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REVIEW

Sarcopenia: What a Surgeon Should Know

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Abstract
Sarcopenia is an increasingly frequent syndrome characterized by generalized and progressive loss of muscle mass, reduction in muscle strength, and resultant functional impairment. This condition is associated with increased risk of falls and fractures, disability, and increased risk of death. When a sarcopenic patient undergoes major surgery, it has a higher risk of complications and postoperative mortality because of less resistance to surgical stress. It is not easy to recognize a sarcopenic patient preoperatively, but this is essential to evaluate the correct risk to benefit ratio. The role of sarcopenia in surgical patients has been studied for both oncological and non-oncological surgery. For correct surgical planning, data about sarcopenia are essential to design a correct tailored treatment.

Keywords Sarcopenia · Surgery · Frailty · Sarcopenic obesity

Introduction

The term "Sarcopenia" was first used by Rosenberg in 1989 to describe the age-related decrease of muscle mass [1]. A progressive loss of muscle mass occurs approximately from the 40 years old and has been estimated at 8% per decade until the age of 70 years, after which the loss increases to 15% per decade [2, 3]. Recently, the functional aspect was added to the quantitative aspect in the definition of sarcopenia, and the European Working Group on Sarcopenia in Older People (EWGSOP) recommends using the presence of both low muscle mass and low muscle function (strength and performance) for the diagnosis of sarcopenia [4]. We can define sarcopenia as a syndrome characterized by generalized and progressive loss of muscle mass, reduction in muscle strength, and resultant functional impairment [5]. Sarcopenia represents a state of compromised health caused by low muscle mass and low muscle function with mobility disorders, increased risk of falls and fractures, impaired ability to perform daily activities, disability, loss of security, and increased risk of death [4, 6]. It does not only depend on increasing age but also depend on many other conditions such as a non-optimal diet, presence of chronic diseases, cancer, sedentary lifestyle, and use of some drugs [7].

Prevalence of Sarcopenia

In western countries due to an increase in age and a sedentary lifestyle, sarcopenia is a frequent condition [8, 9]. In a recent systematic review, the prevalence of sarcopenia was estimated

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as 1–29% for older adults living in the community and 14–33% for those living in long-term care institutions [8]. However, sarcopenia is not an exclusive condition of the elderly; in a study conducted on 232 healthy young men, the prevalence of this condition evaluated with body composition analyzers was 15% [10]. Sarcopenia did not appear to be related to gender with similar incidence in both men and women [11]. In a recent study, a projection model based on the current prevalence of sarcopenia and demographic data of the European population suggests that the number of sarcopenic patients will dramatically increase in the next 30 years, making consequences of muscle wasting a major public health issue [12].

Classification of Sarcopenia

Muscle loss and functional impairment of sarcopenia may be present in different clinical conditions.

- Frailty: Frailty is a state of increased vulnerability that has been defined by Fried et al. as meeting three out of five phenotypic criteria indicating compromised energetics: low grip strength, low energy, slowed walking speed, low physical activity, and unintentional weight loss [8]. Frailty is frequently associated with reduced daily activities, compromised nutritional status, impaired cognitive status, and sarcopenia.
- Cachexia: It is a multifactorial syndrome with involuntary progressive weight loss as a result of the reduction of skeletal muscle mass with or without depletion of adipose tissue [9]. It is characterized by systemic inflammation and metabolic changes leading to progressive functional impairment. It is usually associated with severe illness such as cancer, congestive cardiomyopathy, AIDS, chronic obstructive pulmonary disease, and end-stage renal disease [10].
- Sarcopenic obesity: The combination of obesity and sarcopenia is classified as sarcopenic obesity [11]. It is associated with changes in body composition that include an increase in body fat and a decline in skeletal muscle, although body mass index (BMI) may remain relatively unchanged. The pathogenesis of sarcopenic obesity is multifactorial. There is an interplay between aging, sedentary lifestyle, unhealthy dietary habits, insulin resistance, inflammation, and oxidative stress, resulting in a quantitative and qualitative decline in muscle mass and an increase in fat mass [12].

Techniques for Assessing Sarcopenia

Various methods can be used to assess muscle mass, strength, and physical performance.

Muscle Mass

Anthropometric measurements, such as BMI, mid-upper arm circumference, calf circumference, and skinfold thickness, are relatively easy to perform in a normal clinical setting; however, they are not recommended for diagnosing sarcopenia since they are prone to error [4]. CT scan and magnetic resonance imaging can distinguish fat from muscles and provide anatomical details and, in particular, can be used to assess skeletal muscle volume. They allow calculation of segmental and total muscle mass, and assessment of fat infiltration in the muscle, which impacts on muscle quality and force development. For these reasons, CT scan and MRI have considered the gold standard techniques for evaluating muscle mass. Dual-energy X-ray absorptiometry (DXA) can correctly evaluate body composition with good precision and low radiation exposure [13]. Bioimpedance analysis (BIA) is an inexpensive, easy to use, and reproducible method considered a portable alternative to DXA. CT scan and MRI are often available for the surgeon that needs preoperative imaging to plan oncological or non-oncological surgical treatment. The surgeon together with the radiologist can use imaging to assess the area and density of the muscles (usually psoas muscle at the level of L2 or L3). However, the radiological diagnosis of sarcopenia is not simple, and there are risks of mistakes.

Muscle Strength

Muscle strength is commonly evaluated using handgrip strength, which is an easy, reliable, and inexpensive method [14]. Cutoffs for grip strength are less than 20 kg for women and 30 kg for men [4]. Knee flexion techniques are suitable for research studies, but their use in clinical practice is limited by the need for special equipment and training. Peak expiratory flow (PEF) is determined by the strength of respiratory muscles and can be used to assess the strength of respiratory muscles.

Physical Performance

Gait speed is the most widely used technique to assess physical performance [15]. A walking speed slower than 0.8 m/s is being considered a poor performance and it is associated with disability and frailty. The short physical performance battery is a composite of some separate tests that evaluates balance, gait, strength, and endurance. The short physical performance battery can be used as a standard measure of physical performance both for research and in clinical practice. In most of the surgical researches, only the quantitative component of sarcopenia is assessed; muscle mass is a quantitative domain. It is the fastest parameter to perform and is associated with the least risk of error. However, sarcopenia is a multifactorial

condition that should be analyzed in all its components: muscle mass, strength, and physical performance.

Evidence in Surgery

One of the most challenging areas of surgery is accurate patient selection. Treatment decisions based on individual clinical judgment are subject to bias and may result in inappropriate surgery and consequent adverse outcomes [16]. Despite technical improvements and advances in perioperative care, major abdominal surgery is still associated with a high rate of severe complications and mortality. In the last decade, the role of sarcopenia as a parameter of the patient's frailty has been studied to define preoperatively which patients can benefit from surgery and those who have a higher risk of complications and mortality. Many studies showed that patients with sarcopenia had a higher risk of complications and postoperative mortality. In a large meta-analysis on major abdominal surgery, Sandini et al. showed that sarcopenia was associated with postoperative major morbidity, with odds ratio (ORs) ranging from 1.32 to 4.80 [16]. The role of sarcopenia in surgical patients has been studied for both oncological and non-oncological surgery. For correct surgical planning, data about sarcopenia are essential to design a correct tailored treatment.

Evidence in Oncological Surgery

Colorectal Cancer

After surgery for colorectal cancer, sarcopenia was associated with a higher incidence of postoperative complications [17], infections [17], and longer postoperative hospital stays [18]. In the series of Hopkins et al., sarcopenia was independently predictive of worse overall survival (hazard rate, HR 1.45), recurrence-free (HR 1.32), and cancer-specific survival (HR 1.46) [19] while in the series of Charette et al. [20], patients with low muscle index and muscle density had an increased mortality (HR 2.06 and 1.54, respectively).

Pancreatic Cancer

Gruber et al. showed that sarcopenia was associated with a negative impact on overall survival (14 vs. 20 months, $p = 0.016$) for patients who underwent surgery for pancreatic cancer. Sarcopenic patients suffering from obesity showed poorer overall survival (OS) compared with non-sarcopenic obese patients (14 vs. 23 months, $p = 0.007$) [21]. Other authors showed a poorer overall survival in sarcopenic patients when compared with those without perioperative sarcopenia after surgery for pancreatic cancer [22–24]. The risk of postoperative complications and in particular of the clinically relevant postoperative pancreatic fistula was higher in the sarcopenic group (22.0 vs. 10.4%; $p = 0.011$) [25].

Gastric Cancer

In the series of Zhang et al., the overall complication rate after gastric surgery for cancer was significantly higher in sarcopenic patients (62.5 vs. 27.3%) [26]; Shen too showed a higher risk of postoperative complications in sarcopenic patients when compared with non-sarcopenic patients (OR 3.12) [27]. Overall survival was significantly worse in patients with sarcopenia ($p < 0.001$) [28].

Liver Cancer

After liver resection for hepatocellular carcinoma, sarcopenic patients had significantly shorter median overall survival than non-sarcopenic patients (52.3 vs. 70.3 months; $p = 0.015$) [29]. Sarcopenia was an independent predictor of poor overall survival (HR 3.19; $p = 0.013$) and disease-free survival (HR 2.60; $p = 0.001$) [29]. In the series of Harimoto et al. in patients with and without sarcopenia, the 5-year overall survival rate was 71 and 83.7%, respectively, and the 5-year recurrence-free survival rate was 13 vs. 33.2% [30]. Major complications (32.7 vs. 13.2%, $p = 0.033$) and treatment-related mortality (17.3 vs. 2.6%, $p = 0.029$) were more frequent in sarcopenic patients in the series of Levolger et al. [31].

Evidence in Non-Oncological Surgery

Emergency Surgery

In an analysis on 593 patients who underwent open emergency abdominal surgery, Dirks et al. showed that sarcopenia is associated with higher 90-day mortality ($p = 0.0008$), with a higher risk of postoperative complications ($p = 0.0133$) and with a longer length of stay ($p < 0.0001$) [32]. Rangel showed that sarcopenia was independently associated with an increased in-hospital mortality (HR 2.6) and 1-year mortality (HR 2.4) [33] while Du et al. showed that sarcopenic patients had more postoperative complications (45 vs. 15%, $p = 0.005$) and a higher hospital mortality (23 vs. 4%, $p = 0.037$) [34].

Liver Transplant

The presence of sarcopenia before liver transplantation is associated with poorer survival [35, 36] and with higher waitlist mortality (HR 2.36 in the series of Tandon et al. [37]). Sarcopenia predicts a significantly longer length of hospital stay and intensive care unit stay after liver transplant ($p < 0.001$) [36].

Ventral Hernia Repair

In the series of Barnes et al., preoperative sarcopenia was associated with an increased risk for postoperative complications (OR 5.3, $p = 0.04$) and a significantly higher rate of hernia recurrence (33.3 vs. 10.8%; $p = 0.04$) [38]. However, in other series, sarcopenia was not associated with an increase in postoperative complications, surgical site occurrences/infections, or hernia recurrence [39, 40].

Bariatric Surgery

The concept of sarcopenic obesity was firstly proposed by Roubenoff who suggested how the inflammatory cytokines produced by adipose tissue can accelerate muscle catabolism and thus contribute to the vicious cycle that initiates and sustains sarcopenic obesity [41, 42]. Sarcopenic obese patients have higher levels of inflammatory proteins such as IL-6, C-reactive protein, and soluble IL-6 receptor [43]. De Lorenzo et al. recommend bariatric surgery in sarcopenic obese patients as a weapon to change the inflammatory and metabolic profile and interrupt the vicious cycle that sustains sarcopenic obesity [41]. The prevalence of sarcopenic obesity is estimated to represent 2% of patients aged 60 to 69 years and increases to 10% for them aged over 80 years [44]. However, in a recent analysis on of 184 severely obese patients undergoing sleeve gastrectomy, 8% of the patients were sarcopenic before bariatric surgery, despite a low mean age of only 42 years [45]. Unfortunately, the evidence about the effect of sarcopenia in the patient undergoing bariatric surgery is still few and sparse. Gaillard et al. showed that sarcopenic patients have a higher risk of gastric leak after sleeve gastrectomy [46]. In this series, the risk of the gastric leak was 9.1% in sarcopenic patients and 2.2% in non-sarcopenic patients ($p = 0.032$); the sarcopenic patients were 32.2% of the whole series but 66.7% of patients with a gastric leak. Instead in the series of Mastino et al., early complications' rate was not significantly different between the sarcopenic and non-sarcopenic groups after bariatric surgery ($p = 0.807$) [47]. The patient undergoing bariatric surgery loses weight quickly; it is, therefore, necessary to ask how this loss of weight changes the body composition. The ideal body mass reduction should be represented by fat mass loss and maintenance of fat-free mass. The analysis of Crisp et al. showed that for patients that perform regular physical activity, fat mass loss was the major contributor to body mass reduction, showing positive effects on body composition, 12 months after bariatric surgery [48]. In the series of Voican, 32% of patients became sarcopenic 1 year after sleeve gastrectomy due to loss of muscle mass [45] while Davidson et al. found that skeletal muscles are well maintained after bariatric surgery in the presence of a correct diet and exercise [49]. For these reasons, after bariatric surgery is mandatory an early instauration of adequate nutritional support in combination with physical activity to prevent sarcopenia occurrence.

Prevention and Treatment of Sarcopenia

Several mechanisms are involved in the development of sarcopenia. Potentially, modifiable factors include nutrition and physical activity [50, 51]. Consuming an adequate amount of high-quality protein at each meal, in combination with physical activity, appears as a promising strategy to prevent or delay the onset of sarcopenia [52]. Preoperative exercise therapy can improve respiratory function [53] and reduce postoperative complication rates. Also, the length of hospital stay should be reduced with prehabilitation in sarcopenic patients [54]. Before surgery, the most of obese patients are highly sedentary and inactive. Many patients report an increase in their physical activities postoperatively, but to help patients maximize weight loss and other health benefits following bariatric surgery, clinicians need to encourage and support exercise before and following surgery [55]. The perioperative period offers the opportunity to modifying not only perioperative outcomes but also wider health behavior [56]. Obese patients are usually malnourished. Malnourishment in surgical patients is particularly harmful: a malnourished patient has a higher risk to experience perioperative morbidity than a well-nourished patient [57]. Perioperative nutritional interventions have been shown to improve postoperative outcomes across a variety of domains including surgical site infection and anastomotic leak [58]. Protein supplementation in the preoperative period can maintain or support increases in lean body mass, ameliorating physical frailty and supporting the efficacy of other interventions such as exercise training [56]. It is not always easy to perform a preoperative rehabilitation program in an elderly patient also because surgery often can not be delayed. For these reasons, correct information of the elderly population on the importance of a proper diet and physical exercise is fundamental to reduce the number of sarcopenic subjects.

Conclusion

In conclusion, sarcopenia is an increasingly frequent syndrome due to changes in lifestyle and an increase in the average age of the population. This condition is associated with increased risk of falls and fractures, impaired ability to perform daily activities, disability, loss of security, and increased risk of death. When a sarcopenic patient undergoes major surgery, it has a higher risk of complications and postoperative mortality because of less resistance to surgical stress. It is not easy to recognize a sarcopenic patient preoperatively, but this is essential to evaluate the correct risk to benefit ratio.

Sarcopenic obesity is an increasing condition in western countries; it is a multifactorial condition with an interplay between aging, sedentary lifestyle, unhealthy dietary habits, insulin resistance, inflammation, and oxidative stress, resulting in a quantitative and qualitative decline in muscle mass and an increase in fat mass. Bariatric surgery, associated with a correct diet, physical activity, and a change in lifestyle, has proven to be useful for changing body composition in obese sarcopenic patients.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Ethical Approval Statement For this type of study (review of literature), formal consent is not required.

Informed Consent Statement For this type of study (review of literature), formal consent is not required.

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