thereafter. The average time for a pinhole camera view was 2 min and for a scan 6 min.

The scintillation camera with pinhole collimator produced images that were significantly better than those obtained with the scanner. In only three patients was the rectilinear scan better than the camera image. With the pinhole collimator, careful patient positioning was essential to avoid distortion of the image.

We conclude that ^{99m}Tc-pertechnetate is superior to ^{131}I-iodide as a thyroid imaging agent. The scintillation camera with pinhole collimator produces images superior to those obtained with the scanner and in considerably less time.

***In Vivo* Counting of Plutonium with an Internally Amplifying Solid-State Detector** BY K. L. SWINTH, Battelle-Northwest, Richland, Wash.

Plutonium, an alpha emitter, presents a biological hazard due to its radiotoxicity and must be located and removed if possible. When plutonium is present in tissue it cannot be assayed by its alpha particles but must be detected by the L x-rays (average energy 17 keV) emitted by its uranium daughter. The intensity of the x-rays varies with isotopic composi-

tion, but generally about seven x-rays occur for every 100 alpha particles.

Before the advent of the internally amplifying detector, a small maneuverable detector suitable for counting low-energy x-rays (i.e., plutonium) was not available. The detector and preamplifier can be built into a small unit suitable for use by a physician during excision of material imbedded in superficial wounds.

Typically, the detector and electronics are designed to operate as a solid-state analog of a G-M counter, providing no energy information. The intrinsic efficiency of such a unit is about 25% at 5.9 keV; 4.8 ± 0.5% for the ^{239}Pu L x-rays and 0.54 ± 0.04% at 60 keV. Background rates of about 0.26 cpm give a minimum detectable amount of about 200 nCi at 2.5 cm from a plutonium point source.

Attenuation of the x-rays in 0.4 cm of tissue decreases the detected intensity by a factor of two. Other factors which affect the counting rate are: detector temperature sensitivity (2.8%/°C), detector voltage (1.3%/volt), discriminator level and the isotopic composition of the plutonium.

These detectors have also been placed in esophageal tubes for detection of plutonium in the bronchial lymph nodes. For this work a charge-sensitive preamplifier is used resulting in higher background rates and higher detection efficiencies.

Quantitation of Nuclide Uptake with the Gamma Camera and Digital Data Processing BY F. DEAVER THOMAS, JOHN W. KEYES, JR. AND JAMES E. CAREY, Univ. of Michigan, Ann Arbor, Mich.

Standard probe methods of quantitating radionuclide uptake suffer from extremely poor resolution making detailed analysis of small organs difficult. As a new method of surmounting this obstacle, a commercially available package of components for data acquisition (Nuclear-Chicago Pho/Gamma III gamma camera) and digital data processing and storage (Nuclear Data 50/50 Med System) was evaluated for accuracy in quantitative evaluation of uptake. Problems related to the accuracy of such a system include gamma-ray scattering, collimator septal penetration, background activity and camera-field nonlinearity. Useful methods for correcting these problems were devised. Distance relationships are not critical if a parallel-hole collimator is used except for decreasing resolution with distance. Preliminary results were so surprisingly good and appeared so generally applicable that further studies were undertaken to evaluate the effects of volume distribution on accuracy and applications to dynamic situations. Isotope concentrations as low as 0.5 μCi in 2 cc were measured reproducibly with an accuracy of ±4% in comparison with a calibrated ionization chamber.

The resolution of the system is so superior to conventional probe techniques that individual nodules within a gland can be quantitated with respect to the remainder of the gland with the double advantage that (1) a scintigram is produced simultaneously with the quantitative data, and (2) the digital data are stored nondestructively on magnetic tape for comparison studies at a later date, such as after stimulation or suppression. The dynamic range of the system is remarkable. Activity as low as 1 μCi in 5 cc can be quantitated to the above accuracy when measured within 4 cm of a 5 cc source containing 50 μCi and vice versa. The application of this technique to thyroid studies is a significant step. Particularly important applications occur in thyroid cancer where it is important to quantitate small metastatic foci which concentrate iodine poorly, lying close to areas of actively concentrating normal tissue; and in the study of functioning thyroid nodules where the problem is to quantitate changes in the activity of a bit of iodine-concentrating tissue relative to another surrounding area of concentrating tissue. Increasing the volume distribution of nuclide tends to degrade accuracy, but within the range of volumes encountered clinically, the accuracy remains within ±10%. Accuracy also tends to fall in dynamic situations because of statistical variation due to short counting times. Further development of this technique can be expected to significantly improve other organ evaluation such as cerebral blood flow and renal clearance studies.

Hydrated Indium Oxide as an Immunosuppressant BY HENRY N. WAGNER, JR., FRANK P. CASTRONOVO, JR., NORMAN D. ANDERSON, JOYCE CHEN AND DAVID LEVY, The Johns Hopkins Medical Institutions, Baltimore, Md.

The element indium, when injected in colloidal form at pH 7.4, is rapidly removed from the circulation by the reticuloendothelial system. Although small doses had no demonstrable effect, doses greater than 0.3 mg/kg body weight produced depletion of the lymphoid system and bone marrow hypoplasia in dogs and mice. Because of this pharmacological effect, we evaluated the ability of this agent to suppress tissue and humoral immune responses.

Two inbred strains of mice (Jackson Laboratories, Bar Harbor, Maine) were used to study tolerance to skin grafts. Recipients were mature (C57 Bl / 6XA) F1 male mice, and donors were C3H male mice, chosen because of strong histocompatibility barriers to allografting. A dose of hydrated indium oxide

which resulted in the death of approximately 50% of the mice (LD-50) within 4 days of administration was injected into 28 C57 mice. Four days later the survivors of the treatment received skin grafts from the C3H mice. Twelve untreated C57 mice were grafted as controls. All untreated mice rejected their allografts with a mean survival time of 9.8 ± 0.54 (±1 s.d.) days. Survival time of the skin grafts in the mice treated with the indium was considerably longer; the mean survival time of these grafts was 13.7 ± 1.37 (±1 s.d.) days. In similar experiments carried out after a nontoxic dose of hydrated indium oxide, the mean survival time was 9.2 ± 0.53 (±1 s.d.) days.

High dose levels (LD_{50}) had no effect on the antibody response to sheep red blood cells. No significant differences were observed in serum antibody levels by hemagglutination and hemolysis techniques.

Indium oxide may represent a new class of compounds that have suppressive effects on the lymphoid system. Rapid clearance of the hydrate from the blood resulted in high concentrations in the liver, spleen, lymph nodes, bone marrow and thymus and pronounced lymphopenia.

Prolongation of skin graft survival may be related to the lymphopenia.