Obesity and Medical Imaging

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Abstract

Obesity is a growing problem in the United States, and it affects the health care system in a big way. Modern imaging equipment has designated weight limits established in order to ensure patient safety while avoiding damage to the equipment itself, and at most hospitals, there is a lack of equipment that can accommodate the size of obese patients. Obesity is also detrimental to image quality. Increased tissue thickness makes it difficult to obtain diagnostic images; therefore, the quality of care given to these patients suffers.
Introduction

Obesity is a condition that affects approximately one-third of Americans (Reynolds, 2011). Obtaining diagnostic quality images while preventing overexposure or injury to obese patients is something many imaging professionals struggle with on a daily basis. The entire imaging process becomes more difficult when an obese patient is involved. Exams that would be considered routine for an average-sized patient need to be adjusted in order to meet the needs of larger individuals.

Literature Review

Affect on patient care

Obesity impacts imaging in the radiology department every day and is detrimental to patient care. Obese patients experience a myriad of health problems related to their weight. Because of this, physicians order countless diagnostic imaging exams on obese individuals. Uppot et al. (2006) describe how weight limits on imaging equipment hinder many patients from receiving necessary exams and care. For example, Computed Tomography (CT) or Magnetic Resonance Imaging (MRI) scans may be impossible for very large patients because of the weight and size limits of the machines. Sharma (2005) suggests that more investigation into imaging of obese patients is necessary because if high-quality images are not produced, the diagnosis of obese patients can be delayed. This increases medical costs for the patient by lengthening their stay at the hospital.

Furthermore, because obesity in the United States has become a major epidemic, surgical intervention for morbid obesity has become a routine practice. Radiology plays a large role in the post-surgical care of patients who undergo weight loss surgery, and this adds to the list of strains that obesity puts on the radiology department. Computed Tomography (CT) scans or upper
gastrointestinal (UGI) studies are often used to evaluate if a complication exists; therefore, radiologists need to understand the signs of a complication and how the various types of weight loss surgery alter the patient anatomy (Trenkner, 2009).

Because the inability to obtain high quality images on obese patients leads to numerous additional exams, radiation exposure for these patients is increased substantially. In addition, Yanch, Behrman, Hendricks, and McCall (2009) found that excess adipose tissue is directly related to an increased radiation dose to patients. This is most likely due to the need to increase tube voltages in order to penetrate thicker tissue densities.

The quality of patient care should be the same for all patients without bias; therefore, technologists must strive to provide the same level of care that average patients receive to obese patients. Despite a patient’s size, radiologic technologists are ultimately expected to transport obese patients to the radiology department, accommodate them on imaging equipment, and obtain diagnostic-quality images (Uppot et al., 2006).

**Transporting Obese Patients**

At many hospitals there is a shortage of equipment large enough to accommodate obese patients. Equipment such as wheelchairs, hospital beds, and even imaging tables are simply too small to accommodate very large patients. Uppot, Sahani, Hahn, Gervais, and Mueller (2007) discuss how there is a lack of equipment designed to properly accommodate obese patients. Modern imaging equipment has specific weight limits created by the manufacturer in order to ensure patient safety while avoiding damage to the equipment itself. While Modica, Kanal, and Gunn (2011) agree that there is a lack of adequately sized equipment, they also say that manufacturers have been working to design larger equipment that will better suit the needs of imaging facilities.
Also, technologists should use extreme caution when it comes to transferring obese patients onto x-ray equipment. Protecting patients from falling should be the number one priority, but technologists are also at risk of injury. In reference to Radiologic Technologists, Reynolds (2011) states that, “83% have reported some pain when moving obese patients” (p. 236). However, by utilizing team-lifting in conjunction with proper body mechanics the instance of back injury is significantly reduced.

**Image Quality**

According to Uppot et al. (2006), technologists in many different imaging modalities struggle to obtain diagnostic images on obese patients. Decreased image quality is most often due to inadequate penetration of x-rays, insufficient contrast due to scatter radiation, patient motion artifacts, or the area of interest being too large to fit on an image receptor. Reynolds (2011) states that the imaging modalities that are most affected by obesity are chest radiography and Ultrasonography (US).

When imaging obese patients, the x-ray beam must penetrate thick layers of adipose tissue. Increased tissue thickness results in increased scatter radiation which reduces image contrast. This often results in a subpar image and insufficient visualization of the anatomy. In order to remedy this, techniques must be increased and a grid may need to be utilized (Modica et al., 2011). Also, tight collimation to the area of interest will ultimately improve image quality by reducing scatter radiation.

Because image receptor size is limited to a 14 by 17 inch area, another complication with imaging obese patients is that the area of interest may not be appropriately visualized by using only one image receptor; therefore, “technologists must consider the routine use of multiple
cassettes to image quadrants of the body in a large patient instead of using a single cassette” (Uppot et al., 2007, p.435).

Due to body habitus, palpation of anatomic landmarks on obese patients for positioning purposes is sometimes nearly impossible. Therefore, it is necessary to utilize alternate positioning methods in order to improve image quality. For instance, the bend of the elbow is a useful positioning tool, as it corresponds with the level of the iliac crest (Carucci, 2012). By utilizing these landmarks, the need for repeats is significantly reduced, and radiation dose to the patient is kept at a minimum.

**Computed Tomography**

There are many factors that limit CT scans on obese patients. Some of these include table weight limits, gantry diameter, and tube capacity. Modern CT scanners have varying weight limits, but most are approximately 450 pounds. The table weight limit is in place because when performing a CT scan, the table must be able to travel through the gantry at a specific speed, and patients who exceed the weight limit may cause damage to the motor that moves the table (Carucci, 2012).

When performing a CT scan on a very large patient, the images may still be of diagnostic quality, but there have been reports of increased noise, image cropping, and limited field of view which can result in truncation artifacts where the patient’s body lies outside the field of view (Reynolds, 2011). Like with conventional radiology, image noise is caused by inadequate penetration of the beam. CT scanners with a 70 cm aperture diameter are limited to a field of view of only 55-65 cm. Limited visualization of essential anatomy and artifacts may occur when portions of obese patients’ bodies fall outside of the field of view. It is interesting to note, however, there are certain cases in which fat is not necessarily detrimental to CT image quality.
For instance, when patients have a layer of intraperitoneal fat, differentiation of internal structures is improved (Uppot et al., 2007).

There are several factors that should be adjusted when performing a CT scan on an obese patient. In order to reduce the amount of noise present on the images, milliampere-seconds and peak kilovolts should be increased. However, techniques should only be increased enough to produce diagnostic images. For scans that require intravenous contrast, the dosage given to obese patients should be greater than the dosage given to a non-obese patient (Reynolds, 2011).

**Magnetic Resonance Imaging**

Similar to CT, MRI scanners have weight and girth limitations. Typical MRI weight limits are 350 pounds. Patients larger than this will simply not fit inside the magnet, and scanners with a signal-to-noise ratio (SNR) and strong gradients cannot accommodate patients who exceed the weight limit. Images will not be diagnostic. When imaging obese patients with MRI, radiofrequency penetration and gradient strength, scan time, and limited field of view are all important factors. Increased noise is also present on MRI images obtained from obese patients. Also, obesity can increase scan times due to a larger cross sectional area as compared to an average-sized patient. This is detrimental to image quality because longer scan times increase the instance of patient motion artifacts (Uppot et al., 2007).

**Ultrasonography**

Unlike CT or MRI, ultrasound does not have weight limits. However, increased tissue thickness does make obtaining images difficult. Modica et al. (2011) describes the physics of why obtaining images on obese individuals is so troublesome:

“Sound attenuation in fat (in decibels) is defined as the product of the attenuation coefficient (in decibels per centimeter at 1 MHz), the transducer frequency (in megahertz), and
the thickness of fat (in centimeters). Sound attenuation increases with fat thickness and transducer frequency: The higher the frequency, the greater the attenuation. […] Hence, in imaging of an obese patient with 8 cm of subcutaneous fat, 94% of the original sound wave is attenuated before it reaches the peritoneal cavity (p. 812).”

For this reason, sonographers must find an area to scan where the anatomy is closer to the surface of the patient’s body to reduce sound wave attenuation. Ultrasound is the imaging modality that is most affected by patient obesity.

Case Study

The patient was a 57 year old Caucasian male in the Intensive Care Unit (ICU). His weight was approximately 375 pounds. A portable chest was ordered because the patient was suffering from shortness of breath. When raising the head of the bed to ensure the patient was sitting as upright as possible, the head of the bed could not support the patient’s weight and fell back down so the patient was almost supine. A cassette was placed beneath the patient while lying supine. Although he was able to move on his own, the image receptor placement was difficult. A technique of 95 kilovoltage peak (kVp) and 8 milliamperes per second (mAs) was selected to expose the image. A grid was not utilized, though it would have been beneficial.

The quality of the image obtained was not optimal (See Figure 1), but it was acceptable and turned in for the radiologist to read. The report came back and revealed that the patient had mild congestive failure with cardiomegaly. Also, it was noted that the patient had below average lung volumes. These findings had been noted on previous radiologist reports, as well. Previous exams were reviewed (See Figure 2), and the image quality was much better than the portable exam. This is most likely due to the use of a grid and increased tube voltage settings.
Although a diagnostic-quality image was produced for this patient, his level of care could have been improved in several ways. If a portable grid would have been utilized, image quality would have increased substantially. The lack of equipment capable to accommodate for this patient’s weight was ultimately responsible for the decreased image quality and level of care.

**Discussion**

The increased prevalence of obesity in the United States changes the way that imaging professionals do business. Since obesity is becoming such an epidemic in our country, weight loss surgeries and imaging procedures for the obese are common. Radiology plays an important role in the care of the obese, but the entire imaging process becomes more difficult when an obese patient is involved. Exams that would be considered simple to perform on an average-sized patient need to be adapted in order to obtain quality images of obese individuals.

In order to provide quality patient care to obese patients, technologists must be flexible and able to adjust procedures to ensure quality images are produced despite the size of the patient. Obesity hinders image quality for many reasons. In CT and conventional radiography, thick layers of adipose tissue make it difficult for the x-ray beam to penetrate the patient. This causes increased beam attenuation and scatter radiation which decreases the contrast of the image. In US, when a patient has a layer of thick tissue overlying the anatomy of interest, sound waves are attenuated before they reach the patient anatomy.

Very large patients often have difficulty standing for long periods of time because of excess weight on their joints. It is also difficult for obese patients to hold still, so patient motion artifact is another hindrance to obtaining quality images. Palpation of landmarks is almost impossible on obese patients, so utilizing other positioning landmarks, such as the crease in the elbow, is helpful in order to include pertinent anatomy on the images. This practice will decrease
the number of necessary repeats and consequently keep patient radiation dose at a minimum. In some cases, however, patient anatomy is too large to fit on one image receptor. As a result, the anatomy should be imaged using multiple cassettes. For these reasons, technologists must be educated about how to alter exams for obese patients in order to achieve the highest quality images.

It is important to provide high quality patient care while protecting the patient from injury. Radiology departments struggle to provide quality care to patients who are extremely obese. Modern imaging equipment makes it difficult to accommodate patients who are larger than 350 pounds, and table weight limits hinder the type of exams overweight people can receive. MRI and CT scanners have specific weight limits that must be adhered to in order to avoid damage to the equipment or patient injury. Although it is often disregarded, protecting technologists from back injuries while moving obese patients should be a high priority as well.

If a patient exceeds the equipment weight limits, they will not be able to receive that study, or they may need to be transferred to a facility that has imaging equipment designed for large patients. If an oversized scanner is not available, utilizing an alternate imaging modality would be necessary. This degrades the quality of patient care tremendously. Diagnosis is delayed, and their hospital stay is extended.

To conclude, it is becoming increasingly important for imaging professionals to be educated in how to efficiently image obese patients. Increasing technique settings, utilizing grids, imaging anatomy using multiple cassettes, and using alternative positioning landmarks are just some of the ways to improve image quality. By keeping patient radiation exposure as low as possible and by obtaining quality image, the highest-quality patient care can be provided to every patient, despite their size.
Figures

Figure 1. A portable chest x-ray performed on a 57-year-old male.

Figure 2. A chest x-ray performed on the same patient using the upright bucky in the imaging department.
References


