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Review Article

Obesity and its Effects on the Peri-Operative Course in total Hip and Knee Replacement

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Abstract

In 2008, it was estimated that more than 1.46 billion adults were classified as overweight (BMI>25) and 500 million adults were considered obese. Many studies have proven that obesity can add to the risk of chronic medical conditions such as type 2 diabetes, hypertension, dyslipidemia, heart disease, and metabolic syndrome, all of which can affect outcomes of total joint replacement. An association of BMI with more rapid development of osteoarthritis also has been shown. Obese patients undergoing total joint replacement have an increased risk of both deep and superficial infection, wound complications and prolonged drainage, myocardial infarction and other cardiac events, pulmonary complications, and even death. Other problems that may be encountered with obese patients include problems with operative instrumentation and tables and the need for additional anesthetic and pain control agents. Overall, obesity in the United States is thought to be a contributing factor to functional outcomes, mobility, complications, and increased health care burden.Weight control and maintenance of a non-obese BMI may decrease certain risk factors and medical comorbidities. While demand for total joint replacement will likely increase over the next several decades, understanding the pathophysiology of obesity and its effects on the surgical patient will be vital for the delivery of safe, effective, and reliable total joint replacement surgery.

INTRODUCTION

Obesity and worldwide implications

According to the World Health Organization(WHO), obesity is universally defined as a body mass index(BMI) exceeding 30 (kg/m^2), with severe obesity being categorized as a BMI greater than 40. Obesity has quickly become a global epidemic. In 2008, it was estimated that more than 1.46 billion adults were classified as overweight (BMI>25) and 500 million adults were considered obese [1]. Even though there seems to be a slight plateau in the rate of obesity, the United States still has the highest BMI among higher income countries around the world. Based on recent studies and the WHO classification, almost one third of the adult population in the United States is considered obese. The percentage of adults who were categorized as either overweight or obese has risen from around 45% in 1960 to 66.2% in 2004 [2]. The slightly plateauing rate of obesity in the US may be attributed to the progressive increase of severe obesity [3]. The prevalence of severe obesity in the United States has risen from 0.9% in 1960 to 5.1% in 2004, and severe obesity has increased faster than any other class of obesity in recent years [2].

Over the past ten years, public health concerns have not just been limited to the United States alone. The WHO has noted the increasing number of people who are overweight or obese and has begun to address the global implications that obesity has caused[1]. Studies have shown that obesity has begun to overtake tobacco as the biggest preventable cause of disease in many regions around the world [4]. Some studies have even reported large decreases in life expectancy associated with obesity, and in 2001 the US Surgeon General released reports that addressed obesity as a major issue of concern to healthcare. Throughout the last decade, the supply of low cost foods has risen. These food sources are continually attributing to the obesity epidemic because they are so energy dense and easily delivered around the world[1]. The recent increase in public attention to obesity has led to some changes in diet habits and an increase in physical activity in the United States; however, these changes have had little effect on the obesity epidemic [4].

Many studies have proven that obesity can add to the risk of chronic medical conditions such as type 2 diabetes, hypertension, dyslipidemia, heart disease, and metabolic syndrome. One theory involving obesity and the acquisition of type II diabetes involves higher body weights and overeating putting extra stress on the

membranous network of the endoplasmic reticulum. As the endoplasmic reticulum becomes overwhelmed with nutrients, it signals a decrease in the number of insulin receptors on the cell surface. Thus, obesity intensifies insulin resistance in the body, leading to or worsening diabetes [5]. Obesity is a well-known predictor of type II diabetes, which is also a very common metabolic disorder. Individuals diagnosed with type II diabetes have been proven to have continual risk for lifelong morbidity and greater risk of mortality. A recent study by Ganz et al evaluated the impact of obesity on type II diabetes and found that higher BMI, when compared to normal weight, was strongly associated with the risk of a diabetes diagnosis [6].

Increased body weight also has been proven to affect an individual's blood pressure and heart function. Excess visceral fat is a main factor that leads to hypertension. With extra volume and mass, there is an increase in the number of arteriole pathways and resistance that the heart must pump against. Studies by Hall et al suggest that there is a strong association between excess weight gain and hypertension. One of the driving forces of hypertension in their study was the hormone leptin, which can activate the sympathetic nervous system, elevating blood pressure [7]. Not only does increased body weight affect blood pressure, but it also has been shown to lead to cardiovascular disease. Obesity has been estimated to account for almost 23% of ischemic heart diseases [8]. Increased arterial resistance leads to hypertension and significantly increases the risk of congestive heart failure and sudden death. Long-term studies also indicate that obesity is a strong direct predictor of coronary artery disease and coronary atherosclerosis [9].

A major cause of the atherosclerosis and cardiovascular disease is dyslipidemia, which is strongly associated with larger body weights. This obesity-induced dyslipidemia usually is related to the rise in triglycerides, low high-density lipoprotein (HDL) levels, and abnormal low-density lipoprotein(LDL) levels in the blood. As with diabetes, insulin resistance occurs as body mass increases. Insulin resistance seems to heighten the amount of triglycerides in the blood. Dyslipidemia in obese individuals can, however, be treated and ultimately reversed even without any significant weight loss. These individuals are treated with lipid-maintaining therapy that could help to reduce their risk for cardiovascular disease [10].

Since obesity is a major risk factor for other comorbidities, including heart disease, it has been indicated as the main predictor of metabolic syndrome risk. Metabolic syndrome is defined as a group of individual risk factors that increase the risk for cardiovascular disease. Two or more of the following in addition to obesity meet the criteria for a diagnosis of metabolic syndrome: high blood glucose levels, dyslipidemia, and hypertension. In a study done by Atlantis et al, new evidence was provided implicating obesity as the major risk factor for metabolic syndrome independent of any other life style risk factors [11].

With the increased number of individuals now considered overweight or obese, many patients who are candidates for joint arthroplasty are classified as overweight or obese. Some studies have shown that obesity doubles the prevalence of arthritis, and severe obesity has been shown to even quadruple its prevalence. One orthopaedic hospital reported the rate of obesity in patients who had total joint arthroplasty at almost 52% [4]. Patient care becomes especially difficult when severely obese patients exceed the limits of standard medical equipment, such as wheelchairs, imaging equipment, and operating tables. Obese patients also tend to require more resources because of associated comorbidities[2,4]. The highest prevalence of obesity in US adults is in older adults, who are at an age at which they are most likely to need joint arthroplasty. With the increasing number of obese patients undergoing joint arthroplasty, obesity-related health concerns that could affect the outcome of surgery need to be considered.

Necessity of preoperative screening

The appropriate diagnosis and management of metabolic syndrome play a crucial role in limiting perioperative morbidity. A regression analysis by Della Valle et al illustrated that metabolic syndrome was an independent risk factor for the development of major complications, non-routine hospital discharge, and increased hospital cost in patients undergoing hip and knee arthroplasty [12]. In addition, Memtsoudis et al noted that patients with metabolic syndrome who had lumbar spine fusion surgery had increased rates of major life-threatening complications compared to patients without metabolic syndrome [13]. Thus, even before entering the operating room, the surgeon, in conjunction with other medical subspecialists, must be able to effectively diagnose, evaluate, and treat the multiple disorders that affect a patient with metabolic syndrome to minimize the risk of perioperative complications. It is important to note that many of the risk factors associated with metabolic syndrome have no signs or symptoms; the patient's body habitus may be the only visible risk factor at first glance. Further investigation, however, may reveal other comorbidities such as diabetes, hypertension, dyslipidemia, heart disease, or liver disease that may directly influence the patient's surgical outcome. A high BMI (≥30) should alert the surgeon to other medical issues that may need to be considered before and during surgery. The patient must also be counseled on the additional technical challenges that arise secondary to body habitus. Mulhall et al demonstrated that obese patients with total knee arthroplasty are more likely to require earlier revision surgery and to have lower postoperative functional and disability scores than patients of normal weight [14]. Drastic changes in diet and possibly weight loss surgery can positively affect surgical outcomes in obese patients.

Obese patients also should have a thorough obstructive sleep apnea (OSA) workup by a pulmonologist or internal medicine specialist. Those most at risk are overweight males over 50 years of age with a neck circumference > 16 inches. OSA is associated with increased perioperative morbidity in patients who have general or regional anesthesia [15].

In diabetic patients, blood glucose control during and after surgery has a direct effect on surgical outcome. Ideally, strict glucose control should be implemented preoperatively and then maintained perioperatively and postoperatively. Lamloum et al investigated the relationship between glycemic control and postoperative complications in orthopaedic patients and found that 90 (28.3%) of 318 diabetic patients developed postoperative complications [16]. The authors determined that a hemoglobin

A1C < 7% was significantly associated with decreased postoperative infectious complications. Jeon et al determined that patients with pre-operative hypoglycemia and increased inpatient glucose variability had a higher rate of in-hospital mortality [17], and Richards et al concluded that hyperglycemia was an independent risk factor for 30-day surgical site infection in orthopaedic trauma patients, even those without a preoperative history of diabetes [18].

Orthopaedic surgical outcomes also are directly influenced by preoperative cardiovascular risk factors. Dy et al investigated the effects of hypertension, diabetes, dyslipidemia, and obesity on the incidence of myocardial infarction (MI), venous thromboembolism (VTE), and revision arthroplasty in 16,317 arthroplasty patients and determined that the risk of MI increased with the addition of each independent risk factor; patients with all four risk factors had a 128% increased risk of MI [19]. Beta-blockers have been proven to decrease 90-day mortality and inpatient coronary events in at-risk patients undergoing total knee arthroplasty[20]. Patients should continue their prescribed regimen of beta-blockers preoperatively and throughout the perioperative and postoperative periods.

Intra-operative anesthetic considerations of the obese patient

A number of intraoperative and postoperative demands are uniquely associated with obese patients. The anesthesia and orthopaedic teams must be able to effectively communicate and work together to optimize surgical outcomes. Obese patients often are more sensitive to airway manipulation, opioids, sedatives, and muscle relaxants [21]. Thus, regional anesthesia is preferred and, with primary arthroplasty procedures, regional anesthesia is associated with superior perioperative outcomes [21]. Obese patients should also be closely monitored in the recovery room. Patients with OSA who used continuous positive airway pressure (CPAP) preoperatively should be restarted on CPAP in recovery [15].

Limiting intraoperative and postoperative blood loss also is important for obese patients. Continued postoperative wound drainage is associated with an increased risk of infection [22]. Achieving hemostasis with electrocautery and a watertight closure is an important factor that the surgeon can control to decrease wound drainage and subsequent blood loss. Other agents such as tranexamic acid (TXA) can be used intraoperatively to decrease blood loss and postoperative hematoma. TXA works as an antifibrinolytic agent that antagonizes the breakdown of fibrin. Multiple studies have demonstrated the effectiveness of TXA in decreasing total blood loss without an increased risk of thrombosis [22,23,24]. Autologous platelet gels and topical fibrin sealants also have been shown to decrease blood loss and transfusion rates [25,26].

Post-operative pain control has evolved from patient-controlled analgesia to a more multimodal treatment plan. This is especially important obese patients because of their opioid sensitivity and other medical comorbidities [12]. Adequate pain control that does not sedate the patient assists with mobilization, rehabilitation, and thus earlier and safer hospital discharge. Intraoperative surgical site injections along with peripheral nerve blocks can provide excellent pain control. A combination of non-opioid oral medications, including drugs such as non-opioid analgesics, acetaminophen, non-steroidal anti-inflammatories, and gabapentinoids, can provide sufficient pain control without the need for opioids. Again, the surgeon and the anesthesia team need to combine efforts to effectively manage post-operative pain in obese patients.

Functional implications and mobility

The association of BMI with more rapid development of osteoarthritis has been shown in the literature [27]. Elevated BMI is associated with a larger volume of adipose tissue, which is a source of pro-inflammatory cytokines that may further increase joint damage in an already mechanically overburdened joint [28,29]. Cytokines have been shown to have a synergistic effect with other inflammatory cytokines, many of which are expressed in patients with other comorbidities of obesity like hypertension and hyperlipidemia, creating a vicious circle that can compromise a patient's functional status. Liljensøe et al. analyzed the association between preoperative BMI and later quality of life and physical function. They found that elevated preoperative BMI was associated with increased risk of poor quality of life and physical functioning as measured by the Short-Form Health Survey (SF-36) and Knee Scoring System (KSS) scores, respectively [30]. In another study, elevated BMI alone – regardless of baseline weight or medical comorbidities – was shown to limit activities of daily living in one out of five patients. A 20% increase in weight and a reduction of physical activity were shown to result in a twofold increase in later physical disability; 40% of the patients in this study had some sort of limitation in their normal neuromuscular movements as well [31]. Intramuscular and intratendinous fat deposition may be a contributing factor, and the biomechanical function of the knee may be particularly sensitive to these changes [28]. During gait the peak adduction moment shifts in the presence of obesity, and increased force is transmitted to the medial compartment [32]. Over-recruitment of normal walking muscles such as the gluteus medius occurs, and one study has shown that during walking, sagittal and frontal plane joint kinematics are altered, which may predispose an individual to earlier fatigue [33].

Effect on outcomes

Multiple studies have shown that obesity increases the risk of medical comorbidities. Increased adipose tissue may lead to certain biochemical changes that predispose obese patients to complications. A low-grade baseline inflammatory state characterized by elevated neutrophil activity has been implicated as a possible cause [33,34]. Obese patients have an increased risk of both deep and superficial infection, wound complications and prolonged drainage, myocardial infarction and other cardiac events, pulmonary complications, and even death[35, 36]. The total joint surgeon must be aware of the increased morbidity associated with hip or knee arthroplasty and must counsel the patient fully before surgery. Other problems that may be encountered with obese patients include problems with operative instrumentation and tables and the need for additional anesthetic and pain control agents.

Positioning of total knee components in obese patients has

recently become a topic of discussion. Estes et al described how increased soft-tissue opposition may affect component malposition by obscuring bony landmarks and interfering with cutting guides. In their study, there was a trend towards increased component malposition as BMI increased[37]. They found a tendency for the components in obese patients to be malpositioned in varus, which may play a role in the increased risk of aseptic loosening in obese patients. In one study, the risk of revision of THA and TKA was increased 65% and 44%, respectively, both significant differences as compared to non-obese patients[38]. Another study has shown a significantly decreased time to revision arthroplasty of 20 months in obese patients[14].

The degree of overall improvement and patient satisfaction after TJA in obese patients is less than that in non-obese patients [37], with significantly smaller improvements in SF-36, Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), and KSS scores as compared to non-obese patients [14]; however, not all obese patients have poor outcomes and are dissatisfied with their surgery. A different study looking at baseline physical, mental, and overall functional scores between obese and non-obese patients showed that obese patients had significant improvement compared to preoperative scores [39]. Additionally, the risk of complications in obese patients may be modifiable. Kulkarni et al. found a decreased rate of readmission and wound complications in patients who underwent weight control surgery before their total joint operation [40].

Overall, obesity in the United States is thought to be a contributing factor to functional outcomes, mobility, complications, and increased health care burden. Weight control and maintenance of a non-obese BMI may decrease certain risk factors and medical comorbidities. While demand for total joint replacement will likely increase over the next several decades, understanding the pathophysiology of obesity and its effects on the surgical patient will be vital for the delivery of safe, effective, and reliable total joint replacement surgery. As the landscape of health care in the USA changes to one focused on successful outcomes and low readmission rates, patient education, counseling, and referral to weight loss specialists before total joint arthroplasty will become increasingly important.

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