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ORIGINAL CONTRIBUTIONS

Mortality Following Bariatric Surgery Compared to Other Common Operations in Finland During a 5-Year Period (2009–2013). A Nationwide Registry Study

Camilla Böckelman[1] · Tilda Hahl[1] · Mikael Victorzon[1,2]

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Abstract

Purpose A concern regarding the safety of bariatric surgery may explain the fact that only a minor fraction of morbidly obese patients has access to it. This is a population-based, nationwide study reporting 30-day, 90-day, and 1-year mortality rates following bariatric surgery in comparison with mortality rates after other common operations in Finland.

Materials and methods Patients undergoing surgery between January 2009 and December 2013 were included. Data on surgical procedures were obtained from the national hospital discharge registry, and cause of death was obtained from Statistics Finland.

Results Inclusion criteria were met by 156,536 patients. Of these, 3918 underwent surgery for morbid obesity. Three patients (0.08%) died within 30 days following bariatric surgery. The 30-day mortality rate was lower only following prostatectomy. Compared with bariatric surgery, the hazard ratios (HR) for 1-year postoperative mortality were significantly higher for elective cholecystectomy (HR 2.38, 95% CI 1.39–4.08, $p = 0.002$), hysterectomy (HR 2.87, 95% CI 1.68–4.92, $p < 0.001$), knee arthroplasty (HR 2.23, 95% CI 1.31–3.81, $p = 0.003$), hip arthroplasty (HR 11.7, 95% CI 6.90–19.8, $p < 0.001$), colorectal resections (HR 27.5, 95% CI 16.2–46, $p < 0.001$), gastric resection (HR 53.0, 95% CI 30.2–93.2, $p < 0.001$), gastrectomy (HR 74.7, 95% CI 43.0–130, $p < 0.001$), and coronary artery bypass grafting (HR 30.7, 95% CI 17.4–54.3, $p < 0.001$).

Conclusion Mortality rates following bariatric surgery are low and similar or lower than mortality rates following all other common elective surgeries.

Keywords Obesity surgery · Bariatric surgery · Metabolic surgery · 30-day mortality · 90-day mortality · 1-year mortality · Survival

Camilla Böckelman and Tilda Hahl contributed equally to this work.

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✉ Camilla Böckelman
camilla.bockelman@helsinki.fi

[1] Department of Surgery, Vaasa Central Hospital, Hietalahdenkatu 2-4, FI-65130 Vaasa, Finland

[2] University of Turku, FI-20500 Turku, Finland

Introduction

Obesity is associated with many comorbidities [1] and with reduced life expectancy [2–4]. Compared to conservative treatment methods, bariatric surgery has demonstrated well-documented superior long-lasting results in the treatment of morbid obesity and related comorbidity [5]. It is also associated with a reduction in relative risk of death compared to conventional interventions for obesity [6–8]. In addition, surgery seems to decrease health care utilization among morbidly obese patients and improve health expenditure cost-effectiveness [7].

In Scandinavia, a tenfold increase in annual bariatric operations was seen between the years 2006 and 2011 [9, 10]. Between 2008 and 2011, the number of bariatric procedures worldwide seems to have plateaued and even slightly decreased [11]. In accordance with the global trend, the number of annual operations is currently slightly decreasing in Scandinavia. At the same time, however, the obesity epidemic remains a global health concern, and

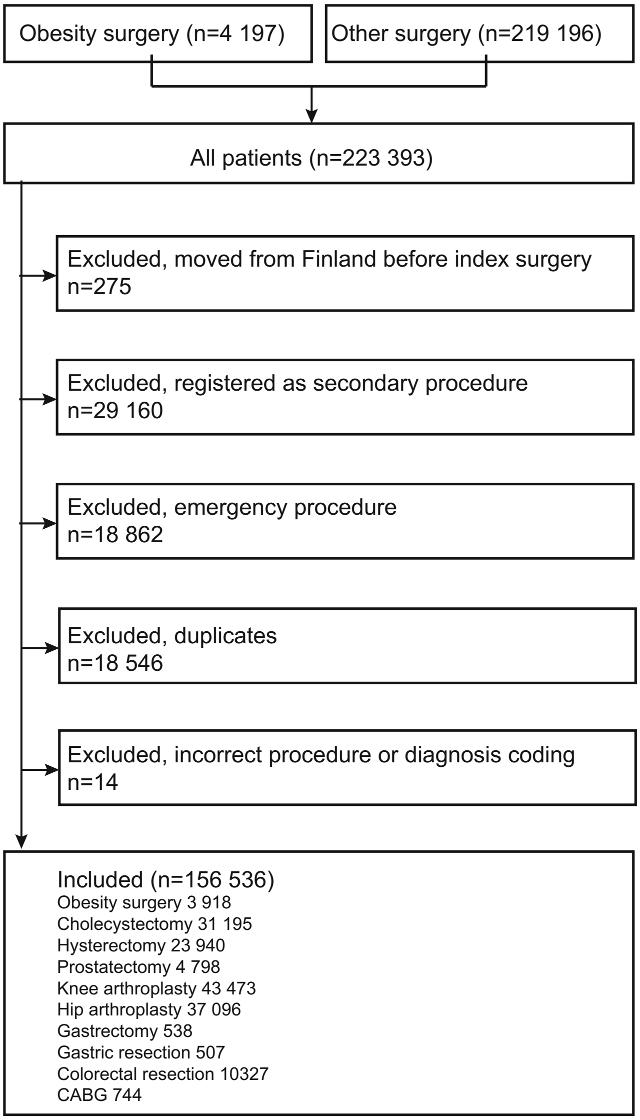

Fig. 1 Flow chart presenting inclusion of patients undergoing bariatric or other common surgery in Finland 2009–2013

despite both the magnitude of the obesity epidemic and the promising long-term results after bariatric surgery, only a minor fraction of the patients, who could benefit from surgery, actually have access to it. The medical community may be too afraid of possible surgical complications.

The reported 30-day mortality following bariatric surgery is low, ranging from 0.04 to 0.3% [12–17]. Still, there seems to be a concern about the safety of bariatric surgery. Surgery is never without risks, but improvement in perioperative management, including enhanced recovery pathways and advanced laparoscopic surgical techniques, has improved safety.

We conducted a nationwide observational study and report 30-day, 90-day, and 1-year mortality rates following bariatric surgery in Finland during a 5-year period (2009–2013) in comparison with the mortality rates after other common operations.

Materials and Methods

Patients

Data on surgical procedures were obtained from the national hospital discharge registry, administered by the National Institute for Health and Welfare, in which all discharge diagnoses and surgical procedures are entered for all Finnish hospitals. The coverage of the registry is nearly 100% from 1987 onwards [18]. The patients in the study group had surgery for obesity including open and laparoscopic gastric banding, bypass (LRYGB), sleeve gastrectomy, and biliopancreatic diversion with or without duodenal switch (International Classification of Operations and Major Procedures codes JDF00-01, JDF10-11, JDF20-21, JDF96-98, JFD00, JFD03-04, JFD96) during a 5-year period (from January 1, 2009 to December 31, 2013). The patients that served as controls underwent during the same time period elective cholecystectomy (JKA20-21), hysterectomy (LCD00-01, LCD04, LCD10-11, LCD30-31, LCD40, LCD96-97), prostatectomy (KEC00-01, KEC10, KEC20), total knee arthroplasty (NGB10, NGB20, NGB30, NGB40, NGB50, NGB60, NGB99), total hip arthroplasty (NFB10, NFB20, NFB30, NFB40, NFB50, NFB60, NFB99), gastrectomy (JDD00, JDD96), gastric resection (JDC00, JDC10-11, JDC20, JDC30, JDC40, JDC96-97), colorectal resection (JFB20-21, JFB30-31, JFB33, JFB40-41, JFB43-44, JFB46-47, JFB50-51, JFB53-54, JFB60-61, JFB63-64, JFB96-97), or coronary artery bypass grafting (CABG; FNC10, FNC20, FNC30, FNC40, FNC50, FNC60, FNC96). Data was retrieved according to procedure code regardless of diagnosis.

All citizens in Finland have unique personal identity codes. The patients identified with the procedure codes above were linked by the personal identity code to data from the nationwide Population Register for censoring due to death or emigration. Cause of death was obtained from Statistics Finland.

The study plan was approved by the National Institute for Health and Welfare in Finland (Dnro THL/307/5.05.00/2015).

Data Processing

Those who moved from Finland before index surgery were excluded. Also, those for whom the procedure code was not noted as the primary procedure were excluded. Patients undergoing emergency surgery (procedure codes ZXD00 or ZXD05) were excluded. Several persons underwent multiple operations during the time period. They were included in the obesity surgery study group if one of the operations was performed for obesity. If the person underwent only other surgery

Table 1 Patient characteristics for elective operations in Finland 2009–2013

	Bariatric		Cholecystectomy		Hysterectomy		Prostatectomy		Knee arthroplasty		Hip arthroplasty		Gastrectomy		Gastric resection		Colorectal resection		CABG	
	n	IQR/ SD/ %	*n*	IQR/ SD/ %	*n*	IQR/ SD/ %	*n*	IQR/ SD/ %	*n*	IQR/ SD/ %	*n*	IQR/ SD/ %	*n*	IQR/ SD/ %	*n*	IQR/ SD/ %	*n*	IQR/ SD/ %	*n*	IQR/ SD/ %
Total (*n*)	3918		31,195		23,940		4798		43,473		37,096		538		507		10,327		744	
Age, median (IQR)	47	40–54	55	42–66	50	45–61	63	58–66	69	62–76	70	62–77	68	60–76	72	62–80	67	58–76	71	64–77
LOS, mean (SD)	2.6	2.4	1.4	2.3	2.3	1.8	3.1	2.4	4.2	1.8	4.0	2.2	10.4	6.5	9.0	7.1	6.7	5.2	7.1	7.7
Male gender (%)	1118	28.5	9688	31.1	59*	0.2	4798	100	14,951	34.4	15,570	42.0	310	57.6	254	50.1	4708	45.6	550	73.9

CABG coronary artery bypass grafting, *IQR* interquartile range, *LOS* length of hospital stay, *SD* standard deviation

*All 59 male patients in the hysterectomy group underwent surgery due to transsexuality

than obesity surgery, they were included only in the group for first surgery performed. For some patients (approximately 10%), no date for the procedure in question was registered in the hospital discharge registry. For these, we made the assumption that surgery was performed on the same day that the person was registered at the hospital.

Statistical Analyses

Length of stay at hospital was calculated from the day of surgery until discharge. Values are reported as median (age) and mean (length of stay at hospital) together with interquartile range (IQR) or standard deviation (SD). Mortality was calculated from the day of surgery until death censoring patients at the end of follow-up (July 31, 2015) or emigration from Finland, whichever occurred first. Survival curves were constructed according to the Kaplan-Meier method and compared with the log rank test. The Cox proportional hazard model served for univariable survival analysis. All statistical tests were two-sided and a p value of <0.05 was considered statistically significant. All statistical analyses were performed with IBM SPSS Statistics version 20.0 for Mac (IBM Corporation, Armonk, NY, USA).

Results

Inclusion criteria were met by 156,536 patients who underwent predefined elective surgery in Finland during a 5-year period (from January 1, 2009 to December 31, 2013; Fig. 1). Of these, 3918 underwent surgery for morbid obesity (85.6% LRYGB, 11.4% sleeve gastrectomy, 2.6% biliopancreatic diversion with or without duodenal switch, and near 100% were done by laparoscopy. The total number of patients in other surgery groups is presented in Table 1. Those who underwent obesity surgery, as well as those undergoing cholecystectomy and hysterectomy, were in general younger than patients undergoing joint arthroplasty, gastrointestinal surgery, or CABG (Table 1). Length of stay at hospital was also shorter in these groups, compared to those undergoing joint arthroplasty, gastrointestinal surgery, or CABG. The median age for obesity surgery patients was 47 years (IQR 40–54) and mean length of stay at hospital 2.6 days (SD 2.4). The majority of obesity surgery patients were women (71.5%).

Postoperative Mortality Rates (30 and 90 days)

Following obesity surgery, three patients died within 30 days (0.08%) and four within 90 days (0.10%). The corresponding figures for 30-day and 90-day mortality rates in all surgery groups are presented in Table 2. Two of the three bariatric patients who had died within 30 days had undergone gastric

Table 2 Mortality rates after elective operations in Finland 2009–2013

	Patients, total	Mortality, 30 days		Mortality, 90 days		Mortality, 1 year	
	n	*n*	%	*n*	%	*n*	%
Bariatric	3918	3	0.1	4	0.1	14	0.4
Cholecystectomy	31,195	50	0.2	89	0.3	265	0.8
Hysterectomy	23,940	20	0.1	57	0.2	245	1.0
Prostatectomy	4798	0	0	2	0.0	19	0.4
Knee arthroplasty	43,473	35	0.1	85	0.2	346	0.8
Hip arthroplasty	37,096	428	1.2	774	2.1	1516	4.1
Gastrectomy	538	16	3.0	41	7.6	130	24.2
Gastric resection	507	23	4.5	39	7.7	88	17.4
Colorectal resection	10,327	285	2.8	465	4.5	968	9.4
CABG	744	44	5.9	58	7.8	76	10.2

CABG coronary artery bypass grafting

bypass operation (total $n = 3371$, mortality rate 0.059%), and one had undergone biliopancreatic diversion (total $n = 100$, mortality rate 1.0%). Within 30–90 days, one death occurred after gastric bypass. In Cox regression analysis, the 30-day mortality rate following obesity surgery was similar to the mortality rates after cholecystectomy, hysterectomy, prostatectomy, and total knee arthroplasty (Table 3). Postoperative mortality rate after obesity surgery was clearly lower than that after total hip arthroplasty, other gastrointestinal procedures such as gastrectomy, gastric resection, and colorectal resection, as well as after CABG (Table 3).

One-Year Mortality Rates

At 1 year postoperatively, 14 patients (0.36%) undergoing obesity surgery had died. Ten of those patients had undergone gastric bypass (total $n = 3371$, mortality rate 0.30%), two sleeve gastrectomy (total $n = 446$, mortality rate 0.49%), and two biliopancreatic diversion with or without duodenal switch (total $n = 100$, mortality rate 2.0%). The 1-year mortality rates for other study groups are presented in Table 2. Obesity surgery patients, together with those undergoing prostatectomy, had a clearly better survival compared with those undergoing cholecystectomy, hysterectomy, total knee or hip arthroplasty, other gastrointestinal surgery, or CABG (Fig. 2, $p < 0.001$, log rank test). In Cox regression analysis, the 1-year mortality rates were clearly higher for patients undergoing any other surgery than prostatectomy or obesity surgery (Table 4).

Causes of Postoperative Death

For the three bariatric patients that died within 30 days, the underlying cause of death, as noted in the death certificates, was morbid obesity (Table 5). For two cases, the immediate cause of death was sepsis and for one peritonitis, indicating death due to a postoperative surgical complication. Additionally, 11 bariatric patients died within 1 year with varying causes of death. Notably, one died by suicide and another person died of alcohol-related causes.

Causes of death were divided into five groups for further analyses: cardiovascular diseases, gastrointestinal cancers, other cancers, trauma, and other causes of death, which included all other diagnoses, such as infections, pulmonary diseases, and neurological diseases. Within 30 days after the operation, cardiovascular diseases were the most common causes of death following total knee arthroplasty ($n = 23$; 66%) and CABG ($n = 42$; 96%). Gastrointestinal cancers were the most common causes of death after gastrectomy ($n = 10$; 63%), gastric resection ($n = 10$; 44%), and colorectal resection ($n = 118$; 42%). Following hysterectomy ($n = 11$; 56%), other cancers were the most common causes of death. Trauma was the most common cause of death after total hip arthroplasty

Table 3 Hazard ratio for 30-day postoperative mortality after elective operations in Finland 2009–2013 compared with bariatric surgery

	Hazard ratio	95% CI	*p* value
Bariatric	1.00		
Cholecystectomy	2.09	0.65–6.71	0.214
Hysterectomy	1.09	0.32–3.67	0.888
Prostatectomy	0	NA	0.877
Knee arthroplasty	1.05	0.32–3.42	0.934
Hip arthroplasty	15.1	4.87–47.2	<0.001
Gastrectomy	39.4	11.5–135	<0.001
Gastric resection	60.6	18.2–202	<0.001
Colorectal resection	36.5	11.7–114	<0.001
CABG	79.6	24.7–256	<0.001

CI confidence interval, *NA* not applicable, *CABG* coronary artery bypass grafting

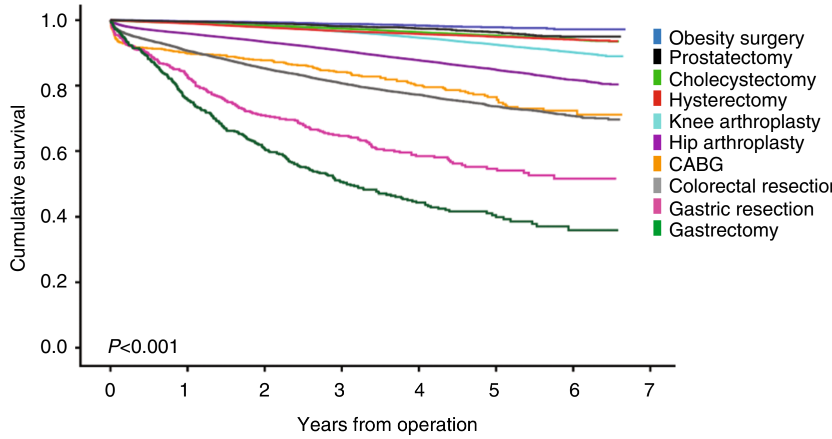

Fig. 2 Overall survival for bariatric surgery patients compared with other common operations according to the Kaplan-Meier method ($p < 0.001$, log rank test). *CABG* coronary artery bypass grafting

($n = 205$; 48%), and other reasons following bariatric surgery ($n = 3$; 100%) and cholecystectomy ($n = 22$; 44%) (Table S1, supporting information). Within 1 year after surgery, cardiovascular diseases were the most common causes of death following bariatric surgery ($n = 5$; 39%), cholecystectomy ($n = 78$; 31%), prostatectomy ($n = 7$; 41%), total knee arthroplasty ($n = 131$; 43%), total hip arthroplasty ($n = 478$; 34%), and CABG ($n = 67$; 91%). Gastrointestinal cancers were the most common causes of death following gastrectomy ($n = 97$; 87%), gastric resection ($n = 59$; 69%), and colorectal resection, ($n = 499$; 56%), and other cancers following hysterectomy ($n = 154$; 69%) (Table S2, supporting information).

Discussion

In this national registry study including 156,536 participants, 3918 underwent surgery for morbid obesity. Almost 86% were LRYGB operations. We found that the 30-day mortality rate after bariatric surgery is similar to that after hysterectomy and total knee arthroplasty, and half of that after cholecystectomy. The 30-day mortality rate of 0.08% following bariatric procedures in this study is consistent with the mortality rates reported in the literature and confirms the low mortality risk associated with bariatric surgery [12–17]. The same trend was seen in 90-day and 1-year mortality rates, which were 0.10 and 0.36%, respectively.

Compared to mortality rates after other common operations, bariatric operations were found to be among the safest. The mortality rate of bariatric procedures was lower than one tenth of that following hip arthroplasty. Prostatectomy was the only procedure in this study that had lower mortality rates than bariatric surgery. However, transurethral resection procedures were also included in the prostatectomy group, which partly explains these low mortality rates. Similar results were seen in two large studies of surgical mortality including bariatric mortality. Aminian et al. studied the surgical mortality in patients with diabetes, comparing mortality after bariatric surgery with mortality following other surgical procedures [19]. They reported a 30-day mortality rate of 0.3% after bariatric surgery, which they found to be similar to that of total knee arthroplasty. A different approach was taken by Harris et al., who studied the 30-day and 1-year surgical mortality rates in general and found a 30-day mortality rate of 0.1% after bariatric surgery, which was the same as that after cataract extraction and slightly lower than that following knee arthroplasty and prostatectomy (0.2%) [20]. In both studies, cholecystectomy, a well-accepted procedure, had higher mortality rate than bariatric procedures.

Approximately one third of the deaths after bariatric surgery have been estimated to occur after 30 days, and therefore, the 30-day mortality rate may underestimate the long-term risk [21]. Within 1 year, but after 30 days postoperatively, 11 deaths occurred in the bariatric group in our study. In comparison to other operations, bariatric surgery had the same 1-year safety profile as prostatectomy and significantly lower mortality rate than other surgery groups. Harris et al. reported a 1-year mortality rate of 0.2% after bariatric surgery [20]. They found that only tonsillectomy had as low 1-year mortality rate

Table 4 Hazard ratio for 1-year postoperative mortality after elective operations in Finland 2009–2013 compared with bariatric surgery

	Hazard ratio	95% CI	*p* value
Bariatric	1.00		
Cholecystectomy	2.38	1.39–4.08	0.002
Hysterectomy	2.87	1.68–4.92	<0.001
Prostatectomy	1.11	0.56–2.21	0.772
Knee arthroplasty	2.23	1.31–3.81	0.003
Hip arthroplasty	11.7	6.90–19.8	<0.001
Gastrectomy	74.7	43.0–130	<0.001
Gastric resection	53.0	30.2–93.2	<0.001
Colorectal resection	27.5	16.2–46.7	<0.001
CABG	30.7	17.4–54.3	<0.001

CI confidence interval, *CABG* coronary artery bypass grafting

Table 5 Cause of death within 30 days and 1 year postoperatively for bariatric patients

Time point	Time to death	Patient	Underlying cause of death	Immediate cause of death	Contributory cause of death
30 days	4 days	65-year-old woman	Obesity (E668)	Peritonitis (K650)	MCC (I251)
	12 days	58-year-old man	Obesity (E669)	Sepsis (A419)	
	14 days	63-year-old man	Obesity (E660)	Sepsis (A419)	Ventricular hypertrophy (I517)
1 year	67 days	62-year-old man	Dressler syndrome (I214)	Dressler syndrome (I214)	Diabetes (E117)
	149 days	50-year-old man	Pulmonary embolism (I269)		MCC (I251)
	170 days	55-year-old woman	Suicide (X60)		
	204 days	52-year-old man	MCC (I251)		Hypertension (I10)
	212 days	61-year-old man	Heart failure (I110)	Pulmonary embolism (I260)	Diabetes (E118)
	236 days	59-year-old woman	Endometrial cancer (C541)		Obesity (E668)
	249 days	50-year-old man	Obesity (E668)	Shock (R579)	Diabetes (E119)
	280 days	46-year-old man	Cerebral infarction (I632)		Hypertension (I10)
	315 days	41-year-old man	Missing (V244)*		
	330 days	60-year-old man	Falling (W01)		Alcohol-related (F1000)
	365 days	61-year-old man	Missing (died in 2014)		

MCC chronic ischemic heart disease

*The cause of death is noted as V244 in the registry of Statistics Finland. No corresponding diagnosis can be found in ICD-10

as bariatric surgery. Other major surgical procedures, including cholecystectomy and total knee arthroplasty, had clearly higher 1-year mortality rates.

Within 30 days, three deaths occurred after bariatric surgery. One was due to peritonitis and two of them were due to sepsis. As this study is based on registry data without detailed patient records, we were not able to determine more specific reasons for these infections. Nevertheless, all of the three deaths can be assumed to be related to the operation, more specifically to anastomotic leakage. In addition to anastomotic leak, pulmonary embolism and cardiac causes have been reported to be the most common fatal complications after bariatric surgery [12, 21, 22]. However, no pulmonary embolism or cardiac causes as a cause of death were seen within 30 days in this study. Death following bariatric surgery is a rare event. While the low number of deaths in general reflects the safety of bariatric surgery, it also limits the possibility of meaningful statistical comparison between the causes of death, despite our large national study population. Within 30 to 365 days postoperatively, we found no causes of death which would have been clearly related to the bariatric operation. One pulmonary embolism as a cause of death occurred 149 days postoperatively and two cardiac deaths at days 204 and 212 postoperatively. One suicide occurred within 1 year after surgery. Previously, it has been suggested that the risk of suicide after bariatric procedures is elevated [6, 23]. However, only a minority of all suicides after bariatric surgery occur within 1 year [23]. There was also one death related to alcohol abuse. Research indicates that bariatric patients, especially those who undergo LRYGB, are at an elevated risk for alcohol-related problems postoperatively, although research also indicates that bariatric surgery patients might be overrepresented in substance abuse treatment facilities [24].

Patients were included in the study populations if they had undergone any of the listed procedures within 2009–2013. Some patients had undergone multiple operations during this time period. In particular, the CABG group is affected as the prevalence of other procedures is higher. Still, there is no reason to assume a selection bias.

Obesity and its comorbidities are risk factors for many diseases, which may lead to operative treatments, such as arthroplasty and cancer surgery [25, 26]. Early interventions in the treatment of obesity may eliminate the need for later high-risk surgical procedures.

The majority of the bariatric procedures in our study period were LRYGB (85.6%). Thus, the mortality rate of bariatric procedures mostly represents mortality of LRYGB and cannot be generalized to other bariatric procedures directly. Only 11.4% were sleeve gastrectomies, though sleeve gastrectomy seems to be supplanting the LRYGB as the most common bariatric procedure in many other parts of the world [27, 28]. Gastric banding has not been performed in Finland after year 2009, mostly due to less satisfying long-term results. However, no deaths from banding operations in Finland have been reported [29], and sleeve gastrectomy has recently been reported to be a more safe operation than LRYGB [30].

Our study is the first national population-based study reporting bariatric surgery mortality rates. The main strength of our study is the large study population, which partly outweighs possible confounding factors. We had a maximum follow-up time of over 6 years. Surgical procedures were obtained from the national hospital discharge registry with nearly 100% coverage [18]. Death and emigration information were obtained from national authorities, which makes them very reliable, as reporting is mandatory. Death as outcome variable is unquestionable, but there are no means of demonstrating causality. The study design of a registry study is a limitation. Confounding factors, like comorbidities or body mass index, could not be extracted, and therefore, we were unable to determine risk adjustments in detail. In Finland, public funding covers most of obesity surgeries. Less than 15% of obesity surgeries are undertaken privately or insurance-covered [10]. The heterogeneous baseline characteristics of the study groups naturally influence the results. This was not a case-controlled study and 1-year mortality following cancer operations is naturally higher. However, the primary aim of this, purely observational study was to compare bariatric surgery with other commonly performed operations during the same time period. Emergency operations were excluded by procedure coding when existing. However, there may have been some incorrect procedure coding.

Conclusion

In conclusion, we found that the postoperative mortality rate following bariatric surgery of 0.08% at 30 days and 0.36% at 1 year is low compared to other common operations. Our findings indicate that for many well-accepted surgical procedures, such as prostatectomy, knee arthroplasty, and hysterectomy, the 30-day mortality rates are similar to that after bariatric surgery. The difference at 1 year is even greater in favor of bariatric surgery. This is a notable fact and may help surgical decision-making in the treatment of morbidly obese patients.

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Compliance with Ethical Standards For this type of study formal consent is not required.

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Conflict of Interest The authors declare that they have no conflicts of interest.

Ethical Approval All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed Consent For this type of study, formal consent is not required.

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