Effect of bariatric surgery on fatty liver disease in obese patients: A prospective one year follow-up study

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Background. Non-alcoholic fatty liver disease (NAFLD), often associated with obesity and metabolic syndrome, manifests itself as steatosis, hepatic fibrosis, cirrhosis, or even end-stage liver disease. NAFLD causes inflammation, insulin resistance and cardiovascular complications. The current study aimed to evaluate the beneficial effects of bariatric surgery on biochemical parameters of hepatic functions in obese patients by comparing them before and one-year after the surgery.

Methods. A total of 72 morbidly obese patients underwent bariatric surgery between 2016 and 2018. The incidence of diabetes mellitus in this group was 29%, median body weight was 124.5 kg (109.0-140.0) and mean body mass index (BMI) was 44.38 ± 6.770 kg/m^2. The used surgical procedures included gastric bypass, sleeve gastrectomy, laparoscopic gastric plication, and single anastomosis duodeno-ileal bypass-sleeve gastrectomy. Biochemical parameters including ALT/AST ratio (AAR), NAFLD fibrosis score (NFS), hepatic fibrosis index (FIB-4) and Fatty Liver Index (FLI) were evaluated in all patients at the time of surgery and one year after the intervention.

Results. Significant improvement after the intervention was observed in 64 patients. A significant reduction in body weight (P<0.0001), waist circumference (P<0.0001), and body mass index (P<0.0001) were observed. NAFLD liver fibrosis index changed significantly (P<0.0001), suggesting a trend of improvement from advanced fibrosis towards stages 0-2. The FIB-4 fibrosis index indicated significant improvement (P=0.0136). Besides, a significant decline in hepatic steatosis (P<0.0001) was observed after bariatric surgery as compared to the pre-surgery fatty liver conditions.

Conclusion. Among the strategies to overcome NAFLD-associated impediments, bariatric surgery can be considered effective in reducing obesity and metabolic co-morbidities.

Trial Registration: ClinicalTrials.gov (NCT04569396)

Key words: NAFLD, bariatric surgery, obesity, liver fibrosis

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INTRODUCTION

Nonalcoholic fatty liver disease (NAFLD), as well as non-alcoholic steatohepatitis (NASH), are highly prevalent hepatic disorders, especially in the developed countries[1]. NAFLD is a spectrum of chronic liver diseases which range from steatosis to NASH and liver fibrosis, which in turn causes metabolic complications[2]. Risk factors include type 2 diabetes, obesity and hyperlipidemia[3]. Obese patients are in a chronic inflammatory state that correlates with insulin resistance (IR) as well as with elevation of both tumour necrosis factor-α (TNF-α) and monocyte chemotactic protein-1, which causes impairment of adipocyte insulin sensitivity[4]. Inflammation and activation of several immune pathways in obese patients affect hepatic lipid metabolism, leading to hepatic injury[5]. Hepatic steatosis is associated with increased production of interleukin-6 and other pro-inflammatory cytokines by hepatocytes and non-parenchymal cells, including Kupfer cells[6]. This overexpression of cytokines is likely to play a key role in the progression of NAFLD as well as of cardiovascular diseases. NAFLD, even without fibrosis, represents a nourishing environment for the development of hepatocellular carcinoma (HCC) through insulin resistance and steatosis, which leads to inflammation, increased adipokine action, oxidative stress and lipotoxicity, all of which support hepatocellular carcinogenesis[7]. In the general European population, the prevalence of NAFLD cases doubled over the last twenty years; similarly, an increase of 42.6-69.5% was observed in patients with Type 2 diabetes[8]. In the United States of America (USA), about six million individuals were reported to have NASH and 0.6 million to have NASH-induced liver cirrhosis[9,10]. Evidence suggests that obesity is a major contributing factor to developing NAFLD (ref.[2,3]). In 2005, the estimated global numbers of obese and overweight adults were 937 and 396 million, respectively[7]. According to 2008 reports, there were about 500 million obese adults and about 1.4 billion overweight individuals globally, which can gradually predispose them to Type 2 diabetes and

hepatic complications[11,12]. The number of overweight and obese individuals is projected to be 1.35 billion and 573 million by 2030 (ref.[9]). The management strategies include dietary control, weight loss, lifestyle modifications and use of drugs for reduction of insulin resistance and management of NAFLD-associated hepatic fibrosis[13,14]. Nevertheless, weight loss achieved by lifestyle modifications and drug therapy are very hard to maintain and the incidence of hepatic fibrosis among NAFLD patients is reported to have significantly increased in the last decades[15,16]. Hence, alternative approaches including bariatric surgery were adopted to manage obesity and NAFLD (ref.[17-19]).

Bariatric surgery is considered an important tool for the management of obesity-related complications and about 11.3 million bariatric surgeries annually are performed in USA alone[20]. These surgical interventions have significantly reduced mortality rates and improved patients' quality of life as a result of a significant decline in the body weight, insulin resistance and cardiovascular risks[21-23].

Studies suggest that about 87-94% of bariatric patients exhibit hepatic pathophysiology and that bariatric surgery is highly beneficial in reducing the severity of NAFLD (ref.[24,25]). Bariatric surgeries do not only exhibit beneficial outcomes in the form of weight loss but are also useful in normalizing metabolic alterations and other changes associated with NAFLD, such as blood lipids profile, insulin resistance, adipokines and inflammation[26]. Bariatric surgery is generally recommended for obese individuals with a BMI of 35-40 kg/m2 (ref.[27]). Bariatric surgery is preferred over other weight-reducing procedures for the management of NAFLD as it considerably improves biochemical and histological parameters of NAFLD. The presented study running from 2016 to 2019 was designed to prospectively investigate the effect of bariatric surgery in non-alcoholic obese individuals on liver biochemistry, BMI, NAFLD fibrosis score, FIB 4 index and FLI at a one-year follow-up.

METHODS

Study design and inclusion criteria

The current study is based on data from morbidly obese patients who qualified for bariatric surgery at the Department of Surgery, University Hospital Ostrava, Czech Republic, between 2016 and 2018. Patients >18 years of age, with BMI > 35-40 kg/m2 with hypertension and/or diabetes in whom conservative therapy failed to relieve the symptoms were included in the study. Exclusion criteria were: a history of excessive alcohol consumption, use of hepatotoxic drugs, infectious liver diseases (i.e. hepatitis A, B, C) and genetic hemochromatosis. A total of 72 patients (n=26 during 2016, n=26 during 2017 and n=20 during 2018) who qualified for bariatric surgery were included in the study. All patients signed informed consent for participation in the study.

Approval of the Ethics committee

The study was approved by the Ethics committee at the Department of Surgery, University Hospital Ostrava, Czech Republic.

Patient demographics

Patients' sex, age (years), weight (kg), height (cm) and associated co-morbidities such as diabetes and hypertension were recorded before surgery.

Biochemical Analysis

Biochemical parameters including triglyceride profile, platelet count, Gamma glutamyl-transferase (GGT), albumin concentration, alanine aminotransferase (ALT), aspartate aminotransferase (AST), as well as platelet count, triglycerides and blood glucose were determined using standard procedures[28,29]. BMI, a very useful tool for the prediction of various diseases including cardiovascular diseases and stroke[30-32], was also calculated.

Calculation of AAR

The ALT/AST Ratio known as AAR is an important indicator of liver diseases as well as of other diseases including muscular damage or other arterial occlusive disorders such as limb ischemia[33,34]. AAR was calculated for individual patients from their liver enzymes profile and data for all patients was presented as mean ± standard error of mean (SEM).

Estimation of NAFLD fibrosis score (NFS)

NFS was calculated following the standards set by the American and European Associations for the Study of Liver Disease[35-37]. This non-invasive serum index is based on several parameters including age, BMI, albumin, hyperglycaemia, platelet count and AST/ALT ratio[38-40]. The NFS score was calculated as:

-1.675 + 0.037 x Age (years) + 0.094 x BMI (kg/m^2) + 1.13 x IFG/diabetes score (i.e. yes = 1 & no = 0) + 0.99 x AST/ALT ratio - 0.013 x platelet count (x10^9/L) - 0.66 x albumin (g/dL) (ref.[41]),

where IFG stands for impaired fasting glycaemia.

Assessment of fibrosis using FIB-4 index

FIB-4 index is a non-invasive, highly specific and sensitive approach for prediction of hepatic fibrosis. FIB-4 values were determined for all patients included in the study using the previously reported standard formula[42,43]:

$$FLI = \frac{(e^{0.953 \times \log e(\text{triglycerides}) + 0.139 \times BMI + 0.718 \times \log e(GGT) + 0.053 \times \text{waist circumference} - 15.745)}}{1 + (e^{0.953 \times \log e(\text{triglycerides}) + 0.139 \times BMI + 0.718 \times \log e(GGT) + 0.053 \times \text{waist circumference} - 15.745)}} \times 100$$

$$FIB-4 = \frac{\text{Age of the Patients (years)} \times \text{AST[Unit per litter]}}{\text{Platelets count [per liter]} \times \left(\text{ALT}^{\frac{[\text{Unit per litter}]}{2}}\right)}$$

Patient results were classified into groups F0 (indicating no fibrosis), F1 (mild fibrosis), F2 (moderate fibrosis), F3 (severe fibrosis) and F4 (liver cirrhosis).

Fatty Liver Index (FLI)

FLI is a useful approach for the calculation of liver steatosis and other fatty liver diseases. It is calculated us-

ing information such as waist circumference (Wci), triglycerides (TG), BMI, and GGT (ref.[31,44]).

Surgical interventions

To qualify for the bariatric surgery, the patients underwent extensive multi-disciplinary pre-operative evaluations. Patients were subjected to a specific dietary program before surgery as indicated in recent guidelines for bariatric surgery[45-47]. The most appropriate of the following procedures was used in the individual patients based on the patient condition: gastric bypass (Roux-en-Y), sleeve gastrectomy (LSG), Laparoscopic gastric plication (LGP) (ref.[48-51]).

Statistical analysis

Continuous variables were expressed as mean ± standard deviation (SD) and median (interquartile range, IQR) in case of normal and non-normal distribution, respectively. The Shapiro-Wilk test was used to test for normal distribution. The within-patient changes in clinical parameters (continuous or ordinal variables) from the baseline to one year after bariatric surgery were compared using the Wilcoxon matched-pairs signed-rank test for ordinal variables as well as for continuous variables where the change was non-normally distributed; for normally distributed continuous variables, the paired Student's t-test was used. The statistical testing was done at the two-tailed α level of 0.05. The data were analyzed using GraphPad Prism Version 8.0.2 (GraphPad Software, Inc., USA).

RESULTS

Patient demographics and biochemical analysis before surgery

A total of 72 severely or morbidly obese patients were referred for bariatric surgery between 2016 and 2018. Diabetes mellitus was present in 21 (29%) patients. The baseline characteristics of patients are shown in Table 1.

Post-surgical analysis of biochemical parameters

One year after the bariatric surgery, notable normalization of general health condition was observed in 64 patients (88%) while no significant change was detected in 8 patients (12%). In patients in whom the effect of bariatric surgery on NAFLD was positive, the improvement was confirmed by the clinical and biochemical characteristics (see Table 2). The changes were apparent from the significant decrease in the body weight (P<0.0001), waist circumference (P<0.0001), and body mass index (P<0.0001) as compared to that observed before bariatric surgery in the respective patients. From the biochemical results, a significant decrease in the platelet serum level (P=0.0240), and triglycerides (P<0.0001) was observed after surgery when compared to the corresponding paired values before surgery. However, no substantial change in the patients' biochemical characteristics of GGT, ALT, AST, and AAR was observed. A noticeable effect of bariatric surgery was observed in the extent of liver fibrosis as the NAFLD liver fibrosis index changed significantly

Table 1. Baseline characteristics of morbidly obese patients.

Characteristic	Before surgery (n = 72)
Age (years)	45.49 ± 11.18
Height (cm)	170.4 ± 8.93
Weight (kg)	124.5 (109.0-140.0)
Wci (cm)	128.3 ± 15.45
BMI (kg/m^2)	44.38 ± 6.77
Platelet count (×10^9/L)	274.4 ± 65.71
Triglycerides (mmol/L)	1.70 (1.29-2.05)
GGT (μkat/L)	0.44 (0.31-0.60)
GGT (IU/L)	26.35 (19.04-35.98)
Albumin (g/L)	41.24 ± 2.39
ALT (μkat/L)	0.44 (0.34-0.70)
ALT (IU/L)	25.58 (20.51-41.92)
AST (μkat/L)	0.40 (0.33-0.56)
AST (IU/L)	23.95 (19.61-35.03)
AAR	0.86 (0.67-1.13)
NAFLD	-0.88 (-1.7-0.19)
FIB-4	0.76 (0.61-1.21)
FLI	96.00 (83.50-99.00)

Values expressed as mean ± SD or median (IQR)

(P<0.0001), thereby showing a trend from advanced fibrosis towards stages 0-2. The reduction in the liver fibrosis was also apparent from the FIB-4 fibrosis index, which showed a significant improvement (P=0.0136) and a reduction in the fibrotic severity. A significant decrease in the non-invasive fatty liver index (P<0.0001) was observed after the bariatric surgery compared to the pre-surgery fatty liver conditions, indicating an improvement in the status and in the degree of hepatic steatosis.

NAFLD fibrosis score, fibrosis FIB-4 index and other analyses

To ascertain the relation of bariatric surgery to the change in liver fibrosis and steatosis, the 64 patients were assigned (based on the results of the NAFLD fibrosis scoring system) to cohorts of fibrosis stages F0-F2 (< −1.455 as Cohort 1) and F3-F4 (> 0.675 as Cohort 2), using the cut-off values for the exclusion or presence of advanced fibrosis based on the pre-surgery baseline NAFLD liver fibrosis scoring system (see Table 3). In the Cohort 1 [n = 23 (36%)], a significant decrease in the body weight (P<0.0001), waist circumference (P<0.0001) and body mass index (P<0.0001) was observed one year after the bariatric surgery compared to the pre-surgery values. The pre- and post-surgery paired analysis also revealed a significant reduction in the level of triglycerides (P=0.0037), while no significant changes were observed in the remaining investigated biochemical parameters. A notable improvement in the hepatic fibrotic reversibility was apparent from the significant change in the NAFLD fibrosis index (P=0.0149) and the liver rejuvenation was further confirmed by the significant decrease in the steatosis index (P=0.0031). In the Cohort 2 [n=11 (17%)], a similar improvement in the clinical condition

Table 2. Paired value analysis of changes in clinical, biochemical, and fibrosis indices characteristics in morbidly obese patients before and 1 year after the bariatric surgery.

Characteristics	Before surgery	1 year after surgery	*P*
Weight (kg)	124.0 (109.0-137.8)	90.00 (83.25-102.5)	< 0.0001[a]
Wci (cm)	125.5 (115.0-138.0)	102.0 (96.00-110.0)	< 0.0001[a]
BMI (kg/m^2)	43.24 (38.58-48.75)	31.00 (29.00-34.75)	< 0.0001[a]
Platelets (×10^9/L)	276.0 ± 63.33	263.9 ± 58.55	0.0240[b]
Triglycerides (mmol/L)	1.70 (1.26-2.04)	1.40 (1.20-1.76)	< 0.0001[a]
GGT (μkat/L)	0.44 (0.31-0.61)	0.44 (0.33-0.60)	0.1639[a]
GGT (IU/L)	26.35 (18.67-36.85)	25.00 (19.00-37.50)	0.2188[a]
Albumin (g/L)	41.29 ± 2.301	41.30 ± 2.052	0.9801[b]
ALT (μkat/L)	0.42 (0.34-0.70)	0.46 (0.34-0.60)	0.1720[a]
ALT (IU/L)	25.15 (20.36-42.36)	27.50 (21.00-36.75)	0.1262[a]
AST (μkat/L)	0.41 (0.35-0.58)	0.41 (0.33-0.54)	0.5788[a]
AST (IU/L)	25.00 (20.96-35.78)	25.00 (21.00-31.50)	0.6265[a]
AAR	0.87 (0.66-1.13)	0.90 (0.79-1.05)	0.3824[a]
NAFLD	-0.900(-1.90-0.19)	-1.66 (-2.39–0.40)	< 0.0001[a]
FIB-4	0.77 (0.61-1.20)	0.85 (0.65-1.17)	0.0136[a]
FLI	96.00 (83.50-99.00)	74.00 (50.00-87.00)	< 0.0001[a]

Values expressed as median (IQR) or mean ± SD, n = 64
[a]Wilcoxon matched-pairs signed-rank test
[b]Paired Student's *t*-test

Table 3. Paired value analysis of changes in clinical and biochemical characteristics of morbidly obese patients before and 1 year after bariatric surgery in the cohorts of NAFLD liver fibrosis patients.

Characteristics	NAFLD fibrosis score = < −1.455 (F0-F2)			NAFLD fibrosis score = > 0.675 (F3-F4)		
	Before surgery	1 Year after surgery	*P*	Before surgery	1 Year after surgery	*P*
Weight (kg)	123.4 ± 16.55	92.39 ± 12.85	< 0.0001[a]	151.8 ± 22.79	114.5 ± 27.25	< 0.0001[a]
Wci (cm)	126.2 ± 14.46	105.0 ± 10.56	< 0.0001[a]	142.5 ± 16.57	116.5 ± 19.85	< 0.0001[a]
BMI (kg/m^2)	43.85 ± 6.30	32.61 ± 4.717	< 0.0001[a]	49.62 ± 7.664	37.27 ± 9.758	< 0.0001[a]
Platelets (×10^9/L)	285.3 ± 45.86	279.6 ± 48.21	0.4234[a]	233.0 ± 71.95	215.2 ± 47.67	0.2043[a]
Triglycerides (mmol/L)	1.80 (1.20-2.19)	1.60 (1.20-1.80)	0.0037[b]	2.07 ± 0.49	1.46 ± 0.39	0.0010[a]
GGT (μkat/L)	0.46 ± 0.20	0.45 ± 0.19	0.7180[a]	0.53 ± 0.21	0.50 ± 0.16	0.3463[a]
GGT (IU/L)	28.16 ± 12.55	26.61 ± 11.51	0.6098[a]	31.75 ± 12.54	30.55 ± 9.66	0.5162[a]
Albumin (g/L)	41.05 ± 2.514	40.74 ± 1.912	0.5799[a]	41.75 ± 2.113	41.36 ± 1.629	0.6375[a]
ALT (μkat/L)	0.54 ± 0.37	0.47 ± 0.16	0.3389[a]	0.34 (0.25-0.84)	0.45 (0.33-0.60)	0.3652[b]
ALT (IU/L)	31.93 ± 22.19	28.17 ± 9.796	0.3776[a]	20.36 (15.00-50.30)	25.00 (20.00-36.00)	0.4492[b]
AST (μkat/L)	0.40 (0.30-0.54)	0.41 (0.33-0.50)	0.8797[b]	0.66 ± 0.44	0.50 ± 0.24	0.2277[a]
AST (IU/L)	25.00 (19.00-34.13)	24.00 (19.00-30.00)	0.7940[b]	39.33 ± 26.44	30.09 ± 15.07	0.2452[a]
AAR	0.98 ± 0.37	0.95 ± 0.22	0.6301[a]	1.57 ± 1.62	0.97 ± 0.16	0.2424[a]
NAFLD	-0.870 (-1.02–0.27)	-1.71 (-2.19–0.80)	0.0149[b]	1.70 (0.98- 2.32)	0.25 (-0.61- 1.07)	0.0029[b]
FLI	88.43 ± 10.26	72.09 ± 21.29	0.0031[a]	98.00 (96.00-100.0)	87.00 (73.00-95.00)	0.0098[b]

Values expressed as mean ± SD or median (IQR), *n* = 23 (cohort 1) and 11 (cohort 2)
[a]Paired Student's *t*-test; [b]Wilcoxon matched-pairs signed-rank test

was apparent from the significant decrease in the 1-year post-surgery levels of body weight (P<0.0001), waist circumference (P<0.0001), body mass index (P<0.0001), and the serum level of triglycerides (P=0.0010) compared to the pre-surgery baseline measurements. The bariatric surgery also induced a prominent improvement in this cohort of patients with advanced liver fibrosis, recording a significant improvement in the NAFLD fibrosis index (P=0.0029) after one year, indicating an attenuation of hepato-steatosis as revealed by the significant reduction in the fatty liver index (P=0.0098) compared to the pre-surgery baseline paired controls.

The FIB-4 liver fibrosis index was used in combination with the NAFLD scoring system. Among the 64 bariatric surgery patients, 56 (87%) patients belonged to the cohort of FIB-4 fibrosis stages F0-F1 (FIB-4 index < 1.30), see Table 4, while no patient with advanced fibrosis (≥ F3 = > 2.67) was present in our group. In the FIB-4 F0-F1 cohort of patients, a marked improvement of the morbidity was observed, manifesting itself as a significant decrease in the

Table 4. Paired value analysis of basic changes in clinical and biochemical characteristics of morbidly obese patients before and 1 year after bariatric surgery in the FIB-4 liver fibrosis patients cohort.

Characteristics	FIB-4 fibrosis score = < 1.30 (F0-F1)		
	Before surgery	1 year after surgery	*P*
Weight (kg)	122.0 (108.0-133.0)	90.00 (81.00-100.0)	< 0.0001[a]
Wci (cm)	124.0 (114.0-137.0)	100.0 (96.00-108.0)	< 0.0001[a]
BMI (kg/m^2)	42.96 (37.24-48.00)	31.00 (29.00-34.00)	< 0.0001[a]
Platelets (×10^9/L)	281.1 ± 60.01	269.7 ± 58.20	0.0441[b]
Triglycerides (mmol/L)	1.70 (1.20-2.00)	1.40 (1.20-1.71)	< 0.0001[a]
GGT (μkat/L)	0.43 (0.31-0.60)	0.44 (0.31-0.57)	0.1423[a]
GGT (IU/L)	25.75 (18.56-36.00)	25.00 (19.00-34.00)	0.1636[a]
Albumin (g/L)	41.26 ± 2.319	41.45 ± 1.874	0.5414[b]
ALT (μkat/L)	0.42 (0.34-0.71)	0.46 (0.34-0.66)	0.2287[a]
ALT (IU/L)	25.00 (20.36-42.51)	28.00 (20.00-38.00)	0.1636[a]
AST (μkat/L)	0.40 (0.31-0.54)	0.41 (0.33-0.55)	0.6270[a]
AST (IU/L)	23.95 (19.00-32.00)	25.00 (21.00-32.00)	0.5989[a]
AAR	0.88 ± 0.32	0.94 ± 0.20	0.0691[b]
FIB-4	0.72 (0.60-1.01)	0.83 (0.61-1.10)	0.0007[a]
FLI	95.00 (83.00-99.00)	68.00 (48.00-84.00)	< 0.0001[a]

Values expressed as median (IQR) or mean ± SD, n = 55
[a]Wilcoxon matched-pairs signed-rank test
[b]Paired Student's *t*-test

body weight (*P*<0.0001), waist circumference (*P*<0.0001) and the body mass index (*P*<0.0001) when compared to the individual patients' baseline characteristics. The analysis of the clinically relevant serum biochemical analysis in these patients 1 year after the bariatric surgery showed a significant decrease in the platelet count (*P*=0.0441) and the level of triglycerides (*P*<0.0001). The non-invasive FIB-4 scoring system also further validated the beneficial effects of the bariatric surgery on the reduction of the obesity-associated morbidities and on the enhancement of the overall patient's quality of life. This was substantiated by the significant improvement in the FIB-4 liver fibrosis index (*P*=0.0007) and a change in the severity of steatosis as apparent from the significant decrease in the index of fatty liver conditions (*P*<0.0001) as compared to the parameters of the pre-surgery baseline paired controls in this FIB-4 fibrotic patients' cohort.

DISCUSSION

We set out to assess the outcomes of patients who had undergone bariatric surgery one year after the procedure. Our assessment registered successful outcomes in 88% of patients one year after the surgery as measured by a 10% excess weight loss (EWL), a decrease in FLI, or both.

Using the BMI and lipid levels as our proxy for the metabolic syndrome[52], we found an overall improvement rate of 88% one year after the surgery. Panagioutou et al. 2018 illustrated resolution of dyslipidemia in >95% of patients undergoing bariatric surgery 2 years following surgery and a 95% reduction in the prevalence of the metabolic syndrome five years following surgery. Although the exact mechanisms through which bariatric surgery leads to the resolution of NAFLD is unknown, it is assumed to lead to changes in gut hormones, inflammatory conditions, insulin sensitivity, weight loss and dyslipidaemia[53]. Our results, which were restricted only to patients with severe fibrosis or advanced cirrhosis, showed a change in the proportion of patients with advanced fibrosis (F3-F4). This is in accordance with results of prior studies, in which bariatric surgery has been shown to be capable of reversing even cirrhosis[54]. Similarly, our results are also in accordance with those reported by Nostdet et al. (2016) who have shown that in 80% of patients, fibrosis scores were either improved or unchanged after the surgery[55]. It is also worth mentioning that our results are in agreement with those reported by Nosdet et al. even though in our study, we used a non-invasive indicator of liver damage while Nosdet et al. used liver biopsy. This further corroborates the validity of the non-invasive approach chosen in our study.

Various studies have examined the predictors of success or failure of the surgery. At present, however, there is no consensus on EWL value considered as success; the same can be said about standardization of the follow-up time[56]. In our study, a total of 8 (12%) patients did not show improvement, i.e, their triglyceride levels remained >2.3 mmol/L and/or there was less than 10% change in body weight one year after the surgery. Those who did not show improvements had slightly higher baseline weights, waist circumference, triglyceride levels and liver function tests (Table 5).

Younger age was previously reported to be a significant predictor of weight loss at 12 months following the surgery for patients who underwent Endoscopic Sleeve Gastroplasty[57]. Similarly, a higher body fat percentage has been shown to predict weight loss following surgery[58]. On the other hand, our results showed that a higher proportion of patients with higher triglycerides and anthropo-

Table 5. Comparison of patients who had improvements in weight and metabolic derangements one year following bariatric surgery at the University Hospital Ostrava, Czech Republic, 2016-2018.

Patient characteristics at baseline	Patients who improved (n=64)	Patients who did not improve (n=8)
Median age in years (IQR)	47 (38-45)	44 (38-53)
Gender		
Female	50 (78%)	6 (75%)
Male	14 (22%)	2 (25%)
median weight kg (IQR)	125 (110-143)	129 (118-133)
median waist circumference cm (IQR)	126 (117-136)	136 (127-136)
BMI category kg/m^2		
30.0-39.9	16 (25%)	2 (25%)
≥40	48 (75%)	6 (75%)
Median Triglycerides mmol/L		
<1.7	32 (50%)	0 (0)
1.7-2.2	27 (42%)	2 (25%)
2.3-5.6	5 (8%)	4 (50%)
≥5.7	0 (0)	2 (25%)
FLI		
<60	0 (0%)	0 (0%)
≥60	64 (100%)	8 (100%)
median albumin g/dL (range)	4.20 (3.60-4.70)	4.00 (3.50-4.30)
Median AST IU (range)	23.95 (3.59-108.0)	34.13 (26.95-36.00)
Median ALT IU (range)	25.00 (11.0-113.7)	41.32 (17.96-50.30)
Median GGT IU (range)	25.75 (11.38-68.0)	30.00 (26.95-44.31)
AAR ratio		
<1.0	42 (66%)	4 (50%)
1.0-1.9	20 (31%)	4 (50%)
≥2.0	2 (3%)	0 (0%)
NAFLD Score		
F0-F2	23 (36%)	0 (0%)
Indeterminate	30 (47%)	6 (78%)
F3-F4	11 (17%)	2 (22%)
FIB-4 Index		
<-1.45	56 (87%)	8 (100%)
1.45-3.25	8 (13%)	0 (0%)
>3.25	0 (0%)	0 (0%)
Median Platelet count ×10^9/L (range)	257 (131.0-434.0)	283 (227.0-357.0)
Type of surgery		
Laparoscopic gastric bypass	8 (12%)	3 (37%)
LSG	53 (93%)	3 (37%)
Laparoscopic gastric plication	3 (5%)	2 (26%)
DM		
Present	15 (23%)	6 (75%)
Absent	49 (77%)	2 (25%)
Year of Surgery		
2016	20 (77%)	6 (23%)
2017	25 (96%)	1 (4%)
2018	19 (95%)	1 (5%)

morphic measurements, i.e., values positively correlated with body fat percentage, were found among patients who did not improve. In this, our results are similar rather to other studies[59,60]. In another paper, ALT and AST have been shown to predict successful weight loss one year after the surgery[61,62].

There are three types of bariatric surgery procedures: (i) restrictive procedures such as sleeve gastrectomy or gastric plication that reduce the size of the stomach so that less food can be consumed, (ii) malabsorptive, i.e. biliopancreatic diversion that bypasses a segment of the small bowel so that less food is absorbed and (iii) a hybrid procedure, i.e., the Roux-en-Y gastric bypass[53]. Our results illustrated better outcomes in patients who underwent laparoscopic sleeve gastrectomy (LSG). This is accordance with conclusions by Fobi et al.[51] that LSG negates the need for further intervention and periodic blood testing to identify and treat deficiencies, resulting in substantial

weight loss and resolution of comorbidities up to 3-5 years follow-up. Initial weight loss from the sleeve gastrectomy alone was in their study found to be very good (50-60% excess weight loss) at one year without the need for further intervention. The LSG provides additional advantages; namely, no anastomoses (connections between the bowel parts) are created and it's possible to convert it later to either the gastric bypass or lap band if needed.

Our study comes with some limitations. A shorter follow-up period did not allow us to assess long-term morbidity and mortality rates following surgery as well as other effects on weight loss[64]. We did not perform liver biopsy or imaging procedures for evaluation of the liver condition of individual patients, i.e. methods that are most commonly used for definitive diagnosis of NAFLD (ref.[65]). However, the surrogate non-invasive markers used in our study were shown to provide results of sufficient reliability for diagnosis and follow-up[66].

NFS scores of < -1.455 indicated a fibrosis score of F0-F2, NFS scores of -1.455 – 0.675 indicated an indeterminate fibrosis score, and NFS scores of > 0.675 correlated with a fibrosis score of F3-F4. Patients' results were classified into groups F0 indicating no fibrosis, F1 (mild fibrosis), F2 (moderate fibrosis), F3 (severe fibrosis) and F4 (liver cirrhosis)

CONCLUSION

A prospective study in morbidly obese patients showed that one year following the bariatric surgery, a significant improvement in morbidity-associated clinical conditions was detected in 88% of patients. The patients showed a marked reduction in the body weight, waist circumference, and body mass index, as well as a decrease in the serum level of triglycerides. Using the validated NAFLD-FIB-4 non-invasive scoring system that avoids the need for invasive liver biopsy, it was observed that bariatric surgery bestowed a significant decrease in fibrosis in a majority of patients, along with a reduction in steatosis. It can be concluded that bariatric surgery-induced weight loss may lead to a marked improvement in several factors involved in the regulation of inflammation and fibrogenesis in patients with NAFLD and may therefore substantially safeguard the patients from the development of cirrhosis and hepatocellular carcinoma.

ABBREVIATIONS

AAR, ALT/AST ratio; ALT, Alanine amino-transferases; AST, Aspartate amino-transferases; BMI, Body mass index; EWL, Excess weight loss; FIB-4, Hepatic fibrosis index; FLI, Fatty liver index; GGT, Gamma glutamyl-transferase; IFG, Impaired fasting glycaemia; IQR, Median interquartile range; IR, Insulin resistance; LGP, Laparoscopic gastric plication; LSG, Laparoscopic sleeve gastrectomy; NAFLD, Non-alcoholic fatty liver disease; NASH, Non-alcoholic steatohepatitis; NFS – NAFLD, fibrosis score; SADI-S, Single anastomosis duodeno-ileal bypass-sleeve gastrectomy; SD, Standard deviation; SEM, Standard error of mean; TG, Triglycerides.

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