Total hip arthroplasty in obesity: separating 'fat' from fiction

ABSTRACT

Obesity is a modern-day epidemic with increasing prevalence that is directly impacting the global burden of primary total hip arthroplasty. The risk of requiring total hip arthroplasty for osteoarthritis increases incrementally with increasing obesity class. Surgical intervention in obese patients presents a set of unique challenges that should be recognized by the treating medical team. Although predominantly satisfactory outcomes have been reported, perioperative anaesthetic and surgical concerns require thorough patient assessment. There is an increased potential risk of thrombogenic and septic complications, but the body mass index cutoff level beyond which total hip arthroplasty should not be offered in the obese patient remains controversial. Preoperative medical optimization of the patient and appropriate intraoperative interventions are essential to mitigate the risk of complications.

Obesity is one of the most common causes of preventable death and accounts for over 2.5 million deaths annually worldwide (Lupoli et al, 2017). There are growing concerns about the economic burden that obesity imposes on society and health-care systems. Care of obese patients in the United States of America is responsible for over $275 billion of health-care expenditure, more than the combined expenditure on smoking and alcohol abuse (Haynes et al, 2017). The obesity epidemic transcends socioeconomic classes and geographical differences. More than one in four adults is obese in Australia (27.9%), Canada (25.8%), Chile (25.1%), South Africa (26.5%), the United States of America (38.2%) and the UK (26.9%) (Organization for Economic Co-operation and Development, 2017). Compounding this problem, groups with the highest body mass index are growing at the fastest rate, evidenced by the number of Americans with a body mass index of over 40 kg/m^2 increasing annually by over 50% (Haynes et al, 2017). There is no indication of complete retrenchment of obesity in any country and projections show a steady increase in prevalence globally until at least 2030 (Organization for Economic Co-operation and Development, 2017).

Obesity is defined by the World Health Organization as a body mass index of over 30 kg/m^2 (*Table 1*). There is a direct causal link between obesity and osteoarthritis of the hip (Barrett et al, 2018). Increased biomechanical loading on joints because of the higher body mass results in increased pressure on the joint surfaces leading to cartilage breakdown (Elson et al, 2013). Systemically, lean muscle mass is replaced by high-fat mass resulting in enzymatic degradation and inflammation of cartilage by adipokine released from the adipose tissue (Barrett et al, 2018). There is a dose-dependent relationship between body mass index and clinical and radiological osteoarthritis of the hip – each 5-unit increase in body mass index gives an 11% increase in the risk of hip osteoarthritis (Jiang et al, 2011).

Primary total hip arthroplasty remains a reliable, reproducible and cost-effective surgical procedure to alleviate pain and improve function in patients with end stage osteoarthritis of the hip (Lübbeke et al, 2010). Obese patients require total hip arthroplasty at a younger age than non-obese patients and have a higher risk of complications. Andrew et al (2008) reported that the average age of total hip arthroplasty for non-obese patients (body mass index <30 kg/m^2) was 69.1 years as opposed to 65.5 years and 60.6 years in obese (body mass index 30–40 kg/m^2) and morbidly obese patients respectively. Furthermore, in comparison with normal weight patients, Bourne et al (2007) showed that class I, class II and class III obesity correlated with a 3.42, 5.24 and 8.56-fold increased relative risk of complications following total hip arthroplasty respectively.

Preoperative considerations

Pain management

Non-pharmacological

Thermotherapy and electrotherapy should be used to manage pain in combination with exercise (National Institute for Health and Care Excellence, 2019). Manual therapy is an option to manage pain, especially with graded activity programmes, and should be supervised by a physiotherapist (National Institute for Health and Care Excellence, 2019). Aids such as bracing, joint supports and insoles can assist with pain management for activities of daily living (National Institute for Health and Care Excellence, 2019). If daily functional activity is compromised, devices such as

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Table 1. Classification of obesity

World Health Organization (2019) definitions		Surgical literature (Jiang et al, 2011; Schwarzkopf et al, 2012)	
Body mass index (kg/m^2)	Class	Body mass index (kg/m^2)	Class
25–29.9	Overweight	25–29.9	Overweight
30–34.9	Class I obesity	≥30	Obese
35–39.9	Class II obesity	35–39.9	Severe obesity
≥40	Class III obesity	40–49.9	Morbid obesity
		≥50	Super obesity

tap turners and walking sticks should be core treatment options in consultation with an occupational therapist (National Institute for Health and Care Excellence, 2019). Nutraceuticals, such as glucosamine or chondroitin, and acupuncture are not recommended (National Institute for Health and Care Excellence, 2019).

Pharmacological

Oral analgesics such as paracetamol should be used in addition to the aforementioned non-pharmacological treatment modalities (National Institute for Health and Care Excellence, 2019). If pain relief is insufficient, topical non-steroidal anti-inflammatory drugs are the next option (National Institute for Health and Care Excellence, 2019). If the combined use of these agents is ineffective, oral opioids should be considered (National Institute for Health and Care Excellence, 2019).

Thomazeau et al (2014) reported that obese patients have a higher rate of acute pain episodes than non-obese patients (65% *vs* 44%, $P<0.05$). Preoperative use of strong opioids (13% *vs* 0%) and non-steroidal anti-inflammatory drugs (31% *vs* 14%) was higher in obese patients. Intra-articular corticosteroid injections should be a core adjunct to manage patients with moderate to severe pain, but intra-articular hyaluronan injections are not recommended (National Institute for Health and Care Excellence, 2019).

Non-surgical weight loss

The National Institute for Health and Care Excellence (2019) guidelines recommend weight loss as the first-line treatment option for osteoarthritis of the hip before surgical intervention. Weight loss results in improvements in pain and physical function scores (National Institute for Health and Care Excellence, 2019). Patients should aim to decrease body weight by 10% as this significantly reduces pain (National Institute for Health and Care Excellence, 2019). The European League Against Rheumatism recommends dietary modifications in combination with graded exercise programmes in consultation with a physiotherapist. Psychosocial interventions and patient education are important for maintenance of weight loss (National Institute for Health and Care Excellence, 2019).

Bariatric surgery

Bariatric surgery has been advocated for weight reduction in obese patients before total hip arthroplasty. Bariatric procedures may result in sustained weight loss and an overall reduction of 30% for all-cause mortality (Lupoli et al, 2017). Additionally, bariatric surgery has a positive effect on and the potential to reverse comorbid conditions such as type 2 diabetes, hypertension, obstructive sleep apnoea and steatohepatitis (Lupoli et al, 2017).

However, the efficacy of bariatric surgery before elective total hip arthroplasty remains controversial. Bariatric surgery may result in protein-calorie malabsorption, poor nutrition, vitamin and mineral deficiencies, and limited changes in body morphology (Lupoli et al, 2017). In a meta-analysis comparing 657 patients who had bariatric surgery before total joint arthroplasty and 22 691 who did not, Smith et al (2016) reported that preoperative bariatric surgery did not ameliorate the complication risk or enhance functional outcomes. There was no statistically significant difference in outcomes such as superficial and deep wound infection, deep vein thrombosis, pulmonary embolism, risk of revision surgery or mortality.

While bariatric surgery is a successful procedure to reduce weight, its effect in optimizing patients for total joint arthroplasty is unclear. Therefore the most effective modality for moderating and managing obesity as a risk factor for complications remains controversial.

Anaesthetic implications

Medical comorbidities

Obesity presents several anaesthetic concerns as it is a multisystem disease and results in problems associated with increased pressure, weight and metabolic conditions (Popescu and Schwartz, 2007). Careful preoperative assessment is needed to optimize patients.

Ventilation

Airway management is a major anaesthetic concern as both the upper and lower respiratory tract are affected by obesity. It is estimated that 5% of obese patients have obstructive sleep apnoea and even light sedation can produce complete airway collapse (Popescu and Schwartz, 2007). Obese patients undergo rapid deterioration with apnoea and experience desaturation more quickly than non-obese patients (Popescu and Schwartz, 2007). A restrictive ventilatory defect with reduced functional capacity, limited total lung capacity and poor lung compliance (Popescu and Schwartz, 2007) may exist. Morbidly obese patients have an increased risk of reintubation when undergoing total hip arthroplasty (Ward et al, 2015).

Positioning

Careful positioning of obese patients for surgery is essential as morbidly obese patients are prone to slipping off the operating room table (Popescu and Schwartz, 2007). Morbidly obese patients require specially designed tables which can hold over 450 kg and are wider to accommodate the larger girth.

Patients should be well-strapped and special attention must be given to padding all pressure points. Without adequate strapping, limbs are more likely to fall off the table, causing peripheral nerve injuries (Popescu and Schwartz, 2007).

Pharmocokinetics

Increased adiposity influences the pharmokinetics of various drugs because of the decreased volume of distribution resulting from increased drug clearance (Janson and Thursky, 2012). Calculation of drug doses should be based on ideal body weight rather than full body weight; however, this may not be effective to manage septic risks for obese patients. Body composition results in a greater drug clearance function in obese patients who have a lean:adipose weight ratio of 3:2 compared to 4:1 in non-obese patients (Janson and Thursky, 2012). As a result there is a significant risk of underdosing of antibiotics in obese patients undergoing surgery and this may be the prime factor in the link between obesity and infection (Janson and Thursky, 2012). Some drugs have dichotomised dose recommendations based on total body weight. In obese patients, cephalosporins are the recommended prophylactic antibiotics for total joint arthroplasty. The recommended dose of 1 g is increased to 2 g in obese patients to account for the increase in clearance (Janson and Thursky, 2012).

Given the risks associated with general anaesthetic, regional anaesthetic techniques may be considered. The administration of peripheral nerve blocks is technically more challenging with greater chance of complications because of the lack of visible or palpable landmarks. Nielsen et al (2005) demonstrated that obese patients had a 1.62 times higher risk of a failed peripheral nerve block than those with lower body mass index.

Pain relief is more difficult to obtain in obese patients because a higher dose of medication is required (Popescu and Schwartz, 2007). A multimodal approach to pain management is recommended.

Radiographic templating

Templating before total hip arthroplasty is essential. Achieving adequate radiological images for preoperative diagnosis and planning is a challenge in obese patients. The radiographic image may be magnified because of the increased distance from the X-ray cassette to bone (Uppot, 2007). Attaining the requisite radiographic quality of the underlying bone may require adjustments leading to increased radiation exposure (Uppot, 2007).

Impact of obesity on surgery

Surgical approach

The surgical approach does not seem to play a role in the functional outcomes of total hip arthroplasty in obese patients (Antoniadis et al, 2018). However, there is an increased risk of postoperative infection and re-operation in obese patients undergoing total hip arthroplasty with the direct anterior approach. Russo et al (2015) reported that obese patients undergoing total hip arthroplasty via the direct anterior approach were 8.8 times more likely than non-obese patients to have major complications. This may be a result of the impaired immunity of obese patients and the abdominal pannus compromising the anterior surgical incision close to the groin. However, Antoniadis et al (2018) proposed that the direct anterior approach remained a reliable surgical approach in obese patients as the increased complication rate was still comparable with that in more extensile approaches.

Implant selection

Care should be taken when choosing suitable implants for total hip arthroplasty. Craik et al (2016) reviewed 200 054 cases from the 2013 National Joint Registry involving 25 different total hip arthroplasty and total knee arthroplasty components from various companies of which five listed obesity as a contraindication for implantation. As many as 10 745 patients (16% of all obese patients) received hip and knee components not endorsed for use in obesity by the relevant manufacturers. Mechanical failure of implants in the obese following such 'off-label use' may have medicolegal implications.

Component positioning in obese patients (body mass index >35 kg/m^2) was inferior to that in a non-obese control group (body mass index <25 kg/m^2) (Elson et al, 2013). Obese patients had acetabular cups that were over-abducted and under-anteverted (Elson et al, 2013).

Postoperative complications

Veno-thromboembolic events

Obesity is an independent risk factor for veno-thromboembolic events as a result of decreased antithrombin III levels, fibrinolytic activity, venous stasis and increased levels of prothrombotic factors (Zhang et al, 2015). Each case should be risk stratified and selection of thromboembolic prophylaxis should be individualized (Zhang et al, 2015). Mechanical prophylaxis plays a key role. Graduated compression stockings are recommended although achieving a comfortable fit with thigh-length stockings may be difficult. Intermittent pneumatic compression devices are better tolerated. There are several options for chemical prophylactic agents but no definitive recommendations exist over best options or dosing adjustments (Zhang et al, 2015).

Dislocation

The risk of hip dislocation is 4.42 times greater in obese than non-obese patients with correctly positioned components (Davis et al, 2011). Furthermore, the risk escalates by 113.9% with each 10-point increase in body mass index (Davis et al, 2011). This is likely a result of weaker muscles and poor muscle tone around the hip in obese patients which contributes to greater axial instability via a piston effect and joint separation (Maisongrosse et al, 2015). Dual mobility cups have lower dislocation rates after primary total hip arthroplasty in obese patients (Maisongrosse et al, 2015).

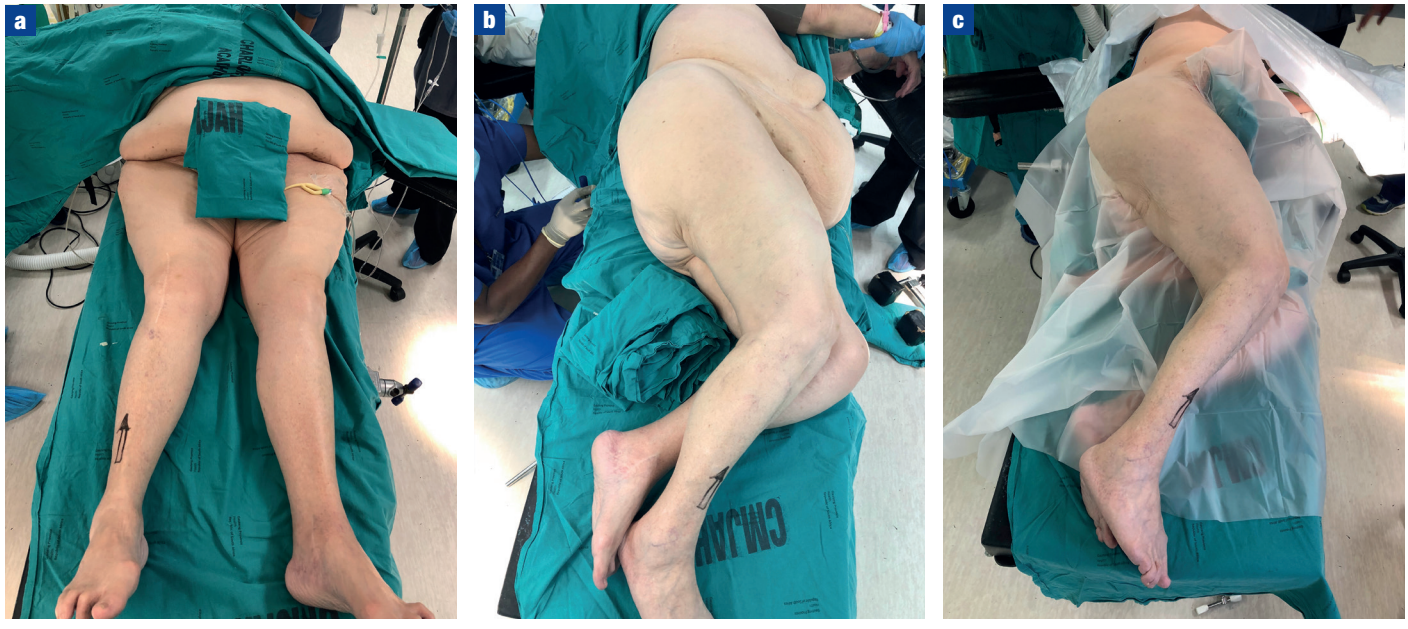

Figure 1. Morbidly obese woman (body mass index 43.2 kg/m^2) being prepared and positioned on lateral side for total hip arthroplasty using a posterior approach. **a.** Patient with pendulous abdomen in supine position during anaesthetic induction. **b.** Patient placed into lateral position before securing with hip positioners highlighting how adiposity rolls away from the surgical site. **c.** Protection of pressure points and secured in hip positioners. **d.** Appropriate positioning and sufficient space for posterior hip approach.

Periprosthetic infection and surgical site infection

Obese patients have increased rates of infection after total hip arthroplasty (Janson and Thursky, 2012; Parvizi et al, 2017). Contributing factors include prolonged surgical time, poor adipose tissue vascularity, demanding surgical exposures, physiologically compromised immunity and inadequate prophylactic antibiotic dosing (Janson and Thursky, 2012). Aseptic technique during preoperative cleaning, thorough surgical site preparation and draping must be practiced to minimize these risks (*Figure 1*).

Lübbeke et al (2008) reported that the frequency of periprosthetic infection was twice as high in patients with severe obesity and four-fold greater in morbidly obese patients. Similarly, a retrospective study of 3672 primary total hip arthroplasty cases demonstrated that morbid obesity was a significant risk factor for periprosthetic infection, with an odds ratio of 4.13 (Barrett et al, 2018). A protracted period of wound drainage is more likely in total hip arthroplasty in the obese patient and subsequently a greater risk of surgical site infection (Parvizi et al, 2017). The International Consensus Meeting on musculoskeletal infections strongly recommended weight loss before total hip arthroplasty for prevention of both periprosthetic infection and surgical site infection (Parvizi et al, 2013).

Aseptic loosening of implant

The load across the hip joint is dependent on the patient's weight (Andrew et al, 2008; Lübbeke et al, 2010). The joint reaction forces are exacerbated in obese patients, but whether this translates into accelerated wear is unclear (Andrew et al, 2008; Lübbeke et al, 2010). Some studies have shown no difference (Andrew et al, 2008; Lübbeke et al, 2010) and others have shown an increased incidence of osteolysis (Electricwala et al, 2016).

In a retrospective study Goodnough et al (2018) reported that obesity was an independent risk factor for aseptic loosening at a rate of 30% within 5 years of implantation – 18% of non-obese patients failed as a result of aseptic loosening over the same period. Electricwala et al (2016) showed that preoperatively obese patients had a 4.7 times increased risk of early revision as a result of osteolysis after elective primary total hip arthroplasty.

Theatre time and length of hospital stay

The theatre time is greatest in morbidly obese patients as a consequence of more technically demanding surgery, increased set-up and anaesthetic time (Bradley et al, 2014). Obese patients have restricted postoperative rehabilitation and delay in reaching functional milestones (Andrew et al, 2008). Obesity has been associated with increased length of postoperative stay (Maradit Kremers et al, 2014). Bradley et al (2014) showed that a 1-point increase in body mass index increases length of hospital stay by 2.9% and extends theatre time by 1.46 minutes.

Cost implications

There are obvious cost implications of total hip arthroplasty in obese patients. Hospital resources are consumed at an accelerated rate (Batsis et al, 2010). Maradit Kremers et al (2014) showed that for primary total hip arthroplasty there was an additional $500 charge in hospital costs with every 5-unit increase in body mass index beyond 30 kg/m^2.

Risk of readmission

In a review of 131 576 total hip arthroplasties, Jeshke et al (2018) reported that the incidence of revision total hip arthroplasty within 1 year and 90-day readmission rates increased with each body mass index category. The probability of deep infection, mortality and peri-prosthetic fracture was higher in morbidly obese patients (Jeshke et al, 2018). This was highlighted in a systematic review of 66 238 morbidly obese patients and 705 619 non-obese in which the overall revision rate was 7.99% and 2.75% respectively (Barrett et al, 2018).

Functional outcomes

The impact of obesity on functional outcome following total hip arthroplasty remains controversial with a number of studies demonstrating suboptimal postoperative function, poorer quality of life and lower satisfaction in obese patients (Haynes et al, 2017; Jeschke et al, 2018). However, other researchers have reported no difference in outcome scores (Andrew et al, 2008; Barrett et al, 2018).

Barrett et al (2018) reported in a systematic review that the Harris Hip Score improved after total hip arthroplasty in all patients, irrespective of body mass index. The median difference in pre- *vs* postoperative Harris Hip Score was 45.6 and 44.8 in morbidly obese and non-obese groups respectively across all studies. Multiple reports indicated that morbidly obese patients may have equivalent satisfaction rates and degree of functional improvement despite poorer Western Ontario and McMaster Universities and Short Form-36 questionnaire scores (Barrett et al, 2018).

Jameson et al (2014) examined a national cohort population and found that all patients, irrespective of body mass index, improved after total hip arthroplasty. However, the degree of joint specific and general health improvements declined with each increase in obesity class. In patients with class II and III obesity there was significantly less appreciable improvements in Oxford Hip Scores and EuroQol five Dimensions (EQ-5D) index. Andrew et al (2008) found that the pre- and postoperative change in Oxford Hip Score was similar for obese and non-obese patients. Therefore, the policy of withholding of total hip arthroplasty for obese patients by health-care administrators on the basis of poorer outcomes may be injudicious and imprudent (Lübbeke et al, 2010).

Super obese

A new sub-classification of patients with body mass index >50 kg/m^2 specified as 'super obese' has been adopted (Schwarzkopf et al, 2012). The prevalence of super obesity in patients undergoing total hip arthroplasty in the USA increased by 120% between 2000 and 2010 (Meller et al, 2016). Total hip arthroplasty does provide functional and clinical improvements in super obese patients (Barrett et al, 2018), but they have an 8.44 times greater risk of suffering in-hospital complications (Schwarzkopf et al, 2012). The risk of complications in super obese patients is greater than even those in revision surgery, with a significantly greater risk of venous thromboembolism, infection, blood transfusion, medical complications, dislocation, readmission and early revision total hip arthroplasty (Barrett et al, 2018).

Subsequently, super obese patients are twice as likely to be readmitted early than morbidly obese patients (Schwarzkopf et al, 2012) The risk of in-hospital and outpatient complications increases incrementally by 1.69 and 2.71 times respectively with each 5-point increase in body mass index above 45 kg/m^2 (Schwarzkopf et al, 2012). Similarly, the length of hospital stay is extended by 13.8% for each 5 point increase beyond a body mass index of 45 kg/m^2 (Schwarzkopf et al, 2012). There is a compounding of financial costs of total hip arthroplasty in super obese patients.

Conclusions

Obesity is a pandemic and the prevalence of total hip arthroplasty in obese patients is increasing worldwide. Functional outcomes and satisfaction rates after total hip arthroplasty in obese patients are equivocal to non-obese patients, but there is a dose-dependent relationship between body mass index and risk of complications, especially septic sequelae. Judicious consideration of the potential benefit of total hip arthroplasty should outweigh surgical risks especially in morbidly and super obese patients. **BJHM**

Conflict of interest: none.

KEY POINTS

- Obesity is an increasing pandemic that transcends socioeconomic classes.
- Obesity has a dose-dependent relationship with the development of osteoarthritis of the hip, earlier age of requiring total hip arthroplasty and a higher rate of complications post-total hip arthroplasty.
- Preoperative weight loss must be advocated as first-line management for obese patients eligible for total hip arthroplasty.
- Obese patients undergoing total hip arthroplasty must be thoroughly assessed preoperatively for anaesthetic risks including control of medical comorbidities.
- Satisfaction rates with total hip arthroplasty in obese patients are equivalent to those in non-obese patients although the degree of functional improvement is inferior.
- A high body mass index alone should not exclude morbidly obese patients from total hip arthroplasty, but orthopaedic surgeons should counsel patients on the increased risk of perioperative complications and early revisions.
- Super obese patients are at substantially increased risk of postoperative complications and whether this outweighs the potential benefits of total hip arthroplasty remains controversial.

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