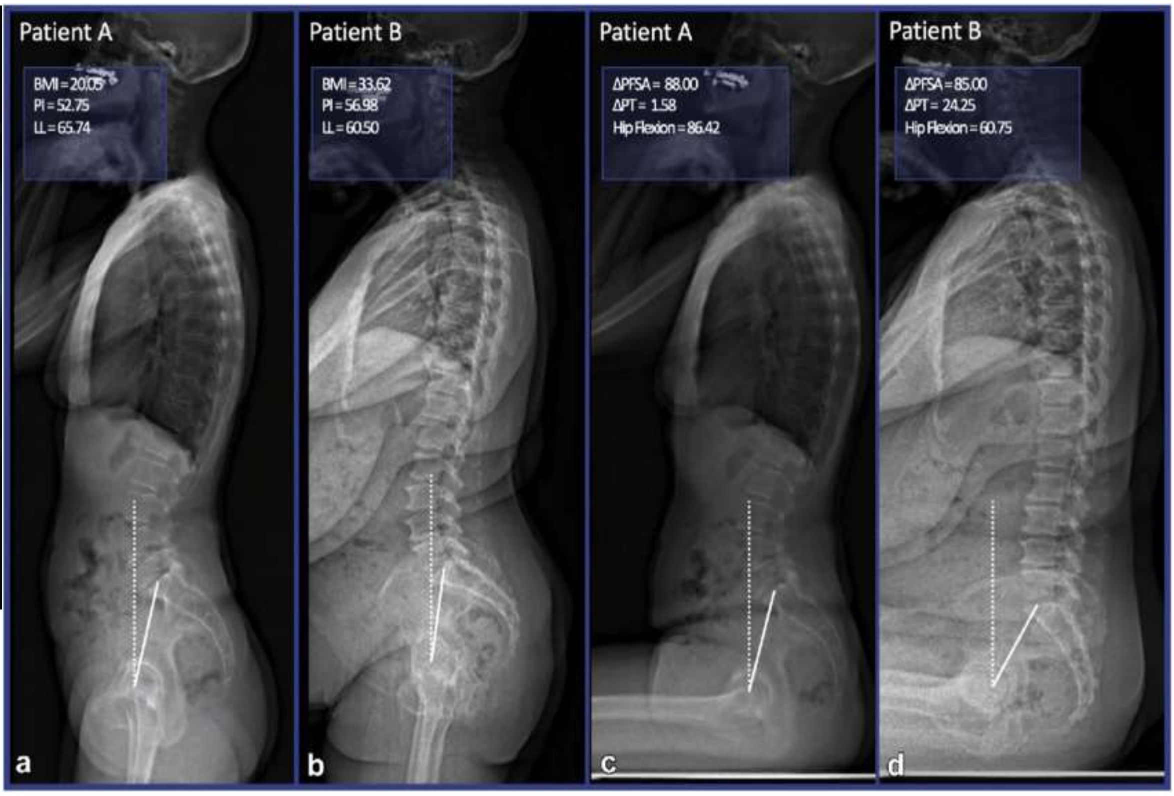

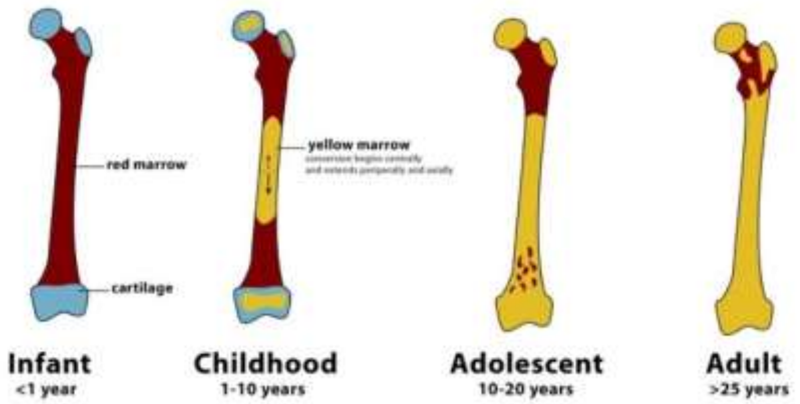

Patient Radiation Dose Descriptions

Fourth Lecture (4)

First semester / Second year

By

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Patient Radiation Dose Descriptions

Entrance Skin Exposure (ESE):

<u>Entrance Skin Exposure (ESE)</u>: is the measurement of radiation output at the point of skin entry for common X-ray examinations, including fluoroscopic and conventional radiology. These units are measured in milli Roentgen (mR).

What are the technique factors of ESE?

Technique factors are the machine settings chosen to produce an acceptable X-Ray image; technique should be adjusted for the imaging system used. It included:

- Tube voltage (KVp)
- Tube electrical charge (mA)
- Exposure time (seconds or pulses).
- Other factors should be considered, such as <u>patient size</u>, <u>projection</u>, and <u>age</u> also should be considered when setting technical factors. Technical factors for pediatrics should be set lower.

Most intro-oral units have fixed KVp and mAs settings; in most cases, exposure may be the only factor that can be adjusted. **Technique factors should be set to optimize the radiograph and minimize radiation exposure to the patient. The selection of appropriate technical factors for pediatric and adult patients will facilitate optimized imaging at a minimal dose.**

Mean Marrow Dose (MMD):

<u>Mean Marrow Dose (MMD):</u> is the average dose to the entire active bone marrow as shown in Figure 1; it is estimated from the Entrance Skin Exposure (ESE).

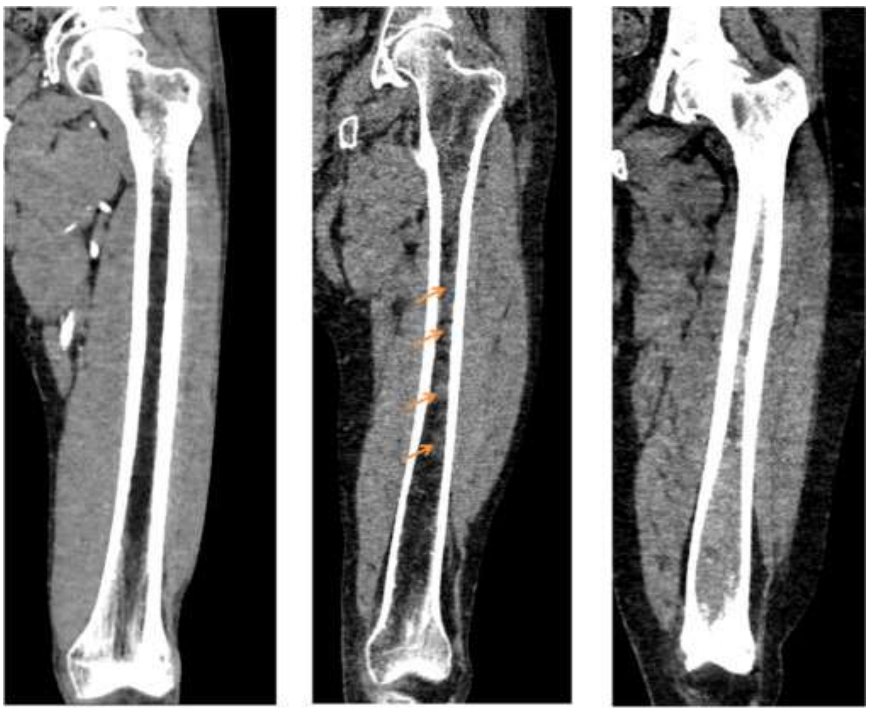

Figure (1): Shows the bone marrow at CT scan.

The Mean Marrow Dose is an estimated measure of the average radiation exposure given to the blood-forming progenitor cells of the bone marrow, e.g., in whole-body radiation treatment. The percentage of active bone marrow in the useful beam is multiplied by the average absorbed dose. **The Mean Marrow Dose is used to estimate the late effect of leukemia.**

Dose Management Principles in Special Cases:

1. X-Ray and Pregnancy:

Special care must be taken for pregnant women, whether was pregnant patients or technologist.

Pregnant Patients:

A special case where individual justification is needed is for patients who are or might be pregnant. **It is about 0.5 rem in gestation period.** It applies to the radiographic examination of any area between the knees and the diaphragm and to the injection of radionuclides. It is based on the principle that there is little or no risk to the live-born child from irradiation during the first 3 weeks or so of gestation, i.e., before the first missed period, except possibly from high-dose procedures such as barium enemas and abdominal or pelvic computed tomography (CT). Figure 2 shows an Abdominal X-ray for a pregnant lady.

Figure (2): Shows an Abdominal X-ray for a pregnant lady.

Pregnant Technologist:

There is a requirement to ensure that the fetus of a pregnant employee is not exposed to a significant risk. **Female staff should not be exposed to spasmodic high doses and, on average, should not receive more than about 1 mSv a month.** A dose limit is set that is equal to the limit for a member of the public. The limit applies over the declared term of the pregnancy, that is, from the date that the employee informs her employer in writing that she is pregnant. For diagnostic X-Rays, it can be assumed that the fetal dose is no greater than 50% of the dose on the surface of the abdomen, i.e., of the dose recorded on the dose monitor.

2. X-Ray and Obese:

Obese Patients:

Imaging starts to become difficult for patients 100 Kg and over, but hospitals are now routinely seeing patients in excess of 136 Kg. Obese patients present many unique challenges to health care facilities, such as:

1. It can be difficult and sometimes dangerous to transport them within the facility on wheelchairs and stretchers.
2. Occasionally, they won't fit on hospital or surgical beds or devices, as shown in figure 3.

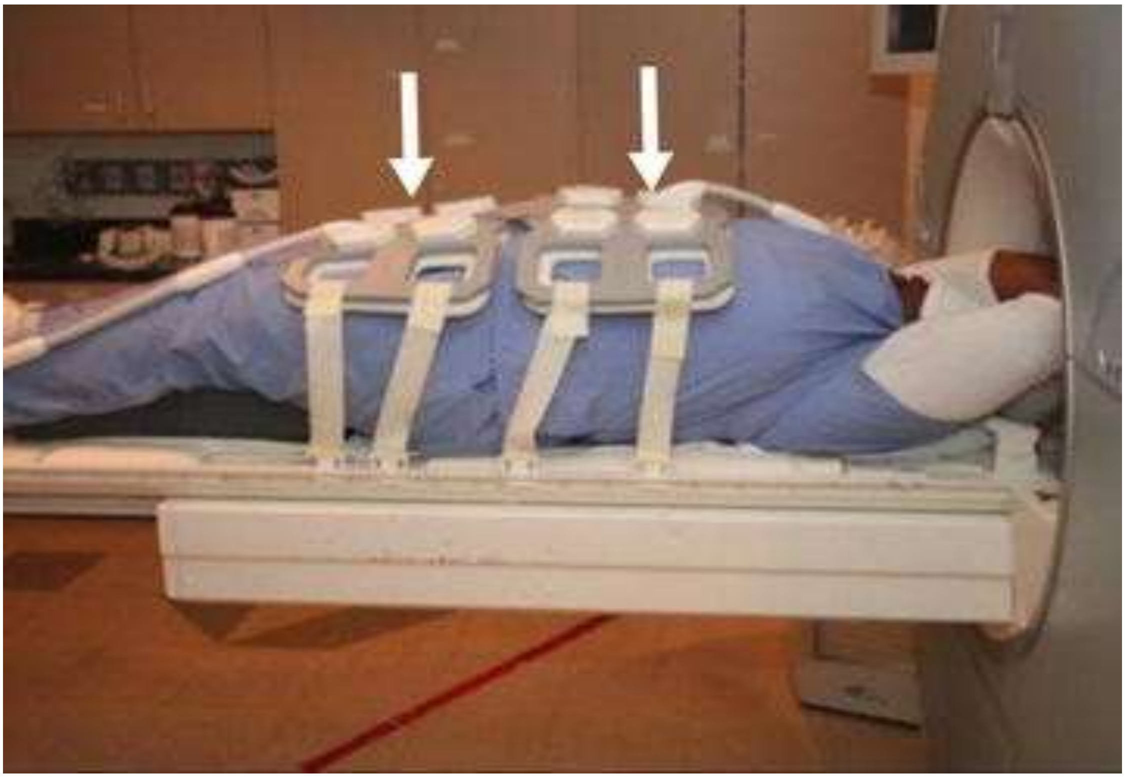

Figure (3): Shows an obese patient that is difficult to place in the device.

Obesity limits the ability to acquire and perform imaging examinations and interventions. Table weight limits and gantry diameter limits present physical limitations in the ability to accommodate them for CT, MRI, or fluoroscopy. A large body habit also degrades image quality, making it difficult or impossible to obtain adequate images for interpretation.

Table 1 above shows the maximum table weight and aperture limits for imaging equipment. **Radiography tables have a weight capacity that ranges from 136 to 272 Kg or more.** Some equipment may even be designed to support bariatric patients with weight capacities exceeding **317.5 Kg.**

Table (1): Maximum table weight and aperture limits for imaging equipment.

Imaging modality	Weight limits (kg)	Maximum aperture opening (cm)	Maximum field of view (cm)
Fluoroscopy	317.5	117	N/A
CT	308.4	85	65 cm
MRI	249.5	70	Virtual field of view 205 cm
Open MRI	249.5	55	

The industry standard for fluoroscopy table weight limit is 158 Kg, and the aperture opening is **45 cm (19 inches)**. Hospitals are now purchasing fluoroscopy equipment that can accommodate patients up to 317.5 Kg, and has aperture openings of **117 cm (46 inches)** or less than that, as shown in figure 4.

Figure (4): Shows two fluoroscopic imaging equipment: (a) A standard fluoroscopic machine with a 45 cm aperture opening, (b) Bariatric fluoroscopic machine with 63 cm aperture opening.

NOW, if a patient won't fit on hospital or surgical beds what is the solution?

When the table can't support the patient's weight for imaging procedures:

1. One workaround is to attempt to do them with the patient standing.
2. Vendors of imaging equipment are beginning to adjust with modifications that include higher table weights.
3. Wider scanner bores and other features make scanning obese patients more practical.
4. Imaging facilities are also developing new tactics and imaging parameters for handling the new, supersized generation of patients.

NOW, what about Mammography? Are there any challenges to obtaining high-quality images?

In mammography, there are numerous challenges to the proper positioning necessary to obtain high-quality images, such as:

1. Breast tissue is very mobile, and large breasts can easily be distorted by twisting or rolling, making it difficult to accurately localize lesions for diagnostic views.
2. Breast folds can be a major problem, and additional views may be necessary to eliminate them.
3. Mosaic or tile imaging may be needed to obtain adequate compression and/or to image all breast tissue. Small breasts may wrap around laterally if the woman is obese and require additional views.

Figure 5 shows the imaging appearance of different breasts of increasing density using three types of imaging modalities including mammography.

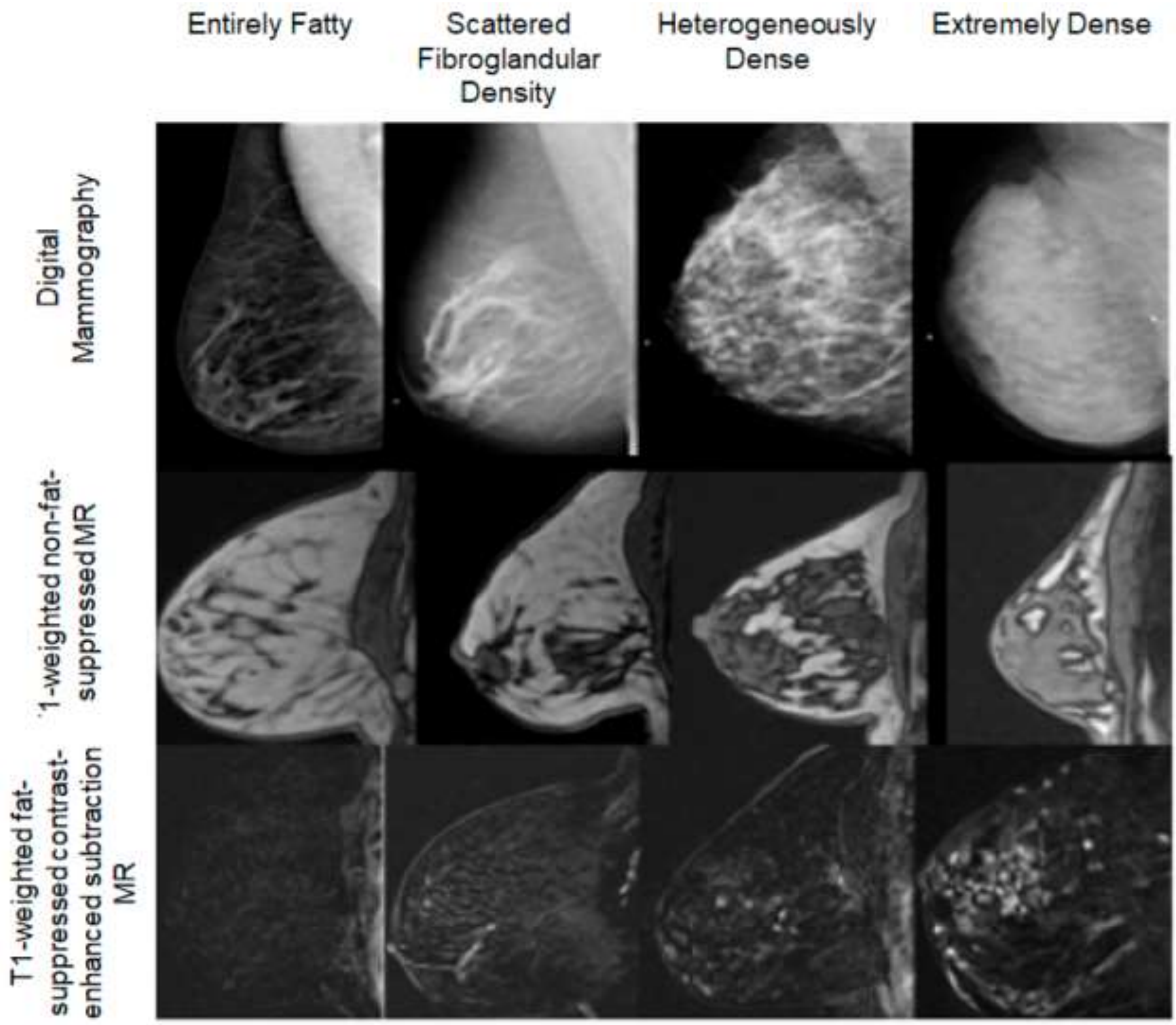

Figure (5): Shows the imaging appearance of different breasts of increasing density using three types of imaging modalities including mammography.

Question: Are there other factors affected by the patient's obesity?

Yes, in addition to the physical constraints of table weight and gantry diameter, CT image quality can be compromised in obese patients by X-Ray attenuation, resulting in photon starvation. Increasing the tube voltage and current can improve image quality. However, it also increases the radiation dose in obese patients. Newly adopted image reconstruction algorithms are now being used to improve image quality at a lower radiation dose. Figure 6 shows the X-Ray of an obese person (Left) and a normal-weighted person (Right) comparison.

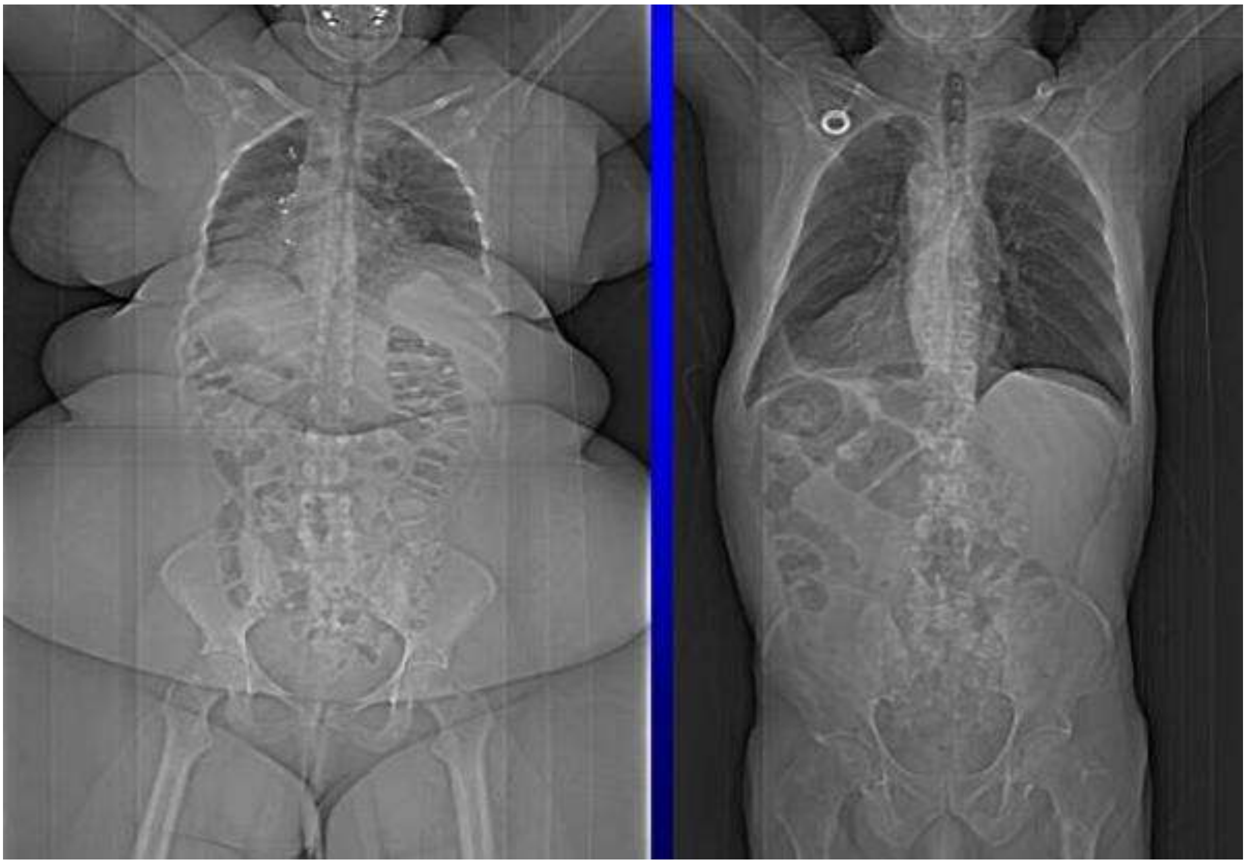

Figure (6): Shows the X-Ray of an obese person (Left) and a normal-weighted person (Right) comparison.

Table 2 shows the CT protocol for standard patients compared to obese patients (>158 Kg). For CT, an increase in the kVp and mAs, and a decrease in the gantry rotation speed can sometimes help. The field of view (FOV) for image reconstruction is smaller than the aperture. Therefore, if the patient is too big, truncation artifacts can appear as bright edges on the image. These can be minimized by using specialized software that allows FOV extrapolation.

Table (2): The CT protocol for standard patients compared to obese patients (>158 Kg).

CT Setting	Standard Setting	Obese Patient Setting
kVp	120	140
mAs	"Fixed mAs"	"Automatic mAs"
Gantry Rotation Speed Per Rotation	0.5 s	1 s