Title
Body imaging in nuclear medicine

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BODY IMAGING IN NUCLEAR MEDICINE

by

Lori L. Semeniuk
B.A. University of California, Santa Barbara 1976

THESIS

Submitted in partial satisfaction of the requirements for the degree of

MASTER OF ARTS

in

Medical and Biological Illustration

in the

GRADUATE DIVISION

of the

UNIVERSITY OF CALIFORNIA

San Francisco

[redacted]

Date University Librarian

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FORWARD

This thesis project is in partial fulfillment of the requirements for the

Master of Arts Degree

from the

University of California San Francisco

Program in Medical

and Biological Illustration

The printed brochures, BODY IMAGING IN NUCLEAR MEDICINE, are available in Room S-455, Nuclear Medicine Department of The University of California San Francisco Medical Center. Subtitles of the seven brochures are:

1. Whole Body Imaging
2. Imaging The Heart
3. Thyroid Imaging
4. Liver and Gallbladder Imaging
5. Head Imaging
6. Kidney Imaging
7. Lung Imaging

Copies are also filed with this thesis.

BODY IMAGING IN NUCLEAR MEDICINE

In the spring of 1979, Ms. Marcie Osborn, B.A., C.N.M.T., approached the Director of the UCSF Graduate Program in Medical and Biological Illustration about the need for an informational booklet for Nuclear Medicine patients. As a student project in the Nuclear Medicine Technology Program at UCSF she had written a text that was being given to patients in xeroxed form. Ms. Osborn wanted this information to be published with appropriate illustrations. Moffitt Hospital Administration had been approached and later agreed to fund the printing and basic art costs for a sixteen-page booklet.

I undertook the task as my thesis/project with the agreement that I would rework the format and text so that optimum communication would take place. The existing text was wordy, technical and appropriate for medically sophisticated readers. Since patients were the population which would read the booklet, I decided that the text needed extensive revision and simplification.

Technical, unfamiliar terms are often used by medical and paramedical personnel when describing diagnostic tests and procedures to patients. As a result, a communication gap may arise between a physician or nuclear medicine technologist and the patient who is not knowledgeable in the subject. This gap may become a significant impediment to the therapeutic relationship between physicians and patients if the patient, because of fear and confusion, gives up participation in a decision that will affect his or her well-being.

Deciding what is "correct" for the average patient is problematic since a patient can be five years old or eighty, college-educated or barely able to understand English. After spending several hours in the Nuclear Medicine waiting area it became evident to me that the common denominator among patients was that they were sick, worried and tired.

Patients who come to Nuclear Medicine for a diagnostic test must wait anywhere from five minutes to three hours between the first part of their procedure and its completion. The proposed booklet can be read during this waiting period. It provides information that will encourage questions and increase knowledge about the relevance of Nuclear Medicine techniques for the patient. Technologists who administer diagnostic tests in Nuclear Medicine "talk" each patient through a procedure, giving pertinent information and answering questions. The booklet is conceived as a primer to support this interaction.

Several meetings were held with my thesis committee (consisting of the three faculty members of the Graduate Program in Medical and Biological Illustration) to determine the objectives to be met by the booklet. Following these brainstorming sessions, careful study of the submitted text, conversations with staff and patients in Nuclear Medicine, and further research into the diagnostic procedures available, several decisions were made.

Foremost, the booklet should be warm, human, brief and easy to understand. Further, it should be interesting to look at and informative and should not alarm its readers. Complex information could be included but explanations must be simple and direct for all readers to understand.

I proposed that the booklet begin with general information about Nuclear Medicine, such as what radionuclides are and how they are introduced into the human body. Following this, about ten separate procedures would be described in detail, including a brief description of the radionuclide material used in each procedure and the amount of time needed for it to concentrate in a specific organ system.

Since a patient usually has just one test, limiting the technical information in the booklet to a single procedure seemed appropriate. In this way, a patient would not be overwhelmed by potentially confusing and extraneous information. Many heart patients, for example, are seriously ill and fatigue easily.

As a result, I designed a format that makes it possible to have seven different brochures printed for about the same cost as one larger more comprehensive booklet. Each patient will receive only the specific brochure which describes the procedure he or she is about to undergo.

The brochures reassure patients that there is almost no risk involved in diagnostic procedures in nuclear medicine. They will inform patients and concerned family and friends that only trace amounts of radionuclides are used, about what to expect during a specific procedure and how much time the experience will take.

In the final design, accordion-like folds divide the printed page into six panels of progressively wider width. These folds allow two panels to be opened at one time or the entire page to be opened up if desired. Illustration and/or textual information appear on both the front and back of every panel. The brochure folds into a 9¼" x 4" size which will fit into a standard envelope. It can be sent to a patient a few days before the test--and it can also be handed to a patient in the clinic and will fit easily into a pocket or purse to be taken home and reread later.

The brochure is printed on a middle value tan paper stock in red and brown ink because these three colors are perceived psychologically as warm. Tan is a color close to skin color and the value chosen softens the contrast between ground and the printed type and drawings.

The title for the brochure mutually agreed upon by the client and myself is "Body Imaging in Nuclear Medicine." Both the title and subject matter are amenable to a drawn image of the human body, a simple outlined image probably the most appropriate. At first I worked to develop a very simplified human form with no detailing--just simple shapes. In one thesis committee meeting we began to discuss the possibility of using a classical form. This idea excited me.

Nuclear Medicine exemplifies sophisticated new medical technology. I decided that the brochure should reflect graphically this sophistication and contemporariness. The fusion of contemporary with a classical figure is appropriate since the human body has remained relatively unchanged through the ages while medical techniques have advanced enormously.

I therefore scanned art history books for an image or idea that would work. I looked at drawings by Michaelangelo, Leonardo da Vinci, Durer and other old masters and finally came upon three Durer figures from a series of studies he had made on proportions of the human form. One figure portrays the human body in profile, another a frontal view of the same body and the third the back of the figure. These drawings appeal to me because they are of a female who is not unrealistically beautiful--not idealized. The figure, in fact, is almost androgynous.

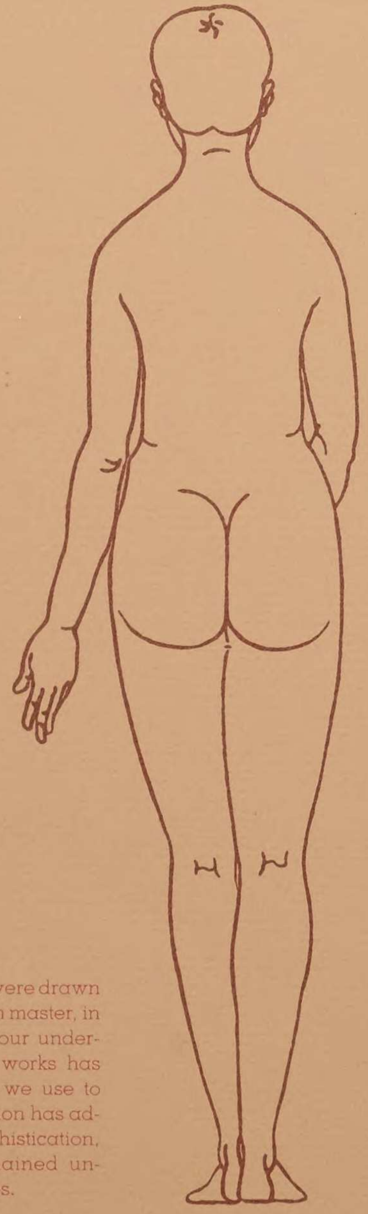
I wanted the front and back of the brochure, when folded, to be related. It will be given to patients and looked at first in folded form. The Durer profile placed on the title page and the drawing of the back of the figure on the back work perfectly in making this connection. The frontal view is used on the front side of the brochure in the middle of the page to show the specific organ involved in a particular procedure in its correct anatomic position. In diagnostic Nuclear Medicine, radioactive material is taken into a patient's body. The organ to be studied collects the radioactivity and literally "lights up" that organ on film.

I chose Stymie as a typeface since it is contemporary and easy to read yet retains classical qualities. I purposely chose a large body type size (12 point light with 2 points of leading) to increase ease of reading.

Although the panel widths vary in size because of the folding, I decided to keep the type in blocks of one standard width. By justifying both the left and right margins, clean blocks of type result. Last minute changes in spacing were easier and cheaper to handle in the paste-up since one standard width was used. The height of the Durer figures determined the top and bottom type block margins. Some brochures contain less information than others. This is fine so long as consistency is maintained. In those instances where a column of type is very short, the type block sits on the bottom margin of that panel.

My task in designing this educational brochure was to transmit information, terminology and basic concepts of diagnostic nuclear medicine to patients undergoing these procedures. To accomplish this, I felt it important to observe the procedures, talk to the patients and the technologists and then use this experience as the basis for my design. As a medical illustrator I have been trained to synthesize available information, do whatever research is needed and make sure a balance exists between aesthetics and ease of communication.

I chose the project because I would be designing and creating a product that would, in fact, be used by real patients. The need for a patient booklet had been established and funding procured. The accompanying seven brochures are my solution to the communication needs between medical personnel and patients in the Nuclear Medicine Department.



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SPECIAL CASES

PREGNANCY AND BREAST FEEDING

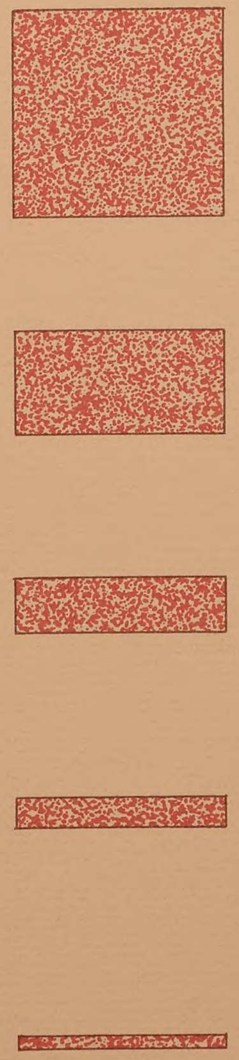
For pregnant patients, organ imaging procedures are restricted because of danger to the fetus. A dose of radioactive isotope that is correct for the mother is much too large for the developing fetus. If you suspect that you might be pregnant, PLEASE TELL OUR TECHNOLOGIST. If you are breast feeding your baby, testing may also be postponed.

CHILDREN

Organ imaging procedures on children are similar to those on adults but a much smaller dose of radioactive isotope is administered, since dosage is determined by the patient's weight.

HOW LONG DOES A RADIONUCLIDE STAY IN YOUR BODY?

All radioactive materials are measured by their half-life: the amount of time it takes for ½ of the material to disappear by means of radioactive emission. For example, if technetium, a commonly used isotope with a half-life of 6 hours, is injected at noon on Monday, by 6 p.m. on the same day only ½ of the original dose will still be in your body. This isotope continues to decay by ½ every 6 hours until it is all gone. So by noon on Tuesday (4 half-lives later) 1/16 of a dose would remain. What we have discussed is a physical half-life of the isotope. Your body further removes isotopes by excreting them in the urine and stool. This process is called the biological half-life. Together, the two processes rapidly remove radioactive materials from your body.



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SCANS DIFFER FROM X-RAYS

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BODY IMAGING
IN NUCLEAR MEDICINE

P1

Design and Illustration
LORI L. SEMENIUK, M.A.
UCSF Graduate Program in Medical and Biological Illustration

Written by
MARCELLINE OSBORN, B.S., C.N.M.T.
and LORI L. SEMENIUK, M.A.

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The procedure starts when a radioactive compound is either injected into a vein in your arm or swallowed. The compound is called a radionuclide or radiopharmaceutical and is specially designed for your test. The compound is a harmless chemical, with a radioactive isotope attached to it, which concentrates in a particular organ. The dose of radiation is in trace amounts. The procedure, almost without exception, is painless and the technologist who administers the compound takes every precaution for your safety.

We use a different radiopharmaceutical for each organ we test. Once the radioactive material reaches the organ to be studied, our highly sensitive cameras are able to detect and record the concentrated material because it gives off thousands of tiny radiation particles. The particles are recorded as dots on a piece of film (the scan), and show the size and shape of the organ. All these factors help our physicians, who specialize in nuclear medicine, make an interpretation of your scan.

The time needed for a radiopharmaceutical to reach the organ of interest varies. Some take as little as 15 minutes while others take 3 hours or longer. When the proper time has elapsed, the picture taking begins.

THYROID IMAGING

Because of symptoms you have described to your own doctor, a thyroid gland disorder may be suspected. Three different routine thyroid function tests are performed: a fluorescent thyroid scan, a thyroid uptake, and a radionuclide thyroid scan. They are usually performed over a 2-day period and often require fasting (from midnight) before the tests begin. In addition, you should notify the technologist about any medication you are taking that contains iodine or about any x-ray studies you have had in the last 6 months in which dye (contrast medium) was used. Iodine and contrast media can interfere with the results of thyroid tests.

FLUORESCENT THYROID SCAN

A fluorescent thyroid scan is one of the few tests that does not require swallowing or receiving an injection of radioisotope. As you lie on a table, a mechanical detector will move back and forth across your neck. The detector will record on film the amount of inorganic iodine naturally occurring in the thyroid. The scanning takes about 30 minutes and during that time you must lie very still and try not to swallow.

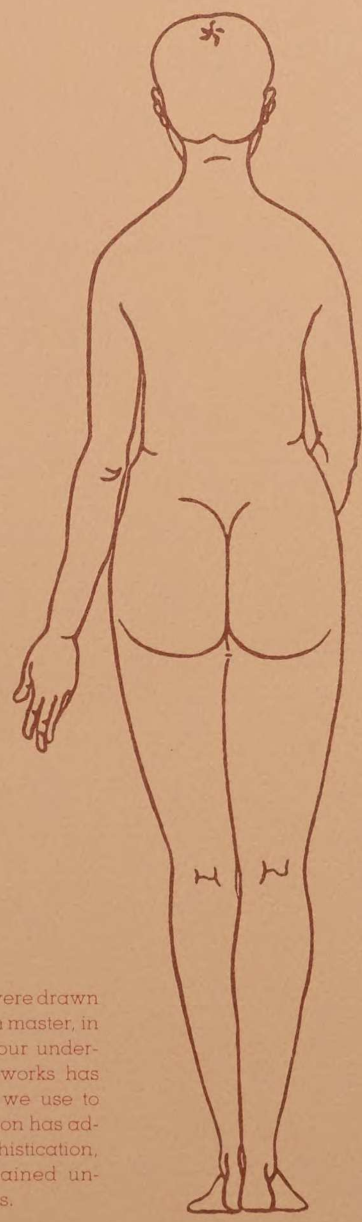
THYROID UPTAKE

You will be asked to drink a colorless and tasteless liquid called radioiodine and to return 3 to 5 hours later for measurement of the amount of radioiodine that has settled in your thyroid gland. You will then be asked to come back again 24 hours later to measure the amount of iodine remaining in the thyroid gland.

RADIONUCLIDE THYROID SCAN

Your doctor can tell from a thyroid scan how well your thyroid gland is working. This test is performed 3 to 5 hours after your drink of radioiodine (for the thyroid uptake). You will lie on a table as in the fluorescent scan and the detector will record on film all areas where radioiodine has concentrated.

YOUR SCAN



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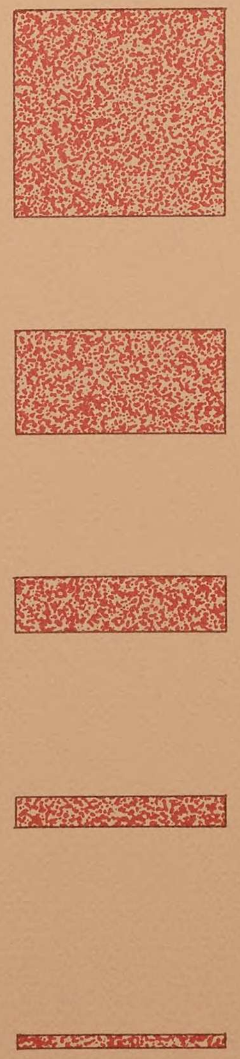

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P.2

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IMAGING THE HEART

WALL MOTION STUDIES

Wall motion (cardiac equilibrium) studies help to determine how much the wall of your heart moves as your heart beats. Two injections are given, ½ hour apart, for radioactive labeling of the red blood cells. An electrocardiogram (EKG) will be taken to synchronize your heart beat with pictures of your heart taken from several angles. The pictures record the isotope as blood is pumped through your heart. About 1 hour is needed for the entire procedure.

MYOCARDIAL INFARCTION

This test is prescribed for patients after open heart surgery or when a heart attack is suspected. It takes 3 hours after injection for the isotope (technetium pyrophosphate) to concentrate in any nonfunctioning areas of your heart. Resulting pictures show portions of your heart muscle which fail to function. Picture taking lasts 25 minutes.

MYOCARDIAL PERFUSION

Exercise. A myocardial perfusion test may be recommended for any shortness of breath or chest pain when you exercise. The doctor will determine what your maximum heart rate should be and you will then exercise on a treadmill to reach that rate as your EKG and blood pressure are observed. You will receive an injection of radionuclide (thallium) and after a short wait, we will begin to take pictures. The radionuclide will concentrate in those portions of your heart that have good blood supply. The whole test takes about 2 hours and you will be asked not to eat anything for the preceding 4 hours.

Rest. If you are unable to exercise, your doctor may request a rest study. You will be given an injection (thallium) and after 15 minutes picture taking will begin.

MYOCARDIAL REDISTRIBUTION

This test is a continuation of the exercise test, after a 3-to-4-hour waiting period. The test tells your doctor how your heart reacts over time compared with its response to peak exercise.

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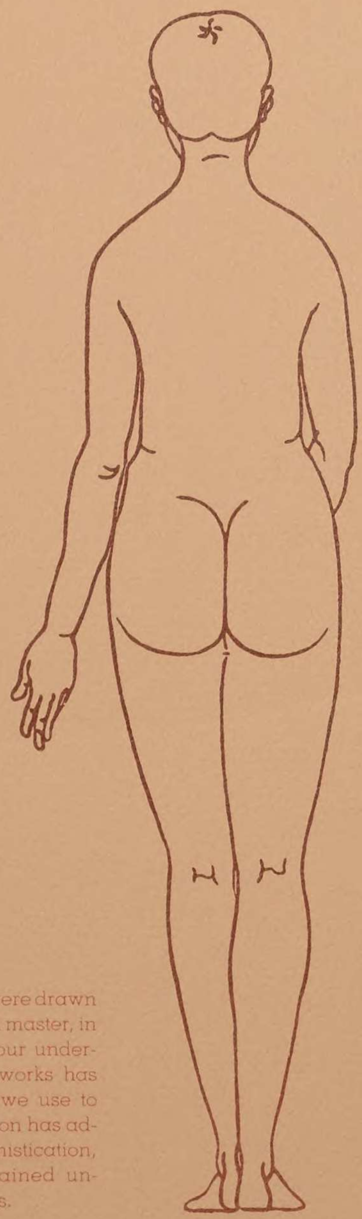

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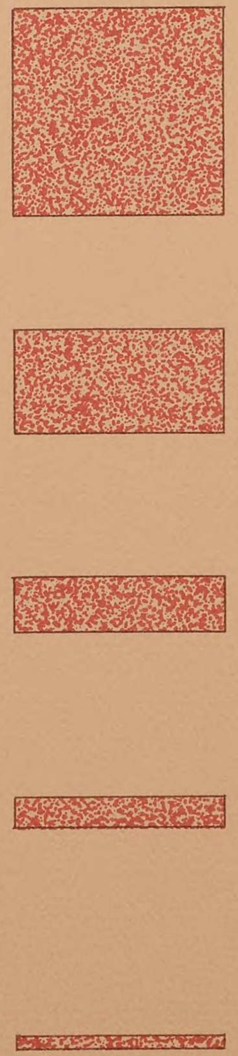

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WHOLE BODY IMAGING

BONE SCAN

We can diagnose bone infections, arthritis, bone fractures, and some cancers with a whole body bone scan. After we inject you with the appropriate radionuclide, you must wait 3 to 4 hours for the substance to concentrate in your bones.

You may leave the Department during this waiting period. You should drink extra fluids between the time of injection and time of the scanning. You will need to empty your bladder several times while waiting and again immediately before the scanning. This is important because your body eliminates radioactive isotopes through the urine and a full bladder masks the pelvic bones which we need to study.

The scanning itself takes about 1 hour. Pictures are taken of every bone in your body, front and back, from head to foot. You must lie perfectly still on the examining table to make the pictures clear. Our tables have mattresses, however, so there is very little discomfort involved.

ABSCESS OR TUMOR SCAN

Gallium is the radionuclide used to detect abscesses and tumors. We will inject you with gallium on one day and will need you to come back 24 to 48 hours later and on several consecutive days to have additional pictures taken. In most instances, you will not need a second injection of isotope. The photographic procedure is similar to a bone scan because you lie on a table and are photographed from head to foot. Each time you come back, scanning will take about 1 hour.

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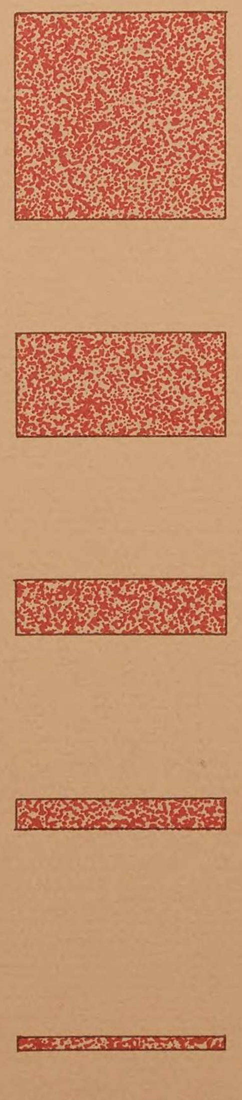

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HEAD IMAGING

BRAIN SCAN
A brain scan has two parts: a "flow" study and a "static" study. The flow study shows blood circulating to your brain. For this part of the test, a rapid series of pictures will be taken just after you have received an injection of radioactive material.

The static study shows the entire supply of blood to your brain. This study is begun 1½ hours after the flow study injection. You are required to sit or lie down while several 5 minute pictures are taken. Brain scan pictures are developed immediately and are shown to the doctor, who will determine whether additional pictures are needed to make a better diagnosis.

The total time required for the flow study is 10 minutes and for the static study 30 to 45 minutes.

CISTERNOGRAM
A test that demonstrates the ventricles of the brain is called cisternography. After the radionuclide is injected, the flow of spinal fluid into the ventricles is imaged. Picture-taking is done several times: 2 to 5 hours, 24, 48, and 72 hours after injection. Each picture taking session will take about 30 minutes.

YOUR SCAN

BODY IMAGING
IN NUCLEAR MEDICINE

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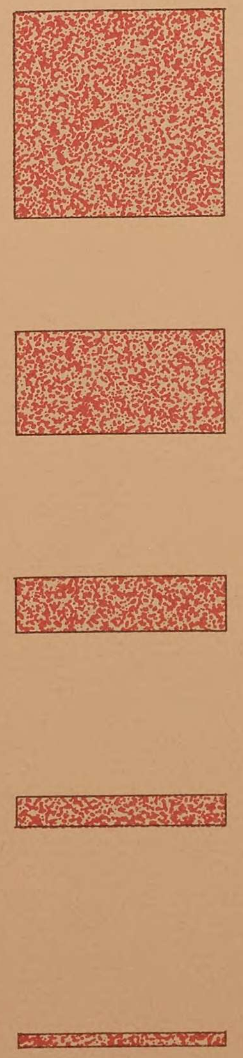
SCANS DIFFER FROM X-RAYS

For radionuclide imaging, a radioisotope is introduced into your body. The radioisotope is not a dye but a radioactively labeled material that concentrates in one organ or area of your body. The isotope follows the metabolism of the organ and we can thus trace its function. The material concentrates in the desired organ and emits radiation capable of exposing film. On the other hand, in diagnostic radiology, x-rays pass from a machine through your body and, in turn, expose film.

STAY IN YOUR BODY?



HOW LONG DOES A RADIONUCLIDE

All radioactive materials are measured by their half-life: the amount of time it takes for ½ of the material to disappear by means of radioactive emission. For example, if technetium, a commonly used isotope with a half-life of 6 hours, is injected at noon on Monday, by 6 p.m. on the same day only ½ of the original dose will still be in your body. This isotope continues to decay by ½ every 6 hours until it is all gone. So by noon on Tuesday (4 half-lives later) 1/16 of a dose would remain. What we have discussed is a physical half-life of the isotope. Your body further removes isotopes by excreting them in the urine and stool. This process is called the biological half-life. Together, the two processes rapidly remove radioactive materials from your body.

SPECIAL CASES

PREGNANCY AND BREAST FEEDING
For pregnant patients, organ imaging procedures are restricted because of danger to the fetus. A dose of radioactive isotope that is correct for the mother is much too large for the developing fetus. If you suspect that you might be pregnant, PLEASE TELL OUR TECHNOLOGIST. If you are breast feeding your baby, testing may also be postponed.

CHILDREN
Organ imaging procedures on children are similar to those on adults but a much smaller dose of radioactive isotope is administered, since dosage is determined by the patient's weight.

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Design and Illustration
LORI L. SEMENIUK, M.A.
UCSF Graduate Program in Medical and Biological Illustration

Written by
MARCELLINE OSBORN, B.S., C.N.M.T.
and LORI L. SEMENIUK, M.A.

DIAGNOSIS

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The procedure starts when a radioactive compound is either injected into a vein in your arm or swallowed. The compound is called a radionuclide or radiopharmaceutical and is specially designed for your test. The compound is a harmless chemical, with a radioactive isotope attached to it, which concentrates in a particular organ. The dose of radiation is in trace amounts. The procedure, almost without exception, is painless and the technologist who administers the compound takes every precaution for your safety.

We use a different radiopharmaceutical for each organ we test. Once the radioactive material reaches the organ to be studied, our highly sensitive cameras are able to detect and record the concentrated material because it gives off thousands of tiny radiation particles. The particles are recorded as dots on a piece of film (the scan), and show the size and shape of the organ. All these factors help our physicians, who specialize in nuclear medicine, make an interpretation of your scan.

The time needed for a radiopharmaceutical to reach the organ of interest varies. Some take as little as 15 minutes while others take 3 hours or longer. When the proper time has elapsed, the picture taking begins.

LIVER AND GALLBLADDER IMAGING

LIVER AND SPLEEN IMAGING

Liver and spleen scans allow the doctor to see whether there are any structural defects in your liver or spleen. We will inject a radiopharmaceutical and then you must wait about 15 minutes before picture taking can begin. You will be lying down and can expect 7 pictures to be taken: 3 of the front, 2 of the back, and 1 of each side. You can plan to be in the Department for about 45 minutes.

BILIARY IMAGING

Biliary imaging allows the doctor to visualize the gallbladder. After injection of the radiopharmaceutical, several pictures are taken over a period of about 1 hour. The doctor may request that additional pictures be taken the same day or the next day.

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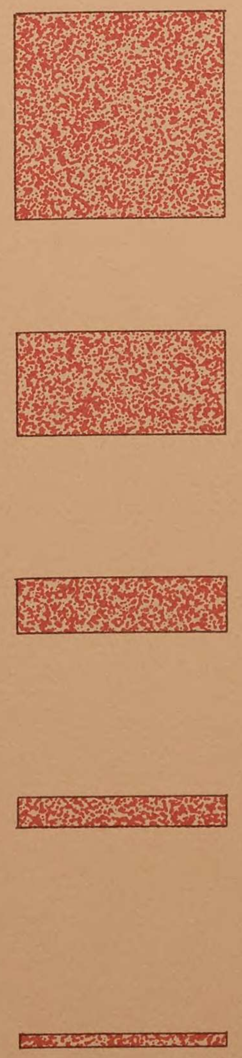

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LUNG IMAGING

A lung scan has two parts. A ventilation study is always done first and takes about 25 minutes. During this part you will be sitting or lying down while breathing an odorless mixture of air and radioactive gas called xenon. A special breathing apparatus is used that is similar to the snorkling equipment of scuba divers. While you are breathing the xenon-air mixture, pictures will be taken of your lungs. This procedure is painless.

The second half of the lung scan, called the perfusion test, shows the flow of blood to your lungs. For this we begin taking pictures immediately after a radionuclide is injected.

The combined lung scan requires about 45 minutes to complete.

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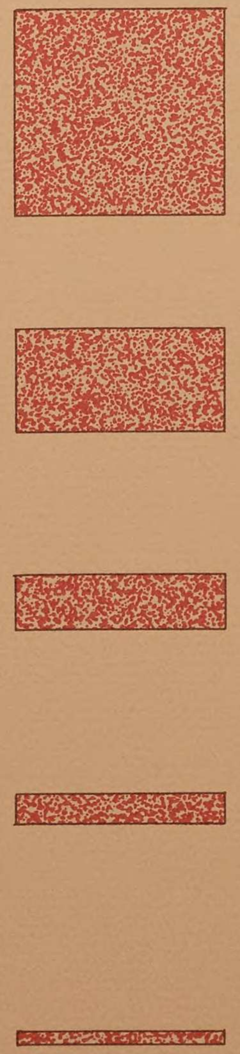

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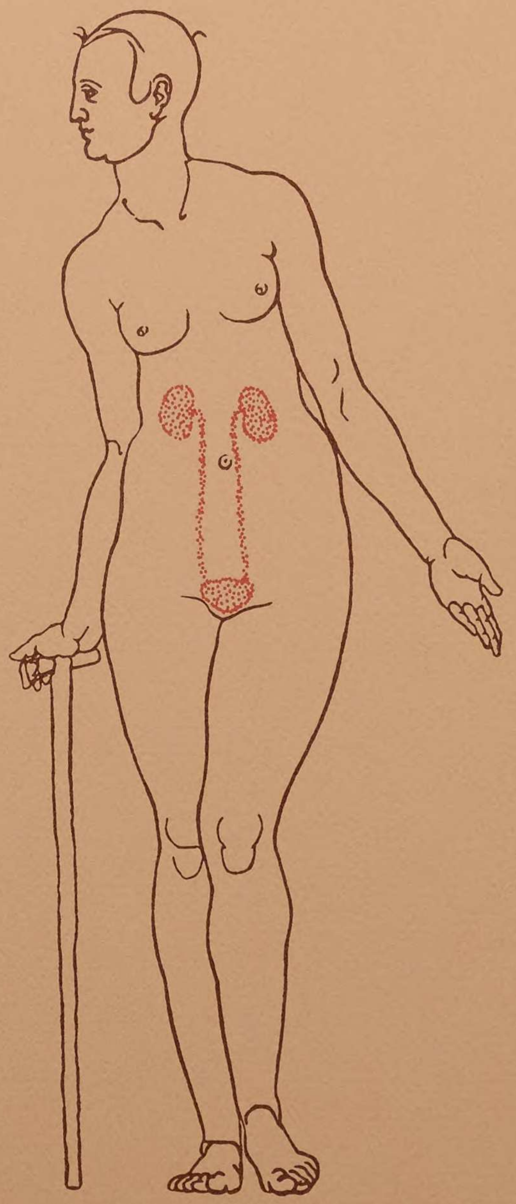

KIDNEY IMAGING

If you have had a kidney transplant, the best method to determine how well your transplanted kidney is working is by renal scanning. You may need additional renal scans throughout your recovery period, but these will be ordered by your own doctor as necessary. Renal scans are also used for patients who have impaired kidney function caused by other diseases.

Before your renal scan you will be given a drink of Lugol's solution, a nonradioactive iodine. The Lugol's solution will collect in your thyroid gland and keep it from taking up the radioactive iodine used for the renal scan. Your kidneys can then take up the radioactive iodine to produce readable pictures.

The procedure is simple. Two radioisotope injections are required. The first, radiolabeled technetium, helps the technologist position the kidney and bladder on the viewing screen to guarantee the best picture. The second injection, a radioiodinated compound, permits a series of pictures of the blood flowing into your kidney. These pictures help the doctor to determine whether your kidney is making urine. The whole test usually takes about 1 hour.

YOUR SCAN