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Cardiovascular Risk After Bariatric Surgery For Obesity

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Abstract

Obese patients have an increased prevalence of cardiovascular (CV) risk factors which improve with bariatric surgery, but whether bariatric surgery reduces long-term CV events remains ill-defined. We conducted a systematic literature review and applied CV risk models in a validation cohort previously published. A standardized MEDLINE search using terms associated with obesity, bariatric surgery, and CV risk factors identified 6 test studies. Our validation cohort consisted of a population-based, historical cohort of 197 Roux-en-Y gastric bypass patients and 163 control patients, identified through the Rochester Epidemiology Project. We applied Framingham (FRS) and Prospective Cardiovascular Munster Heart Study (PROCAM) risk scores to calculate 10-year CV risk. In our validation cohort, absolute 10-year FRS for CV events was lower at follow-up in the bariatric surgery group (7.0 to 3.5%;p<0.001) compared to controls (7.1 to 6.5%;p=0.13), with an inter-group absolute difference in risk reduction of 3% (p<0.001). PROCAM risk in the bariatric surgery group decreased from 4.1 to 2.0% (p<0.001), whereas the control group exhibited only a modest decrease (4.4 to 3.8%;p=0.08). Using mean data from the validation study, the trend and directionality in risk was similar in the Roux-en-Y group. The test studies confirmed directionality of CV risk with estimated relative risk reductions for bariatric surgery patients ranging from 18–79% using FRS compared to 8–62% using PROCAM. In conclusion, bariatric surgery predicts long-term decreases in CV risk in obese patients.

Keywords

Bariatric Surgery; Weight Loss; Risk Prediction; Cardiovascular Disease

INTRODUCTION

Cardiovascular (CV) risk assessment using decision tools allows early identification of patients requiring changes in lifestyle and therapeutic interventions for primary prevention of CV

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disease [1]. The Framingham risk score (FRS) [1] was derived using a US cohort and has been extensively validated and adapted for application in diverse populations [2–4]. Because its applicability to European cohorts has been challenged, [5,6] the Prospective Cardiovascular Munster Heart Study (PROCAM), has also gained wide acceptance [7]. Bariatric surgery, an approved weight loss therapy [8], is increasingly being used [9] in reducing medical co-morbidity and improving CV risk factors [10]. However, its long-term impact on CV events and mortality is still poorly defined [11]. In the present study, we used familiar CV risk models, such as the FRS and the PROCAM to test the predicted CV risk reduction in a validation cohort[12] using patient-level data and subsequently used the mean data of this study and those obtained from a systematic literature search to examine whether overall CV risk trends are altered after bariatric surgery.

METHODS

We performed a broad search of publications paralleling the QUOROM statement [13] related to bariatric surgery, obesity, and CV risk factors using MEDLINE (1950 to cutoff date April 8th, 2008) using the following search terms: obesity surgery, gastroplasty, gastric bypass, bariatric surgery, obesity/su [surgery], anastomosis, roux-en-Y gastric bypass. We independently combined these terms, and obesity with either gastric banding, biliopancreatic diversion, or jejunoileal bypass, thereby providing us with a total of 12,018 citations. We limited these studies to any of the following criteria for type of publication: retrospective studies, randomized controlled trials, longitudinal studies, prospective studies, cohort studies, case-control studies, clinical trial [publication type], comparative study, or follow-up studies, resulting in 4,346 citations. The authors subsequently combined these citations with any of the following keywords: diabetes mellitus, glucose intolerance, metabolic syndrome, hyperlipidemia, hypertension, hypertriglyceridemia, hypercholesterolemia, risk factors, cardiovascular risk factors, or comorbidity. We excluded non-human studies, pediatric studies and limited our search to the English literature, leaving 656 citations.

Of these 656 citations, the primary author (JAB) reviewed the individual abstracts and further excluded case reports, letters, reviews, or commentaries that may have eluded our initial search (n=43). Studies with <6 months follow-up (n=252), those unrelated to bariatric surgery (n=113), and studies with <100 patients (n=104) were omitted. We excluded follow-up studies performed at the same institution (n=4). Of the 140 remaining citations, we excluded those without mention of CV risk factors: diabetes, hypertension, hypercholesterolemia, or weight change (n=64).

We reviewed the entire manuscripts of the remaining 75 citations and excluded studies for the following reasons: study data presented in descriptive or non-numeric form (n=30); cost studies (n=5); no data on CV risk factors (n=4); studies dated earlier than 1980 (n=7); brief reports including a letter, a commentary and an editorial each (n=3); quality of life study (n=3); studies with <100 patients (n=7); 2 studies that utilized the FRS in their analysis; one study each with a follow-up of less than one year and another with >20% of patients with an incomplete follow-up; and 3 studies were re-analyzed data of previously published studies. Four studies had missing numeric data for hypertension or hypercholesterolemia. We contacted these authors in an attempt to obtain data from the primary source. One author supplied this missing data, one responded but did not have the data available and two authors did not respond to our request. Six studies fulfilled all of our inclusion criteria, including our own population-based study (Table 1) [10,12,14–17].

Selection of the validation cohort has been previously published [12]. Briefly, we performed a historical, population-based study examining all Olmsted County residents referred for Roux-en-Y gastric bypass to the Mayo Clinic Nutrition Center from 1990–2003 using the Rochester

Epidemiology Project, a medical record-linkage system. All medical records are available for review allowing for complete ascertainment of patient's history. Our final study cohort consisted of 197 surgical patients and 163 non-operative patients. To validate our previously published risk model [12] we applied the FRS and PROCAM risk scores [1,7] to this cohort. We included only patients with complete data to calculate risk scores. For the FRS, complete data were available on 182 surgical and 158 control patients, whereas for the PROCAM, complete data were available for 173 surgical and 141 control patients.

The FRS is the most commonly used CV risk tool in the USA. Many other risk scores are derived from the FRS and hence were not considered in this study. The predicted score is based on a community-based cohort of 5345 patients, aged 30–74 years at the time of the initial Framingham examination. Follow-up was 12 years with a total of 610 patients experiencing a cardiac event. The latest version [1] was used to compute 10-year risk of fatal or non-fatal coronary events using the following variables in this model: sex, age, total and high density cholesterol, systolic blood pressure, smoking (yes/no), and a diagnosis of diabetes mellitus (yes/no).

The PROCAM score [7] was utilized because many of our included studies were of European origin. The study was performed among German government and company workers between 1979 and 1985 with 96% follow-up. These authors developed a 10-year CV prediction score to estimate the global risk of both fatal and non-fatal coronary events based on an actual 325 acute coronary events in the 5389 men followed-up between 35 to 65 years of age at time of recruitment. Variables included consisted of age, low density lipoprotein, high density lipoprotein, triglycerides, systolic blood pressure, smoking (yes/no), diabetes (yes/no), and a family history of a myocardial infarction (yes/no).

We decided not to use other commonly known risk assessments. The UK Prospective Diabetes Mellitus study and its risk equation [18] is limited specifically to patients with only diabetes mellitus and would not be applicable in our cohort. The Systematic Coronary Evaluation Risk Score [19] focuses on CV and non-CV deaths and not events. Its computed score in younger patients (age<65) based on the risk assessment charts would be very low and therefore was not used.

The FRS and PROCAM risk tables were used to compute 10-year risk for both our validation cohort and the individual studies. For the validation cohort, we calculated 10-year risks separately by gender on the overall cohort, and when the patient's age was standardized at age 55 years. We utilized the mean values for the required risk function variables to calculate the FRS and PROCAM scores. A composite score was obtained and converted into 10-year CV risk using their respective data. The purpose was to delineate directionality of CV risk after surgical intervention, using studies obtained from our systematic review and not to assess 10-year risk precisely. The Friedewald formula was used in studies (n=3) that did not measure low density lipoprotein directly. For studies that did not provide information about specific CV risk factors including smoking status or family history of myocardial infarction, the authors used data previously published from the risk model's original study cohort to impute these values. For the FRS, we assumed that 39% of all patients were smokers at both baseline and follow-up in both sexes. We assumed that 21.6% had a positive family history in calculating the PROCAM score, in studies with missing variables. The proportion of diabetics in the Swedish Obesity study was calculated using the reported % of patients recovered from diabetes along with the number of diabetics at follow-up[10]. For the individual studies, the proportion of diabetics or smokers was multiplied by the number of risk points for that entity. Separate estimates were calculated by sex. Because the FRS consists of two separate tables by gender, we estimated the scores separately, first assuming that all patients were male, and subsequently considered all patients to be females. As all manuscripts contained the demographic mix by

sex, we calculated an overall score using the proportional mix of sexes and each individual score. In studies with a control group, the delta between baseline and follow-up was obtained to determine the difference in CV risk for patients who have undergone bariatric surgery compared to control patients.

For the validation cohort, continuous data are presented as mean ± standard deviation. For comparisons within each cohort between baseline and follow-up, we used a two-sided paired t-tests and Wilcoxon Signed Rank. We compared the changes between groups with a two-sample t-test of unequal variances and the Wilcoxon Rank Sum test. A p-value <0.05 was considered statistically significant. Descriptive statistics were provided only to describe the risks from the mean scores. All analyses were performed using JMP for SAS (Windows version 7.0.0, SAS Institute Inc, Cary, NC).

RESULTS

The patient characteristics of each study are outlined in Table 2. Table 3 represents the absolute 10-year risks for CV disease using our validation cohort for both their actual age and the age standardized to 55 years. The results consistently demonstrate a lower risk after bariatric surgery. The risk reduction was more pronounced after standardizing all patients' ages to 55 years, likely because these risk prediction rules are heavily dependent on age.

Comparing our validation cohort to the mean individual data presented in our study (Table 4), the trends were consistent, demonstrating a decrease in risk after bariatric surgery. The risk analysis using mean values shows changes in CV risk in the same direction to the individual-patient level data and maintain a proportional difference between surgical and non-surgical groups. The absolute risk, however, was clearly underestimated when using the mean values.

Examining the 10-year FRS and PROCAM risks using group data demonstrated reductions in CV risk after bariatric surgery [14–16] (Table 4). Interestingly, the study by Sjostrom [10] which primarily utilized the vertical banded gastroplasty procedure, demonstrated consistent increases and decreases in risk of CV events in the control and surgical groups, respectively, at 2-years; however, at 10-years, CV risk was greater in both groups, although the absolute CV risk was 2.2% lower in the bariatric surgery group. Determination of an age-independent FRS using the baseline age at follow-up confirmed directionality whereby the follow-up risk was consistently less in the bariatric surgery group (data not shown).

DISCUSSION

Our present study demonstrates that clinically important weight reduction by bariatric surgery can lead to major improvements in the predicted CV risk, regardless of the method used to calculate risk. By using studies with long-term follow-up of detailed patient information on CV risk factors, these results confirm and expand the results from previous analyses performed in individual cohorts [12].

Our current study provides insight into the use of multiple CV risk prediction in patients undergoing bariatric surgery. Two other studies using the FRS have demonstrated decreases in the predicted CV risk [20,21]. Vogel *et al* 20 demonstrated an overall reduction of 6% to 4% ($p<0.001$) in patients undergoing laparoscopic Roux-en-Y gastric bypass. However, this study did not have a comparison control group, had a short follow-up period of only 17 months, and defined diabetes as patients on antidiabetic medications and/or a hemoglobin A1c >6%, because their data did not include fasting blood glucose concentrations. Torquati *et al* 21 in their analysis of 500 Roux-en-Y patients similarly had no control group, and their cohort was not population-based. Their actual rate of CV disease was substantially less at 1% than their

predicted risk. Moreover, they excluded patients with a preliminary diagnosis of CV disease, thereby underestimating the true decrease in CV risk at follow-up.

To obtain accurate risk assessments, the patient populations should be similar in to the population in whom the risk function was derived. The mean body mass indices in the PROCAM study were 26 and 24kg/m^2 in males and females, respectively, which is markedly less than those observed in the above studies [22]. Schulte et al [22] observed that the interaction of body mass index with other risk variables in PROCAM did not emerge as an independent risk factor in their multivariate analysis, suggesting that this algorithm can account fully for the contribution of body mass index to the risk of CV disease via intermediate pathophysiologic mechanisms, even in patients with obesity. Interestingly, body mass index was found to have an independent effect on coronary risk in the Framingham study [23], the body mass index of which was 28kg/m^2. We believe that body mass index likely has a significant role in predicting CV events, likely underestimating the crude rates observed using the FRS in this study.

Our data suggest that bariatric surgery offers significant reductions in predicted CV risk. Recently, 2 studies have demonstrated a mortality benefit after bariatric surgery. In one study with a 7.1 year mean follow-up, long-term mortality from any cause was decreased by 40% compared to controls, and mortality from CV disease was decreased by 56% [24]. This study not only relied on death certificates for cause of death, often known to be inaccurate, but the cohort's baseline health status was largely unknown. The Swedish Obesity Study [11] demonstrated similar directionality where the adjusted hazard ratio for death was 0.71 (p=0.01) compared to controls. Our results suggest that risk models may indeed be applied to bariatric surgery patients to inform them of their future risk of CV events and all-cause death.

Our validated dataset comprises of a geographically constrained population from Olmsted County. Previous epidemiologic studies have demonstrated excellent external validity to the majority of the US white population [25]. The results derived from our previous study [12] have been validated in this current study using both the FRS and the PROCAM. The use of a systematic literature search not only limited bias in identifying and rejecting studies but ensured all studies had complete and sufficient follow-up pertinent to the study scope. Using mean study results confirmed the directionality of CV risk. Furthermore, CV risk after bariatric surgery was substantially less in controls, in studies with such a group. In light of the paucity of studies examining CV outcomes after bariatric surgery [11,24], we believe that this study will allow for initial generalizability of using bariatric surgery as a means to decrease CV morbidity and mortality.

One study limitation is that the FRS was derived from a predominantly Caucasian cohort, and cannot be applied to non-Caucasians [2]. Empana *et al* 26 has shown poor estimation of absolute risk using both the FRS and the PROCAM in France and Northern Ireland concluding the need for population-specific risk functions. Other studies have demonstrated that both the FRS and PROCAM show close agreement for average CV risk in Northern European populations [6]. Recent data have shown that re-calibration and adaptation of the FRS to allow correlation with long-term CV outcomes is plausible[2]. Re-calibration also prevents overestimation of risk in low-risk European Mediterranean areas [5] and in British men [27]. Game et al [28] suggests that although there were no systematic calculated differences between CV risks using both the FRS and PROCAM in patients with diabetes, PROCAM scores tended to underestimate CV risk at patients with low levels of risk, but overestimate those at greater levels of risk [28]. This study refutes the evidence presented in our present study where moderately high-risk patients undergoing bariatric surgery had a lower calculated coronary risk using the PROCAM than the FRS. Interestingly, a patient's CV risk may be overestimated when models derived from high risk populations are applied to low risk populations [29]. Whether the converse is true is

unknown, yet possibly a recalibration of the FRS or PROCAM equations may be needed in a bariatric surgery population, a matter which requires further investigation.

The CV risk tables of the FRS and PROCAM were meant to be applied to an individual sample or patient and not to an entire sample mean. To the best of our knowledge, the PROCAM algorithm has not been validated in a female cohort, which may impact our results. Each study variable had significant standard error/deviations, which were not accounted for in the crude analysis. Missing variables were imputed where required by the specific risk table, which would likely underestimate risk assessment, particularly because social habits often change after bariatric surgery. Obese patients assessed for surgery often have substantial co-morbidity and CV risk factors, at levels that may exceed the ceiling of these tables, and hence their 10-year score may be inherently lower than what it should be, because the risk function approaches a range of non-linearity. This approach allowed a “best-guess” estimate as to the directionality of CV risk after intentional weight loss. Our results may actually have understated the potential differences in CV risk between baseline and follow-up. Finally, further study would be required to ascertain the number of CV outcomes in our cohort to further validate these results.

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Table 1

Studies Examined Using Systematic Review

Primary Author	Year Performed	Year Published	Country	Type of Bariatric Surgery	# Patients	Mean Follow-up (years)
Pontirolli [14]	1996	2002	Italy	Laparoscopic Adjustable Gastric Banding	143	1.0
Busetto [15]	1993–2000	2004	Italy	Gastric Banding	650	1.3
Stoopen-Margain [16]	2000–2002	2004	Mexico	Laparoscopic Roux-en-Y	100	1.7
He [17]	1990–2002	2004	New Zealand	Roux-en-Y	310	1.0*
Batsis [12]	1990–2003	2007	USA	Roux-en-Y	163/197#	3.3
Sjostrom [10]	1994–2004	2004	Sweden	Vertical Band Gastroplasty	1660/1845#	2.0
				Vertical Band Gastroplasty	627/641#	10.0

- patient numbers represent controls/surgical patients

* - follow-up extended to 3.5 years but data used in our study was obtained at 1 year

Table 2

Characteristics of Patients in Selected Studies

Variable	Pontirolli [14]		Stoopen [16]		Busetto [15]		He [17]	
	Initial	Follow-up	Initial	Follow-up	Initial	Follow-up	Initial	Follow-up
	143	143	100	100	650	650	310	310
Follow-up (years)	1	-	1.67	-	1.28	-	1	--
Age (years)	43	44	31	33	38	39	42	43
Female	81%	81%	63%	63%	76%	76%	77%	77%
Body Mass Index (kg/m^2)	45	37	50	36	47	38	46	n/a[#]
Systolic Blood Pressure (mmHg)	133	128	155	123	146	131	144	125
Diastolic Blood Pressure (mmHg)	83	81	97	79	94	87	85	82
Diabetes Mellitus	46%	21%	24%	14%	11%	4%	17%	1%
Total Cholesterol (mg/dL)	201	205	204	179	209	203	244	208
High Density Lipoprotein Cholesterol (mg/dL)	48	53	32	53	46	46	36	52
Low Density Lipoprotein Cholesterol (mg/dL)	123	131	123	95	132	134	145	131
Triglycerides (mg/dL)	151	106	246	153	151	115	315	129
Smoker	39%	39%	39%	39%	39%	39%	39%	39%

Variable	Batsis [12]				Swedish Obesity Study [10]							
					Controls		Surgery		Controls		Surgery	
					2 years		2 years		10-years		10-years	
	Controls		Operative		Initial	Follow-up	Initial	Follow-up	Initial	Follow-up	Initial	Follow-up
	Initial	Follow-up	Initial	Follow-up	1660	1660	1845	1845	627	627	641	641
Follow-up (years)	163	163	197	197	2	-	2	-	10	-	10	-
Age (years)	43	47	44	47	49	51	47	49	48	58	47	57
Female	73%	73%	80%	80%	70%	70%	71%	71%	69%	69%	69%	69%
Body Mass Index (kg/m^2)	44	44	50	34	40	40	42	32	40	41	42	35
Systolic Blood Pressure (mmHg)	133	128	134	121	138	138	144	137	138	145	144	145
Diastolic Blood Pressure (mmHg)	77	76	80	72	85	85	89	84	86	84	90	87
Diabetes Mellitus	24%	32%	32%	11%	19%	15%	74%	21%	15%	13%	29%	18%
Total Cholesterol (mg/dL)	207	193	199	154	217	217	226	220	223	209	233	220
High Density Lipoprotein Cholesterol (mg/dL)	45	49	45	55	46	48	46	57	46	51	46	57
Low Density Lipoprotein Cholesterol (mg/dL)	121	109	117	77	135	131	140	134	140	120	146	129
Triglycerides (mg/dL)	227	176	188	111	178	189	198	144	188	192	204	171
Smoker	20%	20%	13%	13%	20%	20%	24%	24%	21%	21%	25%	257%

All values rounded to the neared whole number

[#]this information was unavailable but was not needed for the analysis

All values rounded to the neared whole number

Table 3

Table 3A. Absolute 10-year Risk for Cardiovascular Disease after Bariatric Surgery Using Risk Prediction Models in the study by Batsis *et al*[12] using Individual data

	Non-Operative Group					Operative Group					Inter-Group	
	Initial	Follow-up	Δ Risk	Relative Risk Reduction	P-value	Initial	Follow-up	Δ Risk	Relative Risk Reduction	P-value	Δ Risk	P-value
Framingham												
Males	12.0±9.0	10.2±7.7	−1.8	15	0.04	10.7±6.5	4.5±3.1	−6.2	58	<0.001	−4.4	<0.001
Females	5.2±5.5	5.1±4.9	−0.1	1.3	0.85	6.1±6.2	3.3±3.3	−2.9	47	<0.001	−2.8	<0.001
Overall	7.1±7.3	6.5±6.2	−0.6	8	0.13	7.0±6.5	3.5±3.3	−3.5	50	<0.001	−3.0	<0.001
PROCAM												
Males	6.1±6.0	4.7±4.5	−1.3	22	0.10	5.5±±5.6	2.7±3.2	−2.8	51	<0.001	−1.5	0.04
Females	3.8±4.9	3.4±3.9	−0.4	9	0.34	3.8±4.1	1.8±1.8	−2.0	52	<0.001	−1.6	<0.001
Overall	4.4 ± 5.3	3.8±4.0	−0.6	14	0.08	4.1±4.5	2.0±2.2	−2.1	52	<0.001	−1.5	<0.001

TABLE 3B. Age Standardized at 55 years

	Non-Operative					Operative					Inter-Group	
	Initial	Follow-up	Δ Risk	Relative Risk Reduction	P-value	Initial	Follow-up	Δ Risk	Relative Risk Reduction	P-value	Δ Risk	P-value
Framingham												
Males	17.3±9.2	13.1±6.4	−4.2	24	<0.001	17.0±7.5	5.8±3.5	−11.1	66	<0.001	−7.0	<0.001
Females	9.4±5.4	8.0±4.5	−1.5	16	0.01	9.8±6.0	4.4±2.9	−5.5	56	<0.001	−4.0	<0.001
Overall	11.6±7.5	9.4±5.6	−2.2	19	<0.001	11.2±6.9	4.7±3.1	−6.5	58	<0.001	−4.3	<0.001
PROCAM												
Males	12.5±8.7	7.7±4.5	−4.8	38	<0.001	11.2±6.8	3.6±3.1	−7.6	68	<0.001	−2.8	0.02
Females	8.6±6.4	7.1±6.0	−1.6	18	0.01	8.4±6.5	2.8±1.9	−5.6	67	<0.001	−4.0	<0.001
Overall	9.6±7.2	7.2±5.6	−2.4	25	<0.001	8.9±6.6	3.0±2.2	−6.0	67	<0.001	−3.6	<0.001

All risks are represented as 10-year risk (%) ± standard deviation

Δ Risk calculation is based on unrounded values

A negative Δ Risk represents an improvement at follow-up as compared to baseline. A negative inter-group Δ Risk represents the difference between surgical and controls, in favor of the surgical group. Numbers have been rounded to the nearest whole number.

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Table 4

Absolute 10-year Risk for Cardiovascular Disease after Bariatric Surgery Using Mean Group values

	Batsis et al[12]								
	Non-Operative				Operative				
	Initial	Follow up	Δ Risk	Relative Risk Reduction	Initial	Follow up	Δ Risk	Relative Risk Reduction	Inter Group Δ Risk
Framingham									
Males	6.8	5.1	−1.7	**25**	6.8	2.5	−4.3	**64**	−2.7
Females	3.4	4.7	+1.3	**−39**	3.0	2.7	−0.3	**10**	−1.6
Overall	4.3	4.8	+0.5	**−12**	3.8	2.7	−1.1	**29**	−1.6
PROCAM	1.9	2.8	+0.9	**51**	1.8	1.0	−0.7	**37**	−1.6

	Pontirolli et al[14]				Stoopen et al[16]				Busetto et al[15]				He et al[17]			
	Initial	Follow-up	Δ Risk	Relative Risk Reduction	Initial	Follow-up	Δ Risk	Relative Risk Reduction	Initial	Follow-up	Δ Risk	Relative Risk Reduction	Initial	Follow- up	Δ Risk	Relative Risk Reduction
Framingham																
Males	7.7	5.4	−2.3	30	8.5	3.0	−5.5	65	7.0	4.9	−2.2	31	13.4	4.8	−10.6	79
Females	4.0	3.0	−1.0	25	2.0	1.0	−1.0	50	2.2	1.8	−0.4	18	5.5	2.8	−2.7	49
Overall	4.7	3.5	−1.2	26	4.4	1.7	−2.7	61	3.4	2.6	−0.8	24	7.3	3.3	−4	55
PROCAM	2.2	2.0	−0.2	8.3	<1.0	<1.0	-	-	1.9	1.5	−0.4	19	5.1	2.3	−2.8	55

	Sjostrom et al–Swedish Obesity Study[10]							
	Controls–2 year Data				Surgical Group–2 year Data			
	Initial	Follow up	Δ Risk	Relative Risk Reduction	Initial	Follow up	Δ Risk	Relative Risk Reduction	Inter Group Δ Risk
Framingham									
Males	7.8	9.4	+1.6	−21	12.9	7.9	−5.0	39	−6.6
Females	5.5	8.0	+2.8	−55	10.4	4.3	−6.1	59	−9.0
Overall	5.9	8.4	+2.5	−42	12.2	5.4	−6.8	56	−9.3
PROCAM	4.1	6.4	+2.3	−55	7.1	2.7	−4.4	62	−6.6

	Sjostrom et al–Swedish Obesity Study[10]								
	Controls–10 year Data				Surgical Group–10 year Data				
	Initial	Follow up	Δ Risk	RRR	Initial	Follow up	Δ Risk	RRR	Inter Group Δ Risk
Framingham									
Males	7.7	15.1	+7.3	−95	10.2	12.6	+2.4	−23	−5.0
Females	5.0	11.0	+5.9	−118	6.6	11.5	+4.9	−74	−1.0
Overall	5.9	12.3	+6.4	−108	7.7	11.8	+4.1	−54	−2.2
PROCAM	4.1	7.6	+3.5	−86	5.9	5.1	−0.9	15	−4.4

All risks are represented as 10-year risk (%); Δ Risk calculation is based on unrounded values

A negative Δ Risk represents an improvement at follow-up as compared to baseline. A negative inter-group Δ Risk represents the difference between surgical and controls, in favor of the surgical group. Numbers may not add up due to rounding.

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