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Review article

Obesity in orthopedics and trauma surgery

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ABSTRACT

In 2012, 32.3% of the French population over 18 years of age was considered overweight ($25 \leq BMI < 30 \, kg/m^2$) and 15% obese ($BMI \geq 30 \, kg/m^2$). Worldwide, 2.8 million people die every year from the complications of obesity. In 2008, the prevalence of obesity was almost double that of 1980. Obesity is a genuine concern for the orthopedic surgeon, as it affects bones and soft tissues on the biomechanical and biochemical level. In traumatology, low-energy trauma is more frequent in obese patients and induces complex comminutive fractures of the extremities. In orthopedics, obesity is an independent risk factor for osteoarthritis, particularly for the knee joint. The goals of this review are to describe specific aspects of the care of obese patients in trauma and orthopedics surgery during the pre-, intra- and postoperative periods, as well as the risk-benefit ratio related to the treatment of the obese patients.

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1. Introduction

Obesity is defined as a body mass index (BMI) $> 30 \, kg/m^2$ [1]. BMI is calculated by dividing a person's weight in kg by the square of their height in metres (kg/m^2) [1]. A normal BMI ranges from 18.5 to $25 \, kg/m^2$ [1]. Adults with a BMI between 25 and 29.9 are considered overweight, and those with a $BMI \geq 30$ are considered obese [1]. Severe obesity is defined as a BMI between 35 and 40, with morbid obesity defined as $BMI \geq 40 \, kg/m^2$ [1]. Children and teenager (ages 2–19) are considered overweight if their BMI is between the 85th and 95th percentile and obese if above the 95th percentile for children of the same age and gender [1]. In 2012, 32.3% of adults above 18 years of age in France were considered overweight ($25 \leq BMI < 30 \, kg/m^2$) and 15% were considered obese ($BMI \geq 30 \, kg/m^2$) [2]. Obesity is a growing public health problem worldwide [1]. According to 2008 WHO estimates, 1.4 billion adults were overweight and more than 500 million were obese, while more than 40 million children under the age of five were overweight [1]. The prevalence of obesity has nearly doubled between 1980 and 2008 [1]. Each year, at least 2.8 million people die because of the consequences of being overweight or obese [1]. Obesity requires specific considerations during surgery and there is now a peer-reviewed journal dedicated to this problem [3]. The orthopedic surgeon is not immune to this public health problem, and often is not well prepared to deal with it. In daily practice, orthopedic surgeons have to deal with two distinct categories of patients.

First, patients who are overweight or moderately obese that are treated without being really prepared for the surgery despite the increased risk of complications related to their condition. The second category of patient includes patient who are severely obese or morbidly obese who wander from hospital to hospital looking for a surgeon willing to operate on them. In this second group of patients, a multidisciplinary team approach is essential; in the least, a nutritionist, endocrinologist and psychologist should be supporting the surgeon-anesthesiologist team.

In France, to our knowledge, this is the first time a review has summarized the care of obese patients during orthopedic and trauma surgery. After reviewing pathophysiological and epidemiological aspects, the main focus will be on establishing broad principles for managing obese patients in the pre-, intra- and postoperative stages of orthopedics and trauma surgery.

2. General data

2.1. Pathophysiology

Obesity has historically been attributed to excessive consumption of high-calorie foods and a sedentary lifestyle, factors, which are more widespread in patients with a low socioeconomic status. However, no strong causal relationship between these factors has been established, probably because several other factors come into play [4].

Obesity should not be viewed simply as a biomechanical problem leading to excessive loads and/or a physical problem complicating imaging, surgical approaches, procedures and skin healing [5]. It has recently been found that certain fat-derived

hormones (adipokines) are involved in the development of obesity: leptin (pro-inflammatory) and adiponectin (anti-inflammatory). Although the mechanism of action is not fully understood, it is likely related to altered regulation [6] and changes in cell receptor sensitivity [4].

When added to a whole other series of pro-inflammatory and anti-inflammatory agents that are increased in obesity, the result is a low-grade inflammatory condition linked to cardiovascular and metabolic complications and infectious, wound healing or bone healing complications during orthopedics and trauma surgery [5]. These could also explain some of the failures of diet-related treatments.

A recent international, multicentric prospective study gathered demographic, clinical, laboratory and coronary imaging data from 13,874 patients. A clear link between weight and cardiovascular events, high blood pressure and diabetes was established. When looking at patients who were underweight, normal weight, overweight and obese, there was an increase in the prevalence of diabetes (7, 10, 12 and 19%, respectively), high blood pressure (37, 40, 46 and 59%, respectively) and hyperlipidemia (48, 52, 56 and 56%, respectively) as weight increased [7]. Multivariate analysis identified high BMI as an independent risk factor for coronary heart disease and > 50% coronary stenosis. Obese patients also had a higher risk of myocardial infarction leading to death than non-obese people [7]. This can be explained by the role of adipokines in blood glucose regulation and fat metabolism [5] with the complex cascade of biological events that follows. This cascade involves interleukins (namely IL-6, TNF-alpha and IL-12), which results in obese persons having a permanent inflammatory condition [7].

Furthermore, these adipokines seem to play an important role in the biochemical processes that trigger osteoarthritis [6]. Clinical studies have shown relationships between adipokine levels and cartilage volume loss [6]. For example, leptin triggers the development of an intra-articular inflammatory condition that is responsible for breaking down collagen and then osteoarthritis later on [6]. This may explain why osteoarthritis is more common in the obese, not only in weight-bearing joints such as the knees, but also in the hands [6]. Research is on going to identify new specific antibody-based drugs to control the negative effects of adipokines [5].

2.2. Epidemiology

In 2012, one third of French residents 18 years or older were overweight ($25 < BMI < 30 \, kg/m^2$) and 15% were obese ($BMI \geq 30 \, kg/m^2$) [2]. The average weight of the French population increased by 3.6 kg over 15 years, while height increased by only 0.7 cm [2]. The average BMI went from $24.3 \, kg/m^2$ in 1997 to $25.4 \, kg/m^2$ in 2012 ($P < 0.05$), an increase of $1.1 \, kg/m^2$ in 15 years [2]. However, the rate of increase in obesity has slowed down recently (+3.4% obesity since 2009, versus +10.7% between 2006 and 2009, +10.1% between 2003 and 2006, +17.8% between 2000 and 2003, +18.8% between 1997 and 2000), while the greatest increase occurred in the 18–35 age bracket [2]. By 2012, more women (15.7%) than men (14.3%) were obese ($P < 0.01$).

Furthermore:

- average BMI steadily increases with age [2];
- there is an inverse relationship between obesity and household income and between obesity and town or city size;
- the prevalence of obesity is highest in the northern part of France (21.3%), followed by the Paris area (17.8%) and then the eastern part (17.1%) [2];

- nearly three times more overweight people have diabetes that is being treated or requires dietary modifications; this increases to seven times more in obese people [2];
- the prevalence in the association of three cardiovascular risk factors is 14 times higher with obesity and five times higher when overweight.

The relationship between osteoarthritis, age, gender, nationality and obesity was evaluated in a two-part French and European study of 63,232 households [8]. Hip and knee osteoarthritis increased significantly with increasing age for both genders, and then become more pronounced in women above 50 years of age [8]. Hip osteoarthritis was most common in the Northern regions (Picardy, Lorraine and Brittany) of France, while knee osteoarthritis was most common in the Northeastern areas (Picardy and Lorraine) in both genders. The prevalence of osteoarthritis was correlated with the prevalence of obesity in every region (R: 0.92 for the hip and 0.54 for the knees) [8].

With the population getting older and heavier, and osteoarthritis being correlated to these parameters, the number of obese arthritic patients needing care will increase [8]. There is currently no accurate data on the number of obese patients getting hip or knee arthroplasty in France. Of the 480 total hip and 420 total knee replacements performed by three senior surgeons in our department in 2012, 40% of patients were overweight, 20% were obese and 5% were morbidly obese.

2.3. Financial consequences

2.3.1. Financial impact

In France, the direct annual cost attributed to treating obesity and its related diseases (hypertension, diabetes, etc.) was estimated at 640 million Euros in 2007, according to a study performed on a representative sample of the adult population [9]. Other findings from this study:
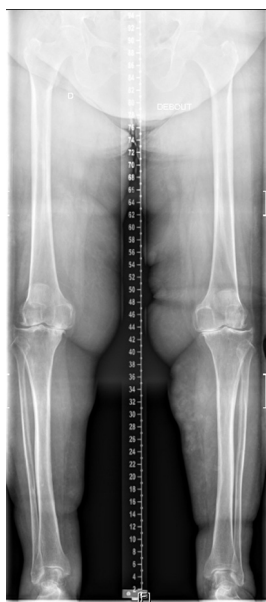
- the direct annual cost reached 1.37 billion Euros when all care was included, even if it was not directly related to the obesity;
- an obese person will need twice as many medical products as a normal weight individual;
- in a 10 year period, the percentage of health expenses attributed to obesity went from 0.7–2% to 1.5–4.6% of the global budget, but this did not include certain costs incurred by and for obese individuals (diets, treatments, specific equipment) that are said to be invisible and difficult to track [9].

The excess cost of performing orthopedics and trauma surgery in obese patients has not been evaluated.

For each operated patients, height and weight must be recorded in the patient's file and discharge summary; depending on the type of procedure, potential comorbidities and duration of hospital study, obesity can increase the cost of the stay [10]. As of January 1, 2013, diagnostic codes were created in France to capture obese children and overweight children and adults. These are in addition to the other codes created in 2006 for obesity (E66), which allows the French Medical Information Ministry to better evaluate the cost of hospital stays attributed to these patients [10]. But these diagnostic codes do not affect the procedure codes and do not take into account the problems encountered by a surgeon caring for an obese patient [10].

2.3.2. Medical imaging

Since obesity has a direct effect on image acquisition, changes must be made when the bones and joints of obese people are imaged. These patients should be referred to a radiology center experienced in managing obese patients, particularly for axial

Fig. 1. Typical loss of contrast in the proximal femur during standard radiographs of an obese patient.

Fig. 2. Standard hospital equipment such as chairs often not suitable for obese patients.

imaging because the standard protocols often need to be modified [11,12].

Changes must also be made to standard radiographs because the increased tissue thickness in these patients increases photon scatter and reduces contrast [11,12]. To get around these problems, the voltage must be increased but this in turn reduces the contrast even more. Increasing the exposure time increases the risk of motion artifacts during the acquisition [11,12]. To avoid this phenomenon and improve the image, the user must narrow the collimator beam, which reduces the field of view, reduces dispersion and reduces the need to increase voltage or exposure time [11,12]. This is particularly true for joints near the trunk, notably the spine, shoulder and hip [12]. Not only is this a significant problem during preoperative imaging (Fig. 1), it is even more challenging during the intra-operative period for trauma cases when fluoroscopy is used; this requires the surgeon to work with a classic fluoroscopy unit that allows the collimator to be adjusted [12]. These challenges extend to the postoperative period, especially when working with the hip [12]. The EOS® Imaging System (EOS®, Paris, France) may be able to capture better quality images without increasing the irradiation dose. It is currently being evaluated in the United States on obese patients [13].

During axial imaging, waist size and weight are more relevant than the BMI itself [12]. For a standard CT scanner, the weight limit is 202.5 kg (450 lbs) and the maximum gantry diameter is 70 cm (27.5 in) [12]. CT scanners suitable for obese people can accept patients with a waist size greater than 90 cm (36.5 in) [12]. An open MRI must be used for imaging, but fewer than 10 of the approximately 650 MRI units in France are open units, which is not enough to meet the demand. This had led to the development of specialized imaging centers in France to improve the care of these patients.

2.3.3. Perioperative period

2.3.3.1. Materials. The hospital environment must be adapted before the surgical treatment can start: beds, chairs (Fig. 2), wheelchairs, bathrooms, and surgical tables. A standard surgical table is built to support a patient weighing up to 180 kg (400 lbs). Wheelchairs and patient lifts may have the same weight limitations.

2.3.3.2. Information. Although many operated patients are overweight (BMI between 25 and 30 kg/m^2), published complications rates are similar to patients having a normal BMI [14]. When caring for an obese patient, the patient and the patient's family must be informed of certain data before the surgical procedure gets under way (Table 1):

- in obese patients with a BMI between 30 and 40 kg/m^2, the risks of thromboembolism and infection are doubled;
- in patients with BMI > 40 kg/m^2, general mortality is twice as high as for a normal weight individual [15], post-surgery mortality rate is nearly 4% [16], anesthesia and surgery times are significantly

Table 1
Ten key points.

	Key points
1	In 2012, one third of French residents 18 years or older were overweight (25 < BMI < 30 kg/m^2) and 15% were obese (BMI > 30 kg/m^2)
2	Obesity is challenging in orthopedics because of increased loading and the patient's pro-inflammatory state related to fat metabolites
3	Obese patients have difficulty walking, which leads to falls and increases the number of comminuted fractures in the extremities
4	Diabetes and comorbidities must be controlled as well as possible before any surgery
5	Morbidity and mortality of obese patients during the perioperative period is significantly greater than in patients with BMI < 30 kg/m^2
6	During hip and knee arthroplasty, the infection rate is nearly 5% in obese patients and nearly 10% in obese, diabetic patients
7	Anesthesia and operative time are significantly greater in all published studies
8	Significant improvement in pain and function scores have been reported in various studies, although functional scores and long-term implant survival is lower than in patients with normal BMI
9	Arthroplasty will not trigger weight loss and bariatric surgery does not help reduce complications during the arthroplasty procedure
10	One of the key aspects of care lies in informing the patient and his/her family

BMI: body mass index.

higher [16] and infection rates after TKA or THA are nearly 5% [17].

In a recent study looking into the mortality rate in a population of 1.46 million Caucasian adults, general mortality, with all causes combined, was higher in overweight patients (RR: 1.88) and obese patients (RR: 2.51) [15]. The relative risk was even higher when these patients underwent surgery [15].

2.3.3.3. Risk of medical complications. Medical consequences of obesity, especially heart and lung problems, have a direct impact on perioperative management and the consequences of anesthesia [16]. One third of patients having a BMI > 40 kg/m^2 had to be admitted to intensive care and 9% needed respiratory assistance [16]. Anaesthesiology teams must be especially vigilant with these patients, and anticipate the possibility of a difficult intubation, including laryngoscopic intubation [16]. Doses of antibiotics and anesthetics must be adapted to the distribution volume [16]. Spinal anesthesia or local anesthesia are potential solutions for limiting the respiratory complications seen with general anesthesia, but these alternative methods are difficult to carry out and take more time [18].

2.3.3.4. Patient position. The patient must be positioned carefully. Even though the soft tissues are fairly thick, obese patients are at risk for pressure sores and nerve compression [17]. When the surgical procedure allows it, lateral decubitus will make ventilation easier [16,17].

2.3.3.5. Incisions. In trauma and elective surgery, the incision size must be adapted to the BMI to provide good exposure and minimize tension on the skin, which is quite fragile in these patients [11].

2.3.3.6. Prevention of thromboembolism. Obesity is a risk factor for thromboembolic events [19]. The standard recommendations for duration of use of anticoagulants apply to these patients [19]. There is no published data or official recommendations on the need to prescribe anticoagulants to an obese patient for a procedure where anticoagulants are typically not used, such as arthroscopic meniscectomy [19]. However, mechanical prophylaxis is recommended [19]. Compression stockings and bandages are not well tolerated by obese patients. This is why plantar pump systems called intermittent pneumatic compression devices are heavily used in the United States, but relatively underused in France [19].

There are no dose recommendations for prophylaxis drugs and no study up to now has been able to identify a dose that prevents thromboembolic complications without greatly increasing the risk of haemorrhage for obese patients [19]. In the United States, the AAOS does not recommend either low-molecular weight heparins or new oral anticoagulants, which is consistent with ACC/AHA and ACCP guidelines [11]. Although there are no clear recommendations in terms of dose or duration, it is also important to prevent venous thrombosis in obese patients undergoing surgery in the upper limb [11].

3. How orthopedic and trauma surgery are affected by obesity

3.1. Children and teenagers

In France, an estimated 18% of children between 3 and 17 years of age are overweight, with 3.5% being obese [1]. Obesity has a direct impact on a child's quality of life, as it impairs mobility and produces a slower, more tentative gait [11]. Elevated leptin levels in obese children and teenagers also affect bone density, leading to greater bone fragility [11]. Knee, foot and back pain are statistically more common than in a control pediatric population [11]. Obesity also has a biomechanical impact on growth plates by making bones mature more quickly; genu valgum and genu recurvatum deformities are also more common, no matter the gender [11,20].

3.1.1. Obesity and trauma in children

A link between obesity and pediatric fractures has been suggested recently. Obese children have greater fracture risk relative to healthy children, especially in the forearm, femur and lateral humeral condyle [11,21]. Various groups have estimated the rate to be 1.6 times higher than in the general population [11,21]. In addition, these fractures are occurring with lower-energy trauma in overweight children and occur mainly in distal part of the forearm [11,21].

Databases have shown the risk of extremity fractures following high-energy trauma is higher in obese children, but the risk of brain trauma is lower [11]. These children and teenagers also have more anesthesia-related problems because of higher baseline blood pressure and a higher frequency of asthma and sleep apnea [11].

Materials used during surgery must be adapted to the child's weight. This is particularly true for femur fractures, where rate of complications such as wound healing problems, non-unions and malunions is higher with obesity [21]. These observations are especially true for unstable femoral fractures treated by flexible intramedullary nailing [21]. When the child's age allows it, these fractures should be stabilized through standard IM nailing [21].

With long bone fractures, obese patients have a similar number of complications and time to return to activities relative to a control group [21]. But there were more complications in trauma cases involving obese children: pressure sores (1% vs. 0.2%), DVT (0.7% vs. 0%), re-fracture, infection, wound healing problems [11,21]. Recommendations in pediatric trauma surgery can be summarized as follows: inform parents of potential anesthesia and complication risks and choose an appropriate bone fixation material during surgery [21].

3.1.2. Obesity and elective surgery in children

In Blount's disease or pathological tibia vara, a strong correlation was found between BMI and the magnitude of genu varum. The failure rate of standard hemi-epiphysiodesis treatment was higher in children with a BMI > 45 kg/m^2 [20]. There is also a positive correlation between obesity and genu valgum, especially in girls [22]. Some advocate performing epiphysiodesis in severe genu valgum secondary to abnormal lateral femoral physis in girls; this abnormality has been attributed to micro-trauma, obesity and genetic predisposition [22].

Slipped capital femoral epiphysis has higher prevalence, occurs earlier on and is more often bilateral in overweight or obese pediatric populations than non-obese ones [23]. It has also been shown that reducing BMI after treatment of slipped femoral epiphysis on one side reduces the risk of it happening on the other side [23].

In scoliosis, the effectiveness of external corrective devices (e.g. corset) is reduced and the effectiveness of conservative treatment using a corset in obese children and teenagers is often limited [24]. There are more kyphosis deformities after surgical treatment, but no significant increases in morbidity and mortality [24].

A trauma or orthopedics case presents a golden opportunity to refer an obese child to a team specialized in childhood obesity [25]. Weight loss programs in children in combination with suitable sports activities have led to excellent results in terms of weight loss and limitation of orthopedic complications related to obesity [25].

3.2. Adults

3.2.1. Traumatology

3.2.1.1. Obesity and fracture types.
Obese patients are exposed to select types of musculoskeletal injuries and their mortality rates are higher when subjected to high-energy trauma [11,26]. Cross-sectional studies in the United States have shown that adults going to the emergency room after an injury have a 15% higher likelihood of being injured if they are overweight (BMI between 25 and 30 kg/m^2) and 48% higher likelihood if they are morbidly obese [11,26,27].

In motor vehicle accidents, obese people are relatively protected from abdominal and pelvic injuries because of their soft tissues [28]. However, they are more likely to incur a pelvic ring injury, because energy absorbed by the abdomen is transferred to the pelvis. They are also more likely to fracture peripheral structures such as the distal femur, ankle or calcaneus and also experience degloving injuries [27–29].

Even with low-energy trauma, they have a tendency to experience comminuted fractures with skin and soft tissues injuries, especially at the distal end of long bones [26,29]. Knee dislocations following low-energy trauma have also been described in obese people, with a high rate of neurovascular complications, which may require amputation of the leg [11]. In the upper limb, fractures following low-energy trauma are also more common because of ambulation problems related to large amounts of soft tissues, leading to falls onto an outstretch arm, often causing comminuted fractures [26].

The relationship between bone density and obesity is not well defined [11]. It was initially thought that overweight and obese patients had higher absolute bone density, but this difference disappeared when the values were adjusted to the lower BMI in the control group patients [11]. The increase in the overall bone density found in obese patients is probably not enough to compensate for the excess loads placed on the skeleton, especially during falls onto the arms [11,26].

After menopause, obese women take more falls than non-obese women, however the former group experiences fewer proximal femur fractures, probably because the fall is cushioned by soft tissues around the proximal femur [11,27]. Research is now being done into how leptin could prevent osteoporosis and potentially even replace oestrogen [5].

3.2.1.2. Imaging evaluation.
The care of obese trauma patients first requires greater attention during the patient information stage and when evaluating the injury [11,12]. For example, because of the thickness of soft tissues at the proximal femur, obese patients have a higher risk of having an undetected fracture above an ipsilateral fracture of the femoral shaft [11,12].

The radiology adjustments recommended earlier on must be followed. Axial CT scanning must be systematically requested when standard radiographs are inconclusive or not of good enough quality, despite narrow collimation of the beam [11,12]. With articular fractures, intra-operative arthrography, feasible but probably difficult to perform, could be used to optimize screw placement in femoral neck and proximal femur fractures [11,12].

3.2.1.3. Technique and fixation choices.
In obese patients, cast immobilization of the lower or upper limbs and temporary or permanent traction are very difficult to achieve. Obesity makes any indication for conservative treatment difficult thereby forcing the surgeon to perform internal fixation. For example, immobilizing a humerus fracture along the chest of an obese woman causes arm abduction, which could be detrimental to fracture alignment [27].

The biggest problems occur with femoral IM nailing. Retrograde nailing is preferred over anterograde nailing since bleeding,

Fig. 3. The treatment of femur fractures in obese patients is technically more complex and known to have a higher complication rate.

surgical time and irradiation are lessened [11,27]. But if the type of fracture requires anterograde nailing, the patient should be placed in lateral decubitus and the trochanter entry point moved laterally [27]. The largest possible nail diameter must be used, with multiple screws providing static locking to optimize the construct stability in as these patients have trouble achieving partial weight bearing. As a consequence, the risk of non-union (Fig. 3) and secondary displacement is higher in obese patients than in normal ones [27]. There are no scientifically based recommendations on the type of implant to use. But materials having the potential for contact welding must be avoided in obese patients.

Complication rates are higher in obese patients relative to patients with normal BMI. The complication risk is 6.8 times higher and the need for re-operation is 4.7 times higher in pelvic ring fracture patients having BMI > 30 kg/m^2 relative to ones with BMI < 30 kg/m^2 [28]. In distal tibia or tibial pilon fractures, obesity was thought to have protective effects relative to skin problems. But evidence of the opposite now exists [28]. In a register including 867,282 patients admitted for proximal humerus fractures, obesity was found to be one of the factors increasing the risk of complications and duration of hospital stay [30].

3.2.2. Elective upper limb surgery
Obese patients are more likely to experience micro-trauma injuries to their upper limbs than patients with normal BMI [11] because of their motor control problems. Carpal tunnel syndrome is also more common, but weight loss has no effect on nerve conduction speed [11]. Obese patients also have more rotator cuff injuries [31]. After rotator cuff repair, there is a significant improvement in function and quality of life, even if the surgical outcomes are worse than patients having normal BMI [31]. With shoulder arthroplasty, obese patients experience significant improvements in function and pain over the long-term, but have more surgical and perioperative problems and higher complication and failure rates than patients with normal BMI [32]. Similar findings were reported for arthroplasty of the lower limb.

3.2.3. Elective lower limb surgery
A clear link has been established between osteoarthritis and obesity, not only due to excess mechanical loads but also due to the biological effects of adipokines on cartilage. The obesity effect is more apparent in the knee than the hip [3,5,6]. The Canadian

arthroplasty register has shown that a person with BMI > 30 kg/m^2 is 8.5 times more likely to need a joint replacement than someone with a normal BMI; this relative risk increases to 18.7 times if BMI > 35 and to 32.7 times if the BMI > 40 [4,11]. Also, obese patients are operated an average of 10 years earlier than patients with a normal BMI [4,11]. Weight loss is effective not only for symptoms but also the kinetics of the pathology [4,11].

One may think that operating on obese patients once they can no longer walk will help them to lose weight once they recover normal function and can expend more calories [33]. But a recent meta-analysis has shown that only 14–49% of patients had lost a significant amount of weight 1 year after the surgery, however many of the included studies had important limitations (patients lost to follow-up, differences in follow-up methods) [33]. Patients cannot be told to expect weight loss after surgery [33]. Thus it seems more logical to ask patients to lose weight before the surgery to reduce the magnitude of symptoms. But this weight loss is often difficult to achieve, even when the patient is surrounded by a team of nutritionists and endocrinologists. Before performing a regular procedure on a menopausal obese woman having followed high-protein diets, her calcium and phosphate levels must be measured. This type of patient often has significant deficiencies, especially in vitamin D, which may make bones more fragile [11].

Another question often asked when working with morbidly obese patients (BMI > 40 kg/m^2), is the need to have them undergo bariatric surgery before the arthroplasty. A recent American study clearly found the answer to be "No" [34]. This level II study included 125 patients undergoing total knee arthroplasty. The anesthesia duration, total operative time, tourniquet time, length of hospital stay, complication rate after 3 months, and transfusion rate were compared between three groups of patients: TKA before bariatric surgery, TKA within 2 years after bariatric surgery, and TKA at least 2 years after bariatric surgery in patients having maintained their initial weight loss. The group with the TKA at least 2 years after bariatric surgery had significantly lower anesthesia time and operative time, but there was no difference in complication rate and length of hospital stay. The authors concluded that the complication rate was elevated in all three groups and that none of the three solutions were ideal, even if the patient had lost weight due to the bariatric surgery, maintained the weight loss and the metabolic adaptation period had passed [34].

Beyond the mortality and the respiratory and thromboembolic events described earlier, infection is the main problem in these patients. A study with 7181 TKA and THA patients showed an increase in the infection rate from 0.57% in patients with a normal BMI to 4.66% in patients with morbid obesity [17]. Diabetes doubled the infection rate, independent of the presence of obesity (RR: 2.3) [17]. In patients who are morbidly obese and diabetic, the infection rate was 10% [17]. The authors questioned whether it was justified to operate on these patients, but this question remains unanswered [17]. But it seems of the utmost importance not to operate on these patients unless the diabetes in completely under control [17]. The patient information step must include this infection risk, which is relatively higher than in patients with a normal BMI. Since this risk is correlated to diabetes and increased in diabetic patients, diabetes must be well controlled and managed during the entire perioperative period [17].

3.2.3.1. Hip surgery. Obesity increases the duration of anesthesia, operative time, and the bleeding, complications and dislocation rates during hip surgery. The surgical approach does not influence the outcome, also long as appropriate retractors are used [35]. With minimally invasive surgery, the skin incision should be at least one third as long as the BMI value (9 cm for BMI of 27 kg/m^2 and 11 cm for BMI of 33 kg/m^2).

Fig. 4. In total knee arthroplasty, surgical problems not only depend on the body mass index but also the ratio of the length of the lower limb to the suprapatellar circumference.
Photo courtesy of Dr Walter B. Beaver, Orthocarolina, Charlotte, NC, USA.

The fracture risk is not increased, despite the cortical index being lower. Since the risk of instability is higher, devices reducing the risk of dislocation must be available when elective THA is performed. But there is currently no data to support recommending systematic use of dual mobility cups, even if they are beneficial in patients at risk for dislocation, with obese patients being part of this at-risk group [35]. Other groups have shown that THA is successful even in obese people, with almost no increase in complications (other than wound healing) and excellent functional results. The authors concluded that obese patients should not be denied the opportunity to have THA solely based on their BMI [36].

3.2.3.2. Knee surgery. With total knee arthroplasty, the likelihood of intra-operative surgical problems can be anticipated by calculating the anthropometric suprapatellar index, which is the ratio of the length of the lower limb to the suprapatellar circumference. The surgery will be more challenging if this ratio is less than 1.6 (Fig. 4) [37]. In patients with BMI > 35 kg/m^2, intramedullary tibial cutting guides should be used instead of extramedullary ones to reduce the likelihood of errors related to soft tissue volume [38]. Although it seems logical to use a tibial extension keel because of the larger forces being applied to the tibial component, no clinical or biomechanical data support this practice [38,39]. Since polyethylene wear is not common at the knee, using a thicker tibial component is not

Fig. 5. The patient should be warned that knee flexion will be restricted after total knee arthroplasty because of skin contact between the posterior side of the calf and thigh.

recommended, because it would lead to the tibial cut being made more distally in lower-quality bone, and a higher risk of loosening [38,39]. Although some studies have found that unicompartment knee arthroplasty provides less good results in obese persons, this procedure is not absolutely contraindicated. It is actually recommended by some authors because morbidity and mortality are lower than TKA in this at-risk population [11].

Obesity limits the survival of the arthroplasty and also reduces clinical functional scores, mainly due soft tissues reducing the amount of knee flexion (Fig. 5) [39]. Nevertheless, it is important to note that improvements between the preoperative and postoperative condition are often greater in obese patients than ones having a normal BMI [40]. Patient satisfaction trends are similar.

4. Conclusion

Treating musculoskeletal injuries in obese patients is a genuine challenge for the orthopedic surgeon. In every case, the surgeon, patient and family must be aware of the potential complications and risk of death, infection or failure because of the obesity.

In traumatology, the need to perform surgery is rarely brought into question. In elective orthopedic surgery, the expected benefits of the procedure must be balanced with the perioperative risks. Any diabetes must be fully controlled and associated diseases managed to reduce the risks as much as possible. Specific measures must be taken relative to anesthesia, patient positioning, instrumentation and surgical approaches.

Although significant improvement in functional and pain scores have been observed, the functional scores and long-term survival of the joint replacement implants are lower than in patients with normal BMI, while morbidity and mortality are higher. But despite this elevated complication rate and the problems encountered, the quality of life in obese patients can be significantly improved through a surgery that is increasingly in demand. In the coming years, the care of obese patients must be optimized in a multidisciplinary manner, without forgetting about prevention.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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