The patient dose can be reduced by at least 50 percent in most examinations by choosing appropriate exposure factors. Exposure and dose have different meanings. Exposure (R) refers to radiation intensity in air. Dose (rad) is a measure of the radiation absorbed as a result of a radiation exposure. Dose is used to identify the irradiation of patients and exposure (R) is used to calculate entrance skin exposure (ESE) in irradiated patients. Physicists usually estimate the ESE, organ dose and gonadal dose by conducting phantom experiments.

The maximum exposure to the patient and the measure of patient dose is the entrance skin exposure (ESE). It is the most common expression to approximate patient exposure because it is safer to assume a maximum effect when attempting to minimize exposure to ionizing radiation. The ESE is easy to measure using radiation dosimeters and it is also relatively easy to estimate by computation. The ESE increases proportionately with increasing mAs and increases quadratically with increasing kVp (that is, proportionately with increasing kVp²). In general, a high-kVp examination results in a lower ESE because much less mAs is required.

Rule of thumb: ESE = 5 mR/mAs.

ESE increases quadratically (Inverse Square Law) as source-to-skin distance (SSD) is reduced. If mR/mAs is known at a given kVp from a medical physicist’s report, ESE can be computed for any technique.

**Radiography**

Patient dose can be reduced by:

- maintaining proper darkroom, processing, and quality control procedures
- using a high-kVp technique
- adding filtration to the primary beam
- using a long source-to-image-receptor distance (SID)
- using faster image receptors (dose is inversely proportional to radiographic intensifying screen speed)
- avoiding retakes (most effective). Patient dose is proportional to the number of views.

Collimation during radiography and fluoroscopy is an application of shielding for patient radiation protection. An added benefit of collimation is the reduction of scatter radiation, resulting in improved image contrast. Positive beam limitation (PBL) is a method of automatic collimation.

Patient dose during radiography can be reduced by using gonadal shields. Gonadal shields should be used on all patients of childbearing age when the use of such shields will not interfere with obtaining the required diagnostic information and the useful beam is within 5 cm of the gonads.

Patient dose increases with the use of grids opposed to non-grid procedures. When the grid ratio is decreased, and exposure is maintained by
decreases in mAs or kVp, a significant dose reduction can be achieved. The use of a grid of unnecessarily high ratio causes routine increases in patient dose as mAs or kVp is increased to maintain exposure.

A routine chest x-ray should not be performed
- as part of the admission of hospital patients
- on asymptomatic patients during routine medical examinations
- as a screening test for tuberculosis.

**Fluoroscopy**

During fluoroscopy, patient dose is principally determined by the on time of the x-ray beam. The ESE during fluoroscopy is approximately 4,000 mR/min. Patient dose during fluoroscopy is proportional to the fluoroscopy time. During fluoroscopy, ESE
- increases proportionately with the number of spot films
- is approximately 200 mR per view for cassette-loaded spot films
- is approximately 100 mR per view for photospots
- is approximately 200 mR per frame for digital fluoroscopy
- is approximately 1,000 mR/s for cineradiography at 15 frames/s and increases proportionately with increasing frame rate.

Fluoroscopy should not be performed on asymptomatic patients as a part of routine medical examinations. During fluoroscopy, the technologist must note the examination time and technique for each patient examination.

**Computed Tomography**

Patient dose during computed tomography (CT) is essentially uniform from skin to midline. During CT, sequential images require irradiation of different tissue and dose is therefore unrelated to the number of scans. Patient dose during CT is approximately 5,000 mrad per scan. Patient dose for a complete CT examination is approximately 10% higher than that for a single-slice examination. During spiral CT, patient dose is lower for a higher pitch.

**Doses**

Organ dose can be estimated and is a good predictor of biological response.

Mean marrow dose (MMD) is the average dose to the active bone marrow. MMD is a predictor of radiation-induced leukemia. MMD from medical x-ray imaging is approximately 100 mrad/y.

The average effective dose (E) from medical x-ray imaging is approximately 50 mrem/y.

Genetically significant dose (GSD) is the average dose to the gonads of patients of reproductive age. GSD is a predictor of radiation-induced genetic mutations. From medical x-ray imaging, the GSD is estimated to be 20 mrad/y.

Mean glandular dose ($D_G$) is the dose to the glandular tissue of the breast. The $D_G$
- is used as a predictor of radiation-induced breast cancer
- is approximately 100 mrad per view for non-grid mammography
- is approximately 200 mrad per view for grid mammography
- is approximately 200 mrad per view for magnification mammography without a grid.