THE YEAR BOOK *of* RADIOLOGY 1973

RADIOLOGIC DIAGNOSIS

EDITED BY

WALTER M. WHITEHOUSE, M.D.

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RADIOLOGIC DIAGNOSIS

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INTRODUCTION

The review of the yield of one year in the radiologic literature always uncovers many items of interest to radiologists that do not lend themselves to easy abstracting. Increasing concern is expressed about the problems of radiologic manpower; interestingly enough, some of the concern in a few areas of the United States suggests too many radiologists are being trained. Careful statistical evaluation of projected needs and training capabilities must be carried out, and it is anticipated that the radiologic literature of the coming year will discuss this in further detail. Despite these considerations, the work load in radiology continues to climb, and it is hoped that the large-scale efficacy studies now underway will provide data during the coming year or two to give us the basis for re-educating ourselves and our clinical colleagues concerning the relative benefits of various radiologic examinations.

The added relief measure of delegating some radiologic tasks to nonprofessional personnel continues to be discussed without any unanimity of opinion.

The uses of the computer in radiology continue to receive wide attention. The appearance of further computer reporting methods indicates the ideal approach has not yet been found. Some advances have been made in computer-assisted instruction and in diagnostic computations of intraocular localizations.

Major memorial lectures in recent months have emphasized the importance of the dynamic physiologic-metabolic approach in diagnostic methods. Increasingly sophisticated audiovisual aids and collections of teaching material are available to aid in this approach to the radiologic instruction of residents and medical students.

By means of an international newsletter, our European colleagues share their concerns about technics, organizations and communications. The increasing governmental concern about ionizing radiation and the importance of professional participation in the formulation and administration of standards are emphasized by many authors.

In the area of technical developments, the transmission tomographic scanning technics for intracranial disease developed by our British colleagues appeared too late for inclusion in this volume, but we anticipate many articles on their use in the next few years. There has been continued interest in the fundamental measurements of diagnostic beams and comparison of equipment, screens and films. Further interest is shown in videodensitometry and new contrast mediums. Many articles continue to be written on the applications of ultrasound technics.

In angiography, there is continuing interest in the anatomy and pathophysiology of intracardiac dysplasia and anomalies. The complications of angiography and functional changes with injection of contrast medium are being evaluated continuously. Complications of pharmacoangiography are reported. In neuroradiology, there is continued interest in detailed vascular anatomy as more elaborate angiographic studies are carried out. Complications of newer technics and contrast mediums are also evaluated.

In skeletal radiology, there is widespread interest in new descriptive information on old disease entities in both children and adults.

In the field of chest disease, the mechanisms of pulmonary edema are discussed in several disease entities. The complications of oxygen alveolopathy are investigated. Drug hypersensitivity information is extended and new responses to industrial exposures are described. Pulmonary complications encountered in dialysis and transplant technics are encountered as the use of these technics is extended. Continuing concern is evidenced in the twin killers, bronchial and breast neoplasms.

In the gastrointestinal tract, unusual pathologic entities are described and physiologic changes in enzyme deficiencies are elaborated. Interventional technics are extended with pharmacologic as well as selective embolization methods. Disease entities predisposing to neoplasm are reported, and evanescent inflammatory disease in the colon is described. Ultrasonic technics in pancreatic cystic lesions are also described.

In the genitourinary tract, interest continues in bladder function, normal variants, antibiotic nephrotoxicity, the hereditary aspects of medullary sponge kidney and the relation of neoplasm to analgesic abuse, among others. New concepts of the pathogenesis of pyelonephritis are being developed. Ultrasound is being more widely used in evaluation of renal cysts and in needle placement in such cysts. Investigation of the utility and possible danger of ultrasound in obstetrics and gynecology continues.

In pediatric radiology, there is continued interest in the more sophisticated classification and detailed analysis of congenital abnormalities. New international classifications of anorectal anomalies and bone dysplasias are being utilized. There is also increased emphasis in neonatal diseases as clinical attention in this area increases, with special emphasis on neonatal respiratory disease. Continued emphasis on separation of pediatric from adult radiologic practice is justified by the unique manifestations of disease in this age group, as shown again in the voluminous literature of the year.

In the current jargon of "putting it all together," review of the year's accumulation shows it to be another interesting summary of the changing, advancing and interweaving paths of the various components of our speciality, which result in the consistent improvement in the patient care, research and teaching aspects of radiology as a whole.

W.M.W.

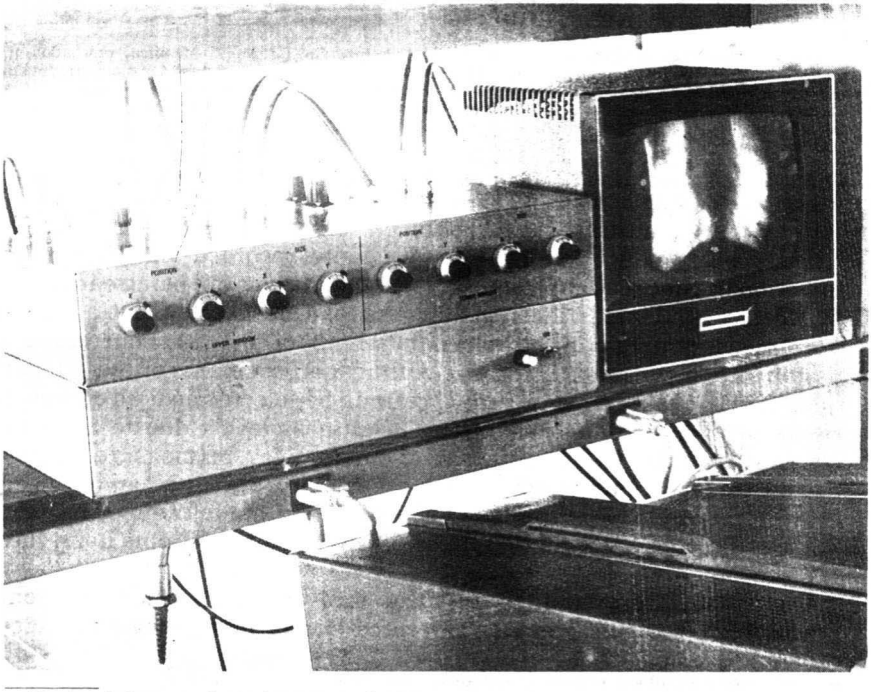
TECHNICAL DEVELOPMENTS

Clinical Videodensitometry is discussed by Norman R. Silverman[1] (Univ. of California, San Diego) when an image intensifier-television chain to view the output of a medical fluoroscope, the optical image is converted to an electronic one that can be discretely and accurately sampled. Television fluorodensitometry, which utilizes a single line from the raster, provides a simple, inexpensive method for analyzing this type of roentgenographic image. Videodensitometry, although more complicated and expensive, offers far more flexibility and seems to be a reasonable approach to accurate physiologic data acquisition from televised medical fluoroscopy.

METHOD.—A dual-channel videodensitometer was constructed (Fig. 1) so that two simultaneous densitometric recordings could be made from any selected area of the video display. Triggering circuits are included for each channel in order to obtain a trigger pulse from any selected gray level. The gray level trigger circuits are used to measure the time interval for any selected brightness level to pass from one window to the next.

High-resolution videotape recordings have been used for video measurements. Physiologic parameters are passed through an FM recording adapter so they can be recorded on the audio channels of the videotape recorder. When the tape is

Fig. 1.—Dual channel videodensitometer with television monitor demonstrating gated output of each channel on the video display. The white rectangles can be independently positioned and their size is variable from 1×1 mm. to about 45% of the total video display. The output of the densitometer windows is recorded on the display cathode ray tube of a suitable storage oscilloscope. (Courtesy of Silverman, N. R.: Am . J. Roentgenol. 114:840-850, April, 1972.)



(1) Am. J. Roentgenol. 114:840-850, April, 1972.

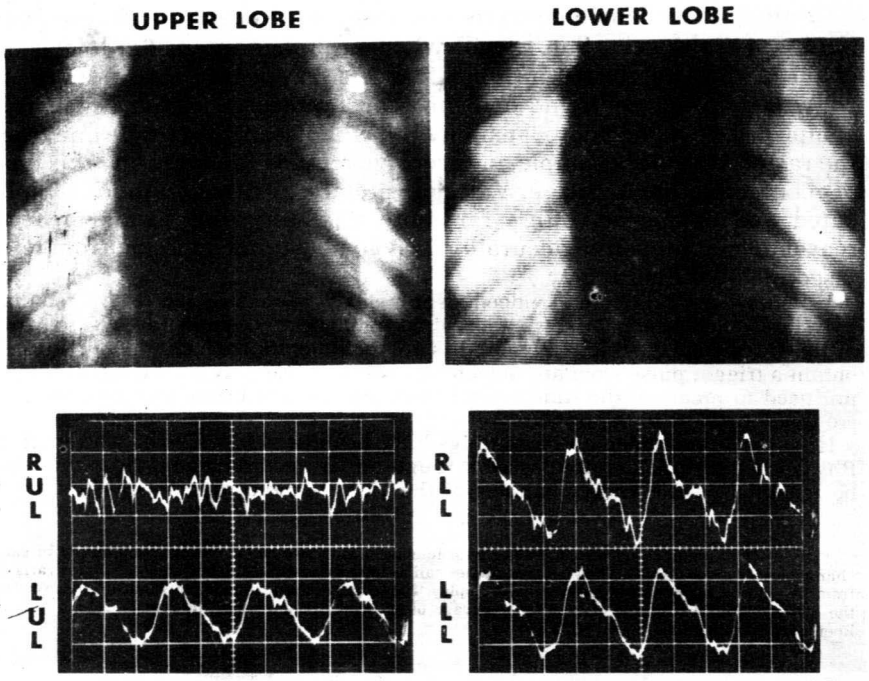


Fig. 2.—Simultaneous video displays and oscilloscope recordings during mechanical ventilation of a 24-kg. dog. The "windows" are placed over upper and lower lobes and the resultant densitometric tracings reflect the ventilation cycle. The right upper lobe bronchus was occluded before the recordings and the abnormality of ventilation in this area is clearly demonstrated. (Courtesy of Silverman, N. R.: Am. J. Roentgenol. 114:840-850, April, 1972.)

replayed, they provide accurate time references and continuous correlation of the video analysis with actual physiologic events.

Pulmonary ventilation and perfusion analyses can be done by videodensitometry (Fig. 2). They require only recorded fluoroscopy (no injection of contrast material). Human evaluations are being carried out in selected patients. Videodensitometry can be used for intra-arterial flow measurements if the ascending limb of the washout curve is assumed to be virtually the same within short segments of the artery in question; the same density (gray level) can be selected on both curves. In tissue perfusion studies, changing brightness levels due to transit of contrast material within an organ of interest can be measured. Tissue transit times of angiographic contrast medium through capillary beds provide estimates of organ perfusion. Washout curves from the canine kidney, the monkey brain and the myocardium of the canine heart have been recorded.

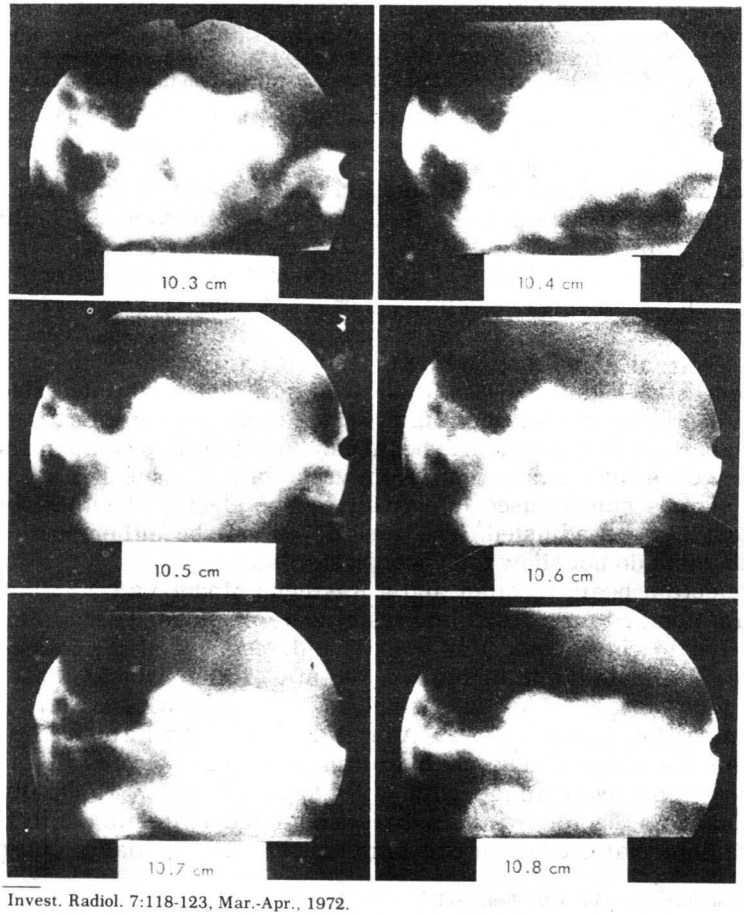
The video information is an ideal form for high-speed electronic processing. It should enhance interpretation of morphologic roentgenographic studies.

► [Videometry of blood vessels is discussed by Doctor Silverman in ***Radiology*** (101:597, December, 1971). It is apparent that videodensitometry is going to have an increasing use in the clinical and laboratory study of pulmonary ventilation and perfusion, and we are all indebted to the author for calling attention to the possibilities of his extension of the methods.

Other densitometric methods are discussed by R. B. George and H. Weill (Fluorodensitometry: A Method for Analyzing Regional Ventilation and Diaphragm Function, J.A.M.A. 217:171, 1971) and by D. C. S. Hutchinson *et al.* (The Measurement of Regional Pulmonary Density, Ventilation and Perfusion by Gamma Ray Densitometry, Brit. J. Radiol. 44:955, 1971).—W.M.W.]

Further Developments in the Use of Holographic Methods for the Storage of Roentgenographic Images are described by Norman A. Baily, Ronald L. Crepeau and Elliott C. Lasser[2] (Univ. of California, San Diego). The goal in holographic research is to perfect a storage system for x-ray films that will reduce cost and space requirements and provide easy recall. It is of utmost importance to prevent deterioration of image quality in this process. As many as 3,000 different 14×17-in. radiographs might be stored on a single 4×5-in. photographic plate. Alternately, 100 roentgenograms might be stored per square inch of photographic emulsion. The original image is reconstructed using the real (holographic) image, which is a high-quality image that may be viewed on television or

Fig. 3.—Six planigraphic sections of temporal bone recorded by direct projection of the real holographic image on sheet film. (Courtesy of Baily, N. A., *et al.*: Invest. Radiol. 7:118-123, Mar.-Apr., 1972.)



Invest. Radiol. 7:118-123, Mar.-Apr., 1972.

by direct projection on a screen. Speckle must be reduced in this system. Moving screens and the use of a less coherent monochromatic beam appear worthy of exploration. The use of closed-circuit television also reduces this source of image degradation.

A revised set-up included a He-Ne (6328 Å.) laser having 4 mw. power. Recordings were made on Kodak 649F high-resolution photographic plates. The reconstruction beam used was made to converge at the plane of diffraction, using a pair of lenses that produced a converging beam with a small area. The results are shown in Figure 3. The examples shown encourage the further development of a high-quality holographic recording and viewing system, which would produce images of diagnostic quality. Although emulsion damage to the hologram reduces brightness and resolution of the resultant image, the holographic recording is reproduced in its entirety, in contrast with other photographic mass storage technics where scratches, dust or film deterioration obliterates parts of the reconstructed image.

Further investigation of holographic storage of roentgenographic images is warranted. Resolution of the holographic camera is greater than 10 line pairs per millimeter. The stored images can be viewed either by closed-circuit television or by direct projection on a viewing screen.

► [With the increasing use of holography in other areas, search has been made for its useful application in radiology, hence the interest in this further report on the storage and retrieval of radiographic images.

The same authors have described another interesting application in "Holographic Imaging of the Vertebral Column," with holographic reconstruction from planigraphic films (Radiology 102:197, 1972).—W.M.W.]

Electron Beam Recorder: Evaluation of Its Use in Diagnostic Roentgenology was carried out by L. S. Carey, G. L. Mansour, E. C. Shaffer and F. A. Hamm[3] (St. Paul, Minn.). The electron beam recorder is an electronic instrument designed to record television signals directly onto 16-mm. film by means of electron exposure. A television camera sends a composite signal to the electron beam recorder which is processed by the video electronics and displayed on a monitor and wave form analyzer. The processed signal drives the electron gun. The modulated electron beam records on conventional film, which is moved continually over a small aperture in the gun. The beam can be adjusted to compensate for differences in the signal arising from variations in tissue density. Weak video signals can be used effectively by the electron beam recorder. Contrast can be adjusted. The recordings can be either positive or negative and do not show television raster lines.

An electron beam recorder and a Raytheon Model XRS-20 television camera modified for a 1,023-line raster were installed. The former was converted to continuous film motion and recorded at 60 frames per second. The installation included a 900-mÅ., 150-kv. single-phase two-pulse generator, an image-intensifier, an x-ray tube with a 1-mm. focal spot and a 16-mm. ciné camera. A brightness level giving an image with tolerable background level of quantum noise was selected. Radiation measurements were made with a Victoreen R-meter. Generally the electron beam recorder recordings were obtained at a significantly lower dosage than that needed for conventional ciné. The spatial resolution of

(3) Radiology 101:105-110, October, 1971.

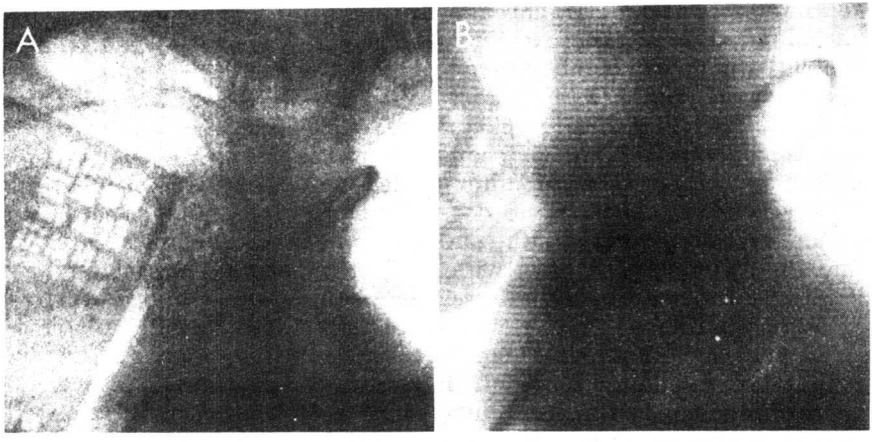


Fig. 4.—Comparison of image quality achieved with conventional 16 mm. ciné (*A*) and 16 mm. electron beam recorder (*B*). An x-ray resolution chart lies on table top beneath chest phantom containing catheter. The film is reversed. (Courtesy of Carey, L. S., *et al.*: Radiology 101:105-110, October, 1971.)

the electron beam recorder recordings was nearly equivalent to that of the ciné recordings (Fig. 4). Resolution of the image-intensifier was the limiting factor in both cases. The vidicon picture tube showed about 15% residual image in the third field with motions significant within $^1/_{60}$ of a second. A plumbicon picture tube showed only about 5% residual image, but its spatial resolution was not as good as that of the vidicon tube. A separate field mesh vidicon tube was then used. It approached 16-mm. ciné in spatial resolution.

Electron beam recording is a convenient method of film exposure at low radiation levels. Satisfactory images of adult human structures can be produced at radiation levels of 1.5-5 R per minute at the table-top level with the tube underneath the patient. Improvement in time resolution must await the development of diminished lag properties, mainly within the television system, combined with spatial resolution at least as good as that of the separate field mesh vidicon tube. The electron beam recorder is compatible with other video equipment and can be used to record previously stored or processed information as well as live signals. With high-quality magnetic recording and data processing, an electron beam recorder could produce high-quality records of anatomic of physiologic information.

► [The reduction in radiation levels with this technic is encouraging, and we look forward to further reports of its use in clinical trials.—W.M.W.]

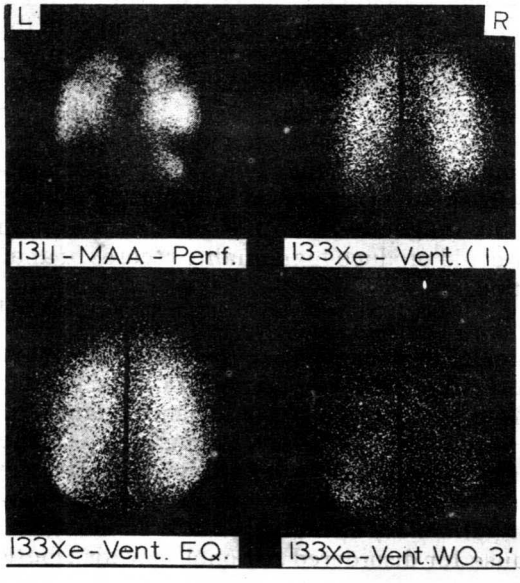
Differentiation of Pulmonary Vascular from Parenchymal Diseases by Ventilation-Perfusion Scintiphotography is described by Kenneth M. Moser, Michel Guisan, Anthony Cuomo and William L. Ashburn[4] (Univ. of California, San Diego). There has been growing disenchantment with perfusion scintiphotography as a definitive diagnostic test for pulmonary embolic disease. The perfusion scan accurately shows the regional distribution of pulmonary blood flow, but it cannot give direct information on the cause for disordered regional flow distribution. Radioxenon

(4) Ann. Int. Med. 75:597-605, October, 1971.

ventilation scintiphotography can distinguish defects due to primary vascular disease and those due to parenchymal lung disease. Integration of ventilation-perfusion scintiphotographic data with pathophysiologic and clinical data has led to the recognition of several distinctive patterns having specific diagnostic implications. Scintiphotos were obtained with a gamma camera. Perfusion scans were made with intravenous injection of macroaggregated albumin labeled with ^{131}I or ^{99m}Tc or ^{133}Xe gas dissolved in saline. Half the dose of albumin was injected with the patient prone and half with the patient supine. Radioxenon was injected into the superior vena cava with the patient supine and holding his breath at functional residual capacity. Ventilation scans were made after the inhalation of radioxenon gas, usually with the patient supine.

Nonperfused lung zones that remain well ventilated are seen in pulmonary vascular diseases. This pattern has been seen in over 20 cases of confirmed pulmonary embolism (Fig. 5). The pattern is also seen in pulmonary artery agenesis and in severe branch stenosis of a pulmonary artery. In parenchymal disease there are nonperfused lung zones that are either nonventilated or poorly ventilated. In the type A pattern, ventilation is absent after the initial xenon breath in the same zones where perfusion is absent, and the affected zones fill slowly on rebreathing of xenon, clearing slowly during washout. This pattern is seen in bullous or emphysematous lung disease and when major bronchi are partially obstructed. In pneumonia or neoplastic infiltration, total bronchial obstruction or cysts or bullae without functional bronchial com-

Fig. 5.—Perfusion scintiphotograph of patient with pulmonary embolism suspected on clinical grounds. Multiple bilateral perfusion defects are shown at upper left. First breath at upper right and equilibrium ^{133}Xe ventilation scan at lower left show homogeneous distribution of ventilation: thus multiple homogeneous V/no Q areas are present. After 3 minutes of washout (*lower right*), ^{133}Xe has cleared rather uniformly from both lungs. (Courtesy of Moser, K. M., *et al.*: Ann. Int. Med. 75:597-605, October, 1971.)



munication, the affected lung zones never fill during rebreathing of xenon (type B pattern).

More quantitative analyses of ventilation-perfusion matches are desirable. Currently the study can greatly help in distinguishing pulmonary vascular from parenchymal disorders. Confusion may arise, however, where infarction or congestive atelectasis develop in embolized areas or where absent or reduced regional blood flow is based on vasoconstriction rather than on anatomic absence or obstruction.

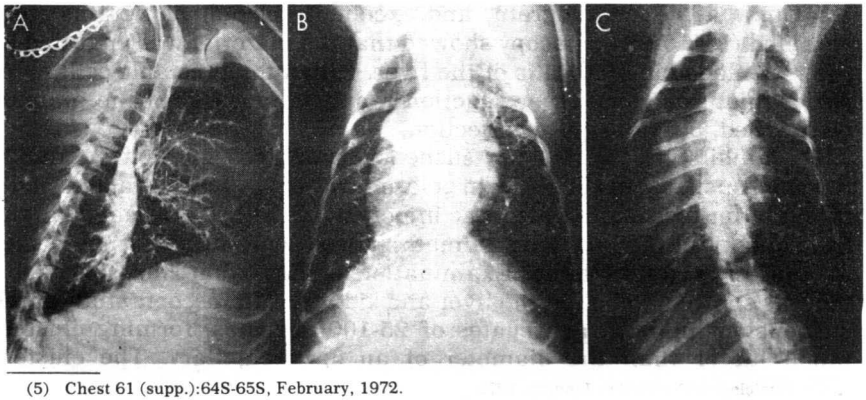
► [The pinpointing of differential diagnostic considerations by these combined technics is impressive. They will undoubtedly be used more widely.—W.M.W.]

Radiopaque Fluorocarbon: New Agent for Studying Pulmonary Structure and Function. David M. Long, Mai Liu, Paul S. Szanto and Paul Alrenga[5] developed two radiopaque perfluorocarbon compounds, perfluoroctylbromide and perfluorohexylbromide, to delineate pulmonary structure and certain facets of function. These compounds have little toxicity when administered into the lungs either by tracheal injection or immersion of the animal in liquid.

Hamsters were immersed for 1-10 minutes in oxygenated brominated perfluorocarbon, and x-rays were taken for 24 hours afterward. Liquid perfluorocarbon was given to dogs by tracheal instillation. Emulsions of perfluorocarbon in lactated Ringer's solution were made using Pluronic F-68 to provide a viscous medium to coat the tracheobronchial tree. Emulsions with a concentration of 8:1 to 12:1 volumes of perfluorocarbon to aqueous medium were most useful.

Hamsters tolerated 1 minute of immersion without mortality. Disappearance and vaporization rates were slower for the 8- than for the 6-carbon perfluorocarbon compound. Different disappearance rates in various parts of the lungs resulted in x-ray delineation of lobar and sublobar structure. No radiopacification of the tracheobronchial tree was obtained with liquid breathing. Immediate alveolization occurred, with excellent radiopacification of the parenchyma. High-quality tracheobronchograms were obtained with emulsions of brominated perfluoro-

Fig. 6.—Chest x-ray film of dog receiving a 10:1 emulsion of perfluoroctylbromide in a dosage of 4 ml./kg. *A*, excellent visualization of tracheobronchial tree at 7 minutes after administration. Rapid clearance resulted in spillover into esophagus with radiopacification of this structure. *B*, minimal residual radiopacification of tracheobronchial tree 3 hours later. *C*, no residual radiopacification of pulmonary structures 24 hours later. (Courtesy of Long, D. M., *et al.:* Chest 61 (supp.):64S-65S, February, 1972.)



(5) Chest 61 (supp.):64S-65S, February, 1972.

carbon. The brominated perfluorocarbon was less radiodense than propyliodone, but visualization of the tracheobronchial tree was superior (Fig. 6). Clearance of radiopaque perfluorocarbon was complete within 6 hours; no residual radiopacification was seen at 24 hours. Examination of the lungs showed nonstaining vacuoles in lung macrophages for up to 3 weeks after exposure, but no fibrosis or granuloma formation was seen after 6 months. Clearance of the emulsion was primarily by mucociliary action. Blood gas studies in lightly anesthetized dogs given pertracheal injections of 1 ml. of 10:1 emulsions of perfluoroctylbromide and propyliodone showed no significant changes for up to 3 hours after administration of these agents.

These results are encouraging. The brominated perfluorocarbon compounds have satisfactory properties of radiodensity and low surface tension. They are chemically nonreactive at body temperature and are nonionic. Additional advantages are the high oxygen solubility and diffusability. The biologic behavior of the compounds permits studies of structure and function to be done with routine x-ray technic and equipment.

► [The search for new bronchographic mediums goes on and has uncovered these interesting compounds. It will be interesting to see if more extensive animal work will justify some human trials in the future.—W.M.W.]

Feasibility Study of Splenohepatography with Tantalum Metal and Tantalum Pentoxide. C. Gianturco (Univ. of Illinois), Byron Ruskin (Mattoon, Ill., Mem'l Hosp.), F. R. Steggerda and Toru Takeuchi[6] (Univ. of Illinois) felt that, if metallic tantalum powder could be suspended in a suitable fluid for injection intravenously, it would behave like Thorotrast and be deposited in the reticuloendothelial cells of the liver and spleen. Suspensions of tantalum in dextrose, dextrin and gum arabic were prepared, using 25% of each in distilled water or normal saline. The best suspensions were those made with dextrin, but even these settled shortly after blending. Most animals given dextrin-tantalum suspension in a dose of 1.5 Gm. metallic tantalum per kilogram, using a pump syringe that agitated the suspension during injection, died of pulmonary embolization. Surviving animals showed good visualization of the liver and spleen. Tantalum pentoxide (Ta_2O_5) was then tried; it has a particle size of 0.5μ. This compound was much easier to suspend in distilled water and dextrin. Five rabbits and 5 dogs showed no immediate reactions to 1.5 Gm. Ta_2O_5 per kilogram, and excellent splenohepatograms were obtained (Fig. 7). Microscopy showed that the material was engulfed by the reticuloendothelial cells of the liver, without appreciable cellular or pericellular reaction. Liver function remained good until the animals were killed, 5 months after injection.

Ten rabbits were given new suspensions of Ta_2O_5 in dextrin, and 27 received suspensions of Ta_2O_5 in gelatin. One of the former rabbits and 6 of the latter died shortly after the injection, all with Ta_2O_5 emboli in the liver and kidneys. Surviving animals showed some emboli at these sites at autopsy 2 weeks later. Examination of dogs that had survived 5 months showed emboli in the liver and kidneys. Microscopic study of the suspensions showed aggregates of 25-100 particles, forming clusters much larger than the diameter of an open capillary. The clusters

(6) Radiology 102:195–196, January, 1972.