Reading Material for

Radiography Technique – I

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CHAPTER 1

INTRODUCTION

1.1 Radiology

Radiology is a branch of medical science which deals with diagnosis and treatment of the disease.

Its main branches are:

1) Diagnostic radiology

2) Radiotherapy or radiation oncology

1.1.1. Diagnostic Radiology

Diagnostic Radiology is concerned with evaluation of disease process by different imaging modalities. These imaging modalities are:

I) X-rays

i. Plain x-rays

ii. Contrast Procedures

2) Ultrasound

3) Doppler Studies

4) CT scan

5) MRI

6) Nuclear medicine

A number of interventional procedures such as aspirations, drainages and biopsies are also done in diagnostic radiology centre.

1.1.2. Radiotherapy or radiation oncology

Radiotherapy or radiation oncology is basically concerned with treatment of different cancers with high intensity radiation.

1.2 Workers in radiology

1.2.1 Radiologist

Radiologist is a specialist doctor who after completion of MBBS spends an additional four to five years exclusively studying Radiology. In Pakistan, many radiologists are members / fellows of College of Physicians and Surgeons (CPSP), Karachi.

1.2.2 Radiographer

Radiographer is a person who is qualified to perform certain radiological examinations himself / herself, also assists radiologist during contrast procedures, ultrasound examinations, interventional procedures and radiotherapy.

CHAPTER 2

PATIENT CARE

Radiographer plays a very vital role in patient care as he is the person who is going to have maximum interaction with the patient. So a radiographer must be polite, tolerant and tactful and he should do his maximum for patient comfort.

Following are various, steps which are considered important in patient's care.

2.1 Reception

Every radiology department has a reception where patients report. At reception, a sensible and polite radiographer should be appointed who checks the entitlement of patients, enters patient's particulars in register and guides the patients towards exanimation room. If radiological investigation is a special one, like contrast procedure, ultrasound or CT, he gives appointment after consulting a doctor and writes preparation for exanimation on request form.

2.2. Waiting

Nearly every patient who attends a radiology department has to spend some time in waiting. The following measures can be taken to make waiting less boring:

a) An efficient appointment system is essential for keeping the waiting time to a minimum.
b) Waiting can be made less boring if the patient is supplied with newspapers and magazines. A television in the waiting area is also helpful in this regard. Whenever possible, separate waiting areas should be available for different types of patients, e.g. male and female patients and officers and soldiers.

2.3 Identity

Before any examination the identity of the patient must be checked by the radiographer. In case of any doubt or difficulty he may take help from radiologist.

2.4 Explanation of procedure

Although it is not necessary to give the patient a detailed explanation of examination to be performed, most patients appreciate being given some information, particularly be" contrast procedures and imaging guided interventional procedures.

If apparatus that makes considerable noise is about to be used, for example MRI the Patient , should be warned about this before examination.

2.5 Change of dress

A dean gown must be provided for those lady patients who are wearing garments that are likely to produce artifacts during the radiographic procedure. Some method for safe deposit of money and valuables must be adopted.

2.6 Privacy

Radiographic examination should be carried out in as much privacy as possible. However there must be an Aya or attendant with every female patient during all radiological examinations.

The door of the examination room should not be open and only the patient and aya / attendant should be present in the room. It is of particular importance in examinations such as hysterosalpingography (HSG) that patient should be covered with a sheet or blanket.

2.7 Comfort

If practicable, a foam mattress should be placed on the examination couch, particularly for ultrasound examination or in those procedures where patient has to remain in the same position for a long time. Pillows should be used to make the patient comfortable. A small set of steps should be available so that the patient can climb easily on the examination table. During fluoroscopic examination hand-grips and a firm footrest must be provided. A patient should not be allowed to descend from a table without someone being at hand to help. A nervous patient may try to do so too quickly and fall over. The radiographer must ensure that there is no hurdle in the patient's may e.g. image intensifier tube so that there is no risk of patient striking his head against it. A radiographer must always be nearby when a patient is getting into or out of a wheel chair, and she brakes should be on

2.8. Immobilization

The patient must be absolutely still in the required position while exposure is being made. Any movement during the exposure will cause blurring of the film. The patient must be made as comfortable as possible because if he is in pain or in an uncomfortable position, it is unlikely that he will remain still.

For radiographic examination of the extremities pillows should be used for support and immobilization.

2.9 Hygiene

The room where radiological exanimation is performed should always be clean and tidy. It should be cleaned immediately after use, especially after contrast procedures (like Ba enema) and interventional procedures (like aspirations).

The radiographer should not disclose the diagnosis to a patient for example whether a fracture is present or not. Such information must be given to the patient only by a doctor.

2.10 Consent Forms

Written consent forms are signed by the patients themselves or their relatives before the start of any interventional procedure. The procedure and its complications must be explained to the patient before the signing of consent form.

2.11 After care of the patient

This is important especially after all interventional procedures. The patient remains in the department for some time. His vital signs are checked and he is observed for the development of any complication.

2.12 Collection of reports

The reports of radiological procedures should be prepared well in time. The x-ray reports, for 1 example, should be ready by 9 O'clock next morning. The ultrasound reports should be given on the same day.

2.13 Patient to see, Repeat & Clinical notes cases

These patients need extra care and should be handled on priority basis.

2.14 Priority cases

Patients on stretchers, in wheelchairs, patients with acute pain, elderly patients and small children should be given priority over routine patients.

CHAPTER 3

BASIC X-RAY PHYSICS

3.1 X-Ray Machine

It has three principal parts

1. X-Ray Tube

2. Control Console

3. Generator

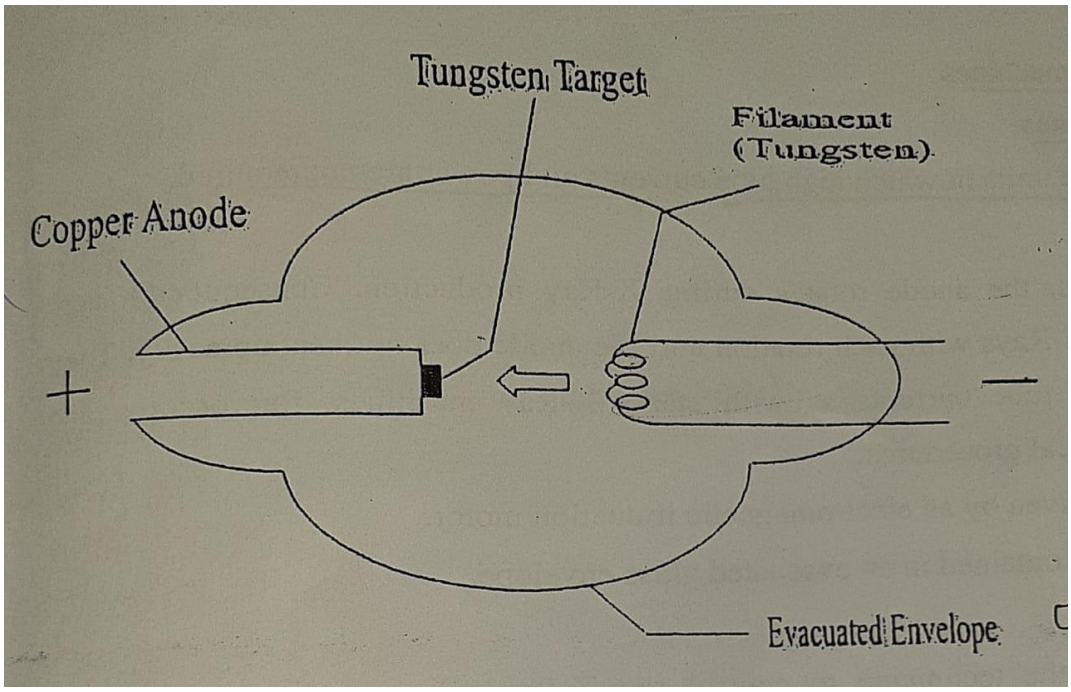
3.1.1. X-Ray Tube

It is contained in protective housing lined with lead.

The protective housing contains oil that serves as an electrical insulator and a thermal cushion.

It contains an:

Anode and a cathode enveloped in glass tube with vacuum in it.



X-Ray Tube:

Cathode:

It is the negative end of the tube. It has two parts:

a. Filament

b. Focusing cup.

The filament is made of Tungsten. Tungsten is used because of its ability to with stand very high temperatures. It has a melting point of 3370°C.

The focusing cup focuses the electrons produced from the cathode towards the anode.

Anode:

It is the tube target.

It is the positive side of the X-Ray tube. Two type of anodes are in use

a. Stationary

b. Rotating

Stationary Anodes:

These do not move when bombarded by electrons from the cathode. Consequently they are liable to heat up:

They are used in:

a. Dental X-Ray machines

b. Portable machines

c. Special purpose units in which high tube currents and power are not required.

Rotating Anode:

As the name indicates, the anode rotates during X-Ray production. Consequently, new surface is exposed to X-Rays with each rotation and the anode does not heat up easily. They are in use with high tube currents as with static X-Ray machines, fluoroscopy, and interventional radiological procedures.

The rotating anode is driven by an electromagnetic induction motor.

The whole assembly is contained in an evacuated glass envelope.

3.1.2 Control Console

This apparatus allows the technician to control the X-Ray tube current (mA) and the kilovoltage (KV).

Kilovoltage:

It determines the energy of the X-Ray photons.

Milliamperage:

It is the tube current i.e. the number of electrons flowing from the cathode to the anode. This in turn depends on:

Temperature of the filament:

The higher the temperature the greater would be the number of electrons emitted.

Filament current:

As the filament current increases, the filament becomes hotter with release of more electrons.

3.1.3. X-Ray Generator

X-Ray generator is a device that supplies electric power to the X-Ray tube.

X-Ray generator may be of 3 types.

a. Single phase X-Ray Generator

b. Dual phase X-Ray Generator

c. Triple phase X-Ray Generator

Nowadays all X-Ray generators are usually triple phase X-Ray generators because the electricity supply to these generators is in three phases which is almost a continuous current.

Parts of X-Ray Generators:

There are 2 main parts of X-Ray generator

a. Operating panel / operating console

b. Transformer assembly

Operating Console / Operating Panel:

It has all main controls & switches on it e.g

a. On/off switch - to switch on X-Ray machine

b. mA selector switch / button

c. KVP selector/control

d. Timer selection/mAs selector

e. Exposure button

f. Auto transformer is within control panel..

Transformer Assembly (X-Ray Generator Assembly):

Transformer assembly is composed of

a. Transformers

b. Rectifiers

c. Meters

Transformers:

Transformers change the voltage. These are of 2 types

a. Step up transformer/high voltage transformer:

- It increases the voltage 500-1000 times
- It supplies current and voltage to the main X-Ray tube for production of X-Rays

b. Step down transformer/low voltage transformer:-

• It decreases the voltage 5-10 times

- It supplies current to heat the filament / cathode so that after heating the filament can emit electrons.

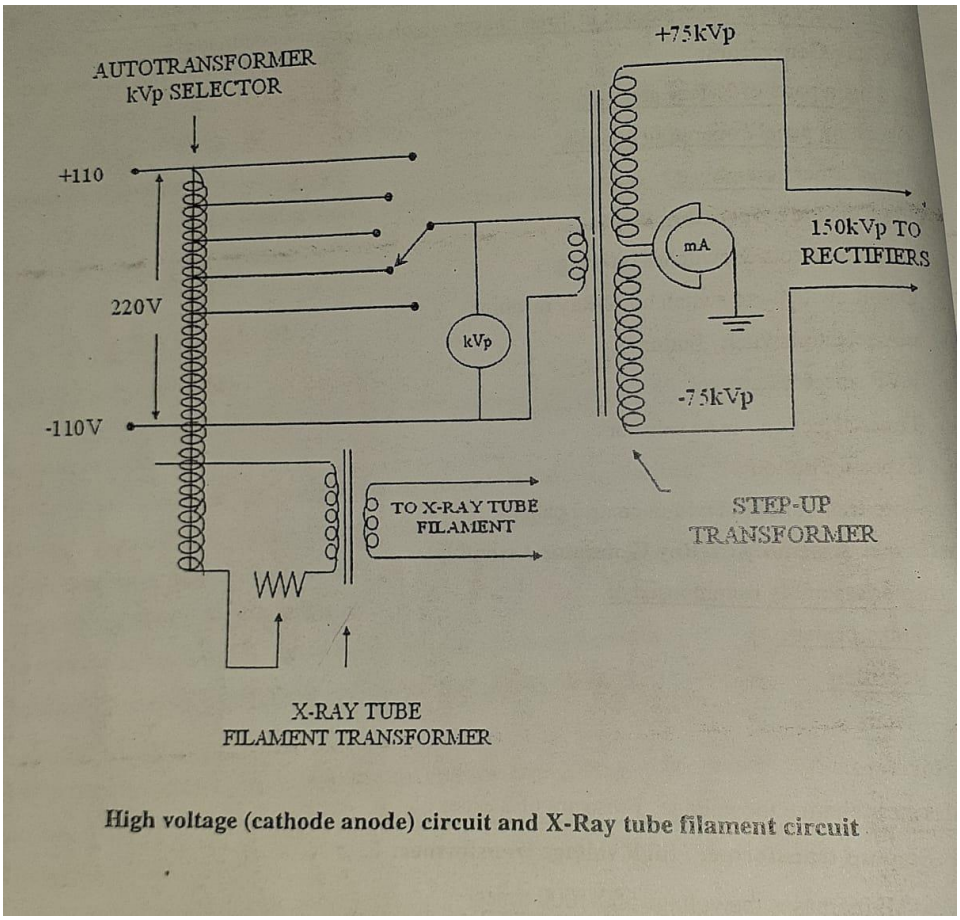
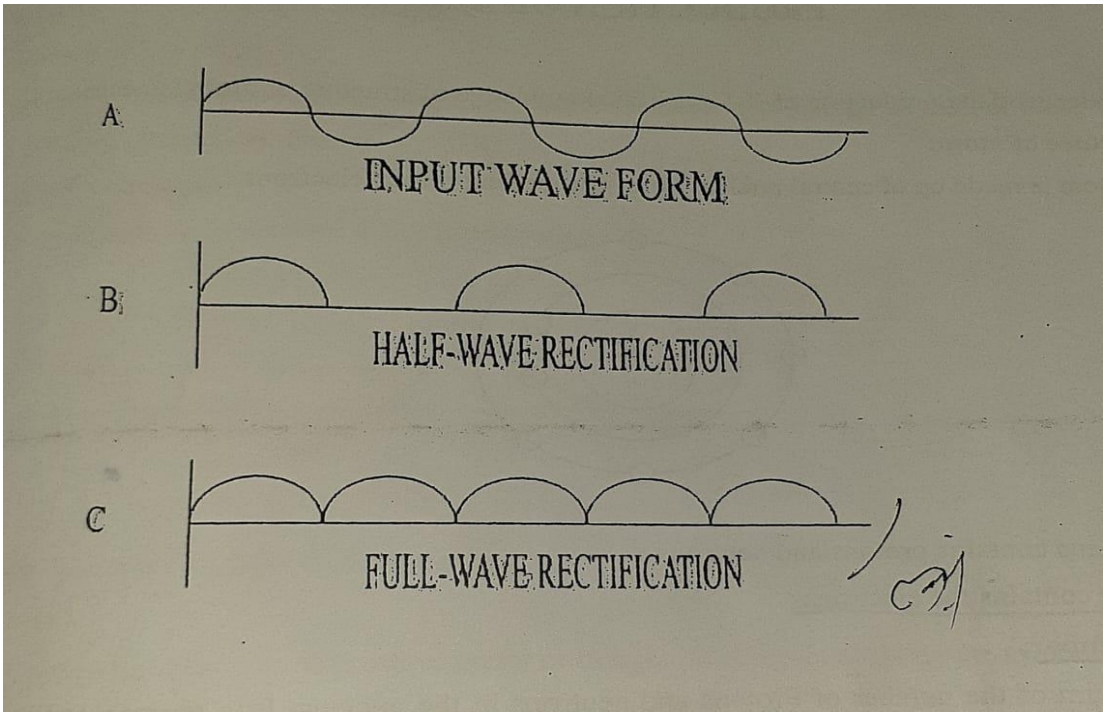


Figure: High voltage (cathode anode) circuit and X-Ray tube filament circuit

Rectifier:

The function of rectifiers is to convert alternating current supplied to it into direct current. X- Rays are only produced during positive phase of voltage of alternating current. Negative phase of voltage of alternating current is useless. So rectifiers change negative phase of voltage into positive phase thus utilizing all phases of current to produce X-Rays.



A INPUT WAVE FORM

B HALF-WAVE RECTIFICATION

C FULL-WAVE RECTIFICATION

Meters:

There are 2 types of meters in transformer assembly. These meters are

a. "Pre reading" KVp meter

b. "mA meter"

KVp meter:

It measures voltage difference across X-Ray tube i.e. potential difference between anode and cathode of X-Ray tube.

mA meter:

It measures X-Ray tube current flowing across X-Ray tube due to flow of electrons.

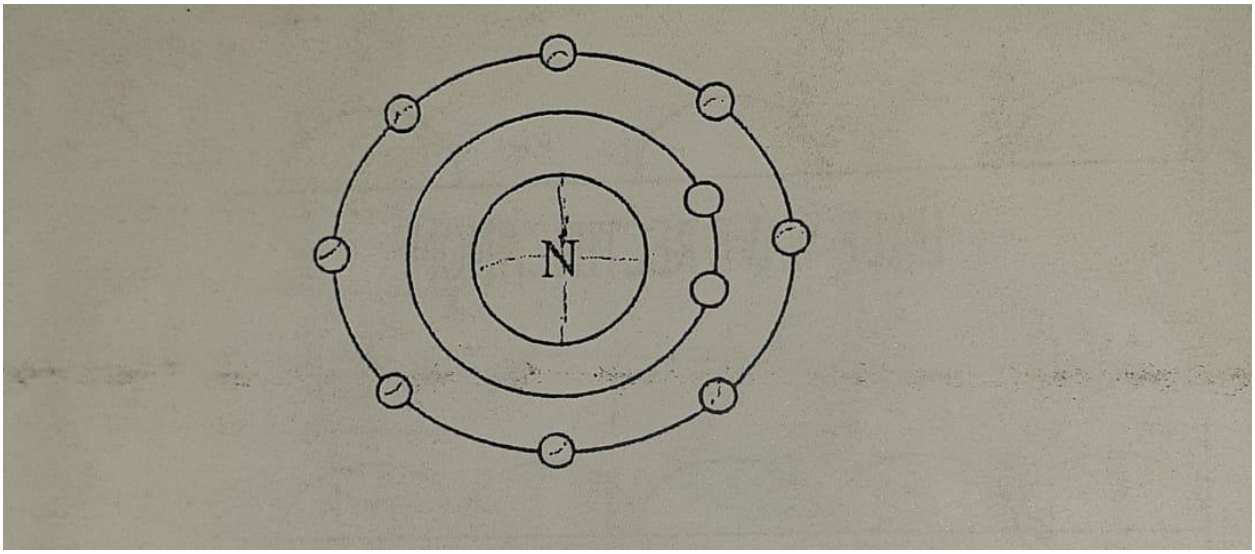
3.2 PRODUCTION OF X-RAYS

To understand the production of X-Rays basic knowledge of structure of atom is necessary.

3.2.1 Structure of atom

The atom is made up of central nucleus with surrounding orbital electrons.

Figure:



Structure of atom:

The nucleus contains protons and neutrons

The orbit contains the electrons.

Mass number:

It is the sum of the number of Protons and neutrons in the nucleus. It is represented by the symbol 'A'.

Atomic number:

It is the number of protons in the nucleus. The number of protons is equal to the number of electrons. Atomic number is represented by the symbol 'Z'.

The number of electrons in each orbit is calculated by the formula 2n{2} where n is the number of the orbit.

The orbits are named as KLMNO and so on where K is the Ist shell, L is the 2nd shell, M is the 3rd shell and so on.

So the number of electrons in K shell is 2n2=2(1)2=2

The number of electrons in the L shell is 2n2=2(2)2=8 and so on.

Electromagnetic Radiation:

Energy traveling across empty space is termed electromagnetic radiation. It has an electric and a magnetic component.

The spectrum of electromagnetic radiation includes:

a. Radio waves

b. Infra red waves

c. Visible light

d. Ultraviolet light

e. X and Gamma rays

The electromagnetic waves travel with the speed of light.

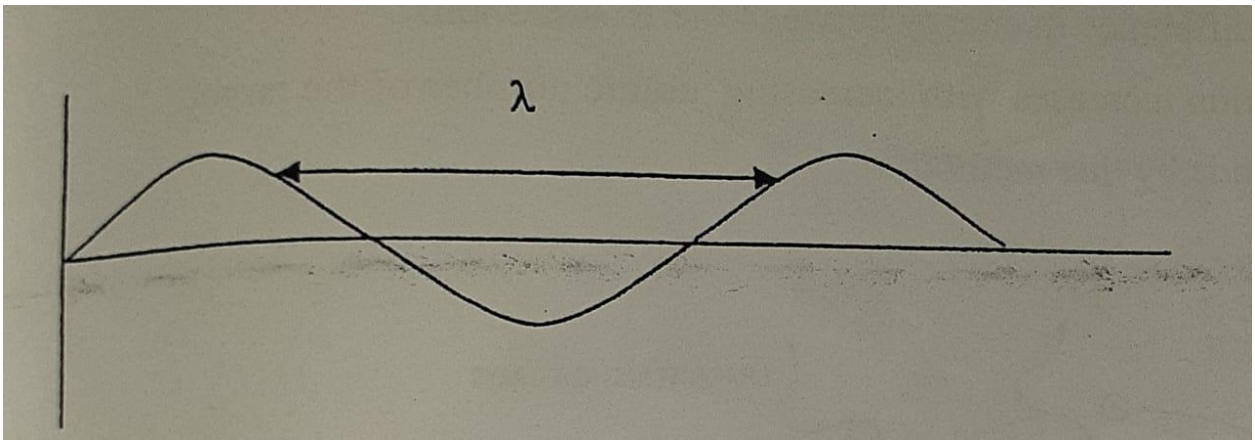
All electromagnetic waves have two aspects:

Quantum aspect / concept:

Electromagnetic waves travel in the form of particles or bundles of energy & each of these bundles is called quantum or photon.

Wave aspect / concept:

The electromagnetic waves travel in the form of waves.



Wave aspect / concept:

The waves have a wavelength and frequency.

Wavelength:

It is the distance between two successive crests or troughs. It is represented by the symbol .

Frequency:

It is the number of waves passing a particular point in a unit of time. It is represented by the symbol ú (Nu).

Frequency and wavelength are inversely related to each other.

2(lambda) + ú = Constant

X-Rays are produced when fast moving electrons are suddenly stopped by impact on a metal target.

The filament is heated and it emits electrons by the process of thermionic emission. The electrons are stopped by the target of the X-Ray tube and their energy is converted into X-Rays (1 %) and heat (99%).

There are two processes by which X-Rays are produced.

3.2.2 Interaction with the K Shell (line Spectrum / characteristic radiation)

When the electron from the filament with an energy greater than the k-shell energy collides with an electron in the k-shell of an atom, the electron would be ejected from the atom. The gap would be filled from an electron falling from the L shell. The X-Ray photon produced will have the energy equal to the difference in energy between the K & L shell.

The energy of characteristic radiation increases with increasing atomic number of the target element. 20% of X-Ray production is by this method

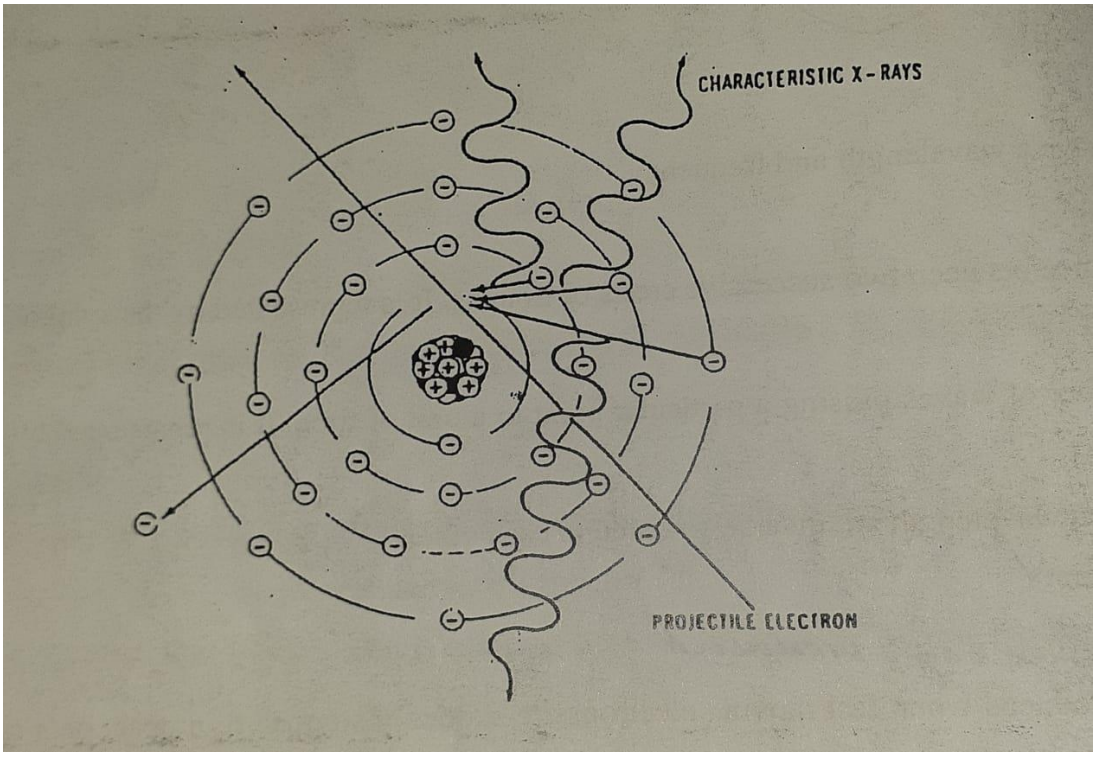


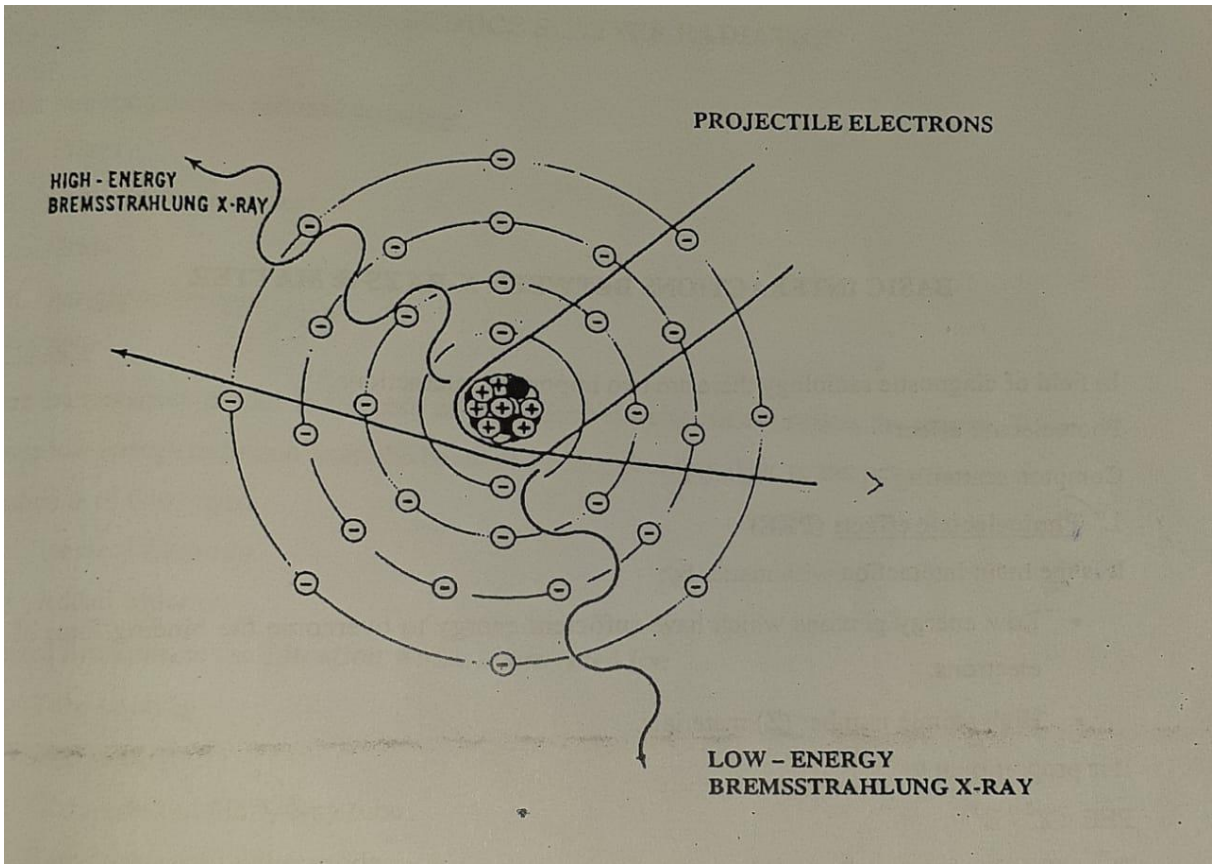
Figure: Characteristic X-Rays

Characteristic X-rays are produced following the ionization of a K-shell electron. When an outer-shell electron fills the vacancy in the K-shell, an X-ray is emitted.

3.2.3 Interaction with nucleus (continuous spectrum / bremsstrahlung radiation)

The high speed electrons pass near the nucleus of the atom, get deflected and lose energy in the form of an X-Ray photon. The greater the deflection of the incident photon, the higher is the energy of the released X-Ray photon.

80% or more of the X-Rays are produced by this method.



Bremsstrahlung x-rays result from an interaction between a projectile electron and target nucleus. The electron is slowed down, and its direction is changed.

3.3 BASIC INTERACTIONS BETWEEN X-RAYS & MATTER

In field of diagnostic radiology there are two important interactions

Photoelectric effect

Compton scattering

3.3.1. Photoelectric effect: (PEE)

It is the main interaction with matter by:

- Low energy photons which have sufficient energy to overcome the binding force of electrons.
- High atomic number (Z) materials.

It is proportional to

PEE a Z^3/ E3

This effect increases radiographic contrast but gives a lot of radiation dose to subject.

Uses:

Contrast studies

Mammography

3.3.2. Compton Scattering:

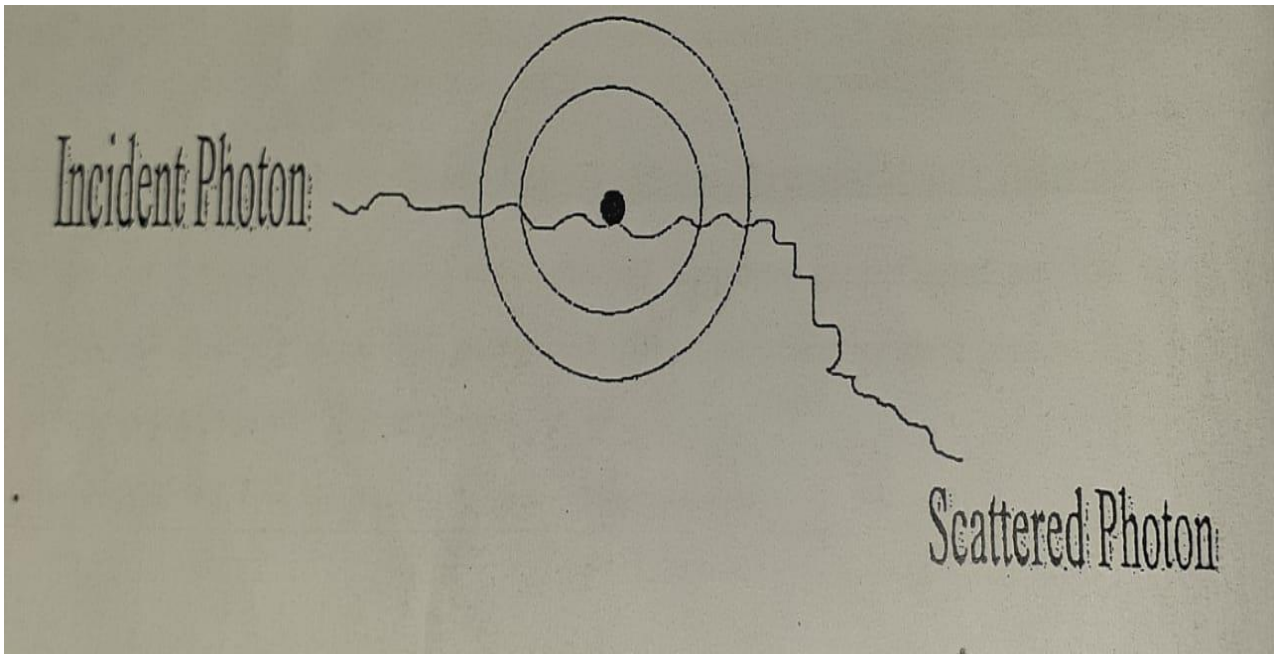
This is the most important source of scatter radiation. It gives radiation dose to the staff around the patient and decreases film contrast.

X-Ray beam, upon interaction with body tissues is deflected from its path.

If the photon is deflected at a small angle, it would fall on the film and degrade the image by increasing film fog.

If the photon is deflected at a large angle, it would increase radiation dose to the staff.

Figure:



3.4 Methods to Reduce Scatter Radiation

Scatter radiation can be reduced by using:

a. Filters

b. X-ray beam restrictors

c. Grids

d. Air gap technique

3.4.1 FILTERS

Filters are materials placed in the path of the beam before the beam strikes the patient. They remove low energy radiation from the beam and hence decrease dose to the patient.

Filtration is of two types:

a. Inherent filtration

b. Added filtration

Inherent filtration is the filtration which is provided by:

a. Tube housing

b. Insulating oil

c. Glass insert of the X-Ray tube

d. Target material i.e the anode

Added filtration:

It is the filtration that is added by interposing a metal, between the X-Ray tube and the patient, usually aluminium.

3.4.2 X-RAY BEAM RESTRICTORS:

The X-Ray beam restrictors regulate the size and shape of an X-Ray beam. They can be classified into three categories.

a. Aperture diaphragms

b. Cones and cylinders.

c. Collimators

Usefulness of X-Ray beam restrictors:

They decrease radiation dose to the patient.

They decrease scatter radiation and hence radiation dose to the staff.

3.4.3 GRIDS

They are strips of lead placed between the patient and radiographic film to decrease the amount of scatter radiation reaching the film.

They are designed to remove the scatter radiation. However, they remove a portion of primary beam also.

There are two main types of grids

a. Stationary grids

b. Moving grids

Construction of grids:

These are made of lead strips separated by interspace material which is transparent to X-Rays.

The orientation of lead strips may be:

Linear

Crossed

Linear grids:

Parallel-in which lead strips are parallel

Crossed:

Angled-The lead strips are angled to align with the X-Ray beam.

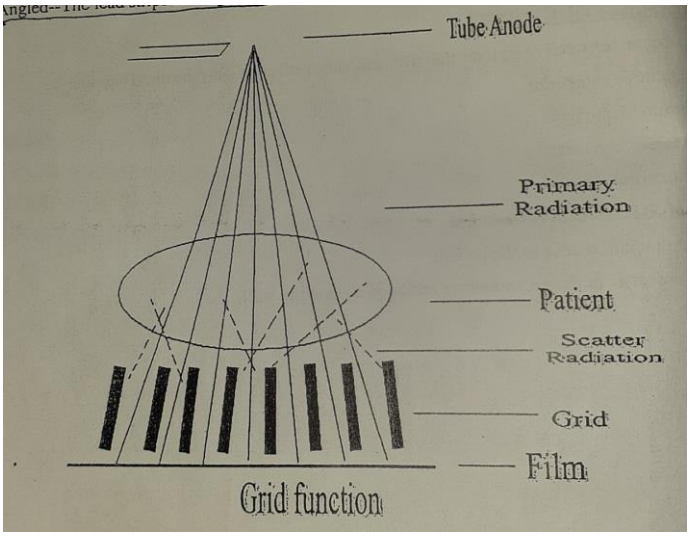


Figure: Grid function

The primary beam should pass through the interspace material. The scatter radiation should be stopped by the lead strips.

Grid ratio:

It is the ratio between the height of the lead strips to the width of the interspace material and is written as:

8:1, 12:1, 10:1 where 8, 12 & 10 are the grid ratios and the second number is always taken as 1. Ideally 8:1 grid ratio grids are used

Use of the grids:

The grids should be used:

a. With proper orientation

b. Within their focal length

There is a great loss of primary radiation if the grids are used:

a. Upside down

b. Tilted with reference to the film

3.4.4 AIR GAP TECHNIQUE

In this technique, air gap is given in between patient and the film. The purpose is the same as grids i.e to reduce the amount of scatter radiation from falling on the film. The scatter radiation from the patient is absorbed in the air gap and does not reach the film.

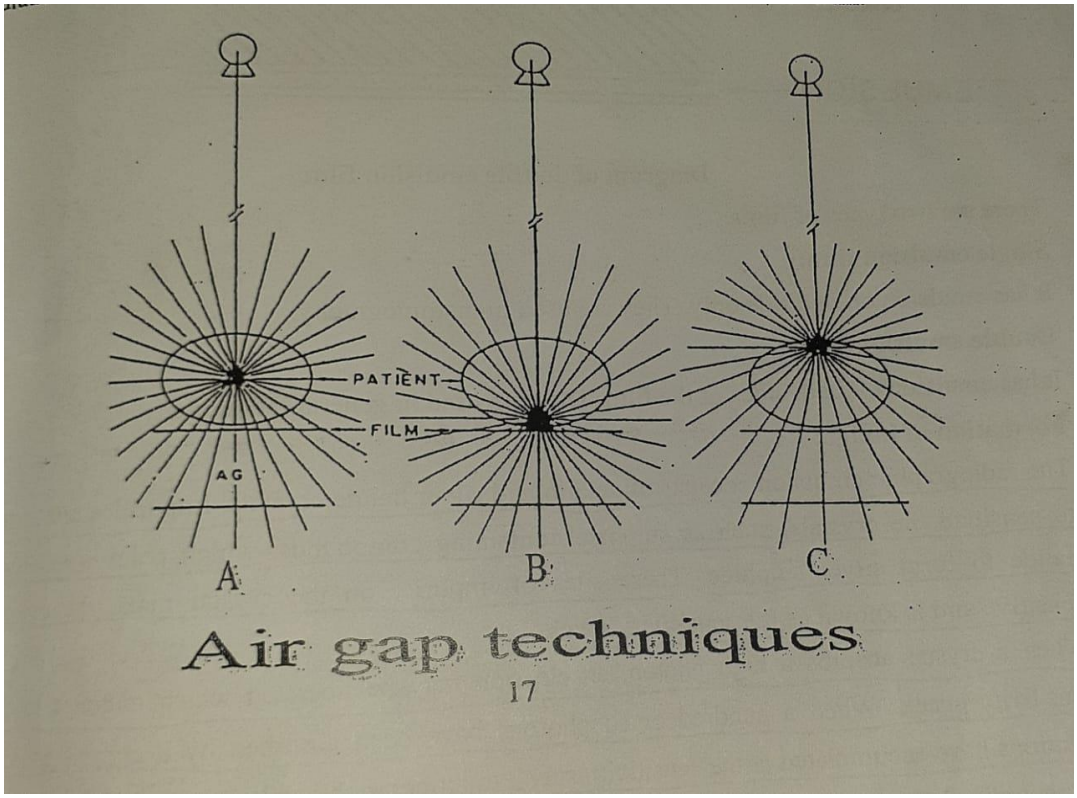


Figure: Air gap techniques

3.5 X-RAY FILM

Construction of X-Ray film:

The radiographic film has two main components:

a. Base

b. Emulsion

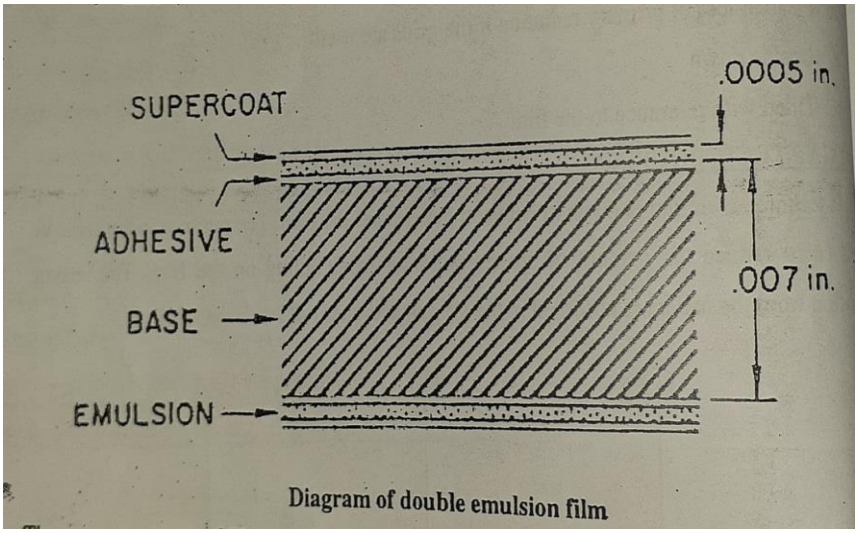


Diagram of double emulsion film:

There are two types of films.

3.5.1 Single emulsion film:

It has emulsion on one side only. They are used in mammography.

3.5.2 Double emulsion film:

It has emulsion on both sides of the film. They are used in general radiography.

Formation of image:

The radiographic emulsion consists of gelatin and silver halide crystals. Impurities are added to sensitize the crystals, such as sulphate containing compounds, which react with silver halide to form silver sulphide. These sites of impurity on the crystal make the crystal sensitive and is known as the sensitivity speck.

When a crystal absorbs a high photon, an electron may be liberated which migrates to the sensitivity speck. When a hundred or so photons have been absorbed by a crystal, enough electrons have accumulated at the sensitivity speck to attract mobile silver ions to join them and be neutralized. They form a submicroscopic speck of silver metal, which forms the latent image. This latent image requires development.

3.6 SCREENS

Intensifying screens are used because they decrease the x-ray dose to the patient.

They are placed on either side of the film.

X-rays falling on the screen are converted to light. The light exposes the x-ray film.

The screens emit light in the blue or green region of the light spectrum. Depending on the sensitivity of the film, corresponding screens are used. The screens which emit light in blue region of spectrum are used with blue sensitive film.

The screens which emit light in the green region of the light spectrum are used with green sensitive films.

Calcium tungstate emits a continuous spectrum of violet and blue light. Lanthanum oxybromide activated with terbium emits blue light. Both of these can be used with blue sensitive X-ray film.

Gadolinium oxysulfide and lanthanum oxysulfide activated with terbium emit a line spectrum of green light. They can be used only with green sensitive film. Green sensitive film is also called orthochromatic film.

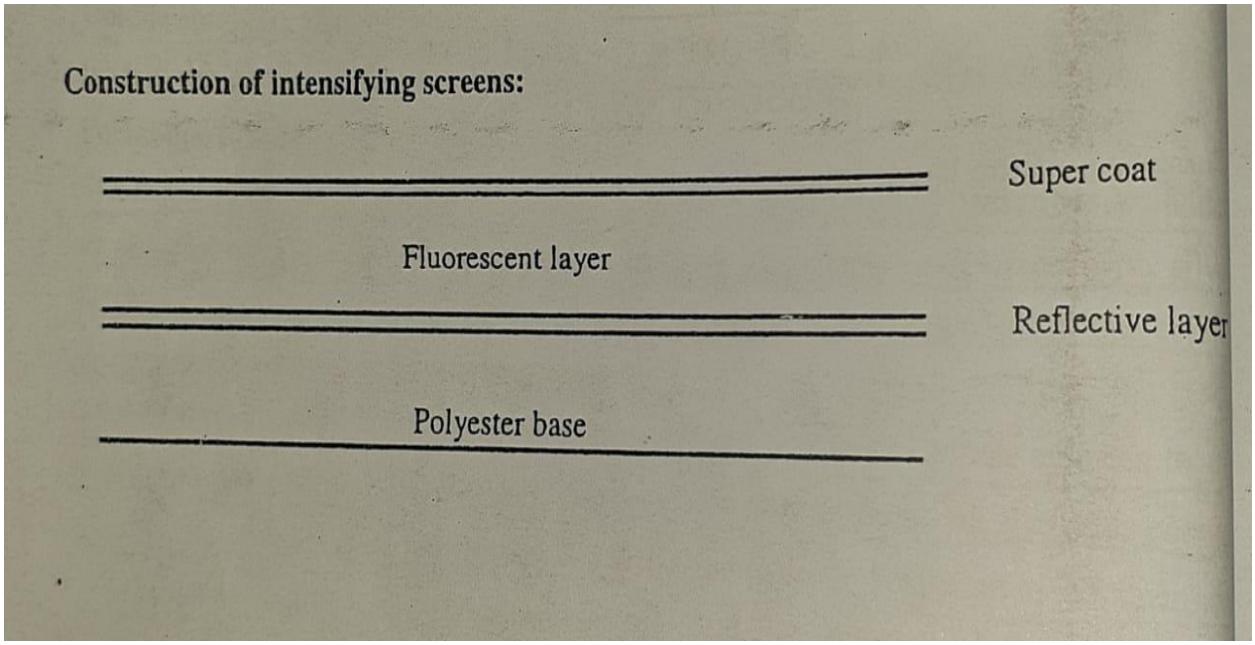
Uses of screens:

They decrease x-ray exposure to the patient.

Double screen is used for double emulsion film.

Single back screen is used for single emulsion film as in mammography.

Construction of intensifying screens:



Super coat

Fluorescent layer

Reflective layer

Polyester base

3.7 FILM CASSETTE

Film cassette is a rigid holder that contains screens and film. The front of the screen is made of low atomic number material such as plastic or cardboard so that X-Ray beam is not attenuated. Attached to the inside of the front cover of the cassette is the front screen.

The back surface of the cassette cover is thicker than the front screen. The back screen is attached to the back cover.

The radiographic film is loaded between these two screens.

Between each screen and cassette cover is a compression device such as felt or rubber that maintains close film screen contact when the cassette is closed.

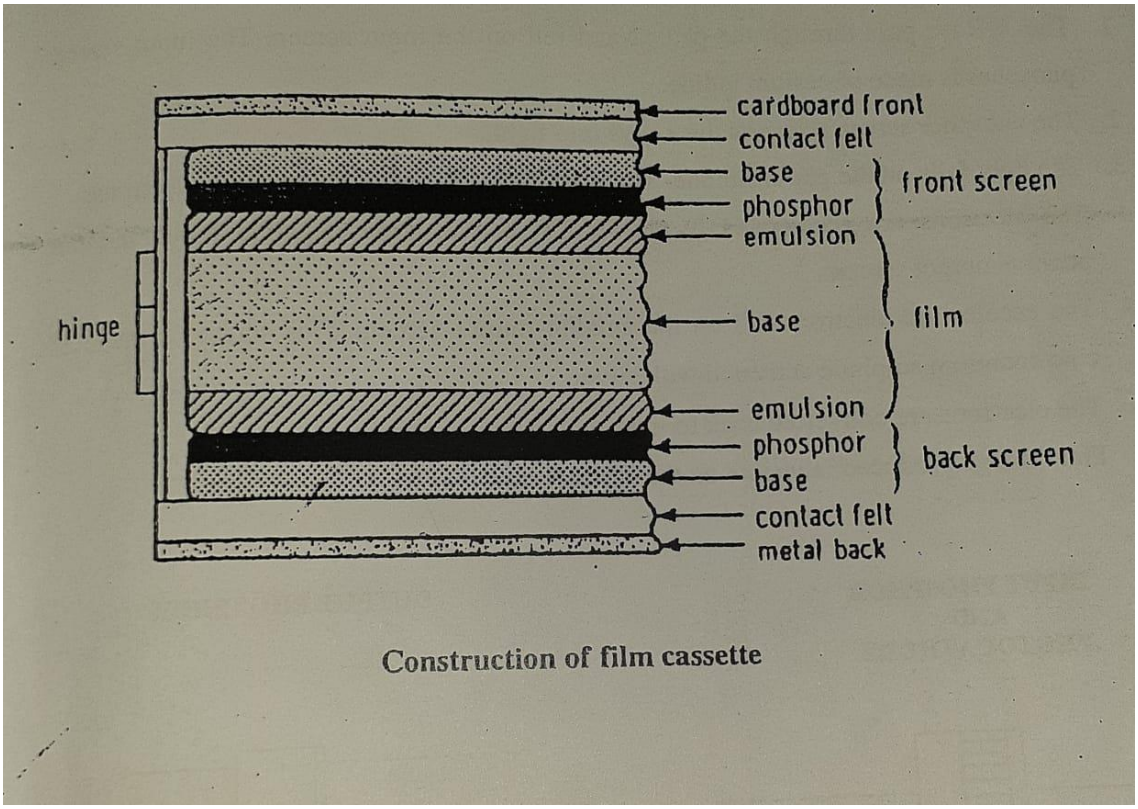


Diagram: Construction of film cassette

3.8 FLUOROSCOPY

In fluoroscopy, visible image is produced by a phosphor screen which converts the pattern of X-Rays leaving the patient into visible image. A phosphor screen converts the X-Rays into light.

Steps of image production by a fluoroscope:

1. The X Rays pass through the patient and fall on the input screen. The input screen phosphor is made of cesium iodide.

2. The phosphor screen converts the x rays into light.

3. The light falls on the photocathode. The photocathode converts light into electrons.

4. The electrons are accelerated by 25-35 KV between the negative input and the positive output screen.

5. The accelerated electrons fall on the smaller output screen. This screen is made of zinc cadmium sulphide activated with silver.

6. The electrons are converted back to light by the output screen.

7. Final image produced is visible on the TV monitor.

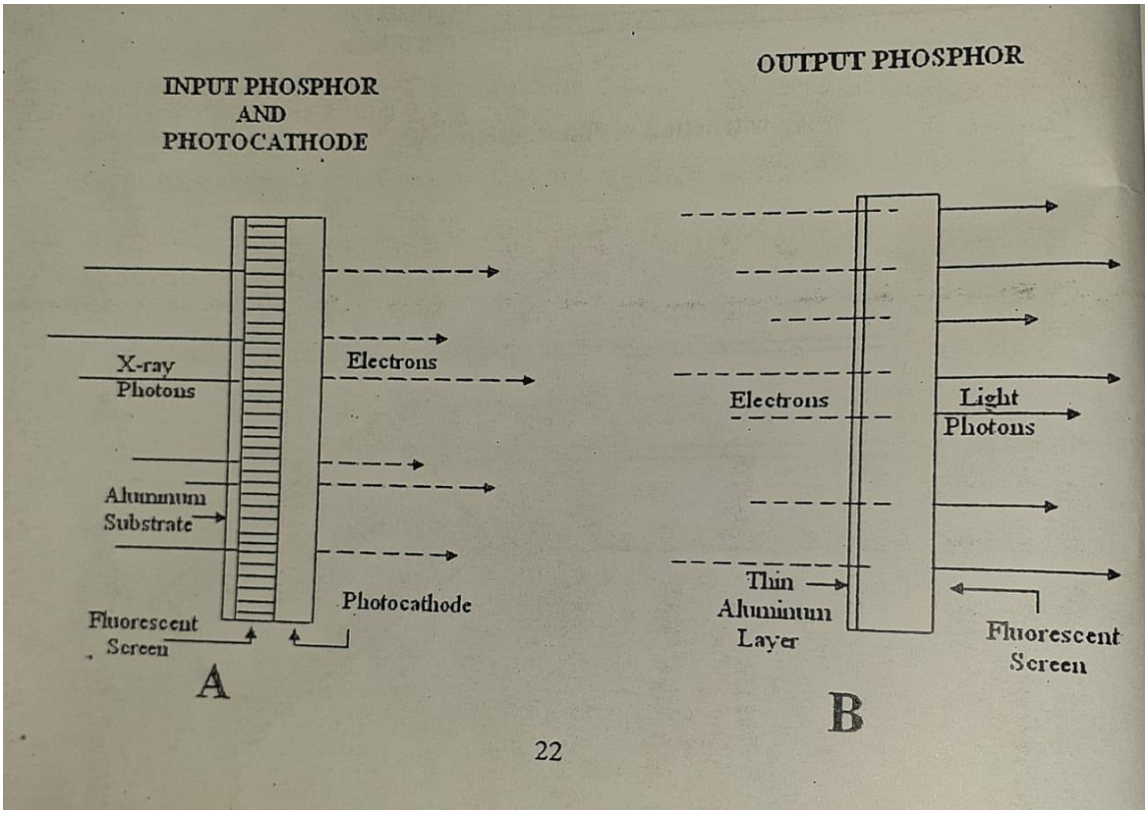


Diagram: a. input phosphor and photocathode, b. output phosphor

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CHAPTER 4

COMPUTED RADIOGRAPHY AND DIGITAL RADIOGRAPHY

4.1 COMPUTED RADIOGRAPHY

It is a form of radiology in which, instead of conventional X-ray film, an imaging plate made of photostimulable phosphor is used to create the image.

Its equipment is similar to conventional radiography. The imaging plate is kept in a special cassette and placed under the body part to be examined and the x-ray exposure is made.

Instead of taking an exposed film into a darkroom or an automatic film processor, the imaging plate is run through a special laser scanner, or CR reader, that reads the image.

The digital image can then be seen and enhanced using computer, which can alter its contrast, brightness, filtration and magnification.

4.1.1 Imaging plate

The CR imaging plate contains photostimulable phosphors, which store the radiation level received. When the plate is put through a scanner, the laser beam of the scanner causes the emission of light, that is equal to the X-ray energy absorbed by the imaging plate. This light is detected by a photo-multiplier tube, which then converts it to an electronic signal. The electronic signal is then converted to digital signal.

Imaging plates can theoretically be re-used thousands of times if they are handled carefully.

An image can be erased by simply exposing the plate to a room-level fluorescent light. The imaging plate can then be re-used.

Advantages

No silver based film or chemicals are required to process film.

Reduced film storage costs because images can be stored digitally.

Lower radiation dose to the patient.

Image acquisition is much faster (less than 15 seconds.)

Images can be enhanced digitally to help in interpretation.

By adjusting image brightness and/or contrast, one exposure, is enough unlike conventional film radiography, which may require multiple exposures.

Images can be stored.

Disadvantages

CR is still not an approved method for higher quality radiologic applications due to lower spatial resolution as compared to conventional radiography.

Imaging plates are expensive and can be damaged if handled roughly.

4.2 DIGITAL RADIOGRAPHY

Digital Radiography (DR) is a form of filmless radiography, where digital X-ray detectors are used instead of traditional photographic film.

These detectors include Flat Panel detectors, and High Density Solid State detectors. The examples are amorphous silicon, amorphous selenium flat panel detectors etc.

The X-ray energy is stored in these detectors, which is released and read out by a digital image capture array of Charge Coupled Devices (CCD's).

The image data file is transmitted to the X-ray technologist at a computer for review and then sent to the radiologist for further interpretation.

The captured X-ray image on a detector, can be presented immediately for reading and can also be stored as a part of patients medical record.

Advantages:

Time is saved because chemical processing is not required and the image can be digitally transferred, and immediately seen on monitor.

Less radiation is used to produce an image of similar contrast to conventional radiography.

Image processing can be done, on computer for over- and under-exposed images.

Reduce costs associated with processing, managing and storing films.

CHAPTER 5

CONTRAST MEDIA USED IN RADIOLOGY

5.1 Contrast media

Contrast media are high density agents used in different radiological procedures. These show identify the anatomy and pathology of organs well.

Contrast media are of two basic types

1) Intravascular contrast media

2) Oral/Gastrointestinal contrast media

5.1.1. Intravascular contrast media

Intravascular contrast media are usually given intravenously and are used in various fluoroscopic contrast studies, CT Scan, ultrasound and MRI. These can also outline the nary tract or biliary tract depending on the route of excretion. Contrast media are used in Angiographies, Intravenous urography, hepatobiliary contrast procedures, ultrasound, CT Sean and MRI. Intravascular contrast media are usually utilized to outline the vessels and give information regarding vascularity of an organ or mass lesion.

5.1.2. Oral/Gastro intestinal contrast media

Gastrointestinal contrast media are usually given orally to outline the gastrointestinal tract and are used in fluoroscopic guided barium studies and CT Scan. These are of the following main types:

a) Barium (barium sulphate suspension) - positive contrast medium used in fluoro guided procedures and CT (appears white or radiopaque on radiograph / CT scan).

b) Water soluble contrast media (gastrographin) - positive contrast medium used in fluoro guided procedures and CT (appears white or radiopaque on radiograph / CT scan).

c) Water - negative contrast medium used in CT scan (appears hypodense to soft tissues on CT).

d) Gases (CO_2, air) - negative contrast medium used in fluoro guided procedures (appears black on radiograph).

1. INTRAVASCULAR CONTRAST MEDIA USED IN FLUOROSCOPY AND CT SCAN:

Intravascular contrast media are high molecular weight iodinated compounds. The iodine atom contained in these contrast media make them radiopaque on radiograph, procedures & CT scan. Intravascular contrast media are usually clear and transparent solutions and it is the duty of radiographer to check the expiry date on bottle and care fully look for any turbidity or cloudiness of solution. In case the solution is turbid in appearance or expired by date, it should be discarded and not used for patients.

These are basically of two types

a. Conventional ionic hypertonic contrast media (high osmolar contrast media / HOCM)

b. Newer non-ionic iso osmolar contrast media (Low osmolar contrast media / LOCM)

Conventional ionic hypertonic contrast media (high osmolar contrast media / HOCM)

- These are conventional, older iodinated contrast media which are hypertonic with osmolalities ranging between 1200 - 1500m osmoles / Kg water. (Approximately 4- 7 times osmolarity of blood).

- Toxicity of these contrast media is more because of their high osmolarity.
- These cannot be used in subarachnoid space.
- Examples - urographin (diatrizoates).

Newer non-ionic contrast media (low osmolar contrast media / LOCM)

- These are newer iodinated contrast media which are isotonic & iso-osmolar to human blood.
- Due to low osmolarity / iso-osmolarity of these contrast media, toxicity with these contrast agents is very low.
- Can be used in subarachnoid space (intrathecally).
- Examples - iopamidol, iopromide, Ultravist.

Advantages and disadvantages of non-ionic low osmolar contrast media over high osmolar contrast media:

Advantages:

More comfortable arteriograms & IV injections for patient.

Less tissue toxicity.

Reduction in number and severity of adverse reactions.

Can be used intrathecally.

Disadvantage:

Relative disadvantage is high cost of non-ionic low osmolar contrast media comparative to low cost of high osmolar contrast media.

2. INTRA VASCULAR CONTRAST AGENTS IN ULTRASOUND:

Gas microbubbles in a solution are the basic formulation of ultrasound contrast media.

Ultrasound contrast media are usually injected intravenously.

These are helpful to visualize the blood vessels on ultrasound and also vascularity of different organs and mass lesions.

Examples of ultrasound contrast media are Echovist, Levovist,

3. INTRAVASCULAR CONTRAST AGENTS IN MRI

PARAMAGNETIC CONTRAST MEDIA:

a. Paramagnetic contrast media (Gadolinium)

Used intravenously.

Cause shortening of T1 relaxation time and produce increased signal intensity (white) on T1 weighted images.

Enhances the pathological lesion and shows it well.

b. Super paramagnetic contrast media

Used intravenously.

Cause reduction in T2 relaxation time, hence producing decreased signal intensity (black) on T2 weighted images.

5.2 GASTROINTESTINAL CONTRAST AGENTS:

5.2.1. Barium (positive contrast medium)

Barium suspension is made from pure barium sulphate. It is a high density compound which is radio opaque and thus outlines the gut very well. Particles of barium must be small (0.1 - 3µm) & a non-ionic suspension is used to prevent clumping.

Examinations of different parts of the gastrointestinal tract require barium preparations with differing properties.

Barium swallow, 250 % 100ml (or more, as required).

Barium meal, 250 % w/v 135 ml. A high-density, low-viscosity barium is required for a double-contrast barium meal to give a good thin coating that is still sufficiently dense to give satisfactory opacification.

Barium follow-through, 60-100 % w/v 300ml (150ml if performed after a barium meal).

Small bowel emema, 1500ml (60% w/v).

Barium enema, 115% w/v 500ml (or more, as required).

Advantages

The main advantage when compared to water soluble contrast agents is the excellent coating which can be achieved with barium, allowing the demonstration of normal and abnormal mucosal patterns.

Low cost.

Disadvantages

If barium spills into the peritoneal cavity there is high morbidity associated with barium peritonitis.

After barium administration, subsequent abdominal CT are rendered difficult to interpret due to artifacts. Patients may be asked to wait for up to 2 weeks to allow satisfactory clearance of the barium. If possible, it is advisable that the CT be performed before the barium study.

Complications

i. Perforation.

The escape of barium into the peritoneal cavity is extremely serious, and will produce pain and severe hypovolemic shock. Despite treatment, which should consist of i.v fluids, steroids and antibiotics, there is still a 50% mortality rate. Of those that survive, 30% will develop peritoneal adhesions and granulomata.

Intramediastinal barium also has significant mortality rate. It is therefore imperative that a water-soluble contrast medium is used for any investigation in which there is a risk of perforation.

ii. Aspiration.

Barium if aspirated is relatively harmless. Sequelae include pneumonitis and granuloma formation. Physiotherapy is the only treatment required (for both aspirated barium and LOCM), and should be arranged before the patient leaves hospital.

iii. Intravasation.

This may result in a barium pulmonary embolus, which carries a mortality of 80%.

5.2.2. Water soluble contrast media (positive contrast medium)

e.g. Gastromiro, e.g Gastrografin

Indications

a) Suspected perforation

b) Meconium ileus

c) To distinguish bowel from other structures on CT. A dilute solution of water-soluble contrast medium (e.g 15 ml of Gastrografin in 1 litre of flavored drink) is used so that minimal artefact 'shadow' is produced.

d) LOCM is used if aspiration is a possibility.

Complications

a) Pulmonary oedema if aspirated (not LOCM)

b) Hypovolemia in children - due to hyperosmolarity of the contrast media drawing fluid into the bowel.

c) Allergic reactions due to absorbed contrast media.

d) Ileus may occur in 4% of patients examined in the postoperative phase.

e) Contrast dilution and thus poor radiographic visibility.

5.2.3. Water (negative contrast medium)

Water is used as a contrast agent in abdominal CT scans to outline the gastrointestinal tract but it is not used as a contrast agent during fluoroscopic guided contrast procedures. It is called a negative contrast medium. Negative contrast means that it does not appear hyperdense or white on CT scan as other contrast media like barium or gastrographin. It appears blackish or hypodense in relation to bowel wall and therefore shows luminal and mucosal abnormality of gut very well.

5.2.4. Gases (negative contrast medium)

Carbon dioxide and, less often, air are used in conjunction with barium to achieve a 'double contrast' effect during fluoroscopic guided gastrointestinal contrast procedures. For the upper gastrointestinal tract, CO_2 is administered orally in the form of gas producing granules / powder. For lower gastrointestinal tract evaluation as in barium enema, air is introduced per rectally by rectal tube.

5.3 ADVERSE EFFECTS OF INTRAVASCULAR CONTRAST MEDIA USED IN FLUOROSCOPY

Intravascular contrast media may lead to many complications which may be very mild to life threatening reactions ranging from slight nausea to even death.

The manifestations of adverse reactions to intravenous contrast medium are:

1. **Mucocutaneous reactions** - flushing, pallor, rhinorrhea, urticaria and in the most severe cases angioneurotic oedema. Onset may be immediate or delayed up to 3 days.

2. **Nausea and vomiting**

3. **Headache**

4. **Sneezing**

5. **Arm pain** locally, due to perivenous injection or due to stasis of the contrast medium in the vein. Less common with LOCM.

6. **Thrombophlebitis and venous thrombosis.**

7. **Abdominal pain.**

8. **Rigors.**

9. **Bronchospasm** - predisposed to by a history of asthma and concurrent therapy with beta blockers. In most patients the bronchospasm is subclinical.

10. **Hypotension** usually accompanied by tachycardia but in some patients there is bradycardia. The latter is rapidly reversed by atropine 0.6-2 mg i.v. Hypotension is usually mild and is treatable by a change of posture. Rarely it is severe and may be accompanied by pulmonary oedema.

11. **Haematological changes** hypertension may be exacerbated. Blood micro-viscosity is increased and pulmonary

12. **Sickle cell crisis** may be provoked.

13. **Sloughing of skin** secondary to extravasation of contrast medium. Less common with LOCM

14. **Convulsions** - especially in patients with an epileptic tendency and in patients with cerebral tumours undergoing CT. Convulsions may also occur secondary to the cerebral hypoxia caused by hypotension +/- cardiac arrest.

15. **Cardiac arrest** due to (a) arrhythmia, (b) ischaemia secondary to hypotension or (c) coronary artery spasm during an anaphylactoid reaction.

16. **Contrast induced nephrotoxicity.**

17. **Anaphylaxis (life threatening complication)** - it is clinically manifested by severe breathlessness, bronchospasm, glottic edema, circulatory collapse / shock, abdominal cramps, diarrhoea. The patient may die unless immediate and appropriate resuscitative measures are taken.

5.4 EMERGENCY EQUIPMENT AND DRUGS FOR THE X-RAY DEPARTMENT

It is very essential that all emergency equipment in radiology department is well maintained and regularly checked to ascertain its functional status. The drugs used should also be kept in cool storage places and regularly checked for expiry status.

5.4.1 Emergency Equipment

1. Oxygen cylinder
2. Stethoscope and BP apparatus.
3. Face mask-adult and paediatric sizes
4. Airway - adult and paediatric sizes
5. Laryngoscope
6. Endotracheal tubes
7. Ventilation bag (ambo bag)
8. Needles and syringes
9. IV set
10. Scalpel blade and French's needle.
11. Suction catheters

5.4.2 Emergency Drugs Used In Radiology

DRUGS with concentration and route:

Adrenaline 1:1000 S.C

Aminophylline 250 mg in 10 ml I.V

Atropine 600 ug in 1 ml IV

Sodium bicarbonate 8.4 %, 200ml IV

Calcium gluconate 10% 10 ml i.v slowly

Chlorpheniramine 10 mg iv diluted with blood over 1 min

Dextrose 5%,500ml, Dextrose 50% w.v, Diazepam 10 mg in 2 ml i.v

Dopamine 800 mg in 5 ml to be diluted in 500 ml N/saline or 5% dextrose iv infusion

Frusemide 10 mg ml-2 ml, 5 ml and 25 ml ampoules iv

Hydrocortisone 100 mg iv slowly

Lignocaine 100 mg in 10 ml iv

Naloxone 400 ug in 1 ml iv

Protamine sulphate 10 mg / ml iv slowly

N saline 500 ml iv

Water for injection.

5.5 TREATMENT OF EMERGENCIES

The radiographer should inform the radiologist in-charge immediately in case of any emergency or contrast reaction.

The flow charts of the following pages outline the steps to be taken during the most frequently occurring emergencies in the X-ray department.

5.5.1 A Guide to Management Of Emergencies In Radiology

PULMONARY OEDEMA

Sit up

Oxygen

I.V

Frusemide

Diamorphine

CONVULSION

i.v diazepam

? Cerebral Oedema

then i.v mannitol

Admit

RESPIRATORY ARREST

Intubate and Ventilate

i.v line

CARDIAC ARREST

CPR

Artificial ventilation

External cardiac massage

ELECTRIC SHOCK

Switch off power source

Artificial ventilation

Treat cardiac arrest

If burns

Treatment of burns

Remove from contact using non-conducting material

Assess Injuries

Assessment and treatment of fractures and dislocations

NAUSEA, VOMITING, UNEASY SENSATION IN EPIGASTRIUM METALLIC TASTE, ETC.

Firm reassurance

SEVERE VOMITING

Metoclopramide

5.5.2 URTICARIA, RHINITIS, CONJUNCTIVITIS

ABDOMINAL COLIC

BRONCHOSPASM

ANGIONEUROTIC OEDEMA

Reassurance. If severe, antihistamines or adrenalin

i.v. line

oxygen

Hydrocortisone

Admit and observe?

repeat drugs

HYPERTENSIVE CRISIS

Beta blocker

Refer to physician

5.5.3 HYPOTENSION

Elevate legs

Lower head

I f no improvement

and bradycardia

- Vagus reaction
- i.v line
- i.v atropine

If Tachycardia

- i.v. line
- Dopamine infusion

CHAPTER 6

DARK ROOM FILM PROCESSING

6.1 Film processing

Film processing is a procedure whereby a latent image on a film is processed to become a visible radiograph in control environment called dark room.

Film loading and development needs to be done in dark.

Film processing consists of four major steps namely: development, fixing, washing, and drying.

6.1.1 Transport system:

Once a film is put into the automatic processor, it is transported by rollers and racks through the different wet tanks and drying chamber and finally is deposited in the receiving bin.

6.1.2 Temperature control system:

Developer temperature is maintained at 95 degree F (35° C) Wash water temperature is maintained at 5° lower.

6.1.3 Circulation system

This system maintains agitation of the film during the process of development.

Circulation of water through the wash tank is necessary to remove all of the processing chemicals from the surface of the film to ensure proper film quality.

6.1.4 Replenishment system

Each time the film passes through the processor, it uses up some of the chemicals. The developer and fixer are constantly replenished. The replenishment rates are approximately 60-70 ml of developer and 100-110 ml of

fixer for every 14 inches of film. Water is continuously and completely replenished.

6.1.5 Dryer system:

The dryer system completely extracts all residual moisture from the processed radiograph and the film comes out absolutely dry in the receiving bin.

6.1.6 Electrical system:

This is done through proper wiring of the automatic processor.

6.2 Importance of proper development:

Film development is a chemical process which is governed by 03 physical characteristics:

a. Time

b. Temperature

c. Concentration of developer

Increased time of development and high developer temperature would lead to increased reduction of the silver in each grain with increased development of the total number of grains.

If the concentration of developer is increased, the reducing agent in the developer becomes more powerful and can more readily penetrate both exposed and unexposed silver halide grains.

All these would increase film fog.

6.2.1 Film fog:

It is the undesirable density on the radiograph which lowers radiographic contrast. The different types of film fog are:

a. Development fog:

It is the development of unexposed silver halide grains. Increased time of development and high developer temperature would lead to increased reduction of the silver in each grain with increased development of the total number of grains thus increasing film fog.

b. Chemical fog:

This is produced by chemical contamination of the developer.

c. Radiation fog:

This is produced by unintentional exposure of film to radiation.

d. Improper storage of film at high temperature and under humid conditions would also contribute to fog.

Film loading and development needs to be done in dark.

6.3 Safe light

Safe light is the light to which the film can be exposed without image formation.

In dark room, red may be used for blue and green sensitive films.

Amber light is used for blue sensitive films.