

# Effect of bariatric surgery on the improvement of metabolic dysfunction associated steatotic liver disease, evaluated with elastography

*Efecto de la cirugía bariátrica en la mejora de la enfermedad hepática esteatótica asociada a disfunción metabólica, evaluado con elastografía*

Jesús E. Rodríguez-Silverio<sup>1,2\*</sup>, Marco A. Gallaga-Rojas<sup>1,2</sup>, Armando Pereyra-Talamantes<sup>2</sup>, Eira Cerda-Reyes<sup>3</sup>, Adriana Martínez-Cuazitl<sup>3</sup>, and Stefanny Cornejo-Hernández<sup>3</sup>

<sup>1</sup>Department of General Surgery, Hospital Central Militar, Secretaría de la Defensa Nacional; <sup>2</sup>Escuela Militar de Graduados de Sanidad, Universidad del Ejército y Fuerza Aérea; <sup>3</sup>Department of Research, Hospital Central Militar. Mexico City, Mexico

## Abstract

**Objective:** To determine the changes in controlled attenuation parameter (CAP) levels in patients undergoing bariatric surgery.

**Method:** The records of patients with obesity who underwent CAP measurement using the elastography prior to bariatric surgery and 6 months after it were reviewed and included. The normality of the data was analyzed and compared with the paired Student's t test or Wilcoxon test. The association of the degree of pre- and postsurgical steatosis was analyzed using the  $\chi^2$  test, considering  $p < 0.05$  a statistically significant value. **Results:** 33 female patients with a mean age of 45.76 years  $\pm 10.1$  years were included, 17 were treated by gastric bypass and 16 with gastric sleeve. A reduction of 11 kg/m<sup>2</sup> (10-12.5 kg/m<sup>2</sup>) was observed. The preoperative CAP levels were 282  $\pm$  52 dB/m, and 6 months after bariatric surgery were 238  $\pm$  dB/m ( $p = 0.0006$ ). The degree of steatosis decreased in 20 patients (60.7%), unchanged in 9 (27.3%) and increasing in 4 (12%).

**Conclusions:** Bariatric surgery was shown to have a positive impact on reducing CAP levels in patients with obesity and metabolic dysfunction associated steatotic liver disease.

**Keywords:** Metabolic dysfunction associated steatotic liver disease. Bariatric surgery. Elastography. Controlled attenuation parameter.

## Resumen

**Objetivo:** Determinar los cambios en el parámetro de atenuación controlada (CAP, controlled attenuation parameter) en pacientes sometidas a cirugía bariátrica. **Método:** Se revisaron e incluyeron los expedientes de pacientes con obesidad a las que se realizó la medición del CAP mediante elastografía previo a la cirugía bariátrica y 6 meses después de esta. Se analizó la normalidad de los datos y se compararon con la prueba t de Student pareada o con la prueba de Wilcoxon; para la asociación del grado de esteatosis pre- y posquirúrgico se utilizó la prueba de  $\chi^2$ . Se consideró estadísticamente significativo un valor de  $p < 0.05$ . **Resultados:** Se incluyeron 33 mujeres con una edad media de 45.76 años  $\pm 10.1$  años, de las cuales 17 fueron tratadas mediante bypass gástrico y 16 con manga gástrica. Se observó una reducción de 11 kg/m<sup>2</sup> (10-12,5 kg/m<sup>2</sup>). Los niveles de CAP preoperatorios fueron de 282  $\pm$  52 dB/m, y a los 6 meses de la cirugía bariátrica fueron de 238  $\pm$  dB/m ( $p = 0.0006$ ). El grado de esteatosis se redujo en 20 pacientes (60.7%), no cambió en 9 (27.3%) y aumentó en 4 (12%).

### \*Correspondence:

Jesús E. Rodríguez-Silverio  
E-mail: drjesusrodriguezs@gmail.com  
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**Conclusiones:** *Se demostró que la cirugía bariátrica tiene un impacto positivo en la disminución de los niveles de CAP en pacientes con obesidad y enfermedad hepática esteatótica asociada a disfunción metabólica.*

**Palabras clave:** *Enfermedad hepática esteatótica asociada a disfunción metabólica. Cirugía bariátrica. Elastografía. Parámetro de atenuación controlada.*

## Introduction

In 2020, the new term “metabolic-associated fatty liver disease” (MAFLD) was proposed, which could be diagnosed in adults with hepatic steatosis detected by imaging modalities, blood biomarkers, or liver histology, with overweight or obesity, or in the presence of type 2 diabetes, or at least two metabolic risk abnormalities; this was endorsed by various international societies. In June 2023, a consensus statement was published introducing the term “metabolic dysfunction-associated steatotic liver disease” (MASLD) and withdrawing “non-alcoholic fatty liver disease” (NAFLD)<sup>1</sup>.

MASLD is one of the most common liver diseases in individuals with overweight or obesity and represents a growing public health challenge worldwide. The relationship between obesity and the development of MASLD is well established, and bariatric surgery has been shown to be an effective strategy for weight control and improvement of metabolic health in patients with obesity. However, there remains a knowledge gap regarding specific changes in hepatic fat content and distribution in patients with MASLD undergoing bariatric surgery. The controlled attenuation parameter (CAP) has emerged as a promising noninvasive tool for the assessment of hepatic steatosis, providing a quantitative measure of fat accumulation in the liver.

MASLD is a metabolic disorder characterized by fat accumulation in hepatocytes in individuals who do not have excessive alcohol consumption or exposure to hepatotoxic drugs or other known causes of secondary steatosis. Currently, MASLD has become the most prevalent chronic liver disease globally. It is defined as fat accumulation in at least 5% of hepatocytes in the absence of viral hepatitis, drugs that may induce steatosis (such as tamoxifen and amiodarone), other liver diseases (such as autoimmune hepatitis, hemochromatosis, or Wilson disease), or significant alcohol consumption<sup>2,3</sup>.

In Mexico, a prevalence of 17.1% has been reported in the asymptomatic general population; however, a

meta-analysis conducted in 2016 reported a global prevalence of 25.24%, with the highest rates in the Middle East and South America, and there is evidence of increasing prevalence with advancing age. The global prevalence of steatohepatitis in patients with MASLD has been reported to be as high as 59.1%<sup>4,5</sup>.

From a clinical standpoint, patients with MASLD are often obese and may present with insulin resistance, type 2 diabetes, dyslipidemia, hypertriglyceridemia, and hypertension, all of which are cardiovascular risk factors that may be present at diagnosis. It is estimated that more than 90% of patients with morbid obesity undergoing bariatric surgery have MASLD<sup>6-8</sup>.

The reason why some patients with MASLD, even those with low levels of hepatic fat, develop steatohepatitis is not yet fully understood. It is well known that the degree of hepatic steatosis is associated with metabolic syndrome and cardiovascular risk<sup>9</sup>. Furthermore, significant steatosis has recently been reported to be associated with fibrosis progression in patients with MASLD.<sup>10,11</sup>

Liver elastography is presented as a noninvasive, rapid, and accurate technique to assess liver stiffness and detect the presence of significant fibrosis in patients with MASLD. Its utility in primary care settings and its ability to quantify hepatic fat make it a cost-effective tool for screening MASLD and liver fibrosis in the general population<sup>12,13</sup>.

## Method

Health records of patients with CAP measurement by elastography before bariatric surgery and 6 months after surgery were reviewed and included. The FibroScan® Expert 630 device was used, considering inclusion criteria and ensuring that no condition listed in the exclusion or elimination criteria was present. The sample consisted only of women because during the study period only female patients were obtained. This was expected, as bariatric surgery at the center where this study was conducted is performed more frequently in women.

The Shapiro-Wilk test was performed to determine normality of quantitative variables. Variables with

normal distribution were expressed as mean and standard deviation, whereas nonparametric variables were expressed as median and IQR. Qualitative data and ordinal quantitative variables were expressed as frequencies and percentages. Variables meeting normality were compared using paired Student's *t* test, and those not meeting normality were analyzed using the Wilcoxon test. The association between pre- and postsurgical steatosis grade measured by elastography was analyzed using the  $\chi^2$  test. A value of  $p < 0.05$  was considered statistically significant. SPSS Statistics v26 and GraphPad Prism v8.02 software were used.

## Results

A total of 33 women meeting selection criteria were included; 17 underwent gastric bypass and 16 sleeve gastrectomy. The mean age was  $45.76 \pm 10.1$  years, with no significant difference between groups:  $48.7 \pm 5.1$  years in the gastric bypass group and  $42.6 \pm 13$  years in the sleeve gastrectomy group ( $p = 0.084$ ). Twenty-seven patients (81.8%) had at least one comorbidity, most commonly type 2 diabetes (Fig. 1).

Preoperative body mass index (BMI) was  $39 \text{ kg/m}^2$  ( $38\text{--}45 \text{ kg/m}^2$ ) and decreased to  $28 \text{ kg/m}^2$  ( $27\text{--}32 \text{ kg/m}^2$ ) postoperatively, showing a significant reduction ( $p < 0.0001$ ) (Fig. 2), with a median decrease of  $11 \text{ kg/m}^2$  ( $10\text{--}12.5 \text{ kg/m}^2$ ), ranging from  $7$  to  $17.9 \text{ kg/m}^2$ , with no significant differences between procedures.

A significant decrease in CAP values was observed after surgery (Fig. 3), from  $282 \pm 52$  preoperatively to  $238 \pm 46$  at 6 months ( $p = 0.0006$ ), with no significant difference across procedures.

Steatosis grade decreased in 22 patients (66.6%), remained unchanged in 7 (21.2%), and increased in 4 (12.1%). Advanced steatosis was eradicated in most patients, with only five remaining in this category. No association was found between initial and final steatosis grade (Table 1 and Fig. 4). Overall, 60.7% had significant hepatic steatosis (at least grade 1), and 42.5% had severe steatosis (at least grade 3). In total, 66% experienced CAP reduction and 51% achieved complete resolution of steatosis (Table 2).

## Discussion

Elastography is a novel noninvasive technique validated in MASLD for assessing liver fibrosis and steatosis. It measures shear-wave velocity using a portable probe (M or XL) in the intercostal space over

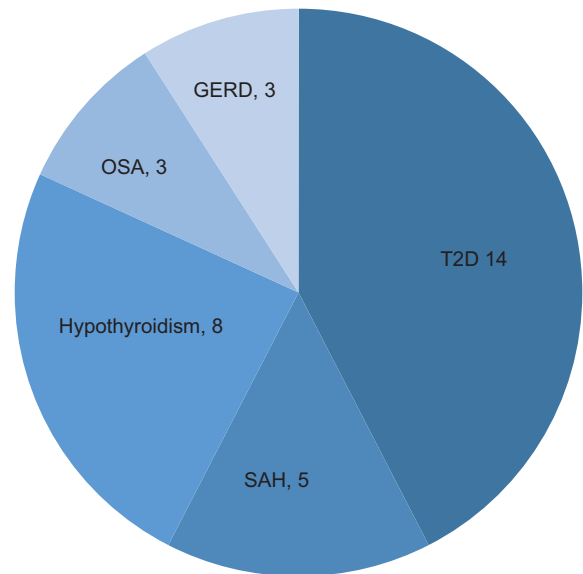


**Figure 1.** Frequency of comorbidities. T2D: type 2 diabetes; GERD: gastroesophageal reflux disease; SAH: systemic arterial hypertension; OSA: obstructive sleep apnea syndrome.

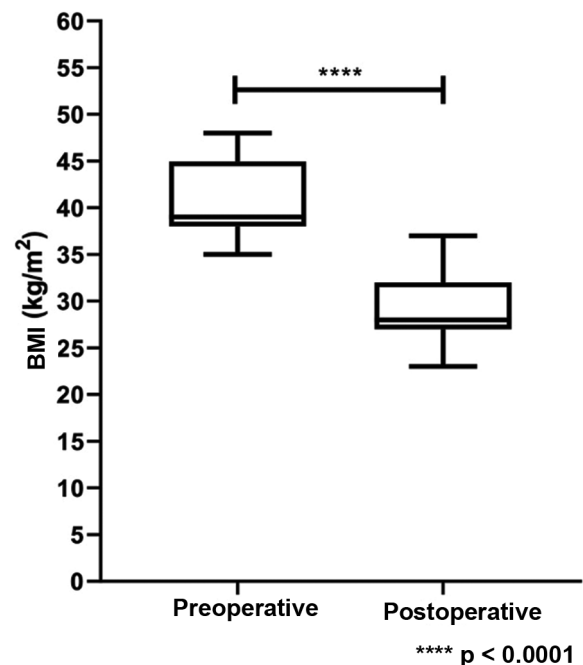


**Figure 2.** Changes in body mass index (BMI). Pre: preoperative; Post: postoperative.

the hepatic lobe. Using vibration-controlled transient elastography attenuation coefficient-based algorithms, shear-wave velocities generate liver stiffness and CAP measurements, correlating with fibrosis and

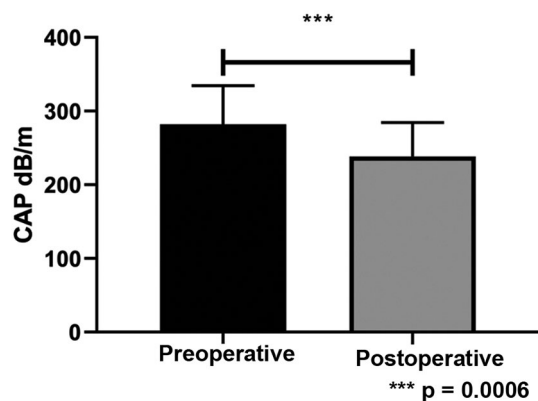


**Figure 3.** Changes in controlled attenuation parameter (CAP). Pre: preoperative; Post: postoperative.

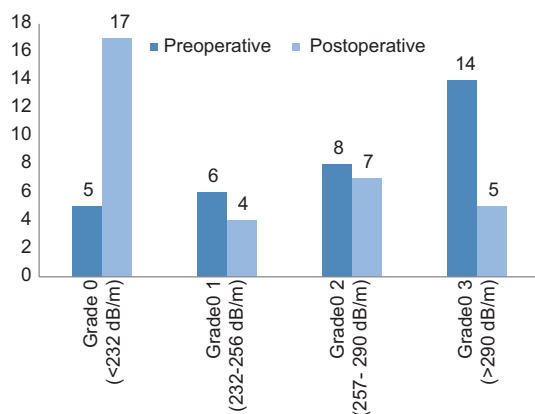


**Figure 4.** Changes in steatosis grade.

steatosis, respectively. In patients with obesity, liver stiffness and CAP have demonstrated utility for diagnosing fibrosis and steatosis<sup>14,15</sup>.

MASLD is one of the leading causes of liver disease; in the general population, prevalence ranges from 25% to 30%, and 70% to 90% of patients with obesity are estimated to develop MASLD, highlighting the need for effective therapeutic approaches. The primary endpoint of this study was to determine changes in CAP levels in patients undergoing bariatric surgery, emphasizing the need to establish more effective therapeutic guidelines.

Liver biopsy remains the reference standard for MASLD diagnosis; however, it is invasive and associated with complications and limitations, such as pain, bleeding, and sampling variability. Therefore, noninvasive methods such as elastography measuring CAP have been developed<sup>16</sup>.

Findings suggest bariatric surgery positively impacts CAP levels in patients with obesity and MASLD.

Significant postoperative BMI reduction reflects decreased adiposity, likely associated with CAP improvement. These results align with prior studies demonstrating beneficial hepatic effects of bariatric surgery in obesity and MASLD. CAP reduction indicates decreased hepatic steatosis and overall liver health improvement.

The mechanisms by which bariatric surgery exerts these positive effects are multifactorial. The weight loss achieved through surgery leads to a reduction in adipose tissue, particularly visceral fat, which plays a fundamental role in the development and progression of MASLD. In addition, bariatric surgery may improve insulin sensitivity and metabolic parameters, which are important factors in the pathogenesis of MASLD. It is worth noting that bariatric surgery is a complex procedure and should be considered on an individual basis, taking into consideration factors such as patient preferences, comorbidities, and potential risks. Further research is needed to better understand the long-term effects of bariatric surgery on CAP levels and liver health in different patient populations. This study contributes to the growing body of evidence supporting the effectiveness of bariatric surgery in improving liver health in patients with obesity and MASLD. Continued research in this field will help refine treatment approaches and further optimize patient outcomes.

## Conclusions

According to the results of the study, it can be concluded that bariatric surgery has a significant impact on reducing CAP levels in patients with a history of obesity and nonalcoholic fatty liver disease. Patients undergoing bariatric surgery showed a significant decrease in CAP levels, as well as in BMI and the degree of hepatic steatosis. These findings support the effectiveness of bariatric surgery as a therapeutic strategy to improve metabolic health and reduce hepatic steatosis in patients with obesity and MASLD. However, it is important to note that further studies are needed to confirm these results and to better understand the underlying mechanisms. Bariatric surgery may be considered an effective treatment option for patients with obesity and MASLD, as it has been shown to reduce CAP levels and improve hepatic steatosis. These findings may have important implications for clinical management and for the development of more effective therapeutic guidelines.

**Table 1. Changes in steatosis grade (n = 33)**

| Steatosis grade prior to surgery | Steatosis grade after surgery |                   |                   |                 |
|----------------------------------|-------------------------------|-------------------|-------------------|-----------------|
|                                  | G0 (< 232 dB/m)               | G1 (232-256 dB/m) | G2 (257-290 dB/m) | G3 (> 290 dB/m) |
| G0 (< 232 dB/m)                  | 4                             | 0                 | 0                 | 1               |
| G1 (232-256 dB/m)                | 3                             | 0                 | 1                 | 2               |
| G2 (257-290 dB/m)                | 5                             | 2                 | 1                 | 0               |
| G3 (> 290 dB/m)                  | 5                             | 2                 | 5                 | 2               |

$\chi^2 = 9.537$ ;  $p = 0.389$ .

**Table 2. Resolution of steatosis grade and CAP reduction (n = 33)**

| Steatosis grade         | Preoperative | Postoperative |
|-------------------------|--------------|---------------|
| CAP median (dB/m)       | 282 ± 52     | 238 ± 46      |
| Grade G1 (< 232 dB/m)   | 5 (15.2%)    | 17 (51.5%)    |
| Grade G2 (232-256 dB/m) | 8 (24.2%)    | 4 (12.1%)     |
| Grade G3 (257-290 dB/m) | 8 (24.2%)    | 7 (21.2%)     |
| Grade G4 (> 290 dB/m)   | 12 (36.4%)   | 5 (15.2%)     |

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## Conflicts of interest

The authors declare no conflicts of interest.

## Ethical considerations

**Protection of human subjects and animals.** The authors declare that no experiments on humans or animals were performed for this research.

**Confidentiality, informed consent, and ethical approval.** The authors have followed their institution's confidentiality protocols, obtained informed consent from all patients, and secured approval from the Ethics Committee. SAGER guidelines have been followed as applicable to the nature of the study.

**Declaration on the use of artificial intelligence (AI).** The authors declare that no generative artificial intelligence was used in the writing or creation of the content of this manuscript.

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