



Radiology Rounds

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Imaging and Obese Patients

- Obesity can limit radiographic evaluation
- Image quality is degraded by a patient's large body habitus; Ultrasound is most affected
- CT, MRI, and X-ray have table weight limits that cannot be exceeded
- The bore diameter of CT (70cm) and MRI (60cm) scanners is too small for the body girth of some patients

Current estimates indicate that 4.7% of the American population today is extremely obese, with a body mass index (BMI) >40; an increase from 0.8% in 1960 and 2.9% in 1988. Obesity presents many challenges in health care. In addition to increasing risk for the development of chronic disease, obesity is a limiting factor in radiology used in all aspects of medical diagnosis and treatment. These limitations include both logistical and image quality issues. For example, obese patients need larger and stronger wheelchairs and gurneys for transportation, while physical limitations of the imaging equipment in terms of table strength and bore size may make the desired examination impossible. Weight limits for examination tables are set by the manufacturers and cannot be exceeded without endangering both the patient and the equipment. Large body habitus also degrades image quality, making it difficult or impossible to obtain adequate images for clinical interpretation.

Factors that Limit Imaging

Ultrasound

Ultrasound images are affected by fat to a greater degree than any other imaging modality. Ultrasound energy is attenuated by fat tissue, especially at higher frequencies. For example, at the frequency range (3-7 MHz) normally used for abdominal imaging, 50% of the beam intensity (watts/cm²) is attenuated when the beam travels through 1 cm of fat and the sound level drops by 3 decibels (dB). In an obese patient with 8 cm of extra-peritoneal fat, there would be about 6% of the original beam intensity or a 24 dB drop in sound level before the beam enters the peritoneal cavity. Attenuation is less at lower frequencies but results in decreased image resolution.

Percentage of All Imaging Studies
"Limited by Body Habitus"

Chest x-ray	0.5%
Abdominal x-ray	0.25%
Ultrasound	2%
Chest CT	0.25%
Abdominal CT	0.4%
MRI	0.1%

Plain Film Radiography and Fluoroscopy

Image quality on plain radiographs is also severely limited by attenuation. Increasing the current and exposure time can improve image quality but also increases the radiation dose to the patient and cause motion artifact due to increased exposure times. Some obese patients are too large to image using a single 14 x 17 inch film cassette and require multiple cassettes. When they exceed the weight limit for the x-ray tables (480 lbs), patients can sometimes be imaged while standing.

X-ray fluoroscopy is also restricted to patients who do not exceed the table weight limit, which in this case is usually 350 lbs. In addition, the clearance between the table and the fluoroscopy tower is 45 cm.

CT

X-ray attenuation also limits image quality for CT images, although to some degree attenuation can be compensated for by increasing the tube current and decreasing the rotation speed of the gantry. However, there are absolute limits on patient's weight and girth. The weight limit for the CT tables is 425-450 lbs,

depending on the scanner. The bore of the gantry has a diameter of 70 cm, which can sometimes be too small for patients who do not exceed the weight limit. Although it is sometimes suggested that veterinary CT scanners are an option, this is rumor only. The scanners used are the same as those used clinically and we know of no veterinary hospitals capable of imaging obese patients.

Nuclear Imaging

Image quality in nuclear medicine severely falls off in obese patients due to absorption and photon scattering, which is greater for lower energy isotopes. Therefore, ^{99m}Tc, which emits higher energy photons than ²⁰¹Tl-thallium, is likely to provide higher quality images in obese patients. Low image quality is especially problematic for myocardial perfusion SPECT in obese patients, since the low number of photons detected makes it difficult to know whether to attribute a drop in photons detected to a soft tissue attenuation artifact or myocardial ischemia.

The quality of PET images is also lower in obese patients for two reasons. First, image quality is

degraded due to the high scatter in soft tissues and increased photon attenuation in a larger body mass. Secondly, it is not possible to give a large enough dose of isotope, as the maximum dose recommended for patient safety can often be well below the mCi/kg dose required for optimal image quality.

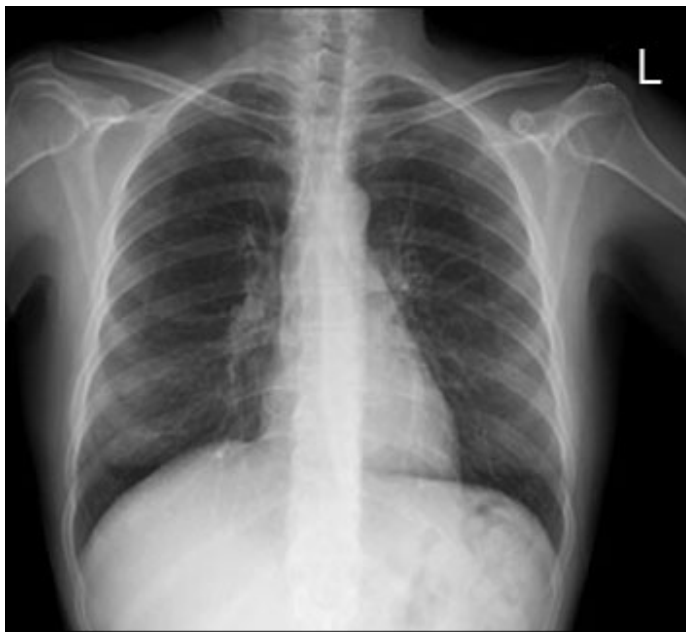
MRI

MRI image quality is least affected by obesity although increased body habitus introduces noise and the large field of view needed decreases the in-plane resolution of the images. The main limitations of MRI are the size of the bore and the table weight limits, which prevent imaging of large patients. MRI bore diameters are smaller than those of CT scanners and contact with the bore creates eddy currents that degrade MR images. Open bore MRI systems, which are not available at MGH, can be used to image larger patients, but they generally offer lower field strength, resulting in degraded image quality, longer exam times causing patient discomfort and motion artifact on images, and inability to perform exams requiring dynamic intravenous contrast administration (MRA, liver scans, etc.).

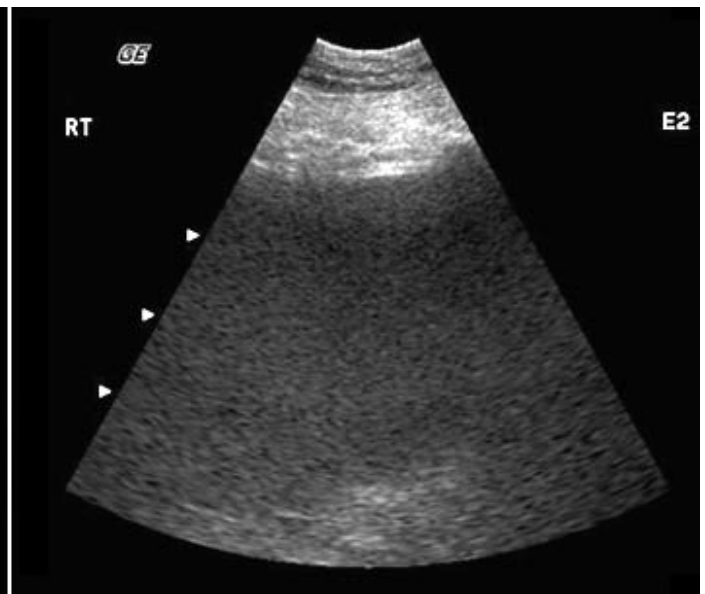
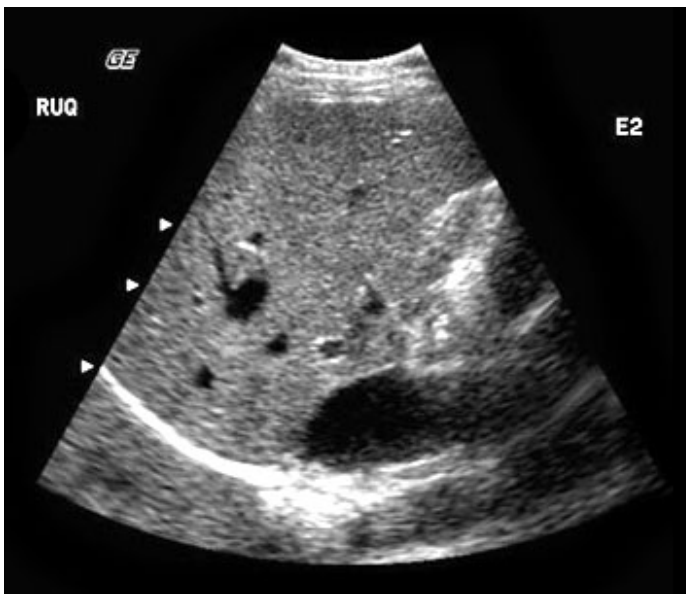
Weight and Size Limits for Imaging and Radiologic Intervention

	Maximum Weight	Bore Diameter or Maximum Distance	Field of View
Radiography Prone Standing	480 lbs None	N/A	14 x 17 in. 14 x 17 in.
Ultrasound	None	N/A	N/A
CT 4-16 slice multi-detector scanners 64 slice multi-detector scanner (Main campus)	425 lbs 450 lbs	70 cm 70 cm	50 cm 50 cm
MRI Siemens (Main campus and Yawkey) GE (Main campus and off-campus imaging centers)	440 lbs 325 lbs	60 cm 60 cm	50 cm 45-50 cm
Nuclear Medicine	400 lbs		
Fluoroscopy Other Innova (Yawkey only)	350 lbs 450 lbs	45 cm	N/A
Interventional Procedures Angiography Spine Mammography biopsy Other	350 lbs 350 lbs 350 lbs 350-400 lbs	N/A	N/A

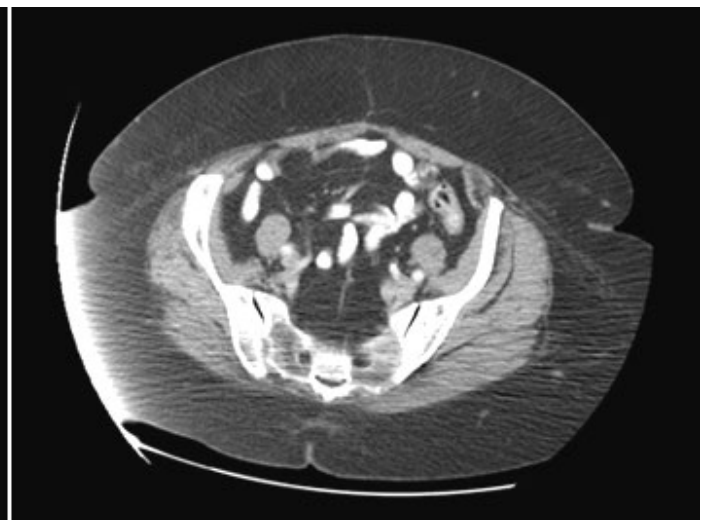
Note: 60 cm diameter = 74 inches circumference; 70 diameter = 87 inches circumference



Chest x-rays of normal weight (left) and obese (right) patients. The latter image quality is limited by body habitus



Ultrasound images of liver in normal weight (left) and obese (right) patients. The latter image quality is limited by body habitus



Abdominal CT images of a normal weight (left) and obese (right) patient. Note image artifact due to patient contact with bore

Impact on Patient Care

If patients cannot be imaged by the modality of choice, this can adversely affect their care. This is particularly important for patients who have undergone weight loss surgery. For example, all patients who have laparoscopic gastric bypass surgery at MGH routinely undergo a follow-up Gastrografin® swallow to check for an anastomotic leak. However, if patients exceed the size limit for fluoroscopy, evaluation for a leak is limited to serial portable chest and abdominal x-rays, which are significantly less sensitive. Imaging of other complications of bariatric surgery, such as abdominal abscess or collection, is nearly impossible if the patient cannot undergo CT. Diagnosis of other post-operative complications such as deep vein thrombosis (with ultrasound or pelvic CT) and pulmonary embolism (with chest CT angiography) is also compromised.

Difficulties in imaging obese patients also lead to delayed diagnoses of other conditions. For example, increased thickness of compressed breast tissue results in lower image quality and, when breast cancer is detected, tumor diameter is significantly larger than in normal weight patients. In addition, the specificity of mammography decreases resulting in more false positives and unnecessary further testing.

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Scheduling

Before ordering an examination or procedure, check that the patient's weight does not exceed the relevant weight limit.

If an obese patient is unable to walk and requires transportation by wheelchair or gurney, it is important to alert the Department of Radiology to the patient's needs to enable the staff to have appropriate transport equipment. Failure to do so leads to delays in examinations and longer waits for other patients.

Appointments can be scheduled by calling 617-724-9729 or through the Radiology Order Entry system, <http://mghroe/>.

Further Information

For further questions, please contact [Raul N. Uppot](#), M.D., Abdominal Imaging and Intervention at 617-726-8396.

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