


Superior socioeconomic status in patients with type 2 diabetes having gastric bypass surgery: a case-control analysis of 10 642 individuals

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ABSTRACT

Introduction The incidence of type 2 diabetes mellitus (T2DM) is increasing, in parallel with the epidemic of obesity. Although bariatric surgery, which profoundly affects T2DM, has increased 10-fold since the millennium, only a fraction of diabetics is offered this treatment option.

Objective To investigate the association between clinical and socioeconomic factors in selecting patients with T2DM for bariatric surgery in a publicly financed healthcare system.

Research design and methods Cohort study using prospectively registered data from two nationwide quality registers, the Scandinavian Obesity Surgery Registry (SOReg) and the Swedish National Diabetes Register (NDR), and data from two government agencies. An age, gender and body mass index-matched case-control analysis containing 10 642 patients with T2DM was performed.

Results Patients with T2DM having bariatric surgery had a higher education level (upper secondary school or college level, OR 1.42% and 95% CI (1.29 to 1.57) and 1.33 (1.18 to 1.51), respectively) as well as a higher income (OR 1.37 (1.22 to 1.53) to 1.94 (1.72 to 2.18) for quartile 2–4) than non-operated patients. Operated patients were more often married or had been married (OR 1.51 (1.37 to 1.66) and 1.65 (1.46 to 1.86), respectively) as well as natives (OR 0.84 (0.73 to 0.95) if born in the rest of Europe). Groups did not differ regarding relevant laboratory data and present medication, nor in former in-patient diagnoses.

Conclusion Despite similar clinical data, superior socioeconomic status was associated with increased rate of bariatric surgery in patients with T2DM. We believe that this warrants actions, for example concerning referral patterns.

INTRODUCTION

The incidence of type 2 diabetes mellitus (T2DM) is increasing, in parallel with the epidemic of obesity.^{1 2} Accordingly, bariatric surgery has increased 10-fold since the millennium^{3 4} and in 2016, almost 700 000 bariatric procedures were done worldwide.³ Although obesity⁵ and the need for bariatric surgery is more prevalent in lower socioeconomic groups,⁶ the impact of socioeconomic status on selecting individuals with T2DM for bariatric surgery has not been studied.

Significance of this study

What is already known about this subject?

▶ Although bariatric surgery profoundly affects type 2 diabetes mellitus, only a fraction of diabetics are offered surgical treatment.

What are the new findings?

▶ Despite similar clinical data, superior socioeconomic status was associated with increased rate of bariatric surgery.

How might these results change the focus of research or clinical practice?

▶ Indications for referring patients to bariatric surgery should be discussed and revised.

Bariatric surgery in diabetes

Bariatric surgery profoundly affects T2DM and is better than all other treatment modalities as demonstrated in several randomized clinical trials.^{7–11} In a recent 5-year follow-up by our group, two-thirds of all patients were still off all their former antidiabetic drugs.¹² At the same time point, the risk of microvascular complications was found to be 47% lower in 1111 patients with treated with bariatric surgery compared with a matched non-operated cohort. Moreover, a large decrease in the risk of diabetic retinopathy (48%) and diabetic kidney disease (46%) was found in this Danish study.¹³ According to the latest recommendation from the American Diabetes Association, patients with T2DM and body mass index (BMI) over 35, in whom conservative weight management has failed, should be recommended surgery. Furthermore, metabolic surgery (performed by identical methods to bariatric surgery) could be considered in patients with T2DM with BMI between 30 and 35 who do not achieve durable weight loss and improvement in comorbidities with reasonable non-surgical methods.¹⁴ Despite this, only a fraction of patients with

T2DM are offered bariatric surgery, for example, 0.07% of 277 862 patients in the multicenter Diabetes Prospective Follow-up Initiative (DPV database) from Germany and Austria.¹⁵ In the DPV database, bariatric patients were predominantly female, younger and had a longer diabetes duration as well as a higher BMI compared with non-operated patients. Socioeconomic factors were however not studied.

Swedish healthcare system

Sweden has a tax-financed healthcare system that aims to give equal healthcare to all citizens. Bariatric surgery with internationally accepted indications¹⁶ is fully covered within this system, that is, physicians at all levels of the healthcare system are free to refer patients with BMI >35 for surgical evaluation. In Sweden, all healthcare contacts are registered on the patient's unique personal identification number, which is also used in quality registers and other governmental databases. The present register-based cohort study of routine clinical practice was based on patients included in the national quality registers for bariatric surgery, the Scandinavian Obesity Surgery Registry (SOReg)¹⁷ and diabetes, the Swedish National Diabetes Register (NDR).¹⁸ Since 2007, SOReg has contained >70 000 patients who have had a bariatric procedure, mainly primary gastric bypass (GBP). At baseline, 15% of all included patients had T2DM. Coverage has been proven high in SOReg when validated to the Swedish National Patient Registry.¹⁹ In 2016, NDR contained data on almost 400 000 unique patients, and when compared with the Swedish Prescribed Drug Register, a 93% conformity regarding patients with T2DM treated with medications for diabetes was seen.²⁰

The aim of the present study was to evaluate which types of patients with T2DM had been selected for primary gastric bypass by comparing socioeconomic variables as well as relevant clinical data and former in-hospital diagnoses.

MATERIAL AND METHODS

After merging SOReg and NDR data, we identified 5321 patients with T2DM who had had a primary GBP between 1 January 2007 and 31 December 2015. Operated patients were matched 1:1 on age, gender and BMI to non-operated patients from the NDR. The Longitudinal Database for Health Insurance and Labor Market studies²¹ provided information about socioeconomic variables; level of education was divided in elementary school (9 years), upper secondary school (10–12 years) and college level (>12 years), while registered income was separated in quartiles (q1–q4). Marital status was divided into single, married, divorced and widowed. Country of birth was determined as Sweden, Europe (except Sweden) and the rest of the world. Patient-specific data (BMI, smoking, hemoglobin A1c, creatinine, glomerular filtration rate, blood pressure and relevant ongoing medication) from the year of surgery were collected

from the two quality registers, SOReg and NDR. Likewise, in-hospital care, based on principal International Classification of Diseases-10 diagnoses from the National Patient Register during 1997–2015 was compared. Data on controls were retrieved similarly and variables were set by the same calendar year as their operated counterparts.

Statistical methods

The study has a case-control design where each case, that is, a person who underwent a gastric bypass was fitted with an untreated person matched on age, gender, BMI and calendar time. The matched data set was then analyzed using a logistic regression model evaluating the association between being treated with gastric bypass and socioeconomic status by estimated OR and 95% CIs. The analysis model contained main effects for the four matching variables in addition to income, level of education and marital status at the time of surgery and country of origin. Descriptive statistics are presented in averages and SEs for continuous variables, and counts and proportions for categorical variables. All statistical tests use $p < 0.05$ as significance level and a standardized difference, difference in proportions divided by SE, >20 was considered to be an imbalance (small effect size). The analysis was done using SAS V.9.4.

RESULTS

In total, we identified 10 642 individuals with T2DM (average age=48 years, average BMI=41 kg/m² and 60% females) and as demonstrated in table 1, the groups differed slightly in age and BMI (standardized difference 12.2 and 11.7, respectively).

Adjusted model

In the adjusted model, the group having had gastric bypass was associated with higher education (upper secondary school or college level, OR 1.42 (95% CI 1.29 to 1.57) and 1.33 (1.18 to 1.51), respectively) as well as a higher income (OR 1.37 (1.22 to 1.53) to 1.94 (1.72 to 2.18) for q2–q4 compared with non-operated patients. Operated patients were more often married or had been

Table 1 Patient characteristics of the 10 642 included patients in the case-control analysis

Variable	Gastric bypass (n=5321)	Controls (n=5321)	Standardized difference (%)
Gender			
Male	2098 (39.4%)	1926 (36.2%)	0.0
Female	3223 (60.6%)	3395 (63.8%)	0.0
Age			
Years	49.0 (9.5)	47.1 (11.5)	12.2
BMI			
kg/m ²	42.0 (5.7)	40.9 (7.3)	11.7

Standardized difference, ie, difference in proportions divided by SE; imbalance defined as absolute value >20 (small effect size).

Table 2 Case-control analysis of the association between socioeconomic variables and gastric bypass surgery

Variable	OR with 95% CI	P value
Education		
Elementary school	Ref	<0.001
Upper secondary school	1.33 (1.18 to 1.51)	
College level	1.42 (1.29 to 1.57)	
Income		
Quartile 1	1.00 (1.00 to 1.00)	<0.001
Quartile 2	1.37 (1.22 to 1.53)	
Quartile 3	1.76 (1.57 to 1.97)	
Quartile 4	1.94 (1.72 to 2.18)	
Marital status		
Single	Ref	<0.001
Married	1.51 (1.37 to 1.66)	
Divorced	1.65 (1.46 to 1.86)	
Widowed	0.88 (0.67 to 1.15)	
Country of birth		
Sweden	Ref	0.007
Europe (except Sweden)	0.84 (0.73 to 0.95)	
Rest of the world	0.87 (0.77 to 1.00)	

Statistical differences within groups were tested by a logistic regression model.

married (OR 1.51 (1.37 to 1.66) and 1.65 (1.46 to 1.86), respectively) as well as natives (OR 0.84 (0.73 to 0.95) if born in the rest of Europe) (table 2).

As demonstrated in table 3, no differences were seen in laboratory values, present medication and former principal inpatient care diagnoses with potential medical relevance in selecting individuals for a bariatric procedure (all standardized differences well below 10).

DISCUSSION

Using nationwide registers, we found that bariatric surgery was more common in patients with T2DM having superior socioeconomic status, that is, higher education and income, married or having been married and natives. Because clinical data did not differ, we believe that this warrants actions, for example, concerning indications for referrals to bariatric surgery.

Education and income

In line with the present study, Memarian *et al* showed that bariatric surgery in Sweden from 1990 to 2010 was most frequent in individuals with >11 years of education.²² Likewise, during 2011–2012 in Australia, individuals with severe obesity in the two most disadvantaged socioeconomic quintiles were 40% less likely to receive bariatric surgery.²³ Moreover, in a recent American publication on self-management education for diabetics (n=84 179), individuals with low education level (high school level or less) received less education (OR 0.71 (95% CI 0.66 to

0.78)) than college graduates.²⁴ In the present study, operated patients had higher income than the non-operated individuals. This is in line with the study by Wallace *et al*, who showed in 2010, that lower income was associated with lower OR for bariatric surgery in a cohort of 774 000 American patients with morbid obesity from the 2006 National Inpatient Sample.²⁵ The same was true for 87 749 patients in the same registry who had had bariatric surgery, when compared with >22 million eligible individuals from the 2005 to 2006 National Health and Nutrition Examination Survey.⁶ Moreover, the eligible individuals with obesity had lower income than non-eligible individuals, that is, normal-weight citizens.

Marital status

In the above-mentioned publication on sociodemographic factors associated with diabetes self-management education, no difference was found between married, widowed/divorced/separated and never married individuals.²⁴ In the literature, being married, perhaps as a proxy for social support, is associated with increased adherence to the postoperative outpatient programme²⁶ and almost seven times increased odds of having superior medium-term weight loss in 250 consecutive patients undergoing bariatric surgery.²⁷ On the other hand, an increased change in marital status, both divorces and marriages, after bariatric surgery has been found in Sweden compared with the general population.²⁸ We believe that this reflects the fundamental changes in life and social situation that occur after bariatric surgery for many patients.

Country of birth

Native Swedes with T2DM were operated more often than immigrants in our study. Likewise, the largest difference in incidence rate between Swedes and immigrants having bariatric surgery overall in 2001–2011 was observed in low-income individuals (3.4 and 2.3 per 100 000 individuals, respectively).²⁹ Because few studies have focused on the selection of individuals for bariatric surgery in first-generation or second-generation immigrants, we searched the literature for differences in race. In the USA, African-Americans were less likely to have been recommended bariatric surgery by their doctors when seen at four diverse primary care practices in Greater Boston.³⁰ When using population-based data from Michigan, a summary measure of race, gender and socioeconomic status from the 2000 census resulted in an inverse linear relationship to rates of bariatric surgery.⁵ Although race and ethnicity were not independently associated with likelihood of proceeding with bariatric surgery in a cohort of 651 patients at two academic centers in the USA,³¹ we believe that the influence of socioeconomic factors should be minimized in modern healthcare.

Possible explanations

The main question about why patients with superior socioeconomic status had bariatric surgery more often

Table 3 Comparison of clinical data, laboratory values and medication and principal in-hospital diagnoses with potential relevance in selecting individuals for a bariatric procedure

	Gastric bypass (n=5321)	Controls (n=5321)	Standardized difference (%)
Smoking (yes)	576 (15.9%)	942 (19.7%)	0.1
Laboratory values, average (SD)			
Hemoglobin A1c (mmol/mol)	59.9 (16.9)	58.5 (16.9)	5.9
Creatinine (mmol/L)	68.1 (27.6)	68.0 (25.4)	0.3
Glomerular filtration rate (mL/min)	97.2 (25.0)	98.3 (27.5)	2.8
Systolic blood pressure (mm Hg)	132.8 (14.5)	132.5 (15.6)	1.3
Diastolic blood pressure (mm Hg)	80.3 (9.6)	80.0 (9.8)	2.1
Medication, n (%)			
Metformin	3947 (74.2%)	3769 (70.8%)	0.1
Sulfonylureas	627 (11.8%)	541 (10.2%)	0.0
DPP-4 inhibitors	257 (4.8%)	239 (4.5%)	0.0
Glitazones	190 (3.6%)	150 (2.8%)	0.0
GLP-1 agonists	310 (5.8%)	245 (4.6%)	0.0
Insulin	1967 (37.0%)	1886 (35.4%)	0.0
NSAID	1852 (34.8%)	1476 (27.7%)	0.1
Opiates	1658 (31.2%)	1026 (19.3%)	0.2
Antihypertensives	2504 (66.2%)	3034 (60.4%)	0.1
Lipid-lowering drugs	2688 (50.5%)	2414 (45.4%)	0.1
Anticoagulants	153 (2.9%)	170 (3.2%)	0.0
Psychiatric drugs	520 (9.8%)	529 (9.9%)	0.0
Drugs for alcohol abuse	94 (1.8%)	122 (2.3%)	0.0
Principal in-hospital care, n (%)			
Coronary heart disease	408 (7.7%)	313 (5.9%)	0.0
Acute myocardial infarction	174 (3.3%)	169 (3.2%)	0.0
Stroke	109 (2.1%)	103 (1.9%)	0.0
Atrial fibrillation	165 (3.1%)	149 (2.8%)	0.0
Heart failure	153 (2.9%)	168 (3.2%)	0.0
Hypoglycemia with coma	57 (1.1%)	61 (1.1%)	0.0
Hyperglycemia	83 (1.6%)	130 (2.4%)	0.0
Kidney failure	60 (1.1%)	82 (1.5%)	0.0
Cancer	113 (2.1%)	158 (3.0%)	0.0
Psychiatric disorders	361 (6.8%)	346 (6.5%)	0.0
Alcohol abuse	94 (1.8%)	122 (2.3%)	0.0
Deep vein/pulmonary thrombosis	74 (1.4%)	65 (1.2%)	0.0
Abdominal pain	387 (7.3%)	334 (6.3%)	0.0
Ulcer and/or reflux	107 (2.1%)	72 (1.3%)	0.0
Gallstone, gallbladder disease	428 (8.0%)	366 (6.9%)	0.0
Malnutrition	22 (0.4%)	41 (0.8%)	0.0

Standardized difference, ie, difference in proportions divided by SE; imbalance defined as absolute value >20 (small effect size). DPP-4, dipeptidyl peptidase 4; GLP-1, glucagon-like peptide 1; NSAID, non-steroidal anti-inflammatory drug.

remains. More privileged patients are perhaps more persuasive because they have increased information on alternative treatments as well as striving more for improved quality of life. In a recent systematic review of

28 qualitative studies with 580 participants, many participants believed that weight loss surgery would produce positive psychological impacts by strengthening their personal identities, their relationships and improving

their engagement in public and professional life.³² Thus, patients seek an improvement in social life to a large extent. In contrast, individuals with lower socioeconomic status might be more grateful for the given treatment in primary care and believe that it is enough. Moreover, patient selection is questionable not only in bariatric surgery. In malignant diseases, low socioeconomic status is associated with inferior prognosis in lung cancer³³ as well as oropharyngeal³⁴ and esophageal cancer³⁵ and a doubled risk of having late-stage breast cancer,³⁶ among other inferiorities. This is probably due to a combination of patients' and doctors' delay. Finally, socioeconomic differences in use of bariatric surgery may also reflect patient's perception about surgery as well, particularly in a publicly funded healthcare system such as the present.

Strengths and limitations

There are several strengths of the study; above all the almost complete, national coverage of patients diagnosed with T2DM, with measured BMI and the possibility to use inpatient registries to identify all hospitalizations. Moreover, the use of the Swedish public healthcare system omitted the influence of insurance companies and other economic factors to a large extent. The bariatric procedure GBP was chosen because it dominated in Sweden during the study period.¹⁷ Furthermore, a recent study showed that patients selected to GBP most often met international criteria for having bariatric surgery and the weight result was more similar between hospitals.³⁷ GBP is also known to be effective in achieving diabetes resolution, for example, 77% vs 60% after sleeve gastrectomy.³⁸ However, in certain populations, such as the Indian, sleeve gastrectomy could be superior.³⁹ The fact that only primary bariatric procedures were studied creates a homogenous cohort but excludes information on the selection of patients having a second bariatric procedure (revisional cases); however, these only represent 4.4% of all cases in SOReg.¹⁷ Compared with the remaining patients registered in SOReg, individuals with diabetes were older (48.6 vs 40.0 years on average, $p < 0.001$) and had a slightly higher average BMI (42.0 vs 41.7, $p < 0.01$), whereas no difference in gender or year of surgery was seen.¹⁷ Finally, the present results concerning marriage status must be interpreted with caution because cohabitation is common in Sweden and we only had information on legal marriages. Moreover, the matching on age, gender, BMI and year of surgery precluded us from studying any differences between the groups for these four variables.

CONCLUSION

Despite the intention to provide equal healthcare in Sweden, socioeconomic factors such as education, income, marital status and country of birth varied between patients with T2DM having had bariatric surgery or not. This warrants action because surgery was more common in patients considered to have superior socioeconomic

status. Initially, national and local indications for referring patients to bariatric surgery should be discussed and revised.

Contributors MS, SF, JO and A-MS contributed to the conception and design of the study, the acquisition and interpretation of data. SF contributed to the analysis of data. MS, JO and A-MS drafted the work and revised it critically for important intellectual content. All authors approved the final version to be published; agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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