OBES SURG (2012) 22:597–601
DOI 10.1007/s11695-011-0538-3

CLINICAL RESEARCH

Lean and Fat Mass Loss in Obese Patients Before and After Roux-en-Y Gastric Bypass: A New Application for Ultrasound Technique

A. Z. Pereira · J. S. Marchini · G. Carneiro · C. H. Arasaki · M. T. Zanella

Published online: 8 November 2011

Abstract
Objective This study aims to evaluate the thickness of the femoral quadriceps and biceps brachii and brachialis muscles bilaterally and the adjacent subcutaneous fat in patients undergoing gastric bypass Roux-en-Y before and after surgery, using ultrasound as the diagnostic method of choice.
Methods We studied 12 patients undergoing this surgical method preoperatively and during the first, third, and sixth postoperative months. During these periods, patients were evaluated by ultrasound to determine the thickness of subcutaneous adipose tissue and muscle of the upper and lower limbs.
Results Postoperatively, these patients showed a reduction in the thickness of the upper and lower extremities muscle and adipose tissue as compared to their preoperative values. There was a significant difference in the loss of muscle thickness in all postoperative months and in the thickness of fatty tissue in the sixth month after surgery, compared to the preoperative muscle and fatty tissue thickness.
Conclusions Ultrasound can be considered as the diagnostic method of choice when assessment of the fat and lean body mass is required in morbidly obese patients before and after bariatric surgery.

Keywords Muscle ultrasound · Fat mass · Obesity · Ultrasound · Lean mass · Gastroplasty · Bariatric surgery · Gastric bypass Roux-en-Y

Introduction

Obesity is one of the major public health challenges of the twenty-first century. The prevalence of obesity is growing exponentially across all age groups and on all continents. This chronic disease is associated with cardiovascular disease, diabetes mellitus type 2, dyslipidemia, increased blood pressure and left ventricular hypertrophy, and other co-morbidities [1–7].

Among current therapeutic possibilities, bariatric surgery results in greater weight loss which is sustained for a longer time compared to other treatments of obesity. Roux-en-Y gastric bypass represents one of the most commonly used techniques [7–9]. The assessment of body composition, including the subcutaneous fat of obese patients, can be performed as a diagnostic or monitoring technique, using one of several established methods. The most commonly used are skinfold, dual-energy X-ray (DEXA), computed tomography (CT), magnetic resonance imaging (MRI), and ultrasound. The DEXA and the CT are sensitive and specific methods for assessment but subject the patient to ionizing radiation. MRI has high sensitivity and specificity and does not subject patients to radiation but presents technical limitations with respect to the weight and size of the patient, which prevents its use in obese patients. This technique is also associated with high financial costs [3, 8, 10–13].

A. Z. Pereira (✉) · G. Carneiro · M. T. Zanella
Department of Medicine, Division of Endocrinology, UNIFESP,
São Paulo, Brazil
e-mail: andreap_pereira@hotmail.com

J. S. Marchini
Department of Medicine, Division of Clinical Nutrition,
University of São Paulo,
Campus Ribeirão Preto,
São Paulo, Brazil

C. H. Arasaki
Department of Surgery, Division of Gastroenterological Surgery,
UNIFESP,
São Paulo, Brazil

Another diagnostic method is the skinfold, a simple, low-cost technique that is free of radiation but provides less sensitivity when used in obese patients because it tends to overestimate the thickness of subcutaneous adipose tissue in these patients [14–16].

Ultrasound examination of subcutaneous tissue, when compared to other methods, exhibits equal or better sensitivity in obese patients and does not subject them to ionizing radiation. Ultrasound can also be used to assess visceral fat, an important cardiovascular risk factor [6]. Moreover, ultrasound equipment can be portable, has no technical limitations with respect to the size and weight of patients, and has the lowest associated financial cost of all available techniques, except for skinfold [2, 3, 5, 12, 13, 15–17].

Aside from the importance of subcutaneous adipose tissue, muscle mass in obese individuals has been widely studied. Obese patients involved in critical situations such as trauma and surgery have a greater loss of muscle mass compared to patients with BMI <30 [18, 19]. Moreover, there is a greater tendency to develop sarcopenia, which is related to increased age and intramuscular fat infiltration [20]. In patients with neuromuscular diseases, ultrasound has been used to evaluate muscle thickness in the upper and lower limbs, as a follow-up diagnosis, due to its advantages over other imaging methods discussed previously [21, 22]. This study aims to evaluate the thickness of the quadriceps femoris muscle and biceps brachii and brachialis muscles, bilaterally as well as the adjacent subcutaneous adipose tissue in patients undergoing Roux-en-Y gastric bypass. These parameters will be evaluated before and after surgery, using ultrasound as the diagnostic method of choice.

Material and Methods

Study Participants

We studied 12 patients seen in the Department of Obesity and Bariatric Surgery, Federal University of São Paulo (UNIFESP): six diabetics and six non-diabetics. The study group comprised three males and nine females, whose average age was 42±14 years (19–57 years). All patients were followed up by a multidisciplinary team consisting of a physician, nutritionist, psychologist, and surgeon.

Diabetic patients were diagnosed according to the criteria of the American Diabetes Association [23].

The criteria for inclusion in the study were BMI >35 associated with co-morbidities or BMI >40 without co-morbidities; age below 65 years and older than 18 years; and clinical, psychological, and nutritional status prior to open Roux-en-Y gastric bypass with a small pouch (approximately 20–30 ml) along the gastric lesser curvature, alimentary limb (measuring 100 cm), and biliopancreatic limb (measuring 50 cm). People with liver and kidney failure, a history of drug use and psychiatric disorders, and psychological factors that hindered their understanding of the surgical procedure were excluded [24].

All patients were measured and weighed by the same examiner using Filizola® digital equipment. The study was approved by the ethics committee of UNIFESP. All patients were instructed on the subject of study and signed a consent form allowing their participation.

Ultrasound Technique

All patients were examined using the Philips® Envisor CHD ultrasound machine, using the 5.0-MHz linear transducer of the quadriceps femoris, in the lower extremity, biceps brachii, and brachialis muscles in the upper extremity as well as their respective corresponding subcutaneous adipose tissue. The muscles biceps brachii and brachialis were measured in thickness only. These muscles were chosen because of its large motor use and the ease in performing the ultrasound technique. For ultrasound measurements, the probe was placed at the position of maximum circumference. The thickness of subcutaneous adipose tissue was measured by the distance between the skin and muscle fascia (mm). And the thickness of muscles was measured by the distance between the muscle fascia and underlying bones (femur and humerus) (mm).

The ultrasound measurements were performed before surgery, at an undetermined time, ranging from 30 to 180 days before surgery and the first, third, and sixth months postoperatively. The upper and lower limbs (right and left) were evaluated by a single examiner, an experienced ultrasound radiologist, who considered the mean of the three ultrasound measurements performed on the same site and in the longitudinal and transverse planes. (Figs. 1 and 2). In the upper limbs, the measures of muscle and subcutaneous tissue were taken 15 cm from the

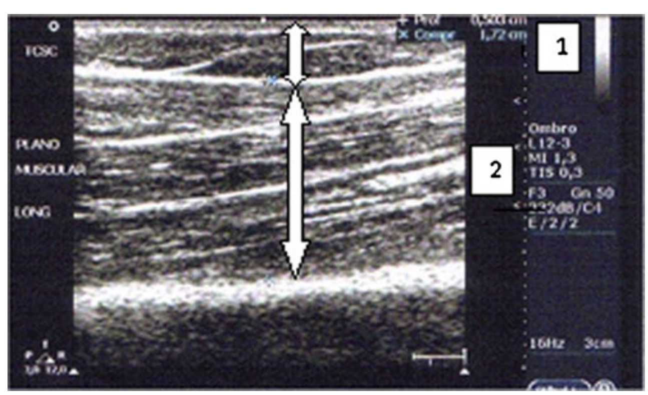


Fig. 1 Ultrasound evaluation of the right upper limb in the longitudinal plane. *Arrows*: *1* thickness of the subcutaneous adipose tissue and *2* thickness of the muscle

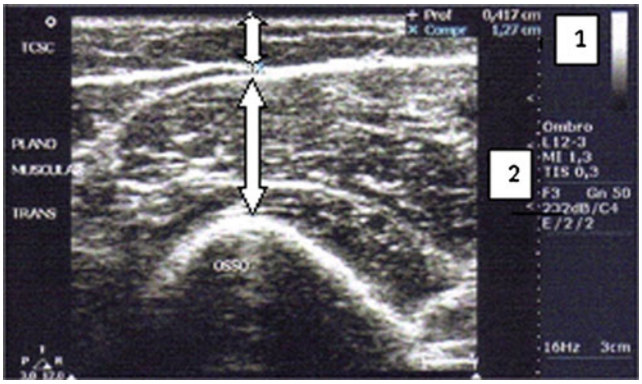


Fig. 2 Ultrasonic evaluation of the right upper limb in the transverse plane. *Arrows*: *1* thickness of the subcutaneous adipose tissue and *2* thickness of the muscle

humeral head, then distally on the ventral and intermediate muscle of the biceps. In the lower limbs, muscle-subcutaneous measurements were performed 15 cm from the superior pole of the patella in the proximal direction on the quadriceps muscle on the ventral, mid-line of the thigh.

Data Analysis

Statistical analysis was performed using Statistical Package for Social Sciences (SPSS) version 16.0 (SPSS Inc., Chicago, IL, USA).

Friedman's statistical test was used to evaluate all comparisons of preoperative and postoperative ultrasound and anthropometric measurements.

Data are expressed as the mean ± standard deviation (SD), and p <0.01 and p <0.05 were considered statistically significant.

Results

Weight

As can be seen in Table 1 and Graph 1, there was a significant reduction in BMI from the preoperative values when compared to those obtained at 30 days, 90 days, and 180 days postoperatively. Although the average BMI of the diabetic patients was lower compared to non-diabetics, this difference was not statistically significant in the periods analyzed.

Fat Mass

The peripheral fat, measured by the same technique as used for subcutaneous tissue, showed progressive reduction of its thickness in relation to preoperative values. This trend was similar in the upper and lower limbs, but significant differences were observed only after 180 days post-surgery, as shown in Table 1. As an example, the measurements in the right thigh obtained by ultrasound using transverse cross-sectional data are illustrated in Graph 2.

Table 1 Comparison of BMI (kg/m^2), ultrasound thickness of fat and muscle, right and left upper limb (biceps brachii and brachii muscles), and lower limb (quadriceps femoris muscle), before and after surgery, in the transverse plane

	Baseline	30 Days	90 Days	180 Days
BMI (kg/m^2)	49±10	45±9*	41±9*	38±8**
ULF right (mm)	12±4	12±4	11±5	8±2*
ULF left (mm)	12±4	11±3	10±4	9±4*
ULM right (mm)	27±7	22±6*	18±4*	15±5**
ULM left (mm)	28±6	22±5*	16±5*	16±4**
LLF right (mm)	22±6	21±8	18±6	16±7*
LLF left (mm)	22±7	22±8	18±6	16±7*
LLM right (mm)	32±6	27±7*	22±6*	21±6**
LLM left (mm)	30±7	25±5*	23±5*	22±5**

Baseline—before surgery, *ULF* upper limb fat, *ULM* upper limb muscle, *LLF* lower limb fat, *LLM* lower limb muscle

*p<0.05, **p<0.01 from baseline

Lean Mass

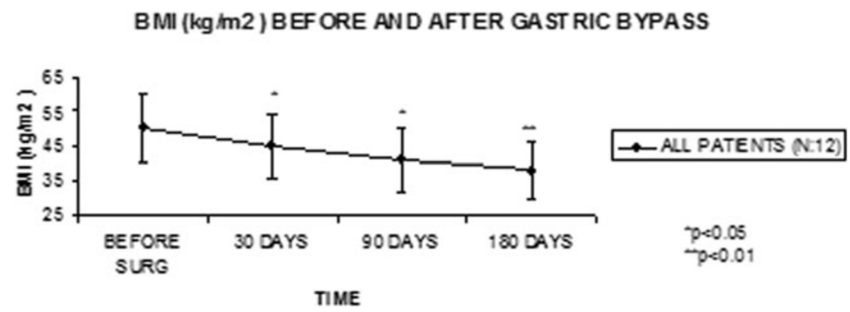
Muscle thickness of the upper and lower limbs was reduced 30 days postoperatively. The reduction was more pronounced in the first 90 days, as shown in Table 1. As an example, the measurements of the right thigh obtained by ultrasound using transverse cross-sectional data are illustrated in Graph 2.

Discussion

The loss of subcutaneous fat and lean mass in patients undergoing bariatric surgery has been discussed by various authors and has been reported to occur in varying proportions [8].

The major concern with the loss of muscle mass that occurs in combination with the loss of fat is the reduction of body protein, which becomes the main source of protein for antibody production. Furthermore, the reduction in muscle mass may impair the increase in insulin sensitivity that would be obtained from the loss of fat mass after bariatric surgery [8, 25].

The obese typically have greater muscle mass, which increases the force of muscle contraction, especially in the quadriceps muscle. This greater muscle mass is necessary to sustain the loss in body weight after a surgical procedure.



Graph 1 Mean ± standard deviation of BMI (kg/m^2) for all patients, pre- and postoperatively

Any large degree of weight loss is more accelerated than the weight loss that occurs in individuals with BMI <30 [18, 19, 25].

Hence, assessing the degree of muscle mass loss and the development of therapeutic measures that might reduce this loss is important. According to some authors, it is possible to demonstrate a reduction in intramuscular protein synthesis during the postoperative period of different surgical procedures, which indicates reduced amounts of intramuscular RNA [26]. In clinical practice, however, there are few methods that allow for the adequate assessment of changes in muscle mass.

The measurement of lean mass loss in obese patients undergoing bariatric surgery has been studied in several papers, due to the essential functions performed by muscle mass, the loss of which may contribute to postoperative complications. The DEXA is the method of choice for this purpose, but this method, although sensitive and specific, subjects the patient to radiation, presents technical limitations depending on the patient's weight, has high costs, and does not allow the direct assessment of structures such as muscle and adipose tissue [27].

Ultrasound for the evaluation of muscle mass could be an alternative method without the limitations of DEXA, which allows the measurement of subcutaneous tissue loss topographically. Ultrasound also enables the evaluation of percent changes in fat mass and lean mass, with higher specificity than the skinfold technique in obese individuals [16, 28].

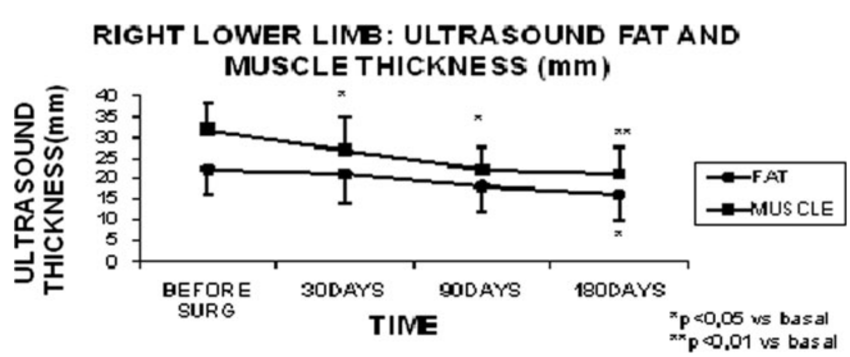
Furthermore, the ultrasound method also allows the evaluation of visceral fat, which is important for the assessment of cardiovascular risk [6, 29].

In future studies, it will be possible to take only one ultrasound measurement of subcutaneous tissue and muscle thickness, respectively, rather than bilateral measurements of the upper and lower limbs. This is because the statistical trend was similar for both fat and lean muscle mass.

All measurements were possible due to the use of a single diagnostic method that requires no previous preparation, does not subject the patient to radiation (regardless of the size and weight of the patient), and is low in cost compared to the other available methods. These characteristics render ultrasound a good option for the evaluation and follow-up of obese patients undergoing bariatric surgery.

Conclusion

Ultrasound can be used to evaluate the loss of fat and lean muscle mass in obese patients. Due to the limitations of other methods already discussed, ultrasound represents a viable alternative that can be used as a noninvasive diagnostic tool for follow-up in this group of patients. This examination not only allows the direct visualization of muscle and subcutaneous tissue but is also quick and relatively inexpensive. Furthermore, the technique requires no advance preparation and can be performed anywhere



Graph 2 Mean ± standard deviation of the ultrasound thickness of the muscle and adipose tissue of the right lower limb (mm) in a transversal cross-section of all patients, pre- vs. postoperatively

using portable equipment, which facilitates its use pre- and postoperatively in the context of bariatric surgery.

Conflicts of interest The authors affirm that they have no conflicts of interest to declare.

References

1. Buckley O, Ward E, Ryan A, et al. European obesity and the radiology department. What can we do to help? Eur Radiol. 2009;19:298–309.
2. Sabir N, Pakdemirli E, Kazil S, et al. Sonographic assessment of changes in thickness of different abdominal fat layers in response to diet in obese women. J Clin Ultrasound. 2002;42(1):26–30.
3. Pontiroli AE, Pizzocri P, Ferla G, et al. Ultrasound measurement of visceral and subcutaneous fat in morbidly obese patients before and after laparoscopic adjustable gastric banding: comparison with computerized tomography and with anthropometric measurements. Obes Surg. 2002;12:648–51.
4. Stefan N, Kantartzis K, Thamer C, et al. Identification and characterization of metabolically benign obesity in humans. Arch Intern Med. 2008;168(15):1609–16.
5. Serap S, Erçin O, Nuran S, et al. Body fat distribution in childhood obesity: association with metabolic risk factors. Indian Ped 2008; 457(45).
6. Ribeiro-Filho FF, Faria NA, Ferreira SRG, et al. Ultrasonography for the evaluation of visceral fat and cardiovascular risk. Hypertension. 2001;38(2):713–7.
7. Donadelli S, Salgado Jr W, Nonino CB, et al. Change in predicted 10-year cardiovascular risk following Roux-en-Y gastric bypass surgery: who benefits? Obes Surg. 2011;21:569–73.
8. Carey DG, Pilego GJ, Raymond RL, et al. Body composition and metabolic changes following bariatric surgery: effects on fat mass, lean mass and basal metabolic rate. Obes Surg. 2006;16:469–77.
9. Zalesin KC, Franklin BA, Lillystone MA, et al. Differential loss of fat and lean mass in the morbidly obese after bariatric surgery. Metabol Synd Relat Dis. 2010;8(1):15–20.
10. Pineau JC, Filliard JR, Bocquet M, et al. Ultrasound techniques applied to body fat measurement in male and female athletes. J Athl Train. 2009;44(2):142–7.
11. Plank LD. Dual-energy X-ray absorptiometry and body composition. Curr Opin Clin Nutr Metab Care. 2005;8:305–9.
12. Pineau JC, Lalys L, Dabbas-Tyan M, et al. Ultrasound measurement of total body fat in obese adolescents. Ann Nutr Metab. 2010;56:36–44.
13. Genton L, Hans D, Kyle U G et al. Dual-energy X-ray absorptiometry and body composition: differences between devices and comparison with reference methods. Nutrition 2002; 18(1).
14. Gray DS, Bray GA, Kirk S, et al. Skinfold thickness measurements in obese subjects. Am J Clin Nutr. 1990;51:571–7.
15. Selkow NM, Pietrosimone BG, Saliba SA. Subcutaneous thigh fat assessment: a comparison of skinfold calipers and ultrasound imaging. J Athl Train. 2011;46(1):50–4.
16. Kuczmarski RJ, Faneii MT, Koch GG. Ultrasonic assessment of body composition in obese adults: overcoming the limitations of the skinfold. Am J Clin Nutr. 1987;45:717–24.
17. Pineau JC, Guihard-Costa AM, Bocquet M. Validation of ultrasound techniques applied to body fat measurement a comparison between ultrasound techniques, air displacement plethysmography and bioelectrical impedance vs. dual-energy X-ray absorptiometry. Ann Nutr Metab. 2007;51:421–7.
18. Port AM, Apovian C. Metabolic support of the obese intensive care unit patient: a current perspective. Curr Opin Clin Nutr Metab Care. 2010;13(2):184–91.
19. Dickerson RN. Hypocaloric feeding of obese patients in the intensive care unit. Curr Opin Clin Nutr Metab Care. 2005;8(2):189–96.
20. Thornell LE. Sarcopenic obesity: satellite cells in the aging muscle. Curr Opin Clin Nutr Metab Care. 2011;14:22–7.
21. Trip J, Pillen S, Drost G, et al. Muscle ultrasound measurements and functional muscle parameters in non-dystrophic myotonias suggest structural muscle changes. Neuromuscul Disord. 2009;19:462–7.
22. Maurits N, Alexander E, Beenaker C, et al. Muscle ultrasound in children: normal values and application to neuromuscular disorders. Ultrasound Med Biol. 2004;30(8):1017–27.
23. American Diabetes Association (ADA). Diagnosis and classification of diabetes mellitus. Diabetes Care. 2011;34:S62–9.
24. Mechanick JI, Kushner RF, Spitz AF, et al. American Association of Clinical Endocrinologists, The Obesity Society, and American Society for Metabolic & Bariatric Surgery Medical Guidelines for Clinical Practice for the Perioperative Nutritional, Metabolic, and Nonsurgical Support of the Bariatric Surgery. Obesity. 2009;17(1):S1–S70.
25. Wadstrom C, Backman L, Forsberg AM, et al. Body composition and muscle constituents during weight loss: studies in obese patients following gastroplasty. Obes Surg. 2000;10:203–13.
26. Rubenoff R, Castaneda C. Sarcopenia—understanding the dynamics of aging muscle. JAMA. 2011;286(10):1230–1.
27. Savastano S, Di Somma C, Colao A, et al. Growth hormone treatment prevents loss of lean mass after bariatric surgery in morbidly obese patients: results of a pilot, open, prospective, randomized, controlled study. J Clin Endocrinol Metab. 2009;94(3):817–26.
28. Stevens-Simon C, Thureen P, Stamm E, et al. Skinfold caliper and ultrasound assessments of change in the distribution of subcutaneous fat during adolescent pregnancy. Int J Obes. 2001;25:1340–5.
29. Radominski R, Verozzo DP, Halpern A, et al. O Uso da ultrasonografia na avaliação da distribuição de gordura abdominal. Arq Bras Endocrinol Metab. 2000;44(1):5–12.