PART I - PATIENT PROTECTION (10-15 QUESTIONS)

1. TARGET-TO-PANEL AND TARGET-TO-SKIN DISTANCE - INFLUENCE ON PATIENT EXPOSURE (DOSE)

Most x-rays directed at patient are absorbed by patient.

2. FACTORS INFLUENCING EXPOSURE RATE AT THE PANEL OR TT (TABLE TOP) FOR ROUTINE FLUOROSCOPY

Filtration, kVp, target-to-panel (target = focal point on anode, panel = table top) distance directly influence table top exposure.

For an undetachable tube, maximum intensities are received above the TT level at an angle of 135 degrees and minimum intensities at 90 degrees (right behind protective curtain).

3. PURPOSE AND USE OF OPTIONAL HIGH EXPOSURE LEVEL CONTROL

This "boost" control increases the tube current (mA) and tube potential (kVp) above normal limits.

 Shall only be utilized when it is necessary to produce an acceptable image, which will enable it to override routine exposure limits = heavy patient.

When this "boost" control is engaged, a continuous manual activation is required.

4. FILTRATION AND PATIENT EXPOSURE

Material placed in path of useful beam to absorb less penetrating radiations, thus reducing a great deal of unnecessary exposure to patient.

5. COLLIMATION - AREA EXPOSED VS. PATIENT DOSE

The greatest contribution of unnecessary radiation exposure to the patient comes from the x-ray operator's failure to collimate beam to area of interest only.

If exposure area is doubled, patient dose and operator exposure is doubled.

EXPOSURE TIME

Doubling the exposure time doubles the patient exposure.

CUMULATIVE TIME

A cumulative manual-reset timer activated by exposure switch the produces an audible signal or temporarily interrupts x-ray beam when fluoro time has exceeded five (5) minutes max must be provided.

MILLIAMPERAGE (mA) USED AND ITS INFLUENCE ON PATIENT EXPOSURE

As the mA is increased and the kVp is decreased the patient skin exposure is increased.

Exposure delivered to patient is directly proportional to mA.

The mA setting is typically less than 5 mA preferably below 3 mA.

6. CONTINUOUS AUDIBLE SIGNAL DURING HIGH LEVEL CONTROL OPERATION

When this "boost" control is engaged, a continuous audible signal (buzzer) is required.
7. USE OF VIDEO DISC AND ITS INFLUENCE ON PATIENT EXPOSURE

Manuacturers report up to 95% dose reduction when utilizing video disc recording during fluoro vs. continuous fluoro exposure - once image is stored, exposure is terminated automatically by equipment even though the operator continues to stand on footswitch.

8. MINIMUM PERMISSIBLE SOURCE-TO-SKIN DISTANCE

Shorter target-to-panel distances result in a greater skin dose and greater distortion of image. TPD distances may vary but image intensifier should always be positioned as close as possible to patient to keep exposure low.

9. MAXIMUM PERMISSIBLE EXPOSURE RATE AT THE TABLE TOP (PANEL)

Intensity of beam should not exceed 2.2 R/min for each mA of operating tube current at 80 kVp.

10. INVERSE SQUARE LAW (FROM POINT SOURCES)

If you double your distance from a source of radiation, your exposure will be reduced by 1/4th of the original dose.

If 4 mR/mAs at 40” distance is delivered to patient, at 80” distance, the radiation output from tube in mR/mAs = 1 mR/mAs.

If 1 mR/mAs at 40” distance is delivered to patient, at 80” distance, the radiation output from the tube in mR/mAs = .25 mR/mAs.

11. RADIOSENSITIVITY OF VARIOUS CELLS AND ORGANS

Biological effects of radiation are known to be influenced by type of radiation & dose rate, total dose, and type of cells being exposed (Law of Bergonie & Tribondeau).

Depends on degree of mitotic activity, number of undifferentiated cells in the tissue, & length of time the cells are in active proliferation (Law of Bergonie & Tribondeau).

Several hundred rads (200 rads) of acute x-radiation to the eyes will result in the formation of cataracts.

12. DOSE TO THE PATIENT'S:

A. SKIN

During a CINE exam in which 35mm film and frame rate of 30 frames/sec are utilized, the skin exposure is 2-5 R/minute.

B. BONE MARROW

Exposure is considered a whole-body-dose.

Lymphocytes are the most sensitive type of cells to radiation while muscle cells least, red bone.

A strong correlation exists between incidence of leukemia and dose received by bone marrow.
C. GONADS

Gonadal exposure is considered a whole-body-dose

Approximate gonad dose resulting from a BE exam is approximately 1000 mrad.

Best type of gonadal shielding is shaped contact gonad shield. Use of 0.5mm Pb equivalent shield reduces dose by 92%.

D. THYROID

Dose to thyroid may be useful to determine the probability of certain effects occurring.

E. VARIOUS ROUTINE FLUOROSCOPY EXAMINATIONS

Typical exposure for a 120 second UGI fluoro exam is 5-15 R

Cardiac cath results in a bone marrow dose of approximately 190 mrad.

13. TYPES AND USES OF GONADAL AND OVARIAN SHIELDS

The best gonadal shielding for a male, would be shaped, contact shielding.

Minimum LEAD equivalence of gonadal shielding must be 0.50 mm Pb.

14. PREGNANT AND POTENTIALLY PREGNANT PATIENTS

Risk to embryo/fetus is considered to be negligible at 5 rads or less and risk of malformations is significantly increased above control levels only at doses above 15 rads.

All female patients of childbearing potential should be asked if they are pregnant or think they may be.

15. SPECIAL PROBLEMS FLUOROSCOPING INFANTS AND CHILDREN

Majority of imaging problems are caused by patient motion.

Use of AEC is a valuable tool except when very radiopaque structures fill up center of imaging field, causes patient's exposure to increase to maximum.

AEC will not function properly unless child covers entire exposure detection device.

16. SPECIAL PROBLEMS FLUOROSCOPING WITH C-ARM

PART II - Operator Protection (10-15 questions)

17. PERSONNEL MONITORING DEVICES, TYPES AND USES

Film badges are used because they are a practical means of providing long term exposure records & they can measure exposure with reasonable accuracy.

Film badge report expresses an individual's radiation dose equivalent in rems. (mrem)

Film badge reports shall be preserved indefinitely by the employer.

A disadvantage of an Thermoluminescent dosimeter (TLD) is that no permanent record is provided since dose is cancelled when TLD is read.
Lithium fluoride is the most common material used in TLD dosimeters.

Acceptable types of monitoring devices are FBs and TLDs.

Other types of monitoring devices include pocket ion chambers and audible warning devices.

**When to Wear Monitoring Devices**

Each supervisor must supply devices to any person who is:

1. Likely to receive a quarterly whole-body exposure of 0.3 rems
2. Persons who enter high radiation area (area in which one could receive a dose to whole body in excess of 100 mrem in one hour)
3. Persons who operate mobile x-ray equipment

**Time**

1/3 basic principle to reduce dose to x-radiation

**Distance**

2/3 basic principle to reduce dose to x-radiation

**Shielding**

3/3 basic principle to reduce dose to x-radiation

**Protective Apparel**

Substantial exposure reduction from scattered radiation can be achieved if worn

**Protective Apron**

Everyone in fluoro room should be wearing an apron

A 0.25 mm Pb apron will typically reduce exposure reduction by 97%

**Lead Protective Goggles or Eyeglasses**

Best protective eyewear for the operator to utilize during fluoro is wraparound (side panel) lead glass eyeglasses

**Placement of Monitoring Device**

During fluoro, film badge should be worn above the apron at collar level

**When to Wear Two Monitoring Devices**

May be advisable if worker is pregnant or if performing special procedure examinations

**Scatter from Patient and Other Sources**

The major source of scatter or secondary radiation is from the patient's body.

**Isoexposure Curves**

According to isoexposure curves, the best place to stand for the licentiate would be behind the protective curtain to receive the least amount of radiation exposure should you have to stay in room during fluoro.
30. Efficacy of Protective Apparel of Various Lead Equivalent Thicknesses Exposed to Scattered or Primary X-Ray Beam

Minimum Pb equivalence of protective apparel is 0.25mm Pb, which reduces operator's exposure by 97%. If 0.5mm Pb were used, reduced transmitted exposure reduction to scattered radiation is 99.9%.

Most common thicknesses on market are 0.25mmPb, 0.5mm Pb, & 1.0mm Pb. 1.0 Pb is quite heavy and cumbersome.

31. Bucky Slot Cover

When Bucky tray is moved to end of table it leaves a 2" opening in the side of table right at the gonadal level. This MUST be automatically covered with at least 0.25 mm Pb equivalent material.

32. Protective Curtains or Drapes

33. Possible Exposure to the Eyes and/or Thyroid

34. C-Arm Scatter for Various Examinations

AP Chest view the direction in which there is the most scatter is at 135 degrees from the X-ray tube, back toward the image intensifier.

35. Long Term Effects of Low-Level Exposure

Increased incidence of cancer, effects involving the developing fetus/embryo, life-span shortening, cataracts.

PART III - Regulatory Provisions (10-15 questions)

36. Relating to Patient

A. Optimum and Maximum Permissible Exposure Rate for Routine Fluoroscopy

Approximate exposure to patient during 5 minutes of fluoro would be 10-30 R.

B. Filtration Requirements

2.5mm Al equivalent is the total filtration required to be permanently fixed or intercepting the useful beam to remove less penetrating radiation that would be absorb by the patient and never reach the recording medium anyway.

C. Optimum Target-to-Skin and Target-to-Table Top Distance

D. Minimum Permissible Source (Target) to Patient Distance

For mobile (C-arm) equipment, inherent provisions MUST ensure a minimum source-to-skin distance of 12" or 30 cm.

E. Exposure Switch

37. Relating to Operator

A. Protective Curtains and Drapes

Should be used because scattered radiation exposure at 1 foot from the patient could be as high as 500 mR/hr. (at 2 feet it would be 100 mR/hr, at 3 foot 50 mR/hr.)

B. Leakage Radiation
30. EFFICACY OF PROTECTIVE APPAREL OF VARIOUS LEAD EQUIVALENT THICKNESSES EXPOSED TO SCATTERED OR PRIMARY X-RAY BEAM

Minimum Pb equivalence of protective apparel is 0.25mm Pb, which reduces operator’s exposure by 97%. If 0.5mm Pb were used, reduced transmitted exposure reduction to scattered radiation is 99.9%.

Most common thicknesses on market are 0.25mmPb, 0.5mm Pb, & 1.0mm Pb. 1.0 Pb is quite heavy and cumbersome

31. BUCKY SLOT COVER

When bucky tray is moved to end of table it leaves a 2” opening in the side of table right at the gonadal level. This MUST be automatically covered with at least 0.25 mm Pb equivalent material

32. PROTECTIVE CURTAINS OR DRAPES

33. POSSIBLE EXPOSURE TO THE EYES AND/OR THYROID

34. C-ARM SCATTER FOR VARIOUS EXAMINATIONS

AP Chest view the direction in which there is the most scatter is at 135 degrees from the x-ray tube, back toward the image intensifier

35. LONG TERM EFFECTS OF LOW-LEVEL EXPOSURE

Increased incidence of cancer, effects involving the developing fetus/embryo, life-span shortening, cataracts

PART III - Regulatory Provisions (10-15 questions)

36. RELATING TO PATIENT

A. OPTIMUM AND MAXIMUM PERMISSIBLE EXPOSURE RATE FOR ROUTINE FLUOROSCOPY

Approximate exposure to patient during 5 minutes of fluoro would be 10-30 R

B. FILTRATION REQUIREMENTS

2.5mm Al equivalent is the total filtration required to be permanently fixed or intercepting the useful beam to remove less penetrating radiation that would be absorb by the patient and never reach the recording medium anyway

C. OPTIMUM TARGET-TO-SKIN AND TARGET-TO-TABLE TOP DISTANCE

D. MINIMUM PERMISSIBLE SOURCE (TARGET) TO PATIENT DISTANCE

For mobile (C-arm) equipment, inherent provisions MUST ensure a minimum source-to-skin distance of 12" or 30 cm

E. EXPOSURE SWITCH

37. RELATING TO OPERATOR

A. PROTECTIVE CURTAINS AND DRAPES

Should be used because scattered radiation exposure at 1 foot from the patient could be as high as 500 mR/hr, (at 2 feet it would be 100 mR/hr, at 3 foot 50 mR/hr.)

B. LEAKAGE RADIATION
40. IMAGE PERCEPTION

A. IMAGE INTEGRATION OR RECOGNITION TIME BY THE EYE

Time it takes the human eye to recognize an image = 0.2 sec.

B. INTENSITY DISCRIMINATION

C. VISUAL ACUITY

Means the ability of the human eye to perceive detail.

41. QUALITY CONTROL

A. MINIMUM SOURCE-TO-TABLE TOP DISTANCE

B. X-RAY BEAM RESTRICTION SYSTEM

Beam alignment should be monitored monthly

C. RESOLUTION PERFORMANCE

Resolution (resolving power) is measured in line pairs per millimeter

Image intensifier resolution should be monitored monthly

D. LOW CONTRAST PERFORMANCE

Contrast should be monitored monthly

E. FLUOROSCOPY EXPOSURE RATE

F. FLUOROSCOPY X-RAY BEAM QUALITY

G. AUTOMATIC EXPOSURE CONTROL SYSTEM

When the x-ray tube is fixed below the table, moving the II away from patient will increase patient dose

Function is to maintain a fixed dose rate to the image intensifier

H. GRID ALIGNMENT

42. IMAGE INTENSIFIERS

A. CONSTRUCTION

**INPUT PHOSPHOR** - absorbs x-rays and converts their energy into light photons which strike the **PHOTOCATHODE** causing electrons to be given off in direct proportion to intensity of the fluorescent light. The electrons are speeded up by the **ACCELERATING ANODE** and focused by **ELECTROSTATIC LENSES** onto a second smaller fluorescent layer called the **OUTPUT PHOSPHOR** where electron's energy striking is converted back to light photons which can be picked up and viewed by variety of optical systems (usually TV monitor).

B. COMPONENTS
C. IMAGE QUALITY

Central portion of II possesses the greatest resolution.

If x-ray tube is moved rapidly during fluoro, the image will blur, resulting in what’s called image intensifier tube lag

Fluoroscopic image quality is poor compared to radiography

Two most important factors in evaluating image quality of II are statistical quality and adequate level of light for photopic vision

D. QUANTUM MOTTLE

A grainy appearance in an image caused by statistical fluctuation of absorbed x-ray photons - is seen more with low levels of mA

E. VIEWING SYSTEMS

Closed-Circuit Television System, Cinefluorography, Spot films with conventional cassettes (mA setting is typically over 100 mA), Spot film cameras (photography image off output phosphor), Video disc recording

F. MAGNIFICATION

Occurs when the useful area of input phosphor is decreased while output phosphor remains the same size, increase in patient dose when in this mode due to decrease in minification gain

G. MINIFICATION

Reduction in image size with increase in brightness

H. REAL IMAGE

When light rays intercept on a plane to form an image

I. VIGNETTING

Decrease in light intensity at the periphery of an image

J. QUANTUM NOISE

Statistical fluctuations in image which result in a grainy appearance. More visible in a high-resolution, high contrast image

43. TELEVISION

A. RESOLUTION

Process or capability of distinguishing closely adjacent optical images

B. LAG

It takes a certain amount of time for the image to build up and decay on the vidicon target when utilizing television (vidicon) camera. This blurring or lag of the image as the camera is moved during the procedure is called lag.
C. CLOSED CIRCUIT SYSTEMS

The number of horizontal lines on a TV monitor, regardless of size of monitor, is 525 lines

Has all its signals carried through cables

A Plumicon TV camera results in the least patient exposure

44. IMAGE RECORDING

A. VIDEO DISC AND VIDEO TAPE RECORDING SYSTEMS

Most commonly used video disc frame rate is 30 frame/sec

B. STILL CAMERAS

C. CINE

Using a technique called synchronization to operate the camera shutters at the same frequency as x-ray pulses and thus decrease patient dose

45. OTHER

A. AUTOMATIC EXPOSURE RATE CONTROLS

Fluoro equipment manufactured after 1974 with AEC shall not be operable at any settings which result in an exposure rate in excess of 10.0 R/minute where it enters the patient

Fluoro equipment manufactured after 1974 without AEC shall not be operable at any settings which result in an exposure rate in excess of 5.0 R/minute where it enters the patient

B. SPOT FILMING DEVICE AND GRIDS

The larger the film size used by spot filming cameras, the greater the dose to patient - 90mm vs. 105mm

C. SPOT FILMING MILLIAMPERAGE (mA)

Typical mA setting for spot filming is 150 mA (radiographic tube is engaged)

D. NORMAL VIEWING DISTANCE

For binocular vision is 4" - 10"

E. FACTORS INFLUENCING IMAGE BRIGHTNESS

Flux gain (electron acceleration) and minification result in brighter image being produced at the output phosphor of image intensifier

F. CONTRAST AGENTS

Descriptive characteristics are that they have high atomic numbers and low toxicity (like barium)
49. ADDITIONAL OTHERS

A. VIRTUAL IMAGE

Image that cannot be projected and exists only for computational purposes

B. GENETIC DOSE

Refers to the effects exhibited in future offspring of persons who have been irradiated

C. LINEAR NONTHRESHOLD CURVE

Most conservative type of dose-effect curve; most regulatory guidelines are based on this curve

D. ROENTGEN - written Roentgen - symbol = R

Think of Roentgen when you see the words: exposure; exposure rate; exposure intensity; intensity

Conventional unit of ionizing radiation measuring exposure in air (machine = engine = roentgen)

E. REM - abbreviation = rem

Conventional unit of ionizing radiation of absorbed dose equivalent (radiation equivalent man-occupational dose)
(rad x quality factor of the type of radiation one is exposed to = rem)
x-rays and gamma have a QF of 1, so rad = rem = roentgen in diagnostic x-ray range

SI unit = sievert 1 sievert = 100 rems

F. RAD - abbreviation = rad

SI unit = gray 1 gray = 100 rads

G. PRIMARY BEAM or USEFUL BEAM

Beam of radiation which passes through the x-ray tube window, aperture, cone or other collimating device