# Regression of metabolic syndrome depending on type of bariatric surgery

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**Abstract**

***Introduction:*** *The metabolic syndrome (MS) is the combination of the most hazardous risk factors for development of arteriosclerosis and type II diabetes mellitus. Central obesity is a particularly well recognized factor in aetiology of MS. It is estimated that about 20% of the population in Poland is affected by MS.*

***Material and methods:*** *Two hundred and twenty-two patients were treated for obesity in our department between January 2003 and December 2005. 201 of them met the inclusion criteria (BMI ≥ 40 kg/m$^2$). Postoperative questionnaires were sent to all patients within 12 months after the surgical procedure and 152 (75.62%) responses were received. Metabolic syndrome meeting the criteria of IDF 2005 was diagnosed in 53.3% of cases (n = 81). The main goal of the study was to evaluate the impact of different types of bariatric surgery on metabolic syndrome (regression of MS).*

***Results:*** *The MS regressed in 70.4% (n = 57, p = 0.008). The comparison of the results in the group with BMI ≥ 40 < 50 kg/m$^2$ and with BMI ≥ 50 kg/m$^2$ showed better results in the group with lower BMI [82% (p = 0.0223), 51.6% (p = 0.0043) respectively]. In both groups the best results were observed after gastric bypass (GB), followed by adjustable silicone gastric banding (ASGB) and vertical banded gastroplasty (VBG).*

***Conclusions:*** *Regression of metabolic syndrome was observed after all types of operations, but gastric bypass was the most effective procedure, especially for super-obese patients. This should be taken into consideration when planning surgical treatment.*

***Key words:*** *metabolic syndrome, bariatric surgery, morbid obesity, outcomes.*

## Introduction

The metabolic syndrome is the combination of the most hazardous, often related risk factors of cardiovascular diseases and diabetes mellitus type II [1]. The increasing prevalence of this syndrome is mainly due to the changes of lifestyle which have occurred in most developed countries. These changes, such as limitation of physical activities and easy access to high-calorie food, have caused a growing epidemic of obesity [2]. Similar problems have also been observed in our country.

The relationship between the metabolic syndrome and obesity is well documented [3]. The two most popular definitions of MS published by IDF and NCEP-ATPIII indicated that obesity, especially central type, plays the main role in its aetiology [4, 5]. Metabolic syndrome is a major epidemiological problem [6]. It is estimated that MS affects about 24% of the population in the United States and 20% in Poland [7, 8].

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The treatment of MS should be multidisciplinary and involving relevant specialists. All patients should consult a dietician [9]. Basic elements in management of MS include diet, physical exercise, psychological support, pharmacological treatment of medical comorbidities and surgical procedures [10]. Long-term efficacy of conservative treatment of obesity is very low. Surgical treatment should be considered when conservative measures fail [11].

## Material and methods

Two hundred and twenty-two patients were treated for obesity in our department between January 2003 and December 2005. Two hundred and one of them met the inclusion criteria (BMI ≥ 40 kg/m$^2$). After one year 152 patients returned the postoperative questionnaire (75.6%). The group consisted of 106 women (69.7%) and 46 men (30.3%), aged from 17 to 64 years old, mean age 37.5 years. There were performed three types of operation: 2 restrictive, ASGB ($n$ = 53) and VBG ($n$ = 80) and 1 restrictive-malabsorptive, GB ($n$ = 19). All the operations were performed by one surgeon.

Adjustable silicone gastric banding was done laparoscopically by using five ports located in the upper abdomen. The band was placed by the pars flaccida approach. The anterior part of the band was covered by one or two sutures to avoid slippage.

Vertical banded gastroplasty was performed by the open approach using the standard technique.

Gastric bypass was performed by the open technique. The length of alimentary loop was 150 cm and biliopancreatic one was 100 cm.

Metabolic syndrome meeting the criteria of IDF 2005 was diagnosed in 53.4% ($n$ = 81). Systemic hypertension was observed in 54.6% ($n$ = 83), diabetes mellitus type II (DM) or impaired glucose tolerance (IGT) in 39.47% ($n$ = 60), hypertriglyceridaemia (HTG) in 39.47% ($n$ = 60) and low level of HDL in 40.1% ($n$ = 61). All the patients had central obesity.

In the ASGB group the mean BMI was 44.1 kg/m$^2$ (F 42.9 kg/m$^2$, M 45.1 kg/m$^2$), and MS was observed in 26.53% ($n$ = 16). In the VBG group the mean BMI was 47.5 kg/m$^2$ (F 46.4 kg/m$^2$, M 49.9 kg/m$^2$), and MS was observed in 61.2% ($n$ = 49). In the GB group the mean BMI was 54.8 kg/m$^2$ (F 50.5 kg/m$^2$, M 57.9 kg/m$^2$), and MS was observed in 84.2% ($n$ = 16).

The groups depending on the type of operations differed greatly in the occurrence of MS, its elements and preoperative BMI (Table I).

All operated patients were divided into three groups depending on the type of operation. The ASGB group had the lowest mean BMI, the GB one the highest and the VBG one medium. That is why patients who were qualified for ASGB less often had MS and its components. According to current world literature the operation with lowest %EWL is ASGB [12-14] followed by VBG [15-18] and GB [19-22]. Patients with lower preoperative BMI achieved better results in regression of MS and its components, which is why the preoperative BMI was also considered [22-25]. The patients were divided into two groups, with BMI ≥ 40 < 50 kg/m$^2$ ($n$ = 113) and with BMI ≥ 50 kg/m$^2$ ($n$ = 39).

The main goal of the study was to evaluate the impact of different types of bariatric surgery on metabolic syndrome (regression of MS). The evaluation of ponderal decrease was based on the excess weight loss in percentage (%EWL).

Mean ± standard deviation (SD) was used to express the descriptive data. We used paired Student's $t$ test to analyze pre- and postoperative features between groups. A multivariate logistic regression analysis was carried out to establish the correlation between clinical factors and the prevalence of MS. Two-sided $p$ values were regarded as significant when $p < 0.05$. We used Statistica 6.0 PL for Windows (Statsoft).

**Table I.** BMI according to the type of operation

| Type of operations | $N$ | BMI | | | |
|---|---|---|---|---|---|
| | | mean ± SD | 95% CL[a] | minimum | maximum |
| ASGB | 53 | 44.1 ±3.7 | 43.1-45.1 | 40.1 | 56.8 |
| VBG | 80 | 47.7 ±6.6 | 46.1-49.0 | 40.4 | 66.4 |
| GB | 19 | 54.8 ±7.6 | 51.1-58.5 | 42.2 | 70.0 |
| Σ | 152 | 47.2 ±6.7 | 46.2-48.3 | 40.1 | 70.0 |

[a]*95% confidence limits*

## Results

After 12 months MS had regressed in 70.37% ($n$ = 57, $p$ = 0.008), HT in 69.88% ($n$ = 58, $p$ = 0.0005), DM or IGT in 45% ($n$ = 27, $p$ = 0.0422), HGT in 65% ($n$ = 39, $p$ = 0.0133) and low level of HDL in 78.89% ($n$ = 48, $p$ = 0.0167).

In the group with BMI ≥ 40 < 50 kg/m$^2$ MS was observed in 44.2% ($n$ = 50). There were performed 49 ASGBs [mean BMI 43.3 kg/m$^2$, MS in 13 cases (26.5%)], 60 VBGs [mean BMI 44.4 kg/m$^2$, MS in 34 cases (56.7%)] and 4 GBs [mean BMI 44.4 kg/m$^2$, MS in 3 (75%)] (Table II).

In the super-obesity group, MS was observed in 79.49% ($n$ = 31). There were performed 4 ASGBs [mean BMI 53.7 kg/m$^2$, MS in 3 cases (75%)], 20 VBGs [mean BMI 56.9 kg/m$^2$, in 15 (75%)], GBs [mean BMI 57.6 kg/m$^2$, in 13 cases (86.7%)] (Table III).

In the group with BMI ≥ 40 < 50 kg/m$^2$ MS regressed in 41 cases (82%, $p$ = 0.0223). In the ASGB group MS regressed in 12 cases (92.3%, $p$ = 0.2293), in the VBG group in 26 cases (76.5%, $p$ = 0.0164), in the GB in all the patients ($n$ = 3, 100%, $p$ = 0) (Figure 1).

In the case of super-obesity, MS regressed in 16 patients (51.6%), $p$ = 0.0043. The best results were also achieved after GB [MS regressed in 9 cases (69.3%, $p$ = 0.0164)], followed by ASGB [two cases (66.7% reduction) ($p$ = 0.1757)] and VBG [only 5 cases (33.3%) ($p$ = 0.106)] (Figure 2). Preoperative and postoperative rates of MS in different subgroups are shown in Figure 3.

The mean %EWL differed depending on the type of surgery. In the ASGB group it was 60.8% (F 60.6%, M 62%), in the VBG group 77.5% (F 81.3%, M 69.5%), in the GB group 72.1% (F 70%, M 73%) (Figure 4).

In the group with BMI ≥ 40 < 50 kg/m$^2$ mean %EWL was highest after VBG (80.4%), followed by GB (72%) and ASGB (60.3%) (Table IV).

In the super-obesity group the highest %EWL was achieved after GB (72.2%) followed by VBG (68.7%) and ASGB (67.3%) (Table V).

Regression of MS correlated with %EWL ($p$ < 0.005). There was performed statistical analysis of reaching parameters 50% EWL and 70% EWL. The only statistically significant factor for MS regression for both parameters was the type of operation ($p$ < 0.00001, $p$ < 0.00000). Regression of MS was statistically significant after reaching 70% EWL ($p$ < 0.05 correlation coefficient = 0.38); stepwise multiple regression indicated as the most effective procedure GB followed by VBG and ASGB.

## Discussion

The MS according to IDF criteria was present in 53.4% of participants. This is similar to other studies [26-28]. The loss of weight after bariatric surgery

**Table II.** BMI in the group with BMI ≥ 40 < 50 kg/m$^2$ according to the type of operation

| Type of operations | N | BMI | | | |
|---|---|---|---|---|---|
| | | mean ± SD | 95% CL[a] | minimum | maximum |
| ASGB | 49 | 43.3 ±2.5 | 42.6-44.0 | 40.1 | 48.7 |
| VBG | 60 | 44.4 ±2.9 | 43.7-45.2 | 40.4 | 50.0 |
| GB | 4 | 44.1 ±1.8 | 41.2-47.0 | 42.2 | 46.1 |
| Σ | 113 | 43.9 ±2.7 | 43.4-44.4 | 40.1 | 50.0 |

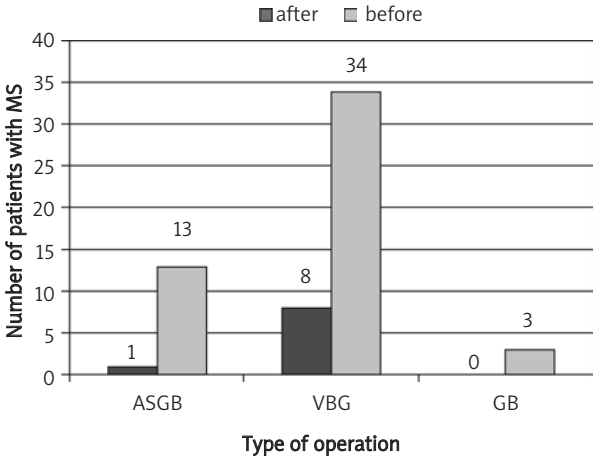


**Figure 1.** Number of patients with BMI ≥ 40 < 50 kg/m$^2$ with MS before and after depending on the type of operation

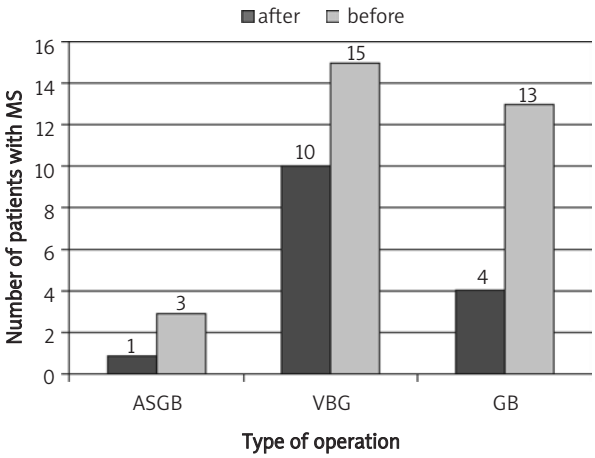


**Figure 2.** Number of patients with BMI ≥ 50 kg/m$^2$ with MS before and after depending on the type of operation

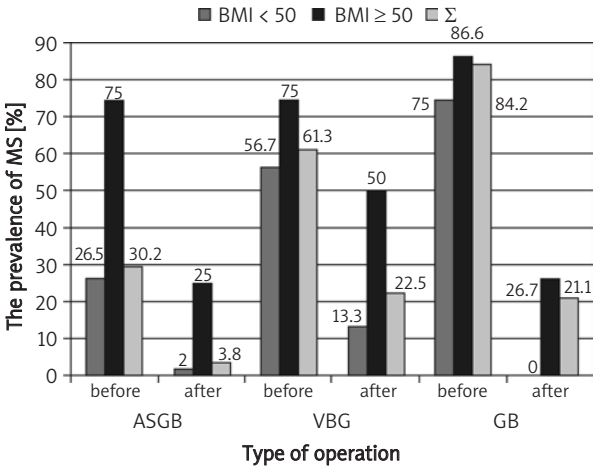


**Figure 3.** Prevalence of MS before and after operation according to preoperative BMI and the type of surgical procedures

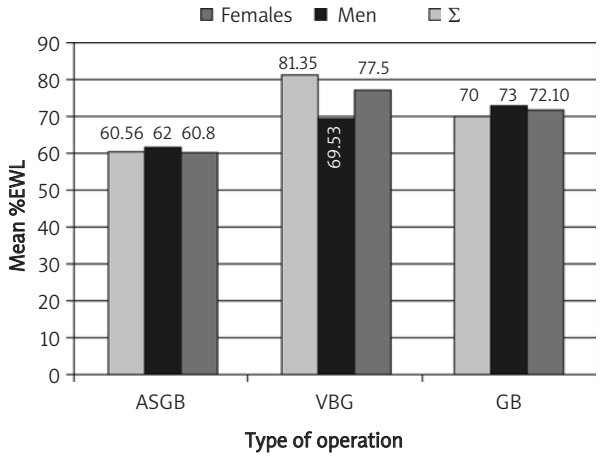


**Figure 4.** The mean %EWL depending of the type of operation and gender

was associated with regression or at least improvement of obesity comorbidities [29]. Our study, to the best of our knowledge, provides the first comparison of resolution of the MS following different types of bariatric operation. It is commonly believed that eating sweets, binge eating, and super-obesity (BMI > 50 kg/m$^2$) can negatively affect the results of ASGB or VBG. Larsen *et al.* reported a negative relation between binge eating and outcome after laparoscopic ASGB [30]. In contrast, Mittermair *et al*. observed no influence of eating sweets and super-obesity on postoperative weight reduction after laparoscopic ASGB [31]. Similar results were demonstrated by Korenkov *et al*. [32]. In our study we observed differences in %EWL between the type of operation; %EWL was 60.8% for ASGB, 77.5% for VBG and 72.1% for GB. Mognol *et al*. compared 179 patients after laparoscopic AGB with 111 patients after laparoscopic GB [33]. The patients after laparoscopic GB had significantly better %EWL than did those after ASGB (63% compared with 41% at 1 year, and 73% compared with 46% at 2 years). Buchwald *et al*. performed a systematic review and meta-analysis of 136 studies that included a total of 22 094

**Table IV.** %EWL in the group with BMI ≥ 40 < 50 kg/m$^2$ depending on the type of operation

| Type of operations | *N* | %EWL | | | |
|---|---|---|---|---|---|
| | | mean ± SD | 95% CL | minimum | maximum |
| ASGB | 49 | 60.3 ±11.0 | 57.1-63.4 | 45.2 | 89.2 |
| VBG | 60 | 80.4 ±15.5 | 76.4-84.4 | 28.6 | 100.0 |
| GB | 4 | 72.0 ±10.9 | 54.6-89.4 | 58.3 | 82.5 |
| Σ | 113 | 71.4 ±16.7 | 68.3-74.5 | 28.6 | 100.0 |

**Table III.** BMI in the group with BMI ≥ 50 kg/m$^2$ according to the type of operation

| Type of operations | *N* | BMI | | | |
|---|---|---|---|---|---|
| | | mean ± SD | 95% CL | minimum | maximum |
| ASGB | 4 | 53.7 ±3.2 | 48.7-58.8 | 50.7 | 56.8 |
| VBG | 20 | 56.9 ±5.7 | 54.3-59.6 | 50.0 | 66.4 |
| GB | 15 | 57.7 ±5.7 | 54.5-60.8 | 50.1 | 70.0 |
| Σ | 39 | 56.9 ±5.5 | 55.1-58.7 | 50.0 | 70.0 |

**Table V.** %EWL in the group with BMI ≥ 50 kg/m$^2$ depending on the type of operation

| Type of operations | *N* | %EWL | | | |
|---|---|---|---|---|---|
| | | mean ± SD | 95% CL | minimum | maximum |
| ASGB | 4 | 67.3 ±23.4 | 30.0-104.5 | 41.5 | 98.1 |
| VBG | 20 | 68.7 ±15.8 | 61.3-76.1 | 48.7 | 96.2 |
| GB | 15 | 72.2 ±5.4 | 69.2-75.1 | 61.0 | 81.8 |
| Σ | 39 | 69.9 ±13.5 | 65.5-74.3 | 41.5 | 98.1 |

patients [34]. The meta-analysis concentrated on weight loss outcomes and the impact of bariatric surgery on four selected obesity comorbidities. The mean (95% confidence limits) %EWL was 61.2% (58.1-64.4%) for all patients, 47.5% (40.7-54.2%) for patients who underwent ASGB, 61.6% (56.7-66.5%) for GB, 68.2% (61.5-74.8%) for VBG, and 70.1% (66.3-73.9%) for BPD or duodenal switch.

There are only a few studies which have used MS criteria in evaluating the outcomes after bariatric surgery, and all of them compared only one type of bariatric operation to conservative treatment. There are some studies comparing the outcomes of ASGB and conservative treatment of obesity. The first of them, a prospective, randomized study made by O'Brien *et al*., showed a significantly higher efficiency of operational treatment in the resolution of the MS and excess weight loss over the conservative treatment [35]. The metabolic syndrome was initially present in 15 patients (38%) in each group and was present in 8 non-surgical patients (24%) and 1 surgical patient (3%) at the completion of the study. Similar observations were made by Gazzaruso *et al*. [36]. Other researchers compared resolution of MS after malabsorptive procedures. Batsis *et al*.'s study showed that the MS is a largely reversible phenomenon in patient with class II and III obesity [37]. They compared the effects of conservative treatment of the MS and bariatric surgery (GB). The number of patients with MS decreased from 156 (87%) of 180 patients to 33 (29%); of the 157 non-surgical patients, MS prevalence decreased from 133 patients (85%) to 117 (75%). They suggested that reversibility of MS depends more on the amount of excess weight lost than on other parameters. Similar observations were made by Ballantyne *et al*. after GB and Scopinaro *et al*. after duodenal switch (DS) [38, 39].

In our study a reduction of %EWL > 70% correlated with statistical significance with resolution of MS. Rossi *et al*. observed a 2.4-fold increase in probability of improvement in risk factors associated with MS with a reduction of %EWL > 67.2% [40].

The results in %EWL after VBG and GB, especially in super-obesity (68.7 ±15.8%, 72.2 ±5.4% respectively), are relatively similar. But there is a big difference in resolution of MS after these operations [33.3% ($p$ = 0.106), 69.3% ($p$ = 0.0164) respectively]. This indicates that loss of weight after bariatric surgery is not the only factor responsible for regression of MS. It needs further evaluation.

## Conclusions

In conclusion, regression of metabolic syndrome was observed after all types of operations, but gastric bypass was the most effective procedure, especially for super-obese patients. This should be taken into consideration when planning surgical treatment.

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