LESSON ASSIGNMENT

LESSON 1
Special Considerations in Radiography and Fluoroscopy.

TEXT ASSIGNMENT
Paragraph 1-1 through 1-27.

LESSON OBJECTIVES
After completing this lesson, you should be able to:

1-1. Successfully answer questions on the skeletal system, fluorography, spot-film radiography, serialography, stereoradiography, fluid level radiography and soft-tissue radiography.

SUGGESTION
After completing the assignment, complete the exercises at the end of this lesson. These exercises will help you to achieve the lesson objectives.
LESSON 1

FLUOROSCOPIC AND SPECIAL RADIOGRAPHIC EQUIPMENT

Section I. FLUOROSCOPY

1-1. GENERAL

a. Fluoroscopy is one of two general methods of radiographic examination by which an image is produced on the fluorescent screen when the part to be examined is interposed between the energized tube and the fluoroscopic screen. One great difference between the fluoroscopic image and the conventional radiographic image is that the former persists only during x-ray excitation of the screen, thereby permitting only limited time for examination, whereas the latter is a permanent record that can be studied at leisure. Another difference is that in the fluoroscopic image the dense portions of the part under examination appear as dark areas on the screen and the radiolucent portions as light areas whereas the reverse is true of the radiographic image. For instance, the lungs would appear lighter than the heart in a fluoroscope examination but in a radiograph, they would look darker.

b. Fluoroscopy permits observation of gross physiology, which is that physiology concerned with motion of the heart, diaphragm, and alimentary tract; transport of contrast media through the alimentary tract; and so forth. The great value of fluoroscopy lies in the opportunity for correlation of anatomy and physiology, normal or abnormal. Added value accrues through the ready alteration of the patient’s position under fluoroscopic observation. This serves to localize an abnormality in relationship to other structures and to establish which positions will be advantageous in radiography. Furthermore, procedures such as progressive filling of sinus tracts or the bronchial tree with contrast medium may be guided fluoroscopically to ensure that films will be exposed at the proper time (that is, neither incomplete outlining nor overfilling).

1-2. APPARATUS

The principal components (in addition to generator, controls, and so forth) required for the production and management of the fluoroscopic image are as follows:

a. X-ray Tube. The x-ray tube is usually located under the table and is attached to the fluoroscopic tower. It is the source of x-rays for excitation of the fluoroscopic equipment. The National Committee on Radiation Protection and Measurements and TB MED 521 specify that the tube-tabletop distance will be not less than 15 inches (38 cm). TB MED 521 further specifies that the total permanent filtration in the useful beam shall be at least 2.5 mm aluminum equivalent.
b. **Fluoroscopic Shutters.** The fluoroscopic shutters limit the area of the screen illuminated by x-rays. They not only reduce the area of irradiation, but also lessen the effect of SR (scattered radiation or secondary radiation) on patient, staff, and fluoroscopic image. TB MED 521 specifies that the useful beam must be restricted to an area that is less than the lead barrier. When the shutters are open to their fullest extent, they should leave a margin of at least 1/4 of an inch of illuminated fluorescent screen with the screen at its greatest practical distance from the tube.

   c. **Image Intensifier.** The image intensifier replaced the fluoroscopic screen, a sheet of leaded glass with zinc-cadmium sulfide coating. The image intensifier is a complex device that receives the remnant x-ray beam, converts it into light (figure 1-1) and increases the light intensity. It is usually contained in an evacuated glass envelope for structural support. The image intensifier is usually mounted with in a metal container to protect it from rough handling.

![Image Intensification Tube Diagram](image)

**Figure 1-1.** An image intensification tube.

### 1-3. PATIENT, FOCAL SPOT, AND SHUTTER RELATIONSHIPS

Starting from the focal spot, the path of the x-ray beam passes through the filters (inserted between the exit portal of the tube and the shutter), the "open" portion of the shutter, the table top, the patient, the grid (if used), and the image intensifier, the beam is stopped and captured at the input phosphor. The lead glass (which stops most of the x-ray beams) provides protection from the CR for the specialist and radiologist. In the typical fluoroscopic assembly, the tube, shutter, and fluoroscopic screen are arranged to always move together, in any direction, at right angles to the path of the CR. The relationships of the tube-to-screen and of the part-to-screen distances affect magnification and distortion of the image, just as in radiography.
1-4. TECHNICAL FACTORS

Modern fluoroscopic equipment has computer controlled preset techniques. However, if the automatic controls are turned off, the average machine settings for fluoroscopy range from 0.5 to 5 mA (milliamperes), and 90 to 120 kVp (kilovolts peak). Positioning for fluoroscopy depends upon the part to be examined and the patient's condition. In general, part or all of the chest, upper gastrointestinal, and bronchial fluoroscopic examinations are performed with the patient erect; colon and myelographic examinations are usually made with the patient lying on the x-ray table.

1-5. EXAMINATION TECHNIQUE

Examination techniques vary not only for different types of examinations, but also from radiologist to radiologist. Each radiologist develops his own routine procedure for a given examination. All these methods require teamwork between the examiner and the specialists; hence, each must be familiar with the routine procedure to expedite the examination. Chest fluoroscopy usually precedes a gastrointestinal examination and is done with the patient upright if his condition permits. It consists basically of examining the various portions of the chest in various projections and phases of respiration; a swallow of barium paste is used to outline the esophagus. Upper gastrointestinal fluoroscopy is performed with the patient upright at first, later horizontal. Colon studies require the patient to be in a horizontal position. The specialist must know when the radiologist wants a cup of barium mixture handed to the patient, when the empty cup is to be taken from the patient, and when the table is to be tilted in a different position. The radiologist, in turn, seeks to guide the specialist by adhering to a routine in his examination and in his remarks to the patient. The specialist knows, for example, that when the examiner tells the patient, "Face me, now," the next step will be to hand the patient the glass of contrast medium. The patient is not dark-adapted. Therefore, when he steps into the “dark” room, he requires guidance. Effort must be made to allay his worry and fear of the examination. The patient's peace of mind must be assured.

1-6. PROTECTION

The following precautions will be observed:

a. A diagnostic-type protective tube housing will be used with equivalent of 2.0 mm lead (IAW TB MED 521).

b. Distance should be utilized as a protective measure. Radiologic technologists must remain away from the fluoroscopic unit whenever their services are not required in the examination. Decreased distance from the source of both primary and secondary radiation accounts for a greater radiation exposure to the radiologist and radiologic technologist during horizontal, as opposed to vertical, fluoroscopy.
c. Time (duration of exposure) should be kept at a minimum compatible with the completion of the examination. TB MED 521 requires that a manual reset, 5-minute cumulative timing device be used to indicate elapsed time of exposure and to "turn off" the tube energizing circuit at the end of 5 minutes.

d. The size of the field should be kept at a minimum to decrease the amount of scatter radiation and tissue irradiation.

e. The dose rate measured in the CR at tabletop will not exceed 10 roentgens per minute (R/min) for fluoroscopic equipment with automatic exposure control, except during cinefluorographic and spot films. Equipment without automatic exposure control will not exceed 5 R/min.

f. Lead gloves and apron will be worn by the radiologist and by the specialist, who must remain close to the unit to perform his work. The lead equivalent of the apron and gloves will be at least 0.5 mm to 0.25 mm measured at 80 kVp. Lead shields between the sources of radiation and the staff serve the same purpose.

g. Structural shielding for radiographic/fluorographic installations should include 1/16-inch lead or equivalent material to a wall height of 7 feet. (Note: fluoroscopic installations only require 1/32 inch lead or equivalent material.)

h. Equipment will comply with the safety provisions of TB MED 521.

i. The fluoroscopic equipment should be operated only by a medical officer of the department of radiology or by a medical officer properly trained and authorized by the radiologist in charge to conduct fluoroscopic examinations.

1-7. SPOT-FILM RADIOGRAPHY

a. During the fluoroscopic study of gastrointestinal physiology, it is often desirable to record a particular finding on film. This finding may be transitory and capable of visualization only while the patient is in a limited number of positions. For such occasions, it is practical to expose a film quickly and without changing the position of the patient. To provide for such exposures, a spot-film device is utilized. As shown in figure 1-2, the cassette loaded with film is stored in a lead shielded area of the spot-film device. The shielded tunnel arrangement is mounted on the backside of the radiographic table. The moment the pertinent view is located, the examiner releases the foot (or thumb) switch and actives the spot-film exposure button. When the spot-film exposure button is activated, the spot-film device acquires the cassette and brings it into position in over the central ray. During this action, the radiographic tube under the table switches from fluoroscopy to spot-exposure mode. This action happens automatically and the device returns the cassette to the shielded storage area until the button is pushed again.
Figure 1-2. Spot-film radiography and serialography.
b. More modern digital spot-images devices capture and store a digital image for later review and printing as necessary. Modern picture archiving and communication systems (PACS) provide the ability to store and recover patient images for an indefinite period of time. The technique factors for modern equipment are set on the control panel or on the spot-film device by pushing a preprogrammed button. All exposures and techniques are now computer controlled to allow safe use of the equipment for patient and staff.

1-8. SERIALOGRAPH

a. Modern fluoroscopic units incorporate computer controlled spot-film devices that provide a virtually unlimited selection of spot-film arrangements. With an advent of digital fluoroscopy and PACS, the use of serialography is obsolete. When using these units, the specialist needs only to load/unload the cassettes into the spot film device and the radiologist makes film position selections automatically.

b. This procedure, known as serialography, consists of making a number of exposures in series. It may consist of exposing a series of radiographs using single-exposure films or exposures may be made limiting the area of the projected image so that a number of exposures can be recorded on a single film.

c. For instance, as shown in B, B1, and B2 of figure 1-2, the exposed area of the fluoroscopic screen may be confined to half (or even less) the area the film. For the first exposure, the film is moved in front of the non-protected portion of the fluoroscopic screen so that only one portion of it is exposed to the radiation. Following this exposure, it may be moved further so as to provide for exposures onto another portion or it may be moved back into its storage position and subsequent exposures may be made as fluoroscopic findings indicate their value.

d. An electrical or spring device is used to shift the film into the exposed "window" of its storage tunnel so that one or more radiographic images will be produced on each film.

1-9. SERIAL FILM CHANGERS

The serial film changer is mostly obsolete due to the use of digital radiology systems. Digital images are captured by biplane digital imaging plates at a rate set by the technologists and controlled by computer. Individual images can then be store in a PACS or printed on a laser printer. The following is provided for those facilities that have not converted to digital radiography.
a. In angiography, the contrast material introduced into the circulatory system is circulated so rapidly that extremely short intervals between exposures are necessary for adequate demonstration of the vasculature. The intervals between exposures are usually fractions of seconds; thus manual cassette changing is impossible. Biplane digital imaging plates are used to rapidly and automatically capture the image, which permits several radiographs to be made in a very short period of time. They are electrically powered and synchronized with the x-ray generator so that the exposures are automatically controlled.

b. These devices can only be used with x-ray generators specifically wired to accept them. Most of the newer units, fixed or portable, that have a potential of at least 200 mA and 125 kVp are so wired.

c. When the biplane digital imaging plates film changer is connected to the x-ray generator, the hand switch circuit of the generator is bypassed and, on some units, the rotor is activated. Thus, the digital imager controls the x-ray tube and subsequent production of x-rays.

1-10. AUTOMATIC CONTRAST MEDIUM INJECTOR

With the advent of new technologies in computerized tomography and magnetic resonance imaging, contrast material must be injected with sufficient pressure to overcome the patient’s systemic arterial pressure and to maintain a bolus to minimize dilution with blood. The flow rate is affected by many variables such as the viscosity of contrast media, length and diameter of the catheter, and injection pressure. There are many types of automatic contrast injectors, including the types pictured in figure 1-3.

Figure: 1-3. Types of automatic contrast media injectors.
1-11. USE OF TELEVISION

Current fluoroscopic equipment displays the patient under fluoroscopy. The use of television (TV) is an integral part of the fluoroscopic system. Television offers more convenience and mobility for viewers, biplane viewing, and the advantage of video recording.

1-12. VIDEOTAPE RECORDING

a. Videotape recording is a means of electronically recording the fluoroscopic image. In contrast to cine, which uses the photographic process to record the image on film, a videotape recorder uses magnetic tape.

b. In the recording phase of operation, the video signal produces a varying magnetic field at the recording head, which imprints the signal information on the magnetic tape. In the playback phase, the information on the tape is converted back into a video signal that is displayed on a monitor much the same as the original signal. Videotape recording offers several advantages over cine recording. Among them are lower radiation dose to the patient, no processing, instant playback, and the reusability of the tape. The major disadvantage is that resolution is somewhat lower than with cine. Consequently, videotape may not be practical when high resolution is required. However, since instant playback is possible with videotape, it can be used in addition to cine to determine if the information recorded on the cine film is adequate. Using videotape as back-up device in this manner eliminates the necessity of having the patient remain in the radiology department until the cine film is processed.

Section II. SPECIAL TECHNIQUES AND EQUIPMENT

1-13. IMAGE INTENSIFICATION

Image intensification relates to a method of producing fluoroscopic images characterized by a high level of brightness. The light gain of an x-ray image intensifier may be defined as the ratio of brightness on the apparatus to the brightness of a standard fluorescent screen, both excited by the identical intensity of radiation. One of the uses of an image intensifier is for doing cinefluorography.

1-14. PRINCIPLES OF IMAGE INTENSIFICATION

a. The basic component use for effecting image intensification is essentially a type of electronic tube (figure 1-4) used in conjunction with an x-ray source, an electrical energizing and controlling system, and an optical system.
b. In the main, the functional aspects of a typical image intensifier tube are as follows:

(1) X-rays, having passed through the patient, impinge on a fluorescent element, or image input phosphor, at the input end of the image intensifier tube. This fluorescent layer then emits light proportional to the x-ray beam impinging on it. A photoelectric layer (photocathode), which is in direct contact with the input phosphor, emits electrons proportional to the light image produced by the fluorescent layer, thus converting the light image into an equivalent electron image. The primary reasons for the conversion of x-rays to light and light to electrons are that x-rays cannot be focused, and they, by themselves, cannot be amplified or accelerated. Once the image is converted into an electron image, it can be electronically amplified and focused.

(2) The electrons comprising the image are accelerated by the accelerating and focusing electrodes to high speeds by the application of high voltage placed across the highly evacuated tube. The photoelectron current is then focused by a low potential on the inside metallic coating of the tube so that it passes through the anode aperture.

(3) The paths of the high-energy electrons flowing from the image-input phosphor converge at a point and are electrostatically focused on the face of the output phosphor, forming bright image on the output phosphor. The output phosphor consists of materials similar to the front of the ordinary television picture tube that will give off light when struck by high-energy electrons. This conversion of electrons to light is necessary for visualization of the image.
(4) The total amount of image intensification or total gain is based on electronic intensification and minification. A high positive voltage (25 to 30 kV) applied to the accelerating electrodes speeds up the electrons emitted to the photo cathode. This accounts for a gain in light intensity of approximately 35 to 45 times. Minification is determined by the ratio of the input phosphor to the output phosphor. For example, if the input area of a 9-inch tube is 9 by 9 inches, or 81 square inches, and the output diameter of this same tube is 1 inch (with an area of 1 square inch), the minification factor is 81:1. The total intensification or total gain is equal to the amount of electronic intensification multiplied by the minification factor. A tube having an electronic intensification of 40 and a minification factor of 81 would have a total gain of 3,240; meaning the image would be 3,240 times brighter than a fluorescent screen excited with the same amount of radiation.

(5) A lens system, which is actually part of the viewing system, collects and collimates the light emitting from the output phosphor.

c. Image intensifiers are rated at 5, 8, 9, and 11 inches. This does not relate to the field size covered, but to the diameter of the input phosphor. The 8-inch and 9-inch image intensifiers are generally preferred for fluoroscopy and/or cinefluorography.

d. Another development is the dual field tube. In effect, it provides a 6-inch or 9-inch input phosphor at the same time so that the fluoroscopist may use either the 6-inch or 9-inch mode at will. By changing the focusing voltages, the minification factor is changed. When using the 6-inch mode, the center 6-inch square of the 9-inch input phosphor is transmitted to the same output phosphor as used for the 9-inch mode. Since the input/output ratio is 6:1, the image will be larger, but part of the amplification is lost. This image enlargement pertains to the dual field tube. Standard image tubes amplify the intensity of the light image, but do not enlarge it.

1-15. BASIC OPERATIONAL CONSIDERATION

a. Installation. A typical image intensifier unit is usually mounted upon a motorized stand balanced with counter-weights that allows easy maneuverability (figure 1-5). To set up for the procedure, the intensifier unit is moved into position, the shielding in moved into place, and the spotfilm device is loaded. After the necessary connections and adjustments have been made, image-intensified fluoroscopy can be accomplished. The x-ray table unit may be titled as for conventional fluoroscopy (figure 1-6).
Figure 1-5. A typical x-ray image intensifier.

Figure 1-6. Image intensifier unit hooked up with an x-ray unit and in position for vertical fluoroscopy.
b. **Viewing.** The image intensifier tube creates a fluoroscopic image that is many times brighter than a conventional fluoroscopic screen, but this image is too small to be of value. Therefore, a means of magnifying and viewing the image is necessary.

(1) An efficient magnification and viewing system should meet the following requirements:

(a) Enlarge the part to approximately life size or greater.

(b) Provide an image for both eyes simultaneously (binocular).

(c) Place minimum restrictions on the user.

(d) Not degrade the resolution of the image.

(e) Not degrade the contrast of the image.

(f) Provide viewing for two or more people simultaneously.

(g) Efficiently gather the light generated at the output phosphor.

(2) Magnification is now controlled by the image intensifier with the ability to control the field size. Observation is now open to anyone that can see the screen of the digital monitor; and there is often a monitor in the control-room as well as the radiologist's office.

(3) To permit TV monitors, cine cameras, or videotape recorders to be used with an image intensifier, a beam-splitting device is used. It is made of plate glass coated with a special layer that reflects part of the incident light and allows the remainder to be transmitted. The beam splitter channels the image to different devices; therefore, the intensity of each image is reduced. To maintain the same light intensity, the technique must be increased, which will result in increased patient exposure. If only one medium of visualization is used, the beam splitter can be moved out of the way.

c. **Focusing.** Focus depends upon the voltage applied across the electrodes of the image-intensification tube. Poor electrostatic focus may cause unsatisfactory image detail. Focus may be checked by observing the resolution obtained from a suitable test object, such as an area of the fine-meshed wire. The resolution capability of an image tube is a measure of its ability to show physiological detail. To do so, it must depict discrete parallel lines of equal width, spaced by an amount equal to the width of each line. These are called line pairs and consist of one black line and one space. To perceive the border of a certain area, this border must be darker or lighter than its surroundings. The contrast between two areas must have a certain minimum value to be visible by the human eye. The contrast of the image is not improved by amplification. If greater contrast is desired, contrast media are used.
d. **Kilovoltage and Milliamperage.** These factors depend on the size and density of the subject under examination and on the level of image brightness desired. Kilovoltages ranging from 70 to 120 kVp at an x-ray current of 1/2 to 2 mA are commonly used. Insufficient current (mA), especially when high kVp is used, may cause the image to lack definition and appear grainy. When this image is viewed in motion, a coarse, mottling effect is apparent. This is the result of scintillation or "quantum noise," and it occurs when the level of x-radiation falls below a given minimum. In other words, there is a level of radiation below which an image of good quality cannot be obtained. The quantum noise in the intensified image is inversely proportional to the number of x-ray photons absorbed in the fluorescent layer of the input phosphor within the integration time of the human eye, which is approximately 0.2 seconds.

**NOTE:** During fluoroscopy, the radiation dose necessary to create an image must be delivered during the integration or recognition time of the eye, while during cinefluorography, the radiation required to create the image must be delivered during the exposure time for each frame of the motion picture.

**1-16. DUTIES AND RESPONSIBILITIES OF THE X-RAY SPECIALIST**

a. The x-ray specialist's duties and responsibilities in the performance of image-intensified fluoroscopy and cinefluorography are much the same as for conventional fluoroscopy for the other procedures. Radiation hazards do exist and the x-ray specialist must be just as careful to take the same precautions as for ordinary fluoroscopy.

b. To function efficiently as a member of the team, he must have a practical understanding of the equipment and their uses and of the technical mechanics of the procedure. For this reason, the x-ray specialist who is to assist in image-intensification work should study the manual of instructions for the particular unit, as well as any other available literature. With this knowledge, he will be better prepared to carry out the radiologist's orders.

**1-17. DENSITY EQUALIZATION FILTERS**

a. Density equalization filters are special accessory devices used when it is desirable to cause a variation of x-ray intensity across a given beam. When the filter is introduced into the path of the x-ray beam, its intensity is modified in differing degrees over given portions of the file being irradiated (figure 1-7). This is achieved by selective absorption.
b. These devices are especially effective where the part or areas to be examined present widely varying densities, all of which must be satisfactorily demonstrated on one film. For example, in making the dorsoplanter projection of the foot (figure 1-8), dorsoplanter or plantodorsal projections of the os calcis, lateral placentograms, and examinations of the thoracolumbar region are needed. When normal radiographic techniques are used to demonstrate such parts, it usually happens that if the thin parts of the subject are properly exposed, the thick parts may be considerably underexposed. Conversely, gross overexposure of thin parts may occur in the exposure factors or are adjusted for satisfactory demonstration of the thick parts. This problem can be corrected by the proper use of the density equalization filters. Also, the absorbed radiation dosage to the patient is decreased.

c. Filters of this type are sometimes referred to as compensating filters, wedge filters, differential-absorption filters, supplementary filters, or balancing filters.
Figure 1-8. Relationships of the density equalization filter, the x-ray cone (or bean), and the thin and thick parts of the anatomical structure being radiographed.
1-18. COMPOSITION AND CONSTRUCTION

a. Density equalization filters may be made up of the following materials:

   (1) Aluminum.

   (2) Brass.

   (3) Copper.

   (4) Opaque plastic paste-like mixture (commercially available) that is especially suited for this purpose.

   (5) Barium sulfate-impregnated paste.

b. Density equalization filters are usually made up in characteristically sloped or wedge-like forms by modeling if a paste-like substance is used or by grinding if a metallic substance is used.

c. Density equalization filters should be built to fit a particular type of examination. For example, a filter made of brass with a heel thickness of approximately 1/8-inch may be practical for making placentograms, but unsatisfactory for making full-length venograms of the lower extremities.

d. These filters should be fabricated in such a way as not to cause the superimposition of distracting densities over any part of the resulting image pattern.

1-19. WHERE DENSITY EQUALIZATION FILTERS MAY BE INTRODUCED

Density equalization filters may be introduced into the x-ray beam at the level of the filter slot near the x-ray tube housing where the normal complement of filters is usually located or at the level of the exit portal of the beam-restricting device or they may be interposed between the part and the film. The normal equivalent of filtration is always retained where any type of density equalization filter is used. In every case, the filter is an addition to the normal filter system.

1-20. BASIC PRINCIPLES

a. The density equalization filter (figure 1-8) must be oriented in the path of the x-ray beam in such a way that its "heel" (thicker-edge) portion is toward the thinner or less-dense portions of the part or area to be radiographed.

b. Whenever a density equalization filter is introduced into the path of the x-ray beam, the exposure factors should be adjusted to deliver sufficient x-ray intensity to achieve optimum visualization over the thickest and densest portions of the part or area under consideration.
Section III. CONTRAST MEDIA

1-21. INTRODUCTION

a. **Photo Absorption.** It would be difficult, if not impossible, to produce diagnostic radiographs of arteries, veins, cavities, or passages without special contrast media. Radiographic contrast is made possible by the selective absorption of x-ray photons. However, photon absorption by a structure that is surrounded by structures of equal or similar densities is not sufficiently selective to produce adequate radiographic contrast. In cases where structure densities are similar, contrast media are used to alter the photon absorption and, therefore, produce the necessary radiographic contrast. The radiographs in figure 1-9 A, B and C, illustrate how a contrast medium alters photon absorption to allow visualization of the stomach. Radiograph 1-9 A is a plain film of the abdomen. The stomach is not seen because its density is similar to the surrounding structures. Radiograph 1-9 B shows that the radiographic contrast between the stomach and surrounding structures has been enhanced because the stomach has been filled with a contrast medium that increased the photon absorption. Radiograph 1-9 C shows the stomach filled with air. In this case, contrast has been improved over that of A because photon absorption has been decreased.

b. **Radiopaque and Radiolucent Contrast Media.** Contrast media that increase photon absorption are termed radiopaque (positive) contrast media and are made from substances of high atomic numbers, such as iodine and barium. Media that decrease photon absorption are classified as radiolucent (negative) contrast media and are substances with low atomic numbers, like gases. These media are sometimes referred to as positive and negative media; however, in this subcourse, they will be termed radiopaque and radiolucent.

c. **Toxicity.** It should be noted that regardless of atomic number, a contrast medium must not be excessively toxic to the patient. If, for example, pure iodine or pure barium were used as a medium, the patient would become violently ill. This is because iodine and barium in their natural states are poisons. So the two requirements for a good contrast medium are that it must change photon absorption and that it must be relatively nontoxic. In the case of iodine and barium, low toxicity is obtained by chemically combining them with other elements.

d. **Grouping of Contrast Media.** In this subcourse, we will consider contrast media grouped by chemical makeup and usage. Media that are chemically similar and those used for the same examination are grouped together. Three examples of such groups are oral, injectable, and noninjectable contrast media. These terms are rather general, so more specific groupings will also be discussed.
Figure 1-9 A. Film showing no gastrointestinal contrast medium

Figure 1-9 B. Stomach with contrast medium.

Figure 1-9 C. Stomach with some of the contrast medium displaced by air.
1-22. ALIMENTARY TRACT RADIOPAQUES

a. Barium Sulfate Radiopaques. Two typical contrast media used for examining the alimentary tract are Barium Sulfate, U.S.P (United States Pharmacopoeia) and Barosperse. Since they are based on barium sulfate, they form a subgroup called barium sulfate preparations.

NOTE: The United States Pharmacopoeia is a listing of the accepted standards for compounding drugs.

(1) Both of the mixtures seen in figure 1-10 are barium preparation and water. They were stirred at the same time and allowed to sit for ten minutes. Notice that Barium Sulfate, U.S.P. settles out of suspension rapidly while Barosperse stays in suspension longer. Barosperse is a barium sulfate derivative that is micronized and ionized so that it stays in suspension longer. It should be noted that barium sulfate is not water-soluble; when mixed with water, it is in suspension rather than in solution.

![Figure 1-10. Comparison of Barium Sulphate, U.S.P., and Barosperse after being stirred and resting a few minutes.](image)

(2) Micronization is a process of grinding things to extremely small particle size. Ionization is the application of like charges to all particles in an ionized medium. Since like charges repel, the forces of repulsion hold the smaller particles in suspension longer. A glass-stirring rod should be used to stir this preparation. Ionized media should not be prepared with a mechanical mixer, metal spoon, or in a metal container because metal provides a conducting pathway resulting in neutralization of the charged particles. The repelling process of the particles is illustrated in figure 1-11.
Figure 1-11. Particles of barium repelling one another in Barosperse.

b. **Alternate Alimentary Tract Radiopaques.** In figure 1-12, barium sulfate was ingested during an upper G.I. The patient did not drink adequate liquids to flush barium from his system, resulting in fecal impaction. The water is absorbed, leaving a residue of barium sulfate particles. These particles would irritate the tissue they come in contact with. This could result in inflammations, adhesions, or other undesirable complications. Contrast media used when gastrointestinal perforations are suspected should be soluble to avoid leaving an irritating residue. To achieve this end, pharmaceutical companies adjust the activity of water-soluble injectable media to nearly neutral. This renders them suitable for oral use. Two examples are Oral Hypaque and Gastrografin. These soluble media leave no particles as residue. Therefore, they are used as alternates in the alimentary canal when perforations are suspected.

c. **Cholecystopaques.** The biliary tract is examined with a group of contrast media called cholecystopaques. These contrast media are chemically compounded to be selectively excreted along with bile, by the liver. They may be oral or injectable.

1. **Oral cholecystopaques.** One example of the oral type of cholecystopaques is Telepaque. Available in tablet form, it is packaged in foil, six tablets to the package. Instructions for their use are found on the package. The tablets are dissolved in the stomach and absorbed by the mucosa of the small intestine, specifically the duodenum and proximal jejunum. The portal system of veins carries the dissolved media from there to the liver. The liver then excretes the media along with bile. Telepaque and other oral cholecystopaques are employed in oral cholecystography.

2. **Injectable cholecystopaques.** The other type of cholecystopaque is injectable; therefore, it is called an intravenous cholecystopaque. One example is Cholografin. This water-soluble medium is compounded specifically to be excreted by the liver. Intravenous cholecystopaques are used for intravenous cholangiography. Intravenous cholangiography is employed to visualize the biliary tract when the oral method has failed in cases of poor intestinal absorption or after gallbladder surgery.
1-23. WATER-SOLUBLE RADIOPAQUES

a. **Introduction.** The largest, most versatile, group of contrast media is the water-soluble radiopaques. Made of iodine compounds, this type of media can be used in radiographic studies of the urinary system, the cardiovascular system, joint spaces, and connective structures, as well as many other radiographic examinations. There are two types of water-soluble contrasts, injectable and noninjectable.

b. **Water-Soluble Injectables.** The water-soluble injectables are categorized into two groups according to their weight-by-volume concentration. Although the dividing line in practice is somewhat vague, those media of lower concentrations are used for general purposes while those of higher concentration are normally reserved for examination of the heart and great vessels. Weight-by-volume concentration does not refer to the iodine content of a particular medium, but to the concentration of the iodine compound. For example, in 100cc (cubic centimeter) of Renografin 60 percent, 60 percent of the weight is the compound methylglucamine diatrizate and 40 percent of the weight is sterile water. On the other hand, the iodine content of this medium is approximately 29 percent.

(1) In 1984, a new generation of contrast media was introduced in the US that also contains iodine as needed for opacity but contains no positive-charged ions, thus called non-ionic contrast. These new contrasts have a low osmolality and fewer severe contrast reactions are experienced. A common non-ionic contrast used is Isovue–300 (Iopamidol Inj 61 percent IV).
(2) Hypaque 50 percent, Conray 50 percent, and Renografin 60 percent are water-soluble injectables of relatively low concentrations. Frequently used for urographic studies, they are generally termed urographic media. These media can also be employed in contrast examinations of joints and portions of the cardiovascular system.

(3) The more concentrated water-soluble injectables are usually reserved for examinations of the heart and great vessels. Hypaque M (75 percent or 90 percent concentration), Angio-Conray 80 percent, and Renografin 76 percent are examples of this group, generally titled angiocardiographic media.

c. **Water-Soluble Noninjectables.** The other kind of water-soluble radiopaque is called noninjectable. Retrografin is a typical example. They are primarily used in retrograde studies of the urinary tract. These media are modified injectables. For instance, Retrografin is essentially Renografin with neomycin, an antibiotic, added. In this case, contrast media and antibiotics are mixed to reduce the danger of infection following retrograde examinations.

### 1-24. **VISCOUS AND/OR OILY RADIOPAQUES**

a. **Introduction.** Ethiodol, Salpix, Pantopaque, and Dionosil are examples of a group of contrast media called viscous and/or oily radiopaques. These viscous or oily radiopaques are rarely used today since the exams that used them have been replaced by exams done in other modalities.

b. **Viscosity and Oiliness.** The reason for the "and/or" above is understood if an analogy is made with a jar of honey, a can of light lubricating oil, and a can of motor oil. The honey is viscous, meaning thick or resistant to flow, but not oily. The light oil is oily, but not viscous. The motor oil is both viscous and oily. The contrast media in this group have various combinations of viscosity and oiliness.

c. **Uses of Viscous and/or Oily Media.** The bronchial tree can be studied by introducing Dionosil or a similar medium. Dionosil, a viscous and oily medium, is used to prevent flow of the contrast agent into the alveolar sacs, and because it is absorbed by the lungs leaving no residue. Salpix is usually used to delineate the uterus and fallopian tubes in hysterosalpingography. Salpix is a water-soluble, viscous medium. Ethiodol, an oily viscous medium, is usually employed in the radiological examination of the salivary glands. Pantopaque that is both viscous and oily is used in myelography (the examination of the spinal cord).

### 1-25. **RADIOLUCENT MEDIA**

a. **Introduction.** Alimentary tract radiopaques, water-soluble radiopaques, and viscous and/or oily radiopaques are all classified as radiopaque media because they increase photon absorption. Contrast media that decrease photon absorption are termed radiolucent media.
b. Radiolucent Media and Their Uses. Oxygen, carbon dioxide, and room air are commonly used as radiolucent media. These common gases are utilized in digital subtraction angiography and joint spaces, as well as for double contrast in certain examinations. Radiolucent media are sometimes used in arthrography. Although the contrast provided this way is quite subtle, some physicians prefer the radiolucent media since it causes less irritation and is quickly absorbed. A radiolucent medium is also commonly used as a double-contrast enema to evaluate the colons for polyps.

1-26. REACTIONS TO CONTRAST MEDIA

a. Introduction. Intravenously injected contrast media can produce a reaction similar to anaphylactic shock. True anaphylaxis is the result of hypersensitivity to a drug to which the patient previously was not sensitive. For example, the first time a patient receives penicillin, he may show no side effects; yet, following a second dose of the same drug, this patient may have an anaphylactic reaction. This is thought to be due to the formation of antibodies against a drug. Reactions to contrast media can occur in patients who may or may not have had the particular radiopaque before. Although the causes of contrast media reactions seem to be different, the symptoms are so similar that they are generally thought of as a variety of anaphylaxis. Basically, two types of reactions can occur following the injection of contrast media. They are classified as histamine imbalance and hemodynamic reactions.

b. Histamine Imbalance Reaction. Histamine, a substance found in all humans, has several functions, one of which is the release of blood plasma through capillary walls to body tissue. This release of fluids produces swelling of tissue called edema. Histamine is held in check by a histamine inhibitor and, in some people, the balance between the two is delicate and rather easily upset. These people are the unfortunate individuals who suffer from allergies such as hay fever.

(1) One of the theories about histamine imbalance is that iodinated contrast media damage the histamine inhibitor sufficiently to cause an overabundance of histamine. This imbalance causes the release of fluids into tissue, producing a set of distinct, easily recognizable signs and symptoms.

(2) Among the signs and symptoms of a histamine imbalance reaction are itching, a flushed appearance, watery eyes, faintness, hives, nausea, and breathing difficulties. In a mild response of this type, the patient may feel hot, faint, or nauseated. A moderate reaction might evoke watering of the eyes, localized swelling (especially of the face and hands), and a flushed appearance. In its most serious form, breathing problems due to swollen bronchial passages appear. Untreated severe bronchial constriction can produce death by suffocation. Generally, this reaction occurs quickly, but the specialist must be watchful for possible delayed reactions.
c. **Hemodynamic Reaction.** Hemodynamics refers to the characteristics of blood action or flow. A hemodynamic reaction to contrast media has serious effects on blood flow, and can result in such complications as systemic shock, myocardial infarction, and renal shutdown.

1. Systemic shock is caused by a drop in blood pressure occurring after the introduction of contrast media. The characteristic course is an immediate, but short-lived, increase in blood pressure followed by an acute drop in blood pressure. The immediate rise is produced by increased heart action; then, trying to compensate, the veins dilate. Because of this venous dilation, blood pressure drops and there is not an adequate return of blood to be oxygenated. Cardiac arrest can result if enough blood is retained by the veins.

2. Myocardial infarction (the death of heart muscle tissue) and renal shutdown are thought to be the product of damage to red blood cells. Some investigators feel the contrast media damage the cell walls of erythrocytes, causing them to clamp together to form clots. If enough of these clots block the internal blood supply, renal shutdown occurs. Similarly, myocardial infarction is caused by the obstruction of the coronary arteries. Either of these complications can be fatal.

3. The symptoms of this hemodynamic response are a weak and barely noticeable pulse, paleness, cyanosis, and possibly even unconsciousness. Like the histamine reaction, this response may be immediate or delayed.

d. **Patient Histories.** Reactions to contrast media cannot be predicted, but many doctors feel that the probability of a reaction can be assessed by evaluating the patient's history. The radiologist should consult the patient's medical records for a past history of reactions to contrast media or drugs. If he has full confidence in an x-ray specialist, he will probably delegate to him the responsibility of explaining the examination to the patient and questioning him for clues to the possibility of a reaction. In such a case, the specialist must use the utmost tact to avoid alarming the patient. He should ask:

1. Have you had this or a similar examination before?

2. Did you have any difficulties with the previous examination? If he answers in the affirmative, ask him:

3. If he answers "yes" questions (1) and (2), ask: "Do you remember the name of the drug that caused your difficulties?"

4. If he answers "no" to questions (1) and (2), ask:

   (a) Are you allergic to iodine?

   (b) Does seafood affect you in any special way?
e. **Allergy.** If the patient indicates that he is allergic to iodine, that seafood makes him sick, or that he had problems during a previous examination, the probability of a reaction is increased. Regardless of the outcome of the questions, the specialist should report his findings to the injecting physicians, preferably outside the exposure room so that the patient cannot hear the conversation.

### 1-27. EMERGENCY TREATMENT OF REACTIONS

a. **Emergency Equipment.** Whenever iodinated contrast media are administered intravenously, emergency equipment must be immediately available. This equipment normally includes an emergency tray, a cut-down tray, and an oxygen therapy apparatus.

1. Although the exact content of an emergency tray is determined by the radiologist, it will include several sizes of needles, a variety of syringes, graduated sizes of endotracheal or oropharyngeal airways, a blood pressure cuff, a stethoscope, a tourniquet, intravenous fluids, and drugs. The needles and syringes are used to administer the drugs; the airways are special tubes for maintaining an open air passage, and the stethoscope and blood pressure cuff are used to monitor the patient's blood pressure and heartbeat. A tourniquet is needed to locate a vein for injections, intravenous fluids to raise blood pressure, and drugs to counteract the reaction.

2. Some of the emergency treatment drugs may be cardiac stimulants such as Epinephrine, blood pressure elevators like Levophed, and antihistamines such as Benadryl. These are typical examples, but the radiologist may choose others.

3. The oxygen therapy equipment is there to aid the patient's respiration. It may be a Reuben (Ambu) bag (a device for pumping air into the patient's lungs) or an oxygen bottle and mask.

**CAUTION:** Do not attempt to use this equipment unless you are specifically trained for it.

4. To maintain an open airway, a tracheotomy or cricothyroid puncture may become necessary. For this purpose, cut-down trays or cricothyroid puncture needles must be readily available.

5. Do **not** try to administer any drugs nor perform any operations for which you have not been fully trained. Such action may harm the patient and make you liable for legal action.

6. The radiologist will specify the items to be used as emergency equipment, but you, the specialist, are responsible for its upkeep. Periodically check the operation of the oxygen apparatus. Drugs and sterile packs must be up-to-date and is good supply. If any items are used, they should be replaced as soon as possible.
b. **Emergency Treatment.** The specialist's primary responsibilities are to recognize a reaction, call a physician, take necessary life-saving action, and aid the doctor in treatment. During special procedures using contrast media, the specialist must be on guard for a reaction. Close observation of the patient and thorough knowledge of the signs of a reaction are absolutely necessary. Never leave the patient unattended at any time.

(1) In the event of a reaction, your immediate response should be to call a doctor, preferably the physician who made the injection. It may become necessary to treat the patient for shock by turning his head to the side, elevating his feet, and keeping him warm or cool as the case warrants.

(2) In serious cases, breathing assistance or cardiac massage may be required. Mouth-to-mouth resuscitation is the most effective respiratory method, and you should learn external cardiac massage. Above all, do not panic. A calm, professional demeanor will aid in keeping the patient calm and secure.

(3) When assisting the physician, you may be directed to prepare drugs for injection. The bottle or vial from which the drug was drawn should be shown to the doctor when handing him the filled syringe. The best assistance you can give the physician is a fast and accurate response to his orders. Knowing exactly where to find each item of the emergency equipment is a must!

(4) Remember that the specialist should not administer any drugs, use any equipment, or perform any operations for which he is not completely trained.

*Continue with Exercises*

*Return to Table of Contents*
EXERCISES, LESSON 1

INSTRUCTIONS: Answer the following exercises by marking the lettered response that best answers the question or best completes the incomplete statement.

After you have completed all the exercises, turn to "Solutions to Exercises" at the end of the lesson and check your answers. For each exercise answered incorrectly, reread the material referenced with the solution.

1. Contrast media are useful where photon absorptions among structures is:
   a. Great.
   b. Negligible.
   c. Similar.
   d. Dissimilar.

2. Radiopaque contrast media are called __________, and radiolucent contrast media are called__________.
   a. Positive, negative.
   b. Weak, strong.
   c. Nontoxic, toxic.
   d. Light, heavy.

3. A good contrast medium must change photon absorption and yet be as __________ as possible.
   a. Liquid.
   b. Lightweight.
   c. Thick.
   d. Nontoxic.
4. Barosperse is different from barium sulphate U.S.P. because it is:
   a. Micronized and ionized.
   b. Water-soluble.
   c. Injectable.
   d. Residue-free.

5. No metal should be allowed to come in contact with a radiopaque media that is:
   a. Iodinated.
   b. Radiopaque.
   c. Ionized.
   d. Radiolucent.

6. Because of possible peritoneal inflammation, __________ contrast medium is contraindicated for use in the perforated alimentary tract.
   a. Barium.
   b. Iodine.
   c. Ionized.
   d. Radiopaque.

7. Cholecystopaques are contrast media used to demonstrate the:
   a. Pancreas.
   b. Large intestine.
   c. Kidneys.
   d. Bile ducts.
8. Water-soluble radiopaques consist of __________ compounds.
   a. Barium.
   b. Iodine.
   c. Methyl.
   d. Glucide.

9. Three water-soluble injectables mentioned in the subcourse that are considered low in concentration are:
   a. Hypaque 50 percent, Cystokon, and Renografin 60 percent.
   b. Retrografin, Conray 60 percent, and Renografin 60 percent.
   c. Hypaque 50 percent, Conray 50 percent, and Renografin 60 percent.
   d. Telepaque, Hypaque 50%, and Renografin 60 percent.

10. Water-soluble injectable contrast media of higher concentrations are normally used only for examinations of the:
   a. Liver and bile ducts.
   b. Kidneys and ureters.
   c. Cranial veins.
   d. Heart and great vessels.

11. Water-soluble noninjectable contrast media are used primarily for the:
   a. Liver.
   b. Urinary tract.
   c. Small intestine.
   d. Large intestine.
12. Oxygen, carbon dioxide, and room air, used in contrast media, are classified as:
   a. Radiopaque.
   b. Radiolucent.
   c. Viscous.
   d. Highly irritating.

13. Radiolucent media are used for:
   a. Arthography.
   b. Double-contrast.
   c. Both a and b above.
   d. None of the above.

14. The two kinds of drug reaction seen with contrast media are histamine imbalance and:
   a. Hemoglobinopathy.
   b. Globus pallidus.
   c. Paraphrenia.
   d. Hemodynamic reaction.

15. A histamine imbalance reaction to contrast media may cause "hay fever" symptoms. The most serious possible result of histamine imbalance is that it may cause:
   a. Liver failure.
   b. Bronchial constriction.
   c. Myocardial infarction.
   d. Stomach cramps.
16. A drug reaction classed as hemodynamic could result in:
   a. Renal shutdown.
   b. Myocardial infarction.
   c. Systemic shock.
   d. Responses b, c, and d above.
   e. None of the above.

17. In case of a reaction to contrast media, emergency equipment nearby should include:
   a. Needles and syringes.
   b. Stethoscope and blood pressure cuff.
   c. Tourniquet, I.V. fluids, and drugs.
   d. Oxygen equipment and airways.
   e. All of the above.
   f. None of the above.

18. Emergency tray items are all easy to use and the x-ray specialist can feel free to use them without any special training.
   a. True.
   b. False.
SPECIAL INSTRUCTIONS FOR EXERCISES 19 THROUGH 21. Match the descriptions in the right hand column to the materials in the left hand column.

<table>
<thead>
<tr>
<th>Descriptions</th>
<th>Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>___ 21. Light oil.</td>
<td>c. Both viscous and oily.</td>
</tr>
</tbody>
</table>

SPECIAL INSTRUCTIONS FOR EXERCISES 22 THROUGH 245. Organs can be visualized better with the use of contrast media. Match the contrast medium in the right hand column to the organs in the left hand column for which it would be primarily be used.

<table>
<thead>
<tr>
<th>Contrast Medium</th>
<th>Organs</th>
</tr>
</thead>
<tbody>
<tr>
<td>___ 24. Hypaque 50 percent.</td>
<td>c. Heart and great vessels.</td>
</tr>
</tbody>
</table>

Check Your Answers on Next Page
SOLUTION TO EXERCISES: LESSON 1

1. c (para 1-21a)
2. a (para 1-21b)
3. d (para 1-21c)
4. a (para 1-22a(1))
5. c (para 1-22a(2))
6. a (para 1-22b)
7. d (para 1-22c)
8. b (para 1-23a)
9. c (para 1-23b(2))
10. d (para 1-23b(3))
11. b (para 1-23c)
12. b (para 1-25b)
13. c (para 1-25b)
14. d (para 1-26a)
15. b (para 1-26b(2))
16. d (para 1-26c)
17. e (para 1-27a)
18. b (para 1-27a(3) Caution)
19. c (para 1-24b)
20. a (para 1-24b)
21. b (para 1-24b)

22. b (para 1-22c(2))

23. c (para 1-23b(3))

24. a (para 1-23b(2))