Obesity and Its Relationship With Pelvic and Lower-Extremity Orthopedic Trauma

Meredith A. Lazar, MD, Elizabeth K. Plocher, MD, and Kenneth A. Egol, MD

Abstract

Obesity has been increasing steadily in the US population over the past 50 years. In trauma patients, obesity is associated with higher morbidity and mortality. There are reported increases in the incidence of cardiovascular, pulmonary, venous thromboembolic, and infectious complications in obese trauma patients. Obese patients who sustain high-energy traumatic injuries often sustain orthopedic injuries to the pelvis or lower extremities. Obese orthopedic trauma patients may be at higher risk for nerve injuries secondary to positioning, intraoperative complications, loss of reduction after surgery, increased intraoperative estimated blood loss, and increased operative times. Orthopedic surgeons must be aware of these results when treating these fractures in obese trauma patients.

Obesity is a severe and rising problem in the United States. It spans both sexes and all ethnicities, age groups, and socioeconomic classes. In 2003-2004, 32.9% of people 20 to 74 years old were obese, as measured by body mass index (BMI); by contrast, in the early 1960s, the incidence of obesity was 11% among men and 16% among women.[1,2] The National Institutes of Health (NIH) established criteria (based on BMI) to categorize weight: Normal weight corresponds to BMI of 25 or less; overweight, 25 to 30; class I obesity, 30 to 35; class II obesity, 35 to 40; and morbid obesity, more than 40.[1] The NIH estimated morbid obesity to represent 5.1% of the US population.[3] Between 2000 and 2005, the incidence of obesity increased by 24%, and for the past 20 years the heaviest BMI groups have been increasing at the fastest rates.[4] In addition, the incidence of BMI over 40 increased by 50% and that of BMI over 50 increased by 75%—2 and 3 times faster than the rises in class I obesity incidence.[4]

Obesity has a profound effect on morbidity and mortality and has been linked with significant medical comorbidities, including hypertension, type 2 diabetes mellitus, coronary artery disease, stroke, osteoarthritis, cancer, sleep apnea, dyslipidemia, and psychological disorders.[5-7] It has also been documented that obesity results in up to a twofold increase in mortality and a 22% reduction in life expectancy.[8] In the United States, deaths directly related to obesity have been estimated at approximately 300,000 per year.[9]

High-energy blunt force trauma, including motor vehicle crash trauma, is one of the leading causes of death in the United States.[10] Obesity has been shown to be an independent risk factor for worse outcomes after such events.[10-14] Additional morbidity for obese patients sustaining severe trauma includes a higher rate of multiple organ failure, chest injuries, and medical complications, including myocardial infarction, sepsis, and number of days in the intensive care unit (ICU).[11]

Several studies in the trauma literature have correlated obesity with increased morbidity and mortality.[10-14] One study directly comparing BMI and mortality rates in a large series of trauma patients found a significantly higher mortality rate for morbidly obese patients (42%) than for patients in the other weight classes (all <10%).[12] The data were not attributed to severity of initial injury, as the groups' mean injury severity scores (ISSs) were not significantly different. A more recent study, which used ISS and BMI to stratify morbidity and mortality in trauma patients, also found a significantly higher mortality rate for morbidly obese trauma patients (10.7%) than for leaner trauma patients (4.1%).[13] That study also found a significantly higher rate of at least 1 in-hospital pulmonary, ventilator, renal, and/or cardiac complication for morbidly obese patients (27%) than for leaner patients (17.6%).

Few investigators have examined the effect that obesity may have on the causes or outcomes of low-energy trauma, such as trauma that occurs in falls. Risk for fracture and loss of reduction may reflect both the characteristics of the fall and the vulnerability of the patient. In a cross-sectional study, mean BMI of all patients with displaced ankle or elbow fractures treated surgically over a 10-year period was compared

Dr. Lazar is Resident, Department of Orthopaedic Surgery, New York University–Hospital for Joint Diseases, New York, New York.
Dr. Plocher is Resident, Department of Orthopaedic Surgery, University at Buffalo, Buffalo, New York.
Dr. Egol is Associate Professor, Vice Chairman for Education, and Chief of Trauma Service, Department of Orthopaedic Surgery, New York University–Hospital for Joint Diseases, New York, New York.

Address correspondence to: Meredith A. Lazar, MD, NYU Hospital for Joint Diseases, 301 East 17th Street, New York, NY 10010 (tel, 516-510-3138; fax, 212-598-6015; e-mail, Meredith.Lazar@nyumc.org).

Am J Orthop. 2010;39(4):175-182.

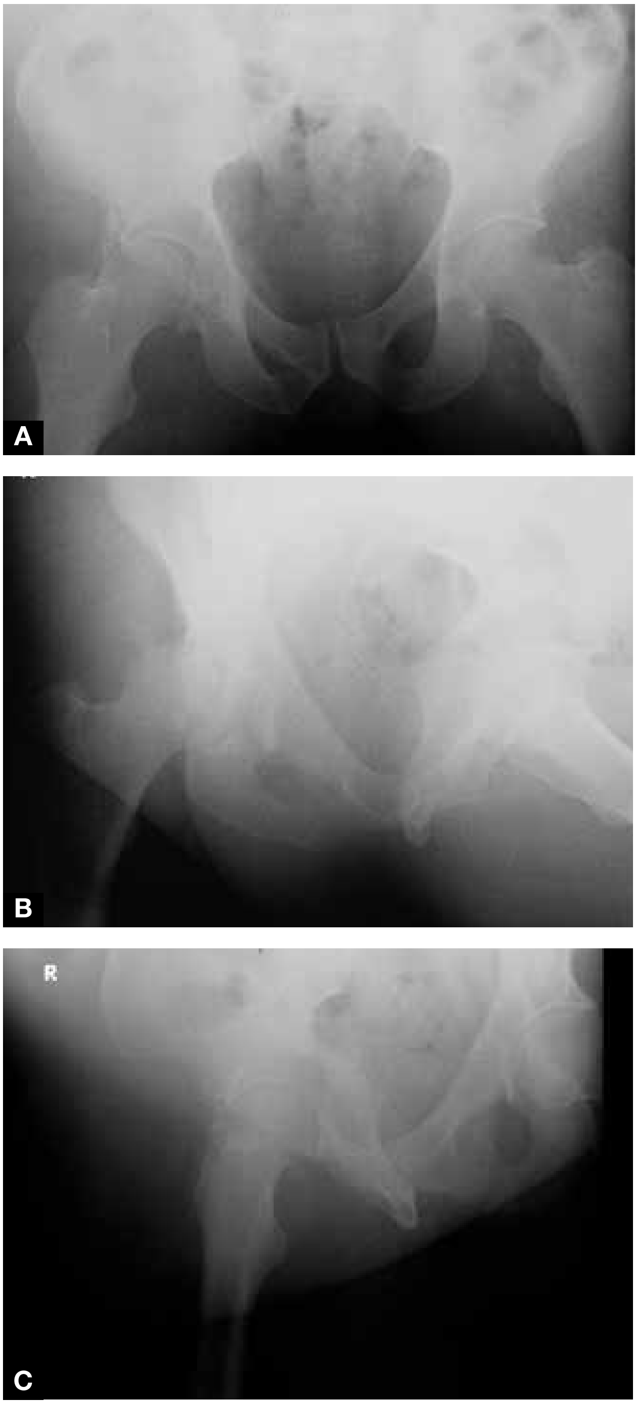

Figure 1. (A) Anteroposterior, (B) obturator oblique, and (C) iliac oblique radiographs of morbidly obese man who sustained right acetabulum fracture. Amount of pannus is significant, beam penetration is diminished, and entire pelvis does not fit on cassette.

with mean BMI of a demographically similar population admitted to the hospital during the same time period.[15] Patients were stratified by age and sex. In most age groups, mean BMI was significantly higher for the patients with ankle or elbow fractures treated surgically. The investigators proposed that the fracture population's higher mean BMI may be attributable to overweight patients' being stiff or clumsy and thus more susceptible to tripping and falling. They also suggested that, as their study addressed only fractures requiring operative fixation, overweight patients were more likely to sustain more significantly displaced fractures because of increased forces on the fracture fragments.

However, Robinovitch and colleagues[16] have suggested that obesity may be protective against hip fractures. In their study, elderly patients with higher BMI reportedly were at decreased risk for hip fracture because of higher regional bone mineral density and excess adipose tissue, which may cushion low-velocity falls.[16] In one of the largest series comparing obese trauma patients (n = 283) with nonobese trauma patients (n = 870), the percentage of lower-extremity fractures sustained by obese patients (53%) was statistically significantly larger than the percentage for nonobese patients (38%).[14] Other higher percentages (ie, of upper extremity and pelvic fractures) were found, but they were not statistically significant. Nevertheless, orthopedic surgeons must be aware of the unique clinical ramifications of treating obese trauma patients who have sustained pelvic and lower-extremity injuries.

Evaluation of Obese Orthopedic Trauma Patients

Emergent evaluation is more difficult with obese trauma patients than with nonobese trauma patients. Transportation of an obese patient is strenuous and difficult for emergency services personnel. A standard-size stretcher may be too small for an obese patient, temporary splints or Thomas traction devices may not fit properly, and safe transportation to the hospital may be difficult. When an obese patient arrives at the emergency department, there are unique considerations while following Advanced Trauma Life Support protocols. The obese body habitus may make secondary surveys more challenging and perhaps less reliable, particularly in terms of pelvis and extremity examinations. It is particularly important to examine all skin folds, which may obscure underlying wounds. Significant soft-tissue swelling may be less obvious, and deep-tissue palpation may be more difficult. Motor, reflex, and sensory examinations can also be challenging. The large size of an extremity may make muscle strength testing physically more difficult. It is important to be aware that morbidly obese patients have a baseline decreased range of motion in hips, knees, and other joints. Therefore, it is critically important to note and evaluate any asymmetries with the physical examination.[6]

Diagnostic studies are an additional challenge for obese patients. Plain radiographs may be of poor quality secondary to adiposity affecting beam penetration. Surgeons should advise radiologic technicians to make both preacquisition and postacquisition adjustments, which include using a Bucky grid to reduce scatter, increasing kilovolts peak and milliamperes to improve

Figure 2. Patient in distal femoral skeletal traction. Pin does not adequately clear soft tissues, and tension bow compresses skin, placing patient at increased risk for pressure ulcers and skin necrosis.

Figure 3. Bean bag is used for correct positioning of obese patient in lateral position. All bony prominences are padded, and patient is firmly secured to operating table.

penetration, and increasing film development speed.[17] In addition, the largest standard cassette (14×17 cm) may not fit an entire body part, which can result in inadequate imaging (Figure 1). A patient may also exceed the weight limit for the computed tomography (CT) and magnetic resonance imaging (MRI) scanners that are in most hospitals (the orthopedist should know the limitations of the machines at the hospital). Average CT scanners can handle approximately 160 kilograms. An often more relevant factor is that an obese patient may exceed gantry limits, both vertical (mean, 15-18 cm) and horizontal (mean, 70 cm). MRI tables have similar parameters (mean gantry limit, 60 cm), though open MRI allows for a larger vertical height limit (range, 45-55 cm).[17] In some cases, obese patients had to be taken to local zoos, which have special large-animal CT and MRI scanners.[6]

"...radiographs may be of poor quality....Surgeons should advise radiologic technicians to make both preacquisition and postacquisition adjustments..."

Another consideration in treating obese patients in the emergency department is placement of skeletal traction (Figure 2). The orthopedist must be aware of the patient's body weight when calculating the amount of weight required to provide for an adequate amount of traction to a limb. The mean amount of weight required is 10% of a patient's body weight. For an obese patient, this may mean a significantly larger amount than what a physician usually uses.

Perioperative Considerations

A standard operating room table holds up to 205 kilograms, but morbidly obese patients often exceed that limit. Special operating room tables have been designed to hold up to 455 kilograms. These tables may be available only at bariatric surgery centers. If specialty tables are not available at an institution, then 2 tables can be secured to each other. It is also important to firmly secure the patient to the table. An inflatable bean bag may be used to augment patient stability, especially when the patient may need to be repositioned throughout the operation[18] (Figure 3).

On the operating table, obese patients also present a challenge with respect to positioning for orthopedic surgery. There are reported higher incidences of nerve palsies and compartment syndromes related to obese patient positioning and inadequate padding during orthopedic surgery.[19] In a study of 22 long-bone fracture nonunions in obese patients, 4 patients had complications related to poorly protected limb positioning or prolonged ischemic pressure.[20] These complications included peroneal compartment syndrome related to right lateral decubitus positioning for 5 hours, gluteal compartment syndrome with sciatic nerve palsy related to a leftward tilting position from padding under the right buttock, bilateral brachial plexus stretch injuries from excessive arm abduction, an anterior interosseous nerve palsy on the contralateral side, and development of an area of scalp alopecia at the completion of an 8.5-hour case.

In a study of acetabular fractures in 131 patients (12 overweight, 5 obese), there was an overall patient complication rate of 58%.[21] Four of the complications were a direct result of poor patient positioning. In 1 of these 4 cases, a morbidly obese patient operated on in the prone position developed a permanent thoracic paraplegia resulting from midthoracic spinal cord ischemia attributed to massive abdominal pannus compression on the cord. Another positioning complication involved an obese patient who was operated on from the lateral decubitus position and recovered from anesthesia with permanent chest wall numbness.[21]

Obese patients also present special challenges for anesthesiologists. These patients often have short, thick necks and heavy chests, which make standard orotracheal or nasotracheal intubation and ventilation difficult. Anesthesiologists should be prepared to perform fiberoptic bronchoscopy, with cannulation over the bronchoscope to facilitate tracheal intubation when necessary. Arterial and venous access may be difficult because of indistinct landmarks resulting from an increase in subcutaneous adiposity. Significant adiposity may also present a challenge for administration of regional anesthetics, as surface landmarks may also be obscured.[22]

The overall utility of intraoperative fluoroscopy may be decreased in obese patients. The standard aperture measures 45 to 63 cm, which is potentially insufficient for viewing the operative field. The surgeon or radiologic technician must know to increase kilovolts peak for improved penetration of adipose tissue.[17]

Postoperative Complications Associated With Obesity

The surgical complications associated with obesity are well documented. The latest study on obesity and postoperative complications of surgery found more than 7,000 complications out of more than 90,000 surgical cases over a 4-year period; 32% of these complications were in obese patients.[23] Obese patients had a statistically significantly higher incidence of myocardial infarction, peripheral nerve injury, wound infection, and urinary tract infection. The mortality rate in both the obese and nonobese groups was 1.3% but was higher for morbidly obese patients (2.2%) than for all other patients (1.2%). Morbidly obese patients also had a higher incidence of tracheal reintubation and cardiac arrest.[23] As many traumatic lower-extremity and pelvic injuries are treated operatively, the orthopedist should be cognizant of the potential complications associated with treating obese patients.

Pulmonary Complications

The obese patient has poor ventilation secondary to decreased chest wall compliance related to increased subcutaneous fat. Known pulmonary complications include decreased functional residual capacity, expiratory reserve volume, partial alveolar oxygen pressure, and increased arterial-alveolar oxygen gradient. Restrictive lung disease, hypoventilation, and anatomical shunts can result in varying degrees of hypoxemia and hypercapnia. Attempts should be made to care for obese patients in the upright position, as most of the respiratory abnormalities that occur are exacerbated by maintaining a supine position. Compared with their nonobese counterparts, obese patients also have elevated gastric residual volumes with lower gastric pH, placing them at higher risk for pulmonary aspiration and pneumonitis. These conditions, combined with poor ventilation, put obese patients at increased risk for atelectasis and pneumonia.[22]

Obesity hypoventilation syndrome results from excessive weight impeding the chest wall from expanding appropriately. It has been suggested that patients with this condition undergo preoperative invasive hemodynamic monitoring with pulmonary artery catheters and optimization of cardiovascular function, should timing permit. After surgery, mechanical ventilation may be required until the pain associated with breathing improves.[22]

Cardiovascular Complications

In obese patients, cardiovascular complications are caused by physiologic alterations and increased incidence of preexisting cardiovascular comorbidities. Obese patients have increased intravascular volume, decreased peripheral vascular resistance, and increased cardiac output. More body mass can increase cardiac work by 40% in the obese,[24] and this increased work can lead to left-ventricular hypertrophy and systolic and diastolic dysfunction, which are risk factors for acute ischemia or infarction, congestive heart failure, and sudden death.[25] Preexisting increased work demand combined with traumatic injury to the body can overload the heart and increase mortality risk. Other studies have confirmed the cardiac risk to obese patients who sustain lower-extremity trauma. Obese patients are at significantly higher risk for myocardial infarction, and morbidly obese patients are at significantly higher risk for cardiac arrest.[22] In the acute posttraumatic period, cardiac index was lower in obese patients who died than in obese survivors, and decreased tissue oxygenation made organ failure and death a possibility—encouraging use of invasive hemodynamic monitoring to maintain cardiac index in obese patients.[26]

Venous Thromboembolism

Many have hypothesized that the risks for deep venous thrombosis (DVT) and pulmonary embolism (PE) are higher for obese patients because of physiology, poor ambulation, and poorer rehabilitation. The relationship between DVT and obesity stems from increased intra-abdominal pressure and venous stasis, most pronounced with central obesity, which tends to induce a hypercoagulable state. The effect of venous stasis in contributing to venous thromboembolism may be accentuated by intraoperative factors, such as pneumoperitoneum and anesthesia-induced paralysis.[25] At the cellular level, obese patients have elevated fasting plasma fatty acid levels, which lead to endothelial damage and activation of the clotting cascade.[22] There is also evidence that obesity is associated with decreased fibrinolytic activity, which can be improved with weight reduction.[22] Much of the information regarding obesity and venous thromboembolism (VTE) with respect to orthopedic patients comes from the arthroplasty literature. There, BMI higher than 30 is usually found to increase risk for symptomatic DVT and PE in the obese population.[27]

The risk that major–orthopedic trauma patients will sustain a proximal DVT is 10% to 20%; a clinically relevant PE, 4% to 10%; and a fatal PE, 0.2% to 5%.[28,29] Current guidelines for VTE prophylaxis in trauma patients with a single risk factor (eg, obesity) suggest starting low-molecular-weight heparin as soon as possible and continuing throughout the patient's hospital stay. For major orthopedic surgical procedures, the recommendation is to time the initiation of pharmacologic VTE prophylaxis according to the efficacy-to-bleeding tradeoffs for the particular agent being used.[28] In a recent retrospective cohort study on DVT prophylaxis in major–orthopedic trauma patients with pelvic, femoral shaft, or complex lower-extremity fractures and in acute spinal cord injury patients admitted to the ICU, the recommendation for orthopedic trauma patients was to use subcutaneous enoxaparin 30 mg twice a day.[29]

Enoxaparin is dosed by patient weight when used to treat DVT and PE. When enoxaparin is used as a prophylactic agent, the dosing is usually different. There has been an effort in the literature to elucidate whether the prophylactic dose of enoxaparin should be increased in morbidly obese patients. In a small series of morbidly obese patients undergoing bariatric surgery (n = 13), it was demonstrated that the level of heparin antifactor Xa was subtherapeutic or undetectable in most patients receiving enoxaparin 30 mg for DVT prophylaxis and that, even when the dose was raised to 60 mg, some obese patients still had subtherapeutic levels, and 1 patient had no level.[30] Inspired by this pilot study, other investigators compared 2 prophylactic doses of enoxaparin in a bariatric surgical patient population.[31] They found that use of a higher prophylactic enoxaparin dose (40 mg twice a day subcutaneous) may have lowered the incidence of postoperative DVT after bariatric surgery without increasing the risk for bleeding. This result may lead orthopedists to consider giving patients with BMI higher than 35 (class II obese patients and morbidly obese patients) a higher enoxaparin dose than what is recommended for DVT prophylaxis. However, there are no conclusive data in the orthopedic literature that address this issue.

Postoperative Infection

Obesity and its effect on the immune system make obese patients more susceptible to surgical site infections, wound complications, nosocomial infections, and serious complications from common infections.[32,33] A higher incidence of both superficial and deep wound infections in obese patients, even with strict glycemic control, appropriate perioperative antibiotics, and impeccable wound care, has been reported.[23]

Possible reasons are reduced subcutaneous tissue perfusion and oxygenation, immune impairment, and secondary ischemia from tension along suture lines. Obesity has been associated with various changes at the cellular level of the immune system affecting both cell-mediated and humeral immunity.[32] Besides being associated with cellular changes, risk for infection is related to increased incidence of preexisting comorbidities, such as diabetes mellitus. In a prospective study that included more than 1,000 blunt trauma patients (5% of whom were obese) and statistically controlled for age and ISS, obese patients were at more than twofold increased risk for acquiring a bloodstream, urinary tract, or respiratory tract infection or being admitted to the ICU.[34]

Obesity and the Intensive Care Unit

In a study of obese patients admitted to a medical ICU, a higher rate of complications, including sepsis, ventilator-associated pneumonia, and central venous catheter–related infections, was directly correlated with increased mortality rates.[35] Another study, which reported on 170 intubated obese patients, also concluded that obesity was significantly associated with increased mortality in the ICU.[36] It was shown that, for hospital or ICU admission longer than 4 days, the morbidly obese surgical patient had a 7.4 times higher mortality risk. However, an ICU stay of less than 2 days did not significantly increase mortality risk.[34] Incidence of obesity in the ICU was 26.7%, with morbid obesity representing 6.8%—both of which are slightly higher than general population estimates and could be specific to the patient population studied or suggest that obese patients are at higher risk for trauma resulting in an ICU stay.[3]

Obesity and Lower Extremity Trauma: Specific Fracture Patterns

Pelvis and Acetabulum Fractures

Numerous studies have reported that obese patients with acetabulum fractures have more complications than their lean counterparts do. In a retrospective series of 424 displaced acetabulum fractures requiring operative fixation, 72% of the clinical outcomes, assessed using the Harris hip score, were excellent or good.[37] Forty-two fractures were in morbidly obese patients. Twenty-two (53%) of obese patients had a fair or poor clinical result (Harris hip score), which was statistically significantly higher than for nonobese patients. This series had 10 deep wound infections, 3 of which required resection of the femoral head for eradication; these 3 infections developed in morbidly obese patients. Heterotopic ossification (HO) occurred in 40% of patients, but all 13 patients with severe HO (grade III or IV) were morbidly obese.

Similar observations were made in another retrospective study, reporting on 169 acetabulum fractures treated with open reduction and internal fixation.[38] Patients were stratified according to NIH-defined weight categories. When BMI was measured as a continuous variable, it was found to have a statistically significant relationship with estimated blood loss during surgery, incidence of wound infection, and incidence of DVT. Incidence of HO, nerve palsy, and PE was not statistically significantly related to BMI. It was concluded that obese

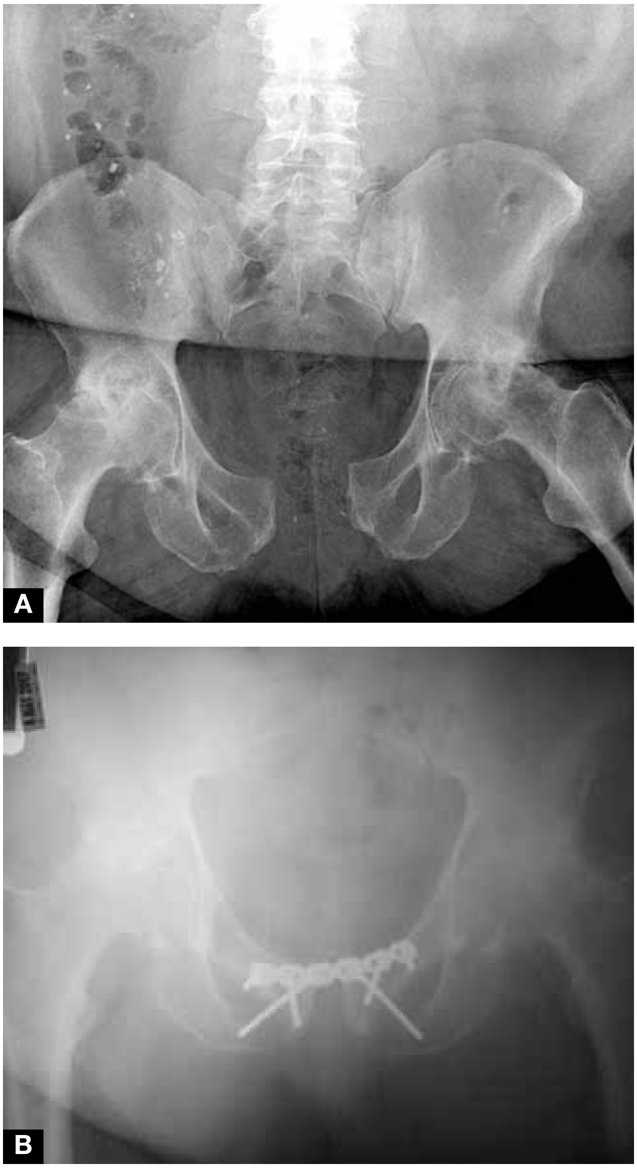

Figure 4. **Forty-eight-year-old morbidly obese man with pelvic ring injury sustained in fall down flight of stairs. (A) Initial anteroposterior radiograph shows Anterior Posterior Compression Type II pelvic ring injury. (B) Postoperative radiograph shows fixation with symphyseal plate. (C) Three-month follow-up radiograph shows failure of fixation and residual widening of pubic symphysis.**

patients were 2.6 times more likely to develop DVT and that morbidly obese patients were 5 times more likely to develop a postoperative wound infection.

The literature on pelvic ring injuries also indicates poorer outcomes for obese patients. According to a retrospective review of 42 pelvic ring fractures, 10 of which were in obese patients, external fixation for the treatment of rotationally unstable pelvic fractures failed significantly more often in obese patients than in nonobese patients.[39] In 2 of the obese patients, external fixation was unsuccessful in obtaining reduction of the pubic symphysis to within 2.5 cm, and there was loss of initial adequate reduction in 3 patients. Inability to stabilize the pelvis with initial external fixation occurred in only 2 of 32 nonobese patients. A statistically significantly higher incidence of inability to achieve acceptable pelvic alignment was found in the obese patients. It is recommended that symphyseal plating be used to repair all unstable pelvic ring fractures in the obese patient as soon as the patient's medical conditions allow for operative fixation. Despite these recommendations, the treating surgeon must keep in mind that obese patients subject internal fixation hardware to abnormal loading forces, and, as such, the fixation may fail (Figure 4).

Femur Fractures

Antegrade intramedullary femoral nailing and its complications were described in a report on 7 morbidly obese patients with femur fractures.[19] The surgeons' mean total operative time was 3.8 hours, more than double their prior average. Mean estimated blood loss exceeded 1 liter, and patients received a mean of 3.5 units of packed red blood cells. Locating the greater trochanteric starting point for the nail proved to be extremely difficult and led to 2 intraoperative greater trochanteric fractures. The difficulty involved the prominence of the buttock, the flank adipose tissue, and the adduction of the leg on the fracture table. After surgery, 2 patients developed wound complications, 4 developed DVT, and 1 died of a fatal PE. The authors suggested considering a lateral position, encouraged use of the largest nail available, and recommended statically locking the nail to allow for early weight-bearing, as obese patients find it difficult to adhere to partial or limited weight-bearing protocols.

The difficulties of antegrade femoral nailing in obese patients have led several authors to suggest considering obesity a relative indication to proceed with retrograde femoral nailing.[40-42] The most recent information is from a prospective cohort study comparing antegrade and retrograde femoral nailing in obese and normal-weight

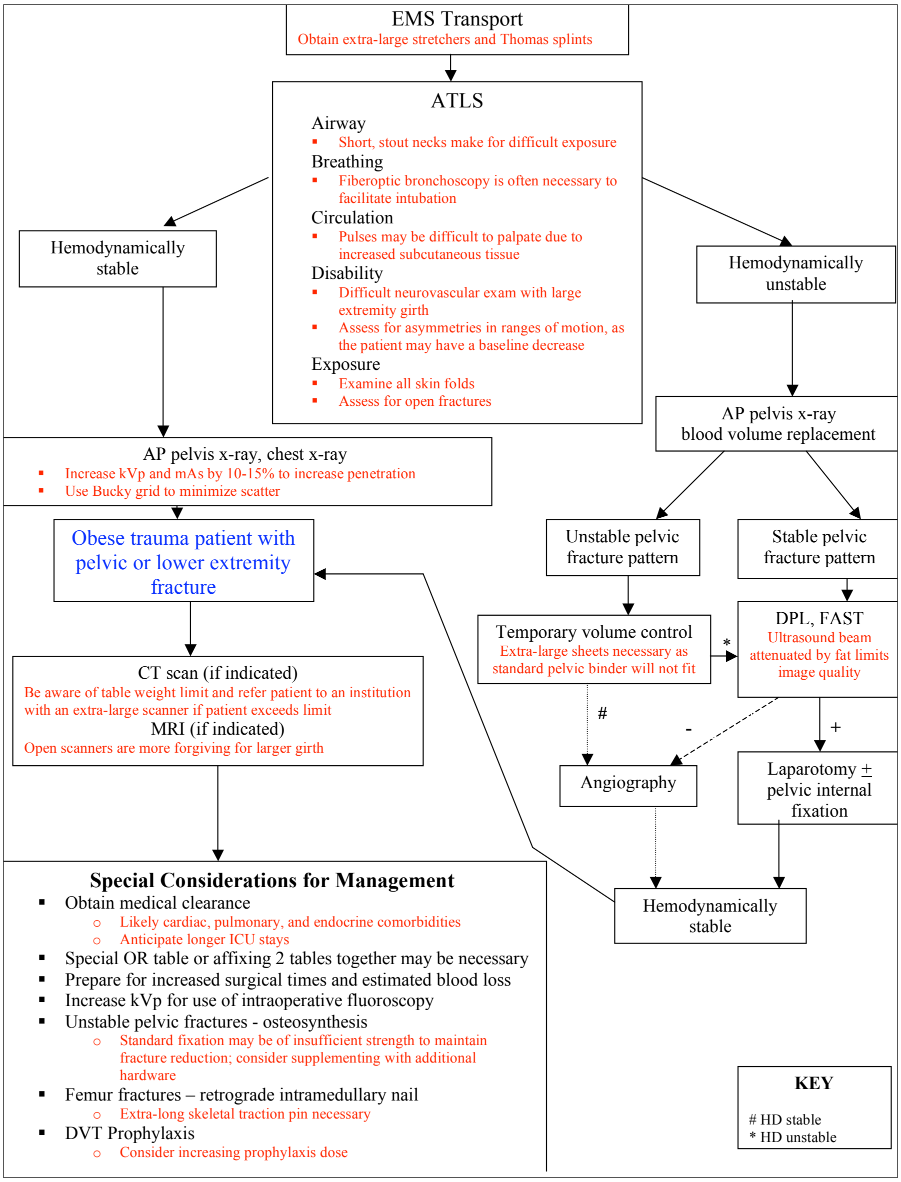

Figure 5. Algorithm for management of obese orthopedic trauma patients. Abbreviations: AP, anteroposterior; ATLS, Advanced Trauma Life Support; CT, computed tomography; DPL, diagnostic peritoneal lavage; DVT, deep venous thrombosis; EMS, Emergency Medical Services; FAST, focused abdominal sonogram for trauma; HD, hemodynamically; ICU, intensive care unit; kVp, kilovolts peak; mAs, milliamperes; MRI, magnetic resonance imaging; OR, operating room.

patients.[43] Choice of surgical procedure was at the discretion of the operating surgeon. The authors found significant differences in operative times and amount of fluoroscopy between their cohorts. Antegrade nailing in the obese group had an operative time 52% longer than that in the nonobese group. Retrograde nailing in the obese patients required 21% more fluoroscopy time than in the nonobese patients, whereas antegrade nailing required 79% more exposure time than retrograde nailing did. There was no significant difference in mean operating times between these groups for retrograde nailing. In the obese patients, antegrade nailing required 40% more operative time than retrograde nailing did. The obese and nonobese groups had similar postoperative complication rates, fracture union rates, wound infections, and functional outcomes.[43]

Ankle Fractures

There is some evidence that BMI may influence the pattern of injury about the ankle. One study prospectively evaluated rotational ankle fractures sustained from a low-energy injury mechanism.[44] The authors examined BMI and compared 24 stable ankle fractures (lateral malleolar, no medial-sided injury) with 24 unstable ankle fractures (bimalleolar or unimalleolar, with medial ligamentous injury). Overall BMI was significantly higher in the unstable fracture group; approximately one third of this group's patients were overweight, whereas only 17% of the patients in the stable fracture group were overweight.

Another study, of 3,061 surgically treated ankle and pilon fractures, evaluated the possible effect of obesity on loss of reduction.[45] Overweight and obese patients, operatively or nonoperatively treated, were found to be at increased risk for losing the reduction. For failed reduction, there were 109 revision operations—77 repeat reductions with revision fixation and 32 corrective osteotomies for angular malunion. Mean BMI was significantly higher for the reoperation group than for the group that maintained reduction. Obese patients' highest failure rates were for fractures of the distal tibia. The authors suggested that obese patients were less likely to be able to adhere to postoperative weight-bearing instructions and attributed loss of reduction to increased sporadic moments of full weight-bearing. They also concluded that malleolar fractures of the ankle were slightly more severe (to statistical significance) in the obese group than in the nonobese group.

A more recent retrospective review, of prospectively collected data on 279 patients who underwent open reduction and internal fixation for unstable ankle fractures, was performed to assess the effect of obesity on fracture severity, perioperative complications, and functional outcomes.[46] Obesity seemed not to affect outcomes in these patients. In this series, 99 patients were obese (BMI, >30), and there was a morbidly obese subset of 18 patients. Although the study found a significantly higher incidence of more severe (transsyndesmotic or suprasyndesmotic) ankle fractures in obese patients, all the patient groups were similar with respect to number of hospital days, operative time, and postoperative complications. Functional outcome scores were also similar for the obese and nonobese patients.

Conclusions

Obesity continues to be a relevant disease in the management of orthopedic lower-extremity trauma. As the problem of obesity continues to rise, orthopedic surgeons must be aware of the potential preoperative, perioperative, and postoperative complications of treating obese patients. An algorithm of recommendations for treating obese orthopedic trauma patients has been constructed (Figure 5). Particularly in DVT prophylaxis modalities, more information is needed as to whether prophylactic doses of anticoagulants should be adjusted for weight, as the treatment doses are.

Current data on pelvic and lower-extremity trauma suggest that obese patients who sustain these injuries have longer surgeries, increased blood loss, increased chance for wound infection, and increased chance for loss of reduction. There is a paucity of literature on obese orthopedic trauma patients, and more investigation is necessary to fully characterize this disease and how it affects the orthopedist's treatment of pelvic and lower-extremity orthopedic injuries.

Authors' Disclosure Statement

The authors report no actual or potential conflict of interest in relation to this article.

References

1. Ogden CL, Yanovski SZ, Carroll MD, Flegal KM. The epidemiology of obesity. *Gastroenterology*. 2007;132(6):2087-2101.
2. Ogden CL, Carroll MD, Curtin LR, McDowell MA, Tabak CJ, Flegal KM. Prevalence of overweight and obesity in the United States, 1999–2004. *JAMA.* 2006;295(13):1549-1555.
3. Nasraway SA, Albert M, Donnelly AM, Ruthazer R, Shikora SA, Saltzman E. Morbid obesity is an independent determinant of death among surgical critically ill patients. *Crit Care Med.* 2006;34(4):964-970.
4. Sturm R. Increases in morbid obesity in the USA: 2000–2005. *Public Health*. 2007;121(7):492-496.
5. Xiang H, Smith GA, Wilkins JR, Chen G, Hostetler SG, Stallones L. Obesity and risk of nonfatal unintentional injuries. *Am J Prev Med.* 2005;29(1):41-45.
6. Brunette DD. Resuscitation of the morbidly obese patient. *Am J Emerg Med.* 2004;22(1):40-47.
7. Must A, Spandano J, Coakley EH, Field AE, Colditz G, Dietz WH. The disease burden associated with overweight and obesity. *JAMA.* 1999;282(16):1523-1529.
8. Pender JR, Pories WJ. Epidemiology of obesity in the United States. *Gastroenterol Clin North Am.* 2005;34(1):1-7.
9. Allison DB, Fontaine KR, Manson JE, Stevens J, VanItallie TR. Annual deaths attributable to obesity in the United States. *JAMA*. 1999;282(16):1530-1538.
10. Neville AL, Brown CVR, Weng J, Demetriades D, Velmahos GC. Obesity is an independent risk factor of mortality in severely injured blunt trauma patients. *Arch Surg.* 2004;139(9):983-987.
11. Brown CVR, Velmahos GC. The consequences of obesity on trauma, emergency surgery, and surgical critical care. *World J Emerg Surg.* 2006;1:1-5.
12. Choban PS, Weireter LJ, Maynes C. Obesity and increased mortality in blunt trauma. *J Trauma.* 1991;31(9):1253-1257.
13. Byrnes MC, McDaniel MD, Moore MB, Helmer SD, Smith RS. The effect of obesity on outcomes among injured patients. *J Trauma.* 2005;58(2):232-237.
14. Brown CVR, Neville AL, Rhee P, Salim A, Velmahos GC, Demetriades D. The impact of obesity on the outcomes of 1,153 critically injured blunt trauma patients. *J Trauma.* 2005;59(5):1048-1051.
15. Bostman OM. Body mass index of patients with elbow and ankle fractures requiring surgical treatment. *J Trauma.* 1994;37(1):62-65.
16. Robinovitch SN, McMahon TA, Hayes WC. Force attenuation in trochanteric soft tissues during impact from a fall. *J Orthop Res.* 1995;13(6):956-962.
17. Uppot RN. Impact of obesity on radiology. *Radiol Clin North Am*. 2007;45(2):231-246.
18. Ogunnaike BO, Jones SB, Jones DB, Provost DP, Whitten CW. Anesthetic considerations for bariatric surgery. *Anesth Analg.* 2002;95(6):1793-1805.
19. McKee MD, Waddell JP. Intramedullary nailing of femoral fractures in morbidly obese patients. *J Trauma.* 1994;36(2):208-210.
20. Jupiter JB, Ring D, Rosen H. The complications and difficulties of management of nonunion in the severely obese. *J Orthop Trauma.* 1995;9(5):363-370.
21. Russell GV, Nork SE, Routt MLC. Perioperative complications associated with operative treatment of acetabular fractures. *J Trauma.* 2001;51(6):1098-1103.
22. Flancbaum L, Choban PS. Surgical implications of obesity. *Annu Rev Med.* 1998;49:215-234.
23. Bamgbade OA, Rutter TW, Nafiu OO, Dorje P. Postoperative complications in obese and nonobese patients. *World J Surg*. 2007;31(3):556-560.
24. Guss D, Bhattacharyya T. Perioperative management of the obese orthopaedic patient. *J Am Acad Orthop Surg.* 2006;14(7):425-432.
25. DeMaria EJ, Carmody BJ. Perioperative management of special populations: obesity. *Surg Clin North Am.* 2005;85(6):1283-1289.
26. Belzberg H, Wo CCJ, Demetriades D, Shoemaker WC. Effects of age and obesity on hemodynamics, tissue oxygenation, and outcome after trauma. *J Trauma.* 2007;62(5):1192-1200.
27. Mantilla CB, Horlocker TT, Schroeder DR, Berry DJ, Brown DL. Risk factors for clinically relevant pulmonary embolism and deep venous thrombosis in patients undergoing primary hip or knee arthroplasty. *Anesthesiology.* 2003;99(3):552-560.
28. Geerts WH, Pineo GF, Heit JA, et al. Prevention of venous thromboembolism: the Seventh ACCP Consensus Conference on Antithrombotic and Thrombolytic Therapy. *Chest*. 2004;126(3 suppl):338S-400S.
29. Slavik RS, Chan E, Gorman SK, et al. Dalteparin versus enoxaparin for venous thromboembolism prophylaxis in acute spinal cord injury and major orthopedic trauma patients: 'DETECT' trial. *J Trauma*. 2007;62(5):1075-1081.
30. Martin LF, Finigan KM. Hermarin antifactor Xa levels in morbidly obese patients receiving Lovenox® prophylaxis [abstract]. *Obes Surg.* 1999;9(2):128.
31. Scholten DJ, Hoedema RM, Scholten SE. A comparison of two different prophylactic dose regimens of low molecular weight heparin in bariatric surgery. *Obes Surg.* 2002;12(1):19-24.
32. Choban PS, Heckler R. Increased incidence of nosocomial infections in obese surgical patients. *Am Surg.* 1995;61(11):1001-1005.
33. Falagas ME, Kompoti M. Obesity and infection. *Lancet.* 2006;6(7):438-446.
34. Bochicchio GV, Joshi M, Bochicchio K, Nehman S, Tracy JK, Scalea TM. Impact of obesity in the critically ill trauma patient: a prospective study. *J Am Coll Surg.* 2006;203(4):533-538.
35. Yaegashi M, Jean R, Zuriqat M, Noack S, Homel P. Outcome of morbid obesity in the intensive care unit. *J Intensive Care Med.* 2005;20(3):147-154.
36. Bercault N, Boulain T, Kuteifan K, Wolf M, Runge I, Fleury JC. Obesity-related excess mortality rate in adult intensive care unit: a risk-adjusted matched cohort study. *Crit Care Med.* 2004;32(4):998-1003.
37. Mears DC, Velyvis JH, Chang CP. Displaced acetabular fractures managed operatively: indicators of outcome. *Clin Orthop.* 2003;(407):173-186.
38. Karunakar MA, Shah SN, Jerabek S. Body mass index as a predictor of complications after operative treatment of acetabular fractures. *J Bone Joint Surg Am.* 2005;87(7):1498-1502.
39. Hupel TM, McKee MC, Waddell JP, Schemitsch EH. Primary external fixation of rotationally unstable pelvic fractures in obese patients. *J Trauma.* 1998;45(1):111-115.
40. Anup K, Mehra MM. Retrograde femoral interlocking nail in complex fractures. *J Orthop Trauma.* 2002;10(1):17-21.
41. Ricci WM, Bellabarba C, Evanoff B, et al. Retrograde versus antegrade nailing of femoral shaft fractures. *J Orthop Trauma.* 2001;15(3):161-169.
42. Herscovici D Jr, Whiteman KW. Retrograde nailing of the femur using an intercondylar approach. *Clin Orthop.* 1996;(332):98-104.
43. Tucker MC, Schwappach JR, Leighton RK, Coupe K, Ricci WM. Results of femoral intramedullary nailing in patients who are obese versus those who are not obese: a prospective multicenter comparison study. *J Orthop Trauma.* 2007;21(8):523-529.
44. Spaine LA, Bollen SR. 'The bigger they come…': the relationship between body mass index and severity of ankle fractures. *Injury.* 1996;27(10):687-689.
45. Bostman OM. Body-weight related to loss of reduction of fractures of the distal tibia and ankle. *J Bone Joint Surg Br.* 1995;77(1):101-103.
46. Strauss EJ, Frank JB, Walsh M, Koval KJ, Egol KA. Does obesity influence the outcome after the operative treatment of ankle fractures? *J Bone Joint Surg Br.* 2007;89(6):794-798.

This paper will be judged for the Resident Writer's Award.