



ARTICLE OPEN



Bariatric Surgery

30-day morbidity and mortality of sleeve gastrectomy, Roux-en-Y gastric bypass and one anastomosis gastric bypass: a propensity score-matched analysis of the GENEVA data

Rishi Singhal^{1,176}, Victor Roth Cardoso^{2,3,176}, Tom Wiggins^{1,176}, Jonathan Super⁴, Christian Ludwig⁵, Georgios V. Gkoutos^{2,3,6,7}, Kamal Mahawar⁸ and GENEVA Collaborators*

© The Author(s) 2021

BACKGROUND: There is a paucity of data comparing 30-day morbidity and mortality of sleeve gastrectomy (SG), Roux-en-Y gastric bypass (RYGB), and one anastomosis gastric bypass (OAGB). This study aimed to compare the 30-day safety of SG, RYGB, and OAGB in propensity score-matched cohorts.

MATERIALS AND METHODS: This analysis utilised data collected from the GENEVA study which was a multicentre observational cohort study of bariatric and metabolic surgery (BMS) in 185 centres across 42 countries between 01/05/2022 and 31/10/2020 during the Coronavirus Disease-2019 (COVID-19) pandemic. 30-day complications were categorised according to the Clavien–Dindo classification. Patients receiving SG, RYGB, or OAGB were propensity-matched according to baseline characteristics and 30-day complications were compared between groups.

RESULTS: In total, 6770 patients (SG 3983; OAGB 702; RYGB 2085) were included in this analysis. Prior to matching, RYGB was associated with highest 30-day complication rate (SG 5.8%; OAGB 7.5%; RYGB 8.0% ($p = 0.006$)). On multivariate regression modelling, Insulin-dependent type 2 diabetes mellitus and hypercholesterolaemia were associated with increased 30-day complications. Being a non-smoker was associated with reduced complication rates. When compared to SG as a reference category, RYGB, but not OAGB, was associated with an increased rate of 30-day complications. A total of 702 pairs of SG and OAGB were propensity score-matched. The complication rate in the SG group was 7.3% ($n = 51$) as compared to 7.5% ($n = 53$) in the OAGB group ($p = 0.68$). Similarly, 2085 pairs of SG and RYGB were propensity score-matched. The complication rate in the SG group was 6.1% ($n = 127$) as compared to 7.9% ($n = 166$) in the RYGB group ($p = 0.09$). And, 702 pairs of OAGB and RYGB were matched. The complication rate in both groups was the same at 7.5% ($n = 53$; $p = 0.07$).

CONCLUSIONS: This global study found no significant difference in the 30-day morbidity and mortality of SG, RYGB, and OAGB in propensity score-matched cohorts.

International Journal of Obesity; <https://doi.org/10.1038/s41366-021-01048-1>

INTRODUCTION


Sleeve gastrectomy (SG), Roux-en-Y gastric bypass (RYGB), and one anastomosis gastric bypass (OAGB) are the three commonest bariatric procedures worldwide [1]. There is currently no randomised controlled trial (RCT) comparing these three procedures in the scientific literature. There are several RCTs comparing two of these three procedures [2, 3] but they were not powered to evaluate differences in morbidity or mortality.

30-day morbidity and mortality is a recognised outcome measure for the evaluation of surgical safety and has been used

in surgical literature for several decades [4]. There are large studies comparing 30-day morbidity and mortality of RYGB and SG. Alizadeh et al. [5] reported from an analysis of Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program (MBSAQIP) data in the United States that RYGB was associated with higher 30-day morbidity (4.4% vs 2.3%; adjusted odds ratio (AOR) 0.53; $p < 0.01$) and 30-day mortality (0.2% vs 0.1%; AOR 0.58; $p = 0.07$) in comparison with SG. However, there is no large data in the scientific literature comparing 30-day morbidity and mortality of SG and OAGB or RYGB and OAGB.

¹Upper GI Unit, University Hospital Birmingham NHS Foundation Trust, Birmingham, UK. ²Institute of Cancer and Genomic Sciences, University of Birmingham, Birmingham, UK. ³Health Data Research UK Midlands, Birmingham, UK. ⁴General Surgery Department, Maidstone and Tunbridge Wells NHS Trust, Tunbridge Wells, UK. ⁵Institute of Metabolism and Systems Research, College of Medical and Dental Sciences, University of Birmingham, Birmingham, UK. ⁶NIHR Experimental Cancer Medicine Centre, Birmingham B15 2TT, UK. ⁷NIHR Surgical Reconstruction and Microbiology Research Centre, Birmingham B15 2TT, UK. ⁸Bariatric Unit, South Tyneside and Sunderland NHS Trust, Sunderland, UK.

¹⁷⁶These authors contributed equally: Rishi Singhal, Victor Roth Cardoso, Tom Wiggins. * A full list of author affiliations appears at the end of the paper.

email: singhal_rishi@hotmail.com

Received: 20 August 2021 Accepted: 29 November 2021

Published online: 15 December 2021

Notwithstanding the lack of such large data, these direct database comparisons are often flawed due to significant differences in the baseline population. Propensity score matching is a valid tool for comparing non-randomised populations by matching them for confounding variables [6]. To the best of our knowledge, there is only one published study comparing 30-day morbidity and mortality of SG and RYGB [7]; and one comparing RYGB and OAGB [8] in propensity score-matched populations. Both of these studies emanate from the MBSAQIP database. In their study, Kapur et al. [7] found lower adverse events with SG in comparison with RYGB. However, the study by Docimo et al. [8] comparing the 30-day morbidity of OAGB and RYGB had too few patients to be meaningful. It is probably because the MBSAQIP database is not likely to have large numbers of OAGB, a procedure not endorsed by the American Society for Metabolic and Bariatric Surgery.

Global 30-day outcomes after bariatric surgery during the COVID-19 pandemic (GENEVA) study [9] is a large, multinational, observational study evaluating 30-day morbidity and mortality of bariatric and metabolic surgery (BMS) during the Coronavirus Disease-2019 (COVID-19) pandemic. The global reach of the study, a large number of patients, and significant numbers of OAGB procedures submitted to this study present a unique opportunity to compare 30-day morbidity and mortality of SG, OAGB, and RYGB in propensity score-matched cohorts.

METHODS

Study design and population

The GENEVA study is an international, multicentre, observational cohort study of BMS performed between 1/05/2020 and 31/10/2020 [9]. The current study included all consecutive patients who underwent a primary SG or RYGB or OAGB during this period. Detailed methods have been published previously [9–11]. Data collection included patients' demographics, details of surgery performed, and in-hospital as well as 30-day morbidity and mortality. Complications were categorised using the Clavien–Dindo (CD) Classification system for reporting surgical complications [12].

Statistical methods

Only patients with a complete data entry were included in the analysis. Continuous data were presented as median and interquartile range. Frequencies were used to summarise categorical variables. To examine differences between the three individual procedure types, the Fisher's exact test was used for categorical variables and Kruskal–Wallis analysis of variance testing for continuous variables.

Propensity score matching was completed in a step-wise fashion. Pairwise propensity matching was performed to robustly assess the quality of matching. Standardized mean difference (SMD) was used statistic to examine the balance of covariate distribution between treatment groups. Patients were matched using the following features: sex, Type 2 diabetes mellitus (T2DM) status (No diabetes; diet controlled; oral hypoglycaemics; insulin therapy), hypertension, hypercholesterolaemia, obstructive sleep apnoea, smoking status, age, and baseline body mass index (BMI).

The patients were matched against individuals that had other surgeries using the "nearest" method which utilises a greedy search to match each sample with their nearest neighbour. The distance was calculated using the Mahalanobis distance, which estimates the distribution closest for each point [13]. This procedure was performed in R (R Core Team 2021) using the MatchIt package [14, 15]. The outcome variable was the presence of a complication at 30-days follow-up.

Multivariate analysis was performed to strengthen the resulting statistics from univariate analysis, correcting the influence of each variable on the outcome measured. Multivariate models were created using all the variables used for propensity score matching plus ethnicity (white ethnicity vs other ethnic groups), presence of any co-morbidity, and other unspecified co-morbidity (other than those listed above). Patients were then analysed using a generalised linear model in R (R Core Team 2021) [14].

RESULTS

A total of 470 surgeons from 179 centres in 42 countries submitted data on 7092 adult patients who underwent primary BMS between 1st May 2020 and 31st October 2020 at the participating centres. Of these, complete 30-day morbidity and mortality data were available for 7084 (99.88%) by the 10th of December 2020.

Basic demographics

Of the 7084 patients, 300 patients underwent other procedures and were excluded. A further 14 patients were excluded due to missing values. Complete data were available for a total of 6,770 patients who underwent a primary SG or RYGB or OAGB (SG $n = 3983$; RYGB $n = 2085$, OAGB $n = 702$). Demographic details for all the patients, who underwent any of these three primary procedures are included in Table 1. There were multiple significant differences in baseline demographics between the three groups as detailed in Table 1. RYGB patients were significantly older than patients in the other two cohorts while patients receiving OAGB were more likely to suffer from co-morbidities (Table 1). Patients undergoing SG had the lowest rate of each of these co-morbidities as detailed in Table 1.

Table 1. Baseline demographics of all patients undergoing a primary SG or RYGB or OAGB (unmatched cohort—14 patients excluded due to incomplete data).

Characteristic	SG ($n = 3983$)	OAGB ($n = 702$)	RYGB ($n = 2085$)	<i>p</i> value
Median Age (years)	38 (29.2–47.0)	40 (33.0–50.0)	43 (34–52)	<0.001 ^a
Median BMI (kg/m ²)	41.91 (38.14–46.77)	43.11 (38.87–48.77)	41.87 (38.67–45.73)	<0.001 ^a
Sex (Female)	2883 (72%)	496 (71%)	1589 (76%)	<0.001 ^b
Non-Smoker	2906 (73%)	528 (75%)	1502 (72%)	0.24 ^b
T2DM	649 (16%)	229 (33%)	484 (23%)	<0.001 ^b
Diet controlled	204 (5%)	74 (11%)	107 (5%)	
Oral hypoglycaemics	370 (9%)	106 (15%)	277 (13%)	
Insulin therapy	75 (2%)	49 (7%)	100 (5%)	
Hypercholesterolaemia	763 (19%)	224 (32%)	476 (23%)	<0.001 ^b
Hypertension	1101 (28%)	272 (39%)	720 (35%)	<0.001 ^b
Obstructive sleep apnoea	975 (24%)	229 (33%)	517 (25%)	<0.001 ^b

SG sleeve gastrectomy, RYGB Roux-en-Y gastric bypass, OAGB one anastomosis gastric bypass, BMI body mass index, T2DM Type 2 diabetes mellitus.

^aKruskal–Wallis test.

^bFisher's exact test.

Table 2. Complications according to primary procedure and CD (Clavien–Dindo) classification system in the full unmatched cohort.

Characteristic	SG (n = 3983)	OAGB (n = 702)	RYGB (n = 2085)	p value
All 30-day complications	233 (5.8%)	53 (7.5%)	166 (8.0%)	0.006 ^a
CD 0	3750 (94.1%)	649 (92.4%)	1919 (92.0%)	–
CD 1	84 (2.1%)	11 (1.6%)	62 (3.0%)	–
CD 2	63 (1.6%)	17 (2.4%)	48 (2.3%)	–
CD 3.1	16 (0.4%)	7 (1.0%)	8 (0.4%)	–
CD 3.2	50 (1.3%)	12 (1.7%)	31 (1.5%)	–
CD 4.1	13 (0.3%)	3 (0.4%)	15 (0.7%)	–
CD 4.2	3 (0.1%)	0	2 (0.1%)	–
CD 5 (Mortality)	4 (0.1%)	3 (0.4%)	0	0.016 ^a

CD Clavien–Dindo, SG sleeve gastrectomy, OAGB one anastomosis gastric bypass, RYGB Roux-en-Y gastric bypass.

^aFisher's exact test.

Table 3. Results of multivariate logistic regression on full unmatched cohort.

Variable	Unmatched patients	
	Odds ratio	95% CI
Age	1.000	1.000–1.001
BMI	1.000	0.999–1.001
Sex (Male)	1.011	0.997–1.025
Diabetes (No)	1.010	0.984–1.037
Diabetes (oral hypoglycaemics)	0.981	0.961–1.000
Diabetes (insulin)	1.047*	1.011–1.083
Hypertension	1.007	0.992–1.022
Hypercholesterolaemia	1.024*	1.009–1.040
Obstructive Sleep Apnoea	1.012	0.998–1.027
Non-Smoker	0.984*	0.971–0.998
White ethnicity	1.010	0.996–1.025
Other co-morbidity	1.004	0.991–1.017
Surgery (OAGB)	1.009	0.989–1.030
Surgery (RYGB)	1.018*	1.005–1.032

BMI body mass index, OAGB one anastomosis gastric bypass, RYGB Roux-en-Y gastric bypass, CI confidence interval.

*Significant values where $p < 0.05$.

30-day morbidity and mortality in the full cohort (unmatched; Table 2)

The overall complication rate was 6.7% (452/6770) (Table 2). RYGB patients had the highest rate of any complication during the 30-day follow-up (8.0% with RYGB vs 7.5% for OAGB and 5.8% for SG ($p = 0.006$)). There were seven post-operative mortalities (0.1%) (4 with SG, 3 with OAGB, and nil with RYGB; $p = 0.016$; Fisher's exact test).

Multivariate analysis of unmatched cohort (Table 3)

On multivariate regression modelling, insulin-dependent T2DM (OR 1.047; 95% CI 1.011–1.083), and hypercholesterolaemia (OR 1.024; 95% CI 1.009–1.040) (Table 3 and Fig. 1) were associated with increased 30-day complications. Being a non-smoker was associated with reduced complication rates (OR 0.984; 95% CI 0.971–0.998). When compared to SG as the reference category, RYGB, but not OAGB, was associated with an increased rate

of 30-day complications (OR 1.018; 95% CI 1.005–1.032 for RYGB and OR 1.009; 95% CI 0.989–1.030 for OAGB).

30-day morbidity and mortality in the propensity score-matched cohort (Tables 4–6)

SG vs OAGB. In total, 702 pairs were matched with a reduction in SMDs for all matched variables (8/8) (Table 4). The overall complication rate in the SG group was 51 (7.3%) as compared to 53 (7.5%) in the OAGB group (Table 7). The difference was not significant ($p = 0.68$).

SG vs RYGB. In total, 2085 pairs were matched with a reduction in SMDs for seven of the eight matched variables (Table 5). The overall complication rate in the SG group was 127 (6.1%) as compared to 166 (7.9%) in the RYGB group (Table 7). The difference was not significant ($p = 0.09$).

OAGB vs RYGB. In total, 702 pairs were matched with a reduction in SMDs in four of the eight matched variables (4/8) (Table 6). The overall complication rate in both the groups was the same 53 (7.5%; $p = 0.07$; Table 7).

DISCUSSION

This study shows that there is no significant difference in 30-day morbidity and mortality of SG, RYGB, and OAGB in propensity score-matched cohorts from a large, global dataset collected during the COVID-19 pandemic. Though RYGB was associated with higher 30-day morbidity in comparison with reference SG (OR 1.018; 95% CI 1.005–1.032) in the unmatched cohort on multivariate analysis, the difference disappeared after propensity score matching ($p = 0.09$). In comparison, OAGB was not associated with higher 30-day morbidity in comparison with SG on either multivariate analysis (OR 1.009; 95% CI 0.989–1.030) or propensity score-matched comparison ($p = 0.68$).

RCTs comparing different bariatric procedures often have weight loss [2] or diabetes control [16] as their endpoints. Some [16] do not even clearly report 30-day morbidity and mortality with different bariatric procedures let alone classifying surgical complications adequately according to the widely used and accepted CD Classification [12]. We cannot, therefore, derive any scientifically valid conclusions regarding complication rates of different procedures from these RCTs.

Outside of RCTs, perceptions regarding relative safety and efficacy of different procedures for different patient groups may introduce potential bias. For example, in this study, we found 33.0% of patients undergoing OAGB were suffering from T2DM compared to 23.0% undergoing RYGB and 16.0% undergoing SG in the unmatched cohorts. This selection bias may be partly accounted for by fact that the randomised studies have shown superior (non-significant as they were not powered to evaluate these) outcomes in terms of diabetes improvement with OAGB in comparison with RYGB [2] and with RYGB in comparison with SG [17]. This is important because T2DM is known to be associated with complications after bariatric surgery [18, 19] and in our study, Insulin-dependent T2DM was independently associated with 30-day morbidity on multivariate analysis of the unmatched cohort.

Similarly, in the unmatched cohort, hypercholesterolaemia was present in 19.0% of patients undergoing SG in comparison with 32.0% of those undergoing OAGB and 23.0% of those undergoing RYGB. However, after matching, in the analysis of SG and OAGB, the hypercholesterolaemia rates in the two groups were the same at 32.0 and 23.0% in the analysis of SG and RYGB. This is also important because hypercholesterolaemia was independently associated with 30-day morbidity on multivariate analysis of the unmatched data and differences in hypercholesterolaemia rates in the unmatched cohort may well have accounted for some of the observed differences in 30-day morbidity. Others [20] have also

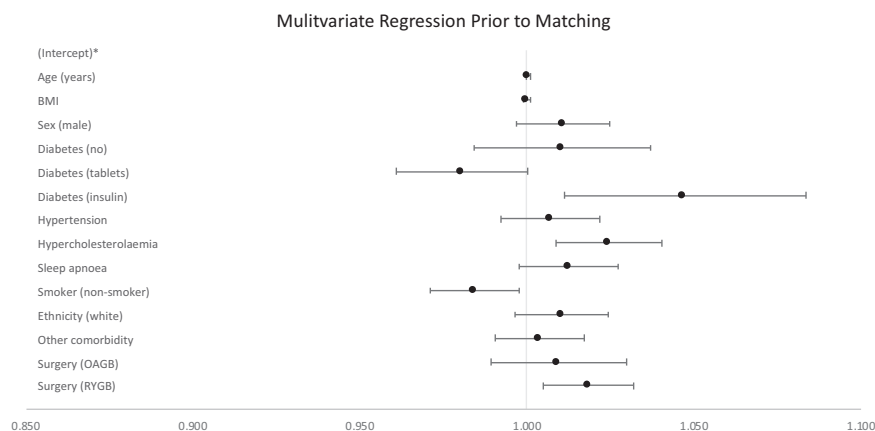


Fig. 1 Multivariate regression results prior to patient matching.

Table 4. A comparison of sleeve gastrectomy (SG) and one anastomosis gastric bypass (OAGB) before and after propensity score matching.

Characteristic	SG (702)	OAGB (702)	Standardised difference pre-matching (95% CI)	Standardised difference post-matching (95% CI)
Median Age (years)	40 (33–49)	40 (33–50)	0.203 (0.122–0.283)	0.011 (–0.093–0.116)
Median BMI (kg/m ²)	42.87 (38.79–48.45)	43.11 (38.87–48.77)	0.132 (0.052–0.212)	0.017 (–0.087–0.122)
Sex (Female)	501 (71%)	496 (71%)	0.038 (–0.042–0.119)	0.016 (–0.089–0.12)
Non-Smoker	527 (75%)	528 (75%)	0.051 (–0.029–0.132)	0.003 (–0.101–0.108)
T2DM	229 (33%)	229 (33%)	0.407 (0.326–0.488)	0 (–0.105–0.105)
Diet controlled	74 (11%)	74 (11%)		
Oral hypoglycaemics	106 (15%)	106 (15%)		
Insulin therapy	49 (7%)	49 (7%)		
Hypercholesterolaemia	224 (32%)	224 (32%)	0.296 (0.215–0.376)	0 (–0.105–0.105)
Hypertension	270 (38%)	272 (39%)	0.237 (0.157–0.318)	0.006 (–0.099–0.11)
Obstructive sleep apnoea	230 (33%)	229 (33%)	0.181 (0.101–0.261)	0.003 (–0.102–0.108)

SG sleeve gastrectomy, OAGB one anastomosis gastric bypass, T2DM Type 2 diabetes mellitus, CI confidence interval.

Table 5. A comparison of sleeve gastrectomy (SG) and Roux-en-Y gastric bypass (RYGB) before and after propensity score matching.

Characteristic	SG (2085)	RYGB (2085)	Standardised difference pre-matching (95% CI)	Standardised difference post-matching (95% CI)
Median Age (years)	42.00 (33.00–51.00)	43.00 (34.00–52.00)	0.362 (0.309–0.415)	0.069 (0.008–0.129)
Median BMI (kg/m ²)	42.19 (38.70–46.14)	41.87 (38.67–45.73)	0.096 (0.043–0.149)	0.064 (0.003–0.125)
Sex (Female)	1604 (77%)	1589 (76%)	0.088 (0.035–0.141)	0.017 (–0.044–0.078)
Non-smoker	1499 (72%)	1502 (72%)	0.021 (–0.032–0.074)	0.003 (–0.058–0.064)
T2DM			0.215 (0.161–0.268)	0.06 (–0.001–0.121)
Diet controlled	107 (5%)	107 (5%)		
Oral hypoglycaemics	277 (13%)	277 (13%)		
Insulin therapy	75 (4%)	100 (5%)		
Hypercholesterolaemia	477 (23%)	476 (23%)	0.09 (0.037–0.143)	0.001 (–0.06–0.062)
Hypertension	722 (35%)	720 (35%)	0.149 (0.096–0.202)	0.002 (–0.059–0.063)
Obstructive sleep apnoea	543 (26%)	517 (25%)	0.007 (–0.046–0.06)	0.029 (–0.032–0.089)

CD Clavien–Dindo, SG sleeve gastrectomy, RYGB Roux-en-Y gastric bypass, CI confidence interval, BMI body mass index, T2DM Type 2 diabetes mellitus.

found dyslipidaemia to be a predictor of complication after bariatric surgery.

Standardised mean differences in age, BMI, sex, smoking status, hypertension rates all reduced after matching for both the matched comparisons involving SG in this study. Given that all of these characteristics are known to be associated with increased

morbidity after bariatric surgery [21–29], differences in these baseline characteristics may have been in part responsible for why the observed difference in morbidity between SG and RYGB or OAGB disappeared after matching. At the same time, and probably because of the fewer number of bypass procedures in the GENEVA database, matching failed to reduce SMDs for age,

Table 6. A comparison of one anastomosis gastric bypass (OAGB) and Roux-en-Y gastric bypass (RYGB) before and after propensity score matching.

	SG (n = 702)	OAGB (n = 702)	p value ^a	SG (2085)	RYGB (2085)	p value ^a
30-day complication	51 (7.3%)	53 (7.5%)	0.68	127 (6.1%)	166 (7.9%)	0.09
CD 0	651 (92.7%)	649 (92.4%)		1958 (94%)	1919 (92%)	
CD 1	18 (2.6%)	11 (1.6%)		41 (2%)	62 (3%)	
CD 2	10 (1.4%)	17 (2.4%)		36 (2%)	48 (2%)	
CD 3.1	7 (1.0%)	7 (1.0%)		10 (0%)	8 (0%)	
CD 3.2	10 (1.4%)	12 (1.7%)		25 (1%)	31 (1%)	
CD 4.1	3 (0.4%)	3 (0.4%)		9 (0%)	15 (1%)	
CD 4.2	1 (0.1%)	0		3 (0%)	2 (0%)	
CD 5	2 (0.3%)	3 (0.4%)		3 (0%)	0 (0%)	

CD Clavien–Dindo, SG sleeve gastrectomy, OAGB one anastomosis gastric bypass, RYGB Roux-en-Y gastric bypass.

^aFisher's exact test.

Table 7. Complications in propensity score-matched populations.

	SG (702)	OAGB (702)	p value ^a	SG (2085)	RYGB (2085)	p value ^a	OAGB (702)	RYGB (702)	p value ^a
30-day complication	51 (7.3%)	53 (7.5%)	0.68	127 (6.1%)	166 (7.9%)	0.09	53 (7.5%)	53 (7.5%)	0.07
CD 0	651 (92.7%)	649 (92.4%)		1958 (94%)	1919 (92%)		649 (92%)	649 (92%)	
CD 1	18 (2.6%)	11 (1.6%)		41 (2%)	62 (3%)		11 (2%)	23 (3%)	
CD 2	10 (1.4%)	17 (2.4%)		36 (2%)	48 (2%)		17 (2%)	10 (1%)	
CD 3.1	7 (1.0%)	7 (1.0%)		10 (0%)	8 (0%)		7 (1%)	4 (1%)	
CD 3.2	10 (1.4%)	12 (1.7%)		25 (1%)	31 (1%)		12 (2%)	9 (1%)	
CD 4.1	3 (0.4%)	3 (0.4%)		9 (0%)	15 (1%)		3 (0%)	7 (1%)	
CD 4.2	1 (0.1%)	0		3 (0%)	2 (0%)		0 (0%)	0 (0%)	
CD 5	2 (0.3%)	3 (0.4%)		3 (0%)	0 (0%)		3 (0%)	0 (0%)	

CD Clavien–Dindo, SG sleeve gastrectomy, OAGB one anastomosis gastric bypass, RYGB Roux-en-Y gastric bypass.

^aFisher's exact test.

sex, smoking status, and hypertension in the comparison between OAGB and RYGB in this study. This may partly account for the observed lack of difference in 30-day morbidity between the two procedures. Future studies on this topic need to be mindful of this.

There is no published study comparing the 30-day morbidity of SG with that of OAGB in propensity score-matched cohorts. This may be due to continued reservations [30] amongst some surgeons about OAGB. Furthermore, and as mentioned above in the Introduction section, there is only one propensity score-matched study [8] in the scientific literature comparing the 30-day safety of OAGB with that of any other procedure (RYGB in this case) and that study only had 279 pairs of OAGB and RYGB. One could argue this is not a large enough sample to study differences in morbidity.

There is only one study [7] in the published literature comparing the 30-day morbidity of SG with that of RYGB. Interestingly that study showed lower complication rates with SG in contrast to our findings. It is however worth noting that these authors do not report standardised mean difference in propensity score-matched populations and given the large numbers matched, it was inevitable that their matching was not perfect with significant difference between the matched populations with regards to important confounding variables such as age, BMI, smoking, insulin-dependent T2DM, etc.

This study represents the first large propensity-matched comparison of 30-day morbidity and mortality of SG, RYGB, and OAGB. This data was collected from a large worldwide collaborative study of real-world bariatric surgical practice. Data completion rates were extremely high with 30-day follow data

available for 97.9% of patients across the entire cohort and this represents a significant strength of this study.

Non-randomised design and self-reported complication rates are two major weaknesses of this study. However, it is not easy to randomise to different procedures with 30-day morbidity as an endpoint and anonymous data collection strategy used in this study may have diminished the desire to under-report complications. Another weakness of this study is that differences in complication rates, though statistically not significant, maybe clinically relevant. Indeed, larger studies may even find statistical significance.

CONCLUSION

The present analysis shows that there is no significant difference in 30-day morbidity and mortality of SG, OAGB, and RYGB in propensity-matched cohorts.

REFERENCES

- Angrisani L, Santonicola A, Iovino P, Ramos A, Shikora S, Kow L. Bariatric surgery survey 2018: similarities and disparities among the 5 IFSO chapters. *Obes Surg*. 2021;31:1937–48. <https://doi.org/10.1007/s11695-020-05207-7>.
- Robert M, Espalieu P, Pelascini E, Caiazzo R, Sterkers A, Khamphommala L, et al. Efficacy and safety of one anastomosis gastric bypass versus Roux-en-Y gastric bypass for obesity (YOMEGA): a multicentre, randomised, open-label, non-inferiority trial. *Lancet*. 2019;393:1299–309. [https://doi.org/10.1016/s0140-6736\(19\)30475-1](https://doi.org/10.1016/s0140-6736(19)30475-1).
- Salminen P, Helmiö M, Ovaska J, Juuti A, Leivonen M, Peromaa-Haavisto P, et al. Effect of laparoscopic sleeve gastrectomy vs laparoscopic Roux-en-Y gastric bypass on weight loss at 5 years among patients with morbid obesity: the

- SLEEVEPASS randomized clinical trial. *JAMA*. 2018;319:241–54. <https://doi.org/10.1001/jama.2017.20313>.
4. Okike N, Payne WS, Neufeld DM, Bernatz PE, Pairolero PC, Sanderson DR. Esophagomyotomy versus forceful dilation for achalasia of the esophagus: results in 899 patients. *Ann Thorac Surg*. 1979;28:119–25. [https://doi.org/10.1016/s0003-4975\(10\)63767-8](https://doi.org/10.1016/s0003-4975(10)63767-8).
 5. Alizadeh RF, Li S, Gambhir S, Hinojosa MW, Smith BR, Stamos MJ, et al. Laparoscopic sleeve gastrectomy or laparoscopic gastric bypass for patients with metabolic syndrome: an MBSAQIP analysis. *Am Surg*. 2019;85:1108–12.
 6. Robins JM, Mark SD, Newey WK. Estimating exposure effects by modelling the expectation of exposure conditional on confounders. *Biometrics*. 1992;48:479–95.
 7. Kapur A, Thodiyil P. Primary laparoscopic sleeve gastrectomy versus gastric bypass: a propensity-matched comparison of 30-day outcomes. *Surg Obes Relat Dis*. 2021;17:1369–82. <https://doi.org/10.1016/j.soard.2021.01.022>.
 8. Docimo S, Yang J, Zhang X, Pryor A, Spaniolas K. One anastomosis gastric bypass versus Roux-en-Y gastric bypass: a 30-day follow-up review. *Surg Endosc*. 2021. <https://doi.org/10.1007/s00464-021-08309-0>.
 9. Singhal R, Tahrani AA, Ludwig C, Mahawar K. Global 30-day outcomes after bariatric surgery during the COVID-19 pandemic (GENEVA): an international cohort study. *Lancet Diabetes Endocrinol*. 2021;9:7–9. [https://doi.org/10.1016/s2213-8587\(20\)30375-2](https://doi.org/10.1016/s2213-8587(20)30375-2).
 10. Singhal R, Ludwig C, Rudge G, Gkoutos GV, Tahrani A, Mahawar K, et al. 30-day morbidity and mortality of bariatric surgery during the COVID-19 pandemic: a multinational cohort study of 7704 patients from 42 countries. *Obes Surg*. 2021;1–17. <https://doi.org/10.1007/s11695-021-05493-9>.
 11. Singhal R, Wiggins T, Super J, Alqahtani A, Nadler EP, Ludwig C, et al. 30-day morbidity and mortality of bariatric metabolic surgery in adolescence during the COVID-19 pandemic—the GENEVA study. *Pediatr Obes*. 2021:e12832. <https://doi.org/10.1111/ijpo.12832>.
 12. Dindo D, Demartines N, Clavien PA. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. *Ann Surg*. 2004;240:205–13. <https://doi.org/10.1097/01.sla.0000133083.54934.ae>.
 13. Chandra, M. On the generalized distance in statistics. In: Proceedings of the National Institute of Science, India. 2021. Available from: <https://www.scienceopen.com/document?vid=a553c5c9-9837-4568-9f20-91a3f1ca1879>.
 14. R Core Team. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. 2019. <https://www.R-project.org/>.
 15. Stuart EA, King G, Imai K, Ho D. MatchIt: Nonparametric Preprocessing for Parametric Causal Inference. *J Stat Softw*. 2011;42:28. <https://doi.org/10.18637/jss.v042.i08>.
 16. Schauer PR, Kashyap SR, Wolski K, Brethauer SA, Kirwan JP, Pothier CE, et al. Bariatric surgery versus intensive medical therapy in obese patients with diabetes. *N Engl J Med*. 2012;366:1567–76. <https://doi.org/10.1056/NEJMoa1200225>.
 17. Sharples AJ, Mahawar K. Systematic review and meta-analysis of randomised controlled trials comparing long-term outcomes of Roux-En-Y gastric bypass and sleeve gastrectomy. *Obes Surg*. 2020;30:664–72. <https://doi.org/10.1007/s11695-019-04235-2>.
 18. Buchwald H, Estok R, Fahrenbach K, Banel D, Sledge I. Trends in mortality in bariatric surgery: a systematic review and meta-analysis. *Surgery*. 2007;142:621–35.
 19. Keidar A. Bariatric surgery for type 2 diabetes reversal: the risks. *Diabetes Care*. 2011;34:S361–S266.
 20. Coblijn UK, Karres J, de Raaff CAL, de Castro SMM, Lagarde SM, van Tets WF, et al. Predicting postoperative complications after bariatric surgery: the Bariatric Surgery Index for Complications, BASIC. *Surg Endosc*. 2017;31:4438–45. <https://doi.org/10.1007/s00464-017-5494-0>.
 21. Nickel F, de la Garza JR, Werthmann FS, Benner L, Tapking C, Karadza E, et al. Predictors of risk and success of obesity surgery. *Obes Facts*. 2019;12:427–39. <https://doi.org/10.1159/000496939>.
 22. Qin C, Luo B, Aggarwal A, De Oliveira G, Kim JY. Advanced age as an independent predictor of perioperative risk after laparoscopic sleeve gastrectomy (LSG). *Obes Surg*. 2015;25:406–12. <https://doi.org/10.1007/s11695-014-1462-0>.
 23. Mocanu V, Dang JT, Switzer N, Madsen K, Birch DW, Karmali S. Sex and race predict adverse outcomes following bariatric surgery: an MBSAQIP analysis. *Obes Surg*. 2020;30:1093–101. <https://doi.org/10.1007/s11695-020-04395-6>.
 24. Husain F, Jeong IH, Spight D, Wolfe B, Mattar SG. Risk factors for early postoperative complications after bariatric surgery. *Ann Surg Treat Res*. 2018;95:100–10. <https://doi.org/10.4174/ast.2018.95.2.100>.
 25. Vanw MR, Smulders FJ, Luyer MD, Vanm G, Vanhimbeek FJ, Nienhuijs SW. Predictors for the occurrence of major complications after primary Roux-en-Y gastric bypass surgery. *Minerva Chir*. 2016;71:286–92.
 26. Dayer-Jankechova A, Fournier P, Allemann P, Suter M. Complications after laparoscopic Roux-en-Y gastric bypass in 1573 consecutive patients: are there predictors? *Obes Surg*. 2016;26:12–20. <https://doi.org/10.1007/s11695-015-1752-1>.
 27. Abraham CR, Werter CR, Ata A, Hazimeh YM, Shah US, Bhakta A, et al. Predictors of hospital readmission after bariatric surgery. *J Am Coll Surg*. 2015;221:220–7. <https://doi.org/10.1016/j.jamcollsurg.2015.02.018>.
 28. Janik MR, Aryaie AH. The effect of smoking on bariatric surgical 30-day outcomes: propensity-score-matched analysis of the MBSAQIP. *Surg Endosc*. 2021;35:3905–14. <https://doi.org/10.1007/s00464-020-07838-4>.
 29. Falvo A, Vacharathit V, Kuhn JE, Fluck M, Cunningham RM, Petrick AT, et al. Comparison of short-term outcomes following Roux-en-Y gastric bypass in male and female patients using the MBSAQIP database. *Surg Obes Relat Dis*. 2020;16:1236–41. <https://doi.org/10.1016/j.soard.2020.04.045>.
 30. Parikh M, Eisenberg D, Johnson J, El-Chaar M. American Society for Metabolic and Bariatric Surgery review of the literature on one-anastomosis gastric bypass. *Surg Obes Relat Dis*. 2018;14:1088–92. <https://doi.org/10.1016/j.soard.2018.04.017>.

AUTHOR CONTRIBUTIONS

Conceptualisation: RS and KM. Data curation: RS, TW, and JS. Data analysis: VRC, GVG, and CL. Tables and figures: RS, VRC, and CL. Manuscript writing and proof reading: all authors.

FUNDING

This study is funded by Bariatric Unit, University Hospital Birmingham NHS Foundation Trust.

COMPETING INTERESTS

The authors declare no competing interests.

ADDITIONAL INFORMATION

Supplementary information The online version contains supplementary material available at <https://doi.org/10.1038/s41366-021-01048-1>.

Correspondence and requests for materials should be addressed to Rishi Singhal.

Reprints and permission information is available at <http://www.nature.com/reprints>

Publisher's note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.



Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this license, visit <http://creativecommons.org/licenses/by/4.0/>.

© The Author(s) 2021

GENEVA COLLABORATORS

Michał Pędziwiatr⁹, Piotr Major⁹, Piotr Zarzycki⁹, Athanasios Pantelis¹⁰, Dimitris P. Lapatsanis¹⁰, Georgios Stravodimos¹⁰, Chris Matthys¹¹, Marc Focquet¹¹, Wouter Vleeschouwers¹¹, Antonio G. Spaventa¹², Carlos Zerrweck¹², Antonio Vitiello¹³, Giovanna Berardi¹³, Mario Musella¹³, Alberto Sanchez-Meza¹⁴, Felipe J. Cantu Jr¹⁴, Fernando Mora¹⁴, Marco A. Cantu¹⁴, Abhishek Katakwar¹⁵, D. Nageshwar Reddy¹⁵, Haitham Elmaleh¹⁶, Mohammad Hassan¹⁶, Abdelrahman Elghandour¹⁶, Mohey Elbanna¹⁶, Ahmed Osman¹⁶,

Athar Khan¹⁷, Laurent Iayani¹⁷, Nalini Kiran¹⁷, Andrey Velikorechin¹⁸, Maria Solovyeva¹⁸, Hamid Melali¹⁹, Shahab Shahabi¹⁹, Ashish Agrawal²⁰, Apoorv Shrivastava²⁰, Ankur Sharma²¹, Bhavya Narwaria²¹, Mahendra Narwaria²¹, Asnat Raziel²², Nasser Sakran²², Sergio Susmalian²², Levent Karagöz²³, Murat Akbaba²³, Salih Zeki Pişkin²³, Ahmet Ziya Balta²⁴, Zafer Senol²⁴, Emilio Manno²⁵, Michele Giuseppe Iovino²⁵, Ahmed Osman²⁶, Mohamed Qassem²⁶, Sebastián Arana-Garza²⁷, Heitor P. Povoas²⁸, Marcos Leão Vilas-Boas²⁸, David Naumann²⁹, Alan Li³⁰, Basil J. Ammori³¹, Hany Balamoun³², Mohamed Salman³², Amrit Manik Nasta³³, Ramen Goel³³, Hugo Sánchez-Aguilar³⁴, Miguel F. Herrera³⁴, Adel Abou-mrad³⁵, Lucie Cloix³⁵, Guilherme Silva Mazzini³⁶, Leonardo Kristem³⁶, Andre Lazaro³⁷, Jose Campos³⁷, Joaquín Bernardo³⁸, Jesús González³⁸, Carlos Trindade³⁹, Octávio Viveiros³⁹, Rui Ribeiro³⁹, David Goitein⁴⁰, David Hazzan⁴⁰, Lior Segev⁴⁰, Tamar Beck⁴⁰, Hernán Reyes⁴¹, Jerónimo Monterrubio⁴¹, Paulina García⁴¹, Marine Benois⁴², Radwan Kassir⁴², Alessandro Contine⁴³, Moustafa Elshafei⁴⁴, Sueleyman Aktas⁴⁴, Sylvia Weiner⁴⁴, Till Heidsieck⁴⁴, Luis Level⁴⁵, Silvia Pinango⁴⁵, Patricia Martínez Ortega⁴⁶, Rafael Moncada⁴⁶, Victor Valenti⁴⁶, Ivan Vlahović⁴⁷, Zdenko Boras⁴⁷, Arnaud Liagre⁴⁸, Francesco Martini⁴⁸, Gildas Juglard⁴⁸, Manish Motwani⁴⁹, Sukhvinder Singh Saggu⁴⁹, Hazem Al Momani⁵⁰, Luis Adolfo Aceves López⁵¹, María Angelina Contreras Cortez⁵¹, Rodrigo Aceves Zavala⁵¹, Christine D'Haese RN⁵², Ivo Kempeneers⁵², Jacques Himpens⁵², Andrea Lazzati⁵³, Luca Paolino⁵³, Sarah Bathaei⁵³, Abdulkadir Bedirli⁵⁴, Aydin Yavuz⁵⁴, Çağır Büyükkasap⁵⁴, Safa Özyayın⁵⁴, Andrzej Kwiatkowski⁵⁵, Katarzyna Bartosiak⁵⁵, Maciej Walędziak⁵⁵, Antonella Santonicola⁵⁶, Luigi Angrisani⁵⁶, Paola Iovino⁵⁶, Rossella Palma⁵⁶, Angelo Iossa⁵⁷, Cristian Eugeniu Boru⁵⁷, Francesco De Angelis⁵⁷, Gianfranco Silecchia⁵⁷, Abdulzahra Hussain⁵⁸, Srivinasan Balchandra⁵⁸, Izaskun Balciscueta Cotellet⁵⁹, Javier Lorenzo Pérez⁵⁹, Ashok Bohra⁶⁰, Altaf K. Awan⁶⁰, Brijesh Madhok⁶⁰, Paul C. Leeder⁶⁰, Sherif Awad⁶⁰, Waleed Al-Khyatt⁶⁰, Ashraf Shoma⁶¹, Hosam Elghadban⁶¹, Sameh Ghareeb⁶¹, Bryan Mathews⁶², Marina Kurian⁶², Andreas Larentzakis⁶³, Gavriella Zoi Vrakopoulou⁶³, Konstantinos Albanopoulos⁶³, Ahemt Bozdog⁶⁴, Azmi Lale⁶⁴, Cuneyt Kirkil⁶⁴, Mursid Dincer⁶⁴, Ahmad Bashir⁶⁵, Ashraf Haddad⁶⁵, Leen Abu Hijleh⁶⁵, Bruno Zilberstein⁶⁶, Danilo Dallago de Marchi⁶⁶, Willy Petrini Souza⁶⁶, Carl Magnus Brodén⁶⁷, Hjörtur Gislason⁶⁷, Kamran Shah⁶⁷, Antonio Ambrosi⁶⁸, Giovanna Pavone⁶⁸, Nicola Tartaglia⁶⁸, S. Lakshmi Kumari Kona⁶⁹, K. Kalyan⁶⁹, Cesar Ernesto Guevara Perez⁷⁰, Miguel Alberto Forero Botero⁷⁰, Adrian Covic⁷¹, Daniel Timofte⁷¹, Madalina Maxim⁷¹, Dashti Faraj⁷², Larissa Tseng⁷², Ronald Liem⁷², Gürdal Ören⁷³, Evren Dilektaşlı⁷⁴, Ilker Yalcin⁷⁴, Hudhaifa AlMukhtar⁷⁵, Mohammed Al Hadad⁷⁵, Rasmi Mohan⁷⁵, Naresh Arora⁷⁶, Digvijaysingh Bedi⁷⁶, Claire Rives-Lange⁷⁷, Jean-Marc Chevallier⁷⁷, Tigran Poghosyan⁷⁷, Hugues Sebbag⁷⁸, Lamia Zina⁷⁸, Saadi Khaldi⁷⁸, Charles Mauchien⁷⁹, Davide Mazza⁷⁹, Georgiana Dinescu⁷⁹, Bernardo Rea⁸⁰, Fernando Pérez-Galaz⁸⁰, Luis Zavala⁸¹, Anais Besa⁸², Anna Curell⁸², Jose M. Balibrea⁸², Carlos Vaz⁸³, Luis Galindo⁸³, Nelson Silva⁸³, José Luis Estrada Caballero⁸⁴, Sergio Ortiz Sebastian⁸⁴, João Caetano Dallegrave Marchesini⁸⁵, Ricardo Arcanjo da Fonseca Pereira⁸⁵, Wagner Herbert Sobottka⁸⁵, Felipe Eduardo Fiolo⁸⁶, Matias Turchi⁸⁶, Antonio Claudio Jamel Coelho⁸⁷, Andre Luis Zaccaron⁸⁷, André Barbosa⁸⁸, Reynaldo Quinino⁸⁸, Gabriel Menaldi⁸⁹, Nicolás Paleari⁸⁹, Pedro Martínez-Duarte⁸⁹, Gabriel Martínez de Aragon Ramírez de Esparza⁹⁰, Valentin Sierra Esteban⁹⁰, Antonio Torres⁹¹, Jose Luis Garcia-Galocha⁹¹, Miguel Josa⁹¹, Jose Manuel Pacheco-Garcia⁹², Maria Angeles Mayo-Ossorio⁹², Pradeep Chowbey⁹³, Vandana Soni⁹³, Hercio Azevedo de Vasconcelos Cunha⁹⁴, Michel Victor Castilho⁹⁴, Rafael Meneguzzi Alves Ferreira⁹⁴, Thiago Alvim Barreiro⁹⁴, Alexandros Charalabopoulos⁹⁵, Elias Sdralis⁹⁵, Spyridon Davakis⁹⁵, Benoit Bomans⁹⁶, Giovanni Dapri⁹⁶, Koenraad Van Belle⁹⁶, Mazen Takieddine⁹⁷, Pol Vaneukem⁹⁷, Esma Seda Akalin Karaca⁹⁸, Fatih Can Karaca⁹⁸, Aziz Sumer⁹⁹, Caghan Peksen⁹⁹, Osman Anil Savas⁹⁹, Elias Chouseb¹⁰⁰, Fahad Elmokayed¹⁰¹, Islam Fakhereldin¹⁰¹, Hany Mohamed Aboshanab¹⁰¹, Talal Swelium¹⁰¹, Ahmad Gudal¹⁰², Lamees Gamloo¹⁰², Ayushka Ugale¹⁰³, Surendra Ugale¹⁰³, Clara Boeker¹⁰⁴, Christian Reetz¹⁰⁴, Ibrahim Ali Hakami¹⁰⁴, Julian Mall¹⁰⁴, Andreas Alexandrou¹⁰⁵, Efstratia Baili¹⁰⁵, Zsolt Bodnar¹⁰⁶, Almantas Maleckas¹⁰⁷, Rita Gudaityte¹⁰⁷, Cem Emir Guldogan¹⁰⁸, Emre Gundogdu¹⁰⁸, Mehmet Mahir Ozmen¹⁰⁸, Deepti Thakkar¹⁰⁹, Nandakishore Dukkupati¹⁰⁹, Poonam Shashank Shah¹¹⁰, Shashank Subhashchandra Shah¹¹⁰, Simran Shashank Shah¹¹⁰, Md Tanveer Adil¹¹¹, Periyathambi Jambulingam¹¹¹, Ravikrishna Mamidanna¹¹¹, Douglas Whitelaw¹¹², Md Tanveer Adil¹¹², Vignyan Jain¹¹², Deepa Kizhakke Veetil¹¹³, Randeep Wadhawan¹¹³, Antonio Torres¹¹⁴, Max Torres¹¹⁴, Tabata Tinoco¹¹⁴, Wouter Leclercq¹¹⁵, Marleen Romeijn¹¹⁵, Kelly van de Pas¹¹⁵, Ali K. Alkhazraji¹¹⁶, Safwan A. Taha¹¹⁶, Murat Ustun¹¹⁷, Taner Yigit¹¹⁷, Aatif Inam¹¹⁸, Muhammad Burhanulhaq¹¹⁸, Abdolreza Pazouki¹¹⁹, Foolad Eghbali¹¹⁹, Mohammad Kermansaravi¹¹⁹, Amir Hosein Davarpanah Jazi¹²⁰, Mohsen Mahmoudieh¹²⁰, Neda Mogharehabet¹²⁰, Gregory Tsiotos¹²¹, Konstantinos Stamou¹²¹, Francisco J. Barrera Rodriguez¹²², Marco A. Rojas Navarro¹²², Omar Mohamed Torres¹²², Sergio Lopez Martinez¹²², Elda Rocio Maltos Tamez¹²³, Gustavo A. Millan Cornejo¹²³, Jose Eduardo Garcia Flores¹²³, Diya Aldeen Mohammed¹²⁴, Mohamad Hayssam Elfawal¹²⁴, Asim Shabbir¹²⁵, Kim Guowei¹²⁵, Jimmy By So¹²⁵, Elif Tuğçe Kaplan¹²⁶, Mehmet Kaplan¹²⁶, Tuğba Kaplan¹²⁶, DangTuan Pham¹²⁷, Gurteshwar Rana¹²⁷, Mojdeh Kappus¹²⁷, Riddish Gadani¹²⁸, Manish Kahitan¹²⁸, Koshish Pokharel¹²⁸, Alan Osborne¹²⁹, Dimitri Pournaras¹²⁹, James Hewes¹²⁹, Errichetta Napolitano¹³⁰, Sonja Chiappetta¹³⁰, Vincenzo Bottino¹³⁰, Evelyn Dorado¹³¹, Axel Schoettler¹³², Daniel Gaertner¹³², Katharina Fedtke¹³², Francisco Aguilar-Espinosa¹³³, Saul Aceves-Lozano¹³³, Alessandro Balani¹³⁴, Carlo Nagliati¹³⁴, Damiano Pennisi¹³⁴, Andrea Rizzi¹³⁵, Francesco Frattini¹³⁵, Diego Foschi¹³⁶, Laura Benuzzi¹³⁶, Chirag Parikh¹³⁷, Harshil Shah¹³⁷, Enrico Pinotti¹³⁸, Mauro Montuori¹³⁸, Vincenzo Borrelli¹³⁸, Jerome Dargent¹³⁹, Catalin A. Copescu¹⁴⁰, Ionut Hutopila¹⁴⁰, Bogdan Smeu¹⁴⁰, Bart Witteman¹⁴¹, Eric Hazebroek¹⁴¹, Laura Deden¹⁴¹, Laura Heusschen¹⁴¹, Sietske Okkema¹⁴¹, Theo Aufenacker¹⁴¹, Willem den Hengst¹⁴¹, Wouter Vening¹⁴¹, Yonta van der Burgh¹⁴¹, Ahmad Ghazal¹⁴², Hamza Ibrahim¹⁴², Mourad Niazi¹⁴², Bilal Alkhaffaf¹⁴³, Mohammad Altarawni¹⁴³, Giovanni Carlo Cesana¹⁴⁴, Marco Anselmino¹⁴⁴, Matteo Uccelli¹⁴⁴, Stefano Olmi¹⁴⁴, Christine Stier¹⁴⁵, Tahsin Akmanlar¹⁴⁵, Thomas Sonnenberg¹⁴⁶, Uwe Schieferbein¹⁴⁶, Alejandro Marcolini¹⁴⁷, Diego Awruch¹⁴⁷, Marco Vicentin¹⁴⁷, Eduardo Lemos de Souza Bastos¹⁴⁸, Samuel Azenha Gregorio¹⁴⁸, Anmol Ahuja¹⁴⁹, Tarun Mittal¹⁴⁹, Roel Bolckmans¹⁵⁰, Tom Wiggins¹⁵⁰, Clément Baratte¹⁵¹, Judith Aron Wisniewsky¹⁵¹, Laurent Genser¹⁵¹, Lynn Chong¹⁵², Lillian Taylor¹⁵², Salena Ward¹⁵², Lynn Chong¹⁵², Lillian Taylor¹⁵², Michael W. Hi¹⁵², Helen Heneghan¹⁵³, Naomi Fearon¹⁵³, Andreas Plamper¹⁵⁴, Karl Rheinwalt¹⁵⁴, Helen Heneghan¹⁵³, Justin Geoghegan¹⁵³, Kin Cheung Ng¹⁵³, Naomi Fearon¹⁵³, Krzysztof Kaseja¹⁵⁵, Maciej Kotowski¹⁵⁵, Tarig A. Samarkandy¹⁵⁶, Adolfo Leyva-Alvizo¹⁵⁷, Lourdes Corzo-Culebro¹⁵⁷, Cunchuan Wang¹⁵⁸, Wah Yang¹⁵⁸, Zhiyong Dong¹⁵⁸, Manel Riera¹⁵⁹, Rajesh Jain¹⁵⁹,

Hosam Hamed¹⁶⁰, Mohammed Said¹⁶⁰, Katia Zarzar¹⁶¹, Manuel Garcia¹⁶¹, Ahmet Gökhan Türkçapar¹⁶², Ozan Şen¹⁶², Edoardo Baldini¹⁶³, Luigi Conti¹⁶³, Cacio Wietzycoski¹⁶⁴, Eduardo Lopes¹⁶⁴, Tadeja Pintar¹⁶⁵, Jure Salobir¹⁶⁵, Cengiz Aydın¹⁶⁶, Semra Demirli Atici¹⁶⁶, Anil Ergin¹⁶⁷, Huseyin Ciyiltepe¹⁶⁷, Mehmet Abdussamet Bozkurt¹⁶⁸, Mehmet Celal Kizilkaya¹⁶⁸, Nezihe Berrin Dodur Onalan¹⁶⁸, Mariana Nabila Binti Ahmad Zuber¹⁶⁹, Wei Jin Wong¹⁶⁹, Amador Garcia¹⁷⁰, Laura Vidal¹⁷⁰, Marc Beisani¹⁷⁰, Jorge Pasquier¹⁷¹, Ramon Vilallonga¹⁷¹, Sharad Sharma¹⁷², Chetan Parmar¹⁷³, Lyndcie Lee¹⁷³, Pratik Sufi¹⁷³, Hüseyin Sinan¹⁷⁴ and Mehmet Saydam¹⁷⁵

⁹2nd Department of General Surgery, Jagiellonian University Medical College, Krakow, Poland. ¹⁰4th Surgical Department, Evaggelismos General Hospital of Athens, Athens, Greece. ¹¹AZ Sint Elisabeth Zottegem, Zottegem, Belgium. ¹²ABC Medical Center Santa Fe, Mexico City, Mexico. ¹³Advanced Biomedical Sciences Department, Naples “Federico II” University, Naples, Italy. ¹⁴Advanced Medicine Institute, Reynosa, Mexico. ¹⁵AIG Hospital, Hyderabad, India. ¹⁶Ain Shams University Hospitals, Cairo, Egypt. ¹⁷Al Shark Hospital, Fujairah, United Arab Emirates. ¹⁸American Medical Clinic, Saint Petersburg, Russia. ¹⁹Amin University Hospital, Isfahan, Iran. ²⁰Apoorvi Hi Tech at Gokuldas Hospital, Indore, India. ²¹Asian Bariatrics, Ahmedabad, India. ²²Assuta Medical Center, Tel Aviv, Israel. ²³Atasam Hospitals, Samsun, Turkey. ²⁴AZBariatrics Obesity Center, Istanbul, Turkey. ²⁵Bariatric and Metabolic Surgery Unit, Ospedale A. Cardarelli, Naples, Italy. ²⁶Bariatric Surgery Department, Faculty of Medicine, Ain Shams University, Cairo, Egypt. ²⁷Bariatric Surgery Experts, Monterrey, Mexico. ²⁸BAROS—Bariatric and Metabolic Surgery, Salvador, Brazil. ²⁹Birmingham Heartlands Hospital, University Hospital Birmingham NHS Foundation Trust, Birmingham, UK. ³⁰BMI Alexandra Hospital, Manchester, UK. ³¹Burjeel Hospital, Abu Dhabi, United Arab Emirates. ³²Cairo University, Cairo, Egypt. ³³Center of Metabolic Surgery, Wockhardt Hospital, Agripada, Mumbai, India. ³⁴Center of Nutrition and Obesity, ABC Medical Center (Observatorio), Mexico City, Mexico. ³⁵Centre Hospitalier Regional d’ORLEANS, Orléans, France. ³⁶Centro de Obesidade do Instituto do Aparelho Digestivo, Porto Alegre, Brazil. ³⁷Centro Hospitalar e Universitario de Coimbra, Coimbra, Portugal. ³⁸Centro Médico de Asturias, Oviedo, Spain. ³⁹Centro Multidisciplinar da Doença Metabólica, Clínica Santo Antonio, Lusiadas, Amadora, Portugal. ⁴⁰Chaim Sheba Medical Center, Affiliated with Sackler School of Medicine, Tel Aviv University, Ramat Gan, Israel. ⁴¹Christus Muguerza Sur, Monterrey, Mexico. ⁴²CHU Félix Guyon, la Réunion, Réunion, France. ⁴³Città di Castello Hospital, Usl Umbria 1, Città di Castello, Italy. ⁴⁴Clinic for Metabolic Surgery, Krankenhaus Nordwest, Frankfurt, Germany. ⁴⁵Clínica Santa Sofía, Caracas, Venezuela. ⁴⁶Clínica Universidad de Navarra, Pamplona, Spain. ⁴⁷Clinical Hospital Centre Osijek, Osijek, Croatia. ⁴⁸Clinique des Cedres, Cornebarrieu, France. ⁴⁹COMS, Apollo Spectra Hospital, New Delhi, India. ⁵⁰Danat Al Emarat Hospital, Abu Dhabi, United Arab Emirates. ⁵¹Defeat Obesity Bariatric and Metabolic Surgery, CHRISTUS MUGUERZA Hospital Reynosa, Reynosa, TAMPAS, Mexico. ⁵²Delta CHIREC Hospital, Brussels, Belgium. ⁵³Department of General Surgery, Center Hospitalier Intercommunal de Créteil, Paris, France. ⁵⁴Department of General Surgery, Gazi University Faculty of Medicine, Yenimahalle/Ankara, Turkey. ⁵⁵Department of General Surgery, Military Institute of Medicine, Szaserów 128, 04-141 Warsaw, Poland. ⁵⁶Department of Public Health, “Federico II” University of Naples, Naples, Italy. ⁵⁷Division of General Surgery and Bariatric Center of Excellence IFSO-EC, University La Sapienza of Rome, Rome, Italy. ⁵⁸Doncaster and Bassetlaw Teaching Hospitals, Yorkshire, UK. ⁵⁹Dr. Lorenzo, Innovación Cirugía Obesidad y Diabetes, Valencia, Spain. ⁶⁰East-Midlands Bariatric and Metabolic Institute (EMBMI), Royal Derby Hospital, Derby, UK. ⁶¹Elisafa Private Hospital and Mansoura University Hospital and Eldelta Hospital, Mansoura, Egypt. ⁶²New York Minimally Invasive Surgery PLLC, New York, NY, USA. ⁶³First Department of Propaedeutic Surgery, Hippocraton General Athens Hospital, National and Kapodistrian University of Athens, Athens, Greece. ⁶⁴Firat University Hospital, Elazığ, Turkey. ⁶⁵Gastrointestinal, Bariatric and Metabolic Center at Jordan Hospital, Amman, Jordan. ⁶⁶GASTROMED-Zilberstein Institute, Sao Paulo, Brazil. ⁶⁷GB Obesitas Skaane, Malmö, Sweden. ⁶⁸General Surgery, University of Foggia, Foggia, Italy. ⁶⁹Glenagles Global Hospital, Lakdikapul, Hyderabad, India. ⁷⁰Grammo SAS IPS, Bogotá, Colombia. ⁷¹Grigore T. Popa University of Medicine and Pharmacy, Iasi, Romania. ⁷²Groene Hart Hospital in Gouda and Dutch Obesity Clinic, The Hague, The Netherlands. ⁷³Gürdal Ören Bariatric Surgery Center, Istanbul, Turkey. ⁷⁴Hayat Hospital, General Surgery, Bariatric and Metabolic Surgery, Bursa, Turkey. ⁷⁵Healthpoint Hospital, Abu Dhabi, United Arab Emirates. ⁷⁶Hope Obesity Centre, Ahmedabad, India. ⁷⁷Hôpital Européen Georges Pompidou, AP-HP, Université de Paris, Paris, France. ⁷⁸Hôpital Privé de Provence (HPP), Aix-en-Provence, France. ⁷⁹Hôpital Ste Musse Centre Hospitalier, Toulon, France. ⁸⁰Hospital Ángeles Lomas, Estado de México, México. ⁸¹Hospital Christus Muguerza Sur, Monterrey, México. ⁸²Hospital Clínic de Barcelona, Barcelona, Spain. ⁸³Hospital CUF Tejo, Lisbon, Portugal. ⁸⁴Hospital General Universitario Alicante Spain, Alicante, Spain. ⁸⁵Hospital Marcelino Champagnat, Curitiba, Brazil. ⁸⁶Hospital Privado de Comunidad, Mar del Plata, Argentina. ⁸⁷Hospital Rios D’Or, Rio de Janeiro, Brazil. ⁸⁸Hospital Unimed Natal, Natal, Brazil. ⁸⁹Hospital Universitario Austral, Bariatric and Metabolic Department, Buenos Aires, Argentina. ⁹⁰Hospital Universitario de Alava, Vitoria-Gasteiz, Spain. ⁹¹Hospital Universitario Madrid Montepíncipe, Hospital Clínico San Carlos, Madrid, Spain. ⁹²Hospital Universitario Puerta del Mar, Cadiz, Spain. ⁹³Institute of Minimal Access, Metabolic and Bariatric Surgery, Max Super-Speciality Hospital, Saket, New Delhi, India. ⁹⁴Instituto Campineiro de Tratamento da Obesidade, Campinas, Brazil. ⁹⁵Interbalcan Medical Center, Pilea, Greece. ⁹⁶International School Reduced Scar Laparoscopy, Brussels, Belgium. ⁹⁷Isppcc chu-André Vésale, Metabolic and Bariatric Surgery, Montigny-le-Tilleul, Belgium. ⁹⁸Istanbul Bilgi University, Turkey (first author), Department of Pulmonary Medicine, Istanbul Yedikule Chest Diseases and Thoracic Surgery Education and Research Hospital (second author), Zeytinburnu, Turkey. ⁹⁹Istinye University, School of Medicine, Istanbul, Turkey. ¹⁰⁰Jackson North Medical Center, Miami, FL, USA. ¹⁰¹King Abdul Aziz Hospital, Alhasa, Saudi Arabia. ¹⁰²King Abdullah Medical Complex, Jeddah, Saudi Arabia. ¹⁰³Kirloskar Hospital, Hyderabad, India. ¹⁰⁴Klinikum Region Hannover-Klinikum Nordstadt, Hannover, Germany. ¹⁰⁵Laiko General Hospital, National and Kapodistrian University of Athens, Athens, Greece. ¹⁰⁶Letterkenny University Hospital, Letterkenny, Ireland. ¹⁰⁷Lithuanian University of Health Sciences, Surgery Department, Kaunas, Lithuania. ¹⁰⁸Liv Hospital Ankara, Ankara, Turkey. ¹⁰⁹Livlife Hospitals, Hyderabad, India. ¹¹⁰LOC Healthcare LLP, Pune, India. ¹¹¹Luton and Dunstable Hospital, Luton, UK. ¹¹²Luton and Dunstable University Hospital, Luton, UK. ¹¹³Manipal Hospital, New Delhi, India. ¹¹⁴Max Medical, Centro de Cirugía Bariátrica/Robótica, Hospital Metropolitano de Quito/Ecuador, Quito, Ecuador. ¹¹⁵Máxima Medical Center, Veldhoven, The Netherlands. ¹¹⁶Mediclinic Hospital Airport Road, Abu Dhabi, United Arab Emirates. ¹¹⁷Memorial Hospital, Istanbul, Turkey. ¹¹⁸Metabolic, Thoracic and General Surgery Team III, Department of General Surgery, Pakistan Institute of Medical Sciences (PIMS), Islamabad, Pakistan. ¹¹⁹Minimally Invasive Surgery Research Center, Division of Minimally Invasive and Bariatric Surgery, Department of Surgery, Rasool-e Akram Hospital, Iran University of Medical Sciences, Tehran, Iran. ¹²⁰Minimally Invasive Surgery Research Center, Isfahan University of Medical Sciences, Isfahan, Iran. ¹²¹MITERA Hospital, Athens, Greece. ¹²²Monterrey Gastro and Bariatric Group, Monterrey, Mexico. ¹²³MtyBariatrics, Monterrey, NL, Mexico. ¹²⁴Najjar Hospital, Beirut, Lebanon. ¹²⁵National University Hospital Singapore, Singapore, Singapore. ¹²⁶NCR International Hospital, Gaziantep, Turkey. ¹²⁷Niagara Falls Memorial Medical Center, Niagara Falls, NY, USA. ¹²⁸Nobesity Bariatric Centre, KD Hospital, Ahmedabad, India. ¹²⁹North Bristol NHS Trust, Bristol, UK. ¹³⁰Obesity and Metabolic Surgery Unit, Ospedale Evangelico Betania, Naples, Italy. ¹³¹Obesity and Aesthetic Surgery Clinic Clínica MED, Cali, Colombia. ¹³²Obesity Center, Municipal Hospital Karlsruhe, Karlsruhe, Germany. ¹³³Obesity Clinic: Los Altos Obesity Surgery, Tepatitlan, Mexico. ¹³⁴Ospedale di Gorizia, Italy, Struttura Complessa Chirurgia Generale, Gorizia, Italy. ¹³⁵Ospedale Galmarini Tradate, Varese, Italy. ¹³⁶Ospedale San Giuseppe IRCCS Multimedica, University of Milan, Milan, Italy. ¹³⁷Parul Institute of Medical Sciences and Research, Parul University, Waghodia, Vadodra, India. ¹³⁸Policlinico San Pietro, Unità di Chirurgia Bariátrica, Bergamo, Italy. ¹³⁹Polyclinique Lyon-Nord, 69140 Rillieux, France. ¹⁴⁰Ponderas Academic Hospital, Bucharest, Romania. ¹⁴¹Rijnstate Hospital/Vitalys Clinics, Arnhem, The Netherlands. ¹⁴²Saint Louis Hospital, Aleppo, Aleppo, Syria. ¹⁴³Salford Royal NHS Foundation Trust, Salford, UK. ¹⁴⁴San Marco Hospital GSD, Zingonia, BG, Italy. ¹⁴⁵Sana Obesity Center Northrhine Westphalia, Clinic for General, Visceral, and Transplantation Surgery, RWTH University Aachen, Aachen, Germany. ¹⁴⁶Sana Obesity Center Northrhine Westphalia, Westphalia, Germany. ¹⁴⁷Sanatorio Británico de Rosario, Rosario, Santa Fe, Argentina. ¹⁴⁸Santa Casa de Marília, Marília, Brazil. ¹⁴⁹Sir Ganga Ram Hospital, Delhi, India. ¹⁵⁰Somerset NHS Foundation Trust, Taunton, UK. ¹⁵¹Sorbonne Université, Institute of Cardiometabolism and Nutrition ICAN, Assistance Publique-Hôpitaux de Paris, Departments of Digestive surgery and Nutrition, Pitié-Salpêtrière University Hospital, Paris, France. ¹⁵²St. Vincent’s Hospital Melbourne, Fitzroy, Australia. ¹⁵³St. Vincent’s University Hospital, Dublin, Ireland. ¹⁵⁴St. Franziskus Hospital, Cologne, Germany. ¹⁵⁵State Clinical Hospital No. 2 of the Pomeranian Medical University in Szczecin, Szczecin, Poland. ¹⁵⁶Sutter Gould Medical Foundation, Dameron Hospital, Stockton, CA, USA. ¹⁵⁷Tecnologico de Monterrey, Monterrey, MX, Mexico. ¹⁵⁸The First Affiliated Hospital of Jinan University, Guangzhou, China. ¹⁵⁹The Shrewsbury and Telford Hospital, Shrewsbury, UK. ¹⁶⁰Tuelife Bariatric and Digestive Surgery Center, Mansoura, Dakahleyya, Egypt. ¹⁶¹Tu Opcion Bariátrica, Monterrey, Mexico. ¹⁶²Türkçapar Bariatrics Obesity Center, Istanbul, Turkey. ¹⁶³U.O. Chirurgia, Ospedale “Guglielmo da Saliceto”, Piacenza, Italy. ¹⁶⁴Unimed Vale do Caí Hospital, Montenegro, BR. ¹⁶⁵Maicé Hospital, Caçador, BR, Brazil. ¹⁶⁶University Medical Center Ljubljana, Ljubljana, Slovenia. ¹⁶⁷University of Health Sciences Tepecik Training and Research Hospital, Department of General Surgery, Izmir, Turkey. ¹⁶⁸University of Health Sciences, Fatih Sultan Mehmet Training and Research Hospital, General Surgery Department, Istanbul, Turkey. ¹⁶⁹University of Health Sciences, Kanuni Sultan Süleyman Training and Research Hospital, Istanbul, Turkey. ¹⁷⁰University of Malaya Medical Centre, Kuala Lumpur, Malaysia. ¹⁷¹Vall d’Hebron University Hospital, Barcelona, Spain. ¹⁷²Vall Hebron Hospital Campus—Hospital de Barcelona-SCIAS, Barcelona, Spain. ¹⁷³Vinamra Swaraj Hospital, Navi Mumbai, India. ¹⁷⁴Whittington Health NHS Trust, London, UK. ¹⁷⁵Department of Metabolic Surgery, Special Etiler Hospital, Istanbul, Turkey. ¹⁷⁶Department of General Surgery, Diskapi Yıldırım Beyazıt Training and Research Hospital, Ankara, Turkey.