# ASSOCIATION OF BODY MASS INDEX WITH SHORT-TERM OUTCOMES AFTER CARDIAC SURGERY: RETROSPECTIVE STUDY AND META-ANALYSIS

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Abstract The relationship between higher body mass index (BMI), decreased morbidity and mortality is known as the "obesity paradox", and has been described in cohorts of patients with hypertension, diabetes, heart failure, coronary and peripheral artery diseases, non-cardiac surgery, and end-stage renal disease. Here we investigated the relationship between BMI and short-term outcomes after adult cardiac surgery to explore the existence of an obesity paradoxical effect. A secondary objective was to perform an updated systematic review to further analyze the association between BMI and 30-day in-hospital mortality after cardiac surgery. A retrospective analysis was performed from a consecutive series of 1823 adult patients who underwent cardiac surgery, that were assigned to five BMI groups: normal weight (18.5-24.9 kg/m<sup>2</sup>), overweight (25-29.9 kg/m<sup>2</sup>), class I obese (30-34.9 kg/m<sup>2</sup>), class II obese (35-39.9 kg/m<sup>2</sup>), and class III obese or morbidly obese (40-49.9 kg/m<sup>2</sup>). A systematic review search was performed including controlled trials and observational studies identified in MED-LINE, Embase, SCOPUS, and the Cochrane library (to the end of June 2017). In the present series, overweight and obese patients had similar or slightly lower in-hospital mortality rates after cardiac surgery compared with normal-weight individuals. Conversely, postoperative complication rates increased with higher BMI levels. Most studies included in the review showed that overweight and obese patients had at least the same mortality rate as normal-weight patients, or even a lower death risk. Pooled-data of the meta-analysis provided evidence on the association between higher BMI levels and a lower all-cause in-hospital mortality rate after cardiac surgery.

Key words: obesity, operative risk, cardiac surgery, meta-analysis

Asociación entre índice de masa corporal y resultados a corto plazo después de la cirugía Resumen cardíaca: estudio retrospectivo v metaanálisis. La relación entre mayor índice de masa corporal (IMC) y menor morbilidad y mortalidad se conoce como "paradoja de la obesidad". Se ha descrito en cohortes de pacientes con hipertensión, diabetes, insuficiencia cardíaca, enfermedad coronaria y arterial periférica, cirugías no cardíacas y enfermedad renal en etapa terminal. Aquí se investigó la relación entre IMC y resultados a corto plazo después de cirugía cardíaca en adultos, y la manifestación de la paradoja de la obesidad. También se realizó una revisión sistemática sobre asociación entre IMC y mortalidad a 30 días de la cirugía cardíaca. Se hizo un análisis retrospectivo de una serie consecutiva de 1823 adultos con cirugía cardíaca, asignados a cinco grupos de IMC: peso normal (18.5-24.9 kg/m<sup>2</sup>), sobrepeso (25- 29.9 kg/m<sup>2</sup>), obesidad clase I (30-34.9 kg/m<sup>2</sup>), clase II (35-39.9 kg/m<sup>2</sup>), y clase III (40-49.9 kg/m²), y una búsqueda sistemática de ensayos controlados y estudios observacionales en MEDLINE, Embase, SCOPUS y Cochrane (hasta 30/6/2017). En la serie, las tasas de mortalidad hospitalaria fueron similares o ligeramente menores en pacientes con sobrepeso y obesidad comparados con aquellos de peso normal. Pero también las tasas de complicaciones postoperatorias aumentaron con el IMC. La mavoría de los estudios observacionales revisados mostraron que los pacientes con sobrepeso y obesidad tenían al menos similar tasa de mortalidad que aquellos con peso normal, o menor riesgo de muerte. Los datos combinados del metaanálisis evidenciaron asociación entre los niveles de IMC mayores y tasa de mortalidad hospitalaria más baja después de cirugía cardíaca.

Palabras clave: obesidad, riesgo operatorio, cirugía cardíaca, metaanálisis

Obesity has been described as a risk factor for the development of coronary artery disease, stroke, cancer, renovascular disease, and other physical and psy-

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chological comorbidities<sup>1-5</sup>. Conversely, several other epidemiological and observational studies on different diseases have shown better outcomes and survival rates in overweight and obese patients than in those with normal body mass index (BMI)<sup>6</sup>. This counter-intuitive relationship between higher BMI and decreased morbidity and mortality is known as the "obesity paradox"<sup>7</sup>, and has been observed in patients with hypertension, diabetes, heart failure, coronary and peripheral artery diseases,

non-cardiac surgery, and end-stage renal disease<sup>8-10</sup>. However, studies examining the association between obesity and adverse outcomes after cardiac surgery still remain controversial<sup>11-15</sup>. For instance, the EuroSCORE II model does not include BMI as a predictive variable for stratification of perioperative death risk<sup>16</sup>. Some studies have demonstrated that overweight and moderately obese patients have better early hospital outcomes in terms of mortality<sup>11, 12, 17</sup>, and a lower incidence of major adverse cardiac and cerebrovascular events<sup>12, 17, 18</sup>. Other studies have not found any clear protective effect of overweight and obesity on mortality or adverse events after cardiac surgery<sup>19-21</sup>; or they have even demonstrated a deleterious effect for sternal wound infection<sup>22-25</sup>, leg infection<sup>26</sup>, sternal dehiscence<sup>27</sup>, renal failure<sup>23, 28</sup>, atrial fibrillation<sup>26, 29</sup>, venous thromboembolism<sup>29</sup>, and pulmonary and gastrointestinal complications<sup>30</sup>. In general, studies with negative evidence for the "obesity paradox" have tended to include far fewer patients than reports with positive evidence, a difference possibly related to the power analysis of sample size. Nevertheless, outcomes from large samples may in turn exaggerate the clinical value of a statistical difference.

The aim of this study was to investigate the relationship between BMI and short-term outcomes after adult cardiac surgery and to explore the existence of an obesity paradoxical effect. A secondary objective was to perform an updated systematic review to further analyze the association between BMI and 30-day in-hospital mortality after cardiac surgery.

### Materials and methods

A retrospective analysis was performed on prospectively collected data (ambispective design) from a consecutive series of 1823 adult patients who underwent different types of cardiac surgery at the Buenos Aires University Hospital and its associated clinics over a 6-year period (2011-2016). All types of on-pump and off-pump elective cardiac surgery were included, except transplantation and transcatheter aortic valve implantation. Baseline and operative data were prospectively collected in a clinical registry, which included the variables needed to estimate the operative risk mortality based on EuroSCORE II16. Additional information on other risk factors and comorbidities was added in the computerized database. In-hospital major postoperative complications (stroke, cardiac arrest, myocardial infarction, renal dialysis, permanent pacemaker implantation, ventricular arrhythmias, reoperation for bleeding, low cardiac output, sternal dehiscence, deep sternal wound infection or mediastinitis, sepsis, prolonged ventilation, and pneumonia). and in-hospital mortality were compared among various BMI groups after cardiac surgery. BMI was automatically recorded in the operation theatre before surgery. Postoperatively, patients were assigned to five BMI groups<sup>31</sup>: normal weight (18.5 to 24.9 kg/m<sup>2</sup>), overweight (25 to 29.9 kg/m<sup>2</sup>), class I obese (30 to 34.9 kg/m<sup>2</sup>), class II obese (35 to 39.9 kg/m<sup>2</sup>), and class III obese or morbidly obese (40 to 49.9 kg/m<sup>2</sup>). Underweight (BMI < 18.5 kg/m<sup>2</sup>) (n = 3) and class IV or "super obese" (BMI  $\geq$  50 kg/m<sup>2</sup>) (n = 1) groups were excluded from the study due to the low number of patients.

Baseline preoperative clinical variables and in-hospital outcome data were recorded and analyzed with the approval of the local Institutional Review Board which waived the need for a written informed consent.

The systematic review search strategy was performed using controlled trials and observational studies identified in MEDLINE, Embase, SCOPUS, and the Cochrane library (to the end of June 2017). Reference lists of primary studies, review articles, and previous meta-analyses were reviewed with no language, age or type of cardiac surgery restrictions. The inclusion criteria required studies to separately report mortality in normal, overweight and obese patients using traditional World Health Organization BMI categories. Studies comparing obese versus non-obese patients (i.e. normal and overweight patients grouped together), and studies published only in abstract form were excluded from the analysis. Articles were also excluded if the total number of deaths was < 3. Two reviewers (R.A.B. and C.A.I.) independently reviewed citations and performed data retrieval, and disagreements were resolved through consensus. No additional data were requested from the primary study authors. The primary endpoint was all-cause mortality. Odds ratios (OR) with 95% confidence intervals (95% CI) and forest plots were calculated with EPIDAT, Version 3.1 (Xunta de Galicia-PAHO/WHO) using fixed and random effect models. Heterogeneity among studies was examined using the  $\chi^2$  test and the Higgins I<sup>2</sup> test (25%, 50%, and 75% I<sup>2</sup> values were interpreted as low, moderate, and high heterogeneity). A funnel plot was used as a graphical method to identify studies affecting heterogeneity, and the Begg test to assess publication bias.

Categorical data were expressed as absolute frequencies and percentages, and continuous variables as mean and standard deviation (SD). The Kolmogorov-Smirnov (K-S) goodness-of-fit test was used to analyze normal distributions. Univariate comparison of discrete variables was performed using  $\chi^2$  or Yates' corrected  $\chi^2$  test. Analysis for linear trends in proportions for postoperative complications was done with X<sup>2</sup> test for trend. One-way analysis of variance (ANOVA) was used to compare more than two means and post hoc multiple comparisons were done with Tukey's test assuming equal variances. The Snedecor F-test was used to assess variance equality. Observed-to-expected operative mortality ratios within groups was also calculated and compared with the  $\chi^2$  test. A propensity-score analysis was used to adjust for preoperative and operative confounding factors in order to minimize baseline differences between the BMI groups. Characteristics independently associated with normal and overweight or obese patients after propensity-score matching were assessed in a multivariate binary logistic regression model with backward stepwise conditional method. Covariates used in the regression model included all the preoperative and operative variables, and final results were expressed as odds ratio (OR) with the associated 95% CI. Non-linear regression analysis and the corresponding coefficient of determination (R<sup>2</sup>) were used to find the best fit for postoperative complications and mortality rates between BMI groups. Statistical analysis was performed with IBM SPSS 23.0 Statistics (IBM Corporation, Armonk, NY). A 2-tailed p value  $\leq$  0.05 was considered statistically significant.

# Results

Classification and proportional distribution of patients based on preoperative BMI is shown in Table 1, where 22.7% (n = 413) was classified as obese, independently of class. For purpose analysis, all types of obesity were considered as a single group (aggregated BMI 30.0-49.9 kg/m<sup>2</sup>). Table 2 lists preoperative baseline characteristics of the BMI groups. Univariate analysis revealed younger age and higher rates of male sex and diabetes in overweight and obese patients compared with normal-weight individuals. Conversely, the normal-weight group showed higher rates of heart failure, pulmonary hypertension and heart valve endocarditis.

Distribution of operative variables and outcomes are shown in Table 3. Isolated coronary surgery and shorter cross-clamping time were more frequent in overweight and obese patients. Overall postoperative complications increased through BMI groups with a slight decrease in overweight patients (Table 3, Fig. 1). Postoperative ventricular arrhythmias were significantly more common in obese patients when complications were disaggregated.

In-hospital mortality rate was slightly higher in the normal-weight group than in the other BMI groups, though differences were not significant (normal versus overweight OR: 1.17, 95% CI: 0.70-1.95, p = 0.554; normal versus obese OR: 1.09, 95% CI: 0.59-2.00, p = 0.789) (Fig. 2). There was no statistical difference between observed and

TABLE 1.– Classification and proportional distribution of patients based on preoperative body mass index (BMI)

BMI (kg/m²)	Classification	Denomination	Number	Percent
18.5-24.9	Normal	Normal	502	27.5%
25.0-29.9	Overweight	Overweight	908	49.8%
30.0-34.9	Obese Class I	Obese	328	18.0%
35.0-39.9	Obese Class II	Severely obese	64	3.5%
40.0-49.9	Obese Class III	Morbidly obese	21	1.2%
		Total	1823	100.0%

TABLE 2.- Distribution of preoperative variables according to body mass index

Variable	Total (18.5-49.9 kg/m²) n = 1823	Normal weight (18.5-24.9 kg/m²) n = 502	Overweight (25.0-29.9 kg/m²) n = 908	Obese (30.0-49.9 kg/m²) n = 413	p value
BMI (kg/m²)	27.5±3.9	23.6±1.3	27.0±1.4	33.2±3.2	<0.0001
Age (years)	66.4±10.8	67.5±11.9	66.6±10.6	64.7±9.6	0.0003
Male sex	1321 (74.5%)	311 (62.0%)	704 (77.5%)	306 (74.1%)	< 0.0001
Hypertension	1014 (55.6%)	259 (51.6%)	514 (56.6%)	241 (58.4%)	0.086
Dyslipidemia	597 (32.7%)	160 (31.9%)	294 (32.4%)	143 (34.6%)	0.640
Diabetes (I-II)	418 (22.9%)	89 (17.7%)	212 (23.3%)	117 (28.3%)	0.0007
Active smoker	200 (11.0%)	53 (10.6%)	104 (11.5%)	43 (10.4%)	0.804
COPD	94 (5.2%)	22 (4.4%)	48 (5.3%)	24 (5.8%)	0.604
Peripheral vascular disease	56 (3.1%)	14 (2.8%)	30 (3.3%)	12 (2.9%)	0.845
Stroke	42 (2.3%)	10 (2.0%)	23 (2.5%)	9 (2.2%)	0.796
Myocardial infarction	140 (7.7%)	43 (8.6%)	75 (8.3%)	22 (5.3%)	0.122
Atrial fibrillation	96 (5.3%)	28 (5.6%)	49 (5.4%)	19 (4.6%)	0.781
Pulmonary hypertension	81 (4.4%)	36 (7.2%)	31 (3.4%)	14 (3.4%)	0.002
Heart failure	43 (2.4%)	20 (4.0%)	18 (2.0%)	5 (1.2%)	0.013
Chronic renal failure (dialysis or	25 (1.4%)	12 (2.4%)	9 (1.0%)	4 (1.0%)	0.070
eCrCl < 30ml/min)					
Previous cardiac surgery	37 (2.0%)	10 (2.0%)	20 (2.2%)	7 (1.7%)	0.830
LVEF (%)	57.3±10.9	56.6±10.9	57.2±11.2	57.7±10.1	0.461
Emergency	60 (3.3%)	17 (3.4%)	33 (3.6%)	10 (2.4%)	0.514
Unstable angina	54 (3.0%)	8 (1.6%)	35 (3.9%)	11 (2.7%)	0.052
Valve endocarditis	57 (3.1%)	27 (5.4%)	20 (2.2%)	10 (2.4%)	0.003

BMI: body mass index; COPD: chronic obstructive pulmonary disease; eCrCl: Cockcroft-Gault estimated creatinine clearance; LVEF: left ventricular ejection fraction

TABLE 3.- Distribution of operative variables and outcomes according to body mass index

Variable	Total	Normal weight	Overweight	Obese	p value
	(18.5-49.9 Kg/m <sup>2</sup> )	(18.5-24.9 kg/m <sup>2</sup> )	(25.0-29.9 kg/m <sup>2</sup> )	(30.0-49.9 kg/m <sup>2</sup> )	
	n = 1823	n = 502	n = 908	n = 413	
Type of surgery:					
CABG alone	954 (52.3%)	235 (46.8%)	480 (52.9%)	239 (57.9%)	0.004
Heart valve surgery alone	491 (26.9%)	153 (30.5%)	230 (25.3%)	108 (26.2%)	
Combined	258 (14.2%)	84 (16.7%)	136 (15.0%)	38 (9.2%)	
Miscelaneous	120 (6.6%)	30 (6.0%)	62 (6.8%)	28 (6.8%)	
Off pump surgery*	258 (27.0%)	67 (28.5%)	124 (25.8%)	67 (28.0%)	0.385
Cross-clamping time (min)	39.3 ± 14.1	40.6 ± 15.0	38.8 ± 13.6	38.3 ± 13.8	0.039
Perfusion time (min)	64.8 ± 16.6	65.2 ± 17.3	64.5 ± 16.6	64.5 ± 15.6	0.744
Postoperative complications:					
Stroke	17 (0.9%)	8 (1.6%)	4 (0.4%)	5 (1.2%)	0.078
Myocardial infarction	16 (0.9%)	3 (0.6%)	9 (1.0%)	4 (1.0%)	0.731
Dialysis	17 (0.9%)	4 (0.8%)	9 (1.0%)	4 (1.0%)	0.933
Mediastinitis	26 (1.4%)	4 (0.8%)	13 (1.4%)	9 (2.2%)	0.214
Sternal dehiscence	5 (0.3%)	1 (0.2%)	3 (0.3%)	1 (0.2%)	0.894
Reoperation for bleeding	28 (1.5%)	10 (2.0%)	12 (1.3%)	6 (1.5%)	0.611
Cardiac arrest	11 (0.6%)	2 (0.4%)	5 (0.6%)	4 (1.0%)	0.519
Low cardiac output	41 (2.2%)	9 (1.8%)	20 (2.2%)	12 (2.9%)	0.524
Prolonged ventilation	22 (1.2%)	6 (1.2%)	11 (1.2%)	5 (1.2%)	0.999
Pneumonia	18 (1.0%)	6 (1.2%)	7 (0.8%)	5 (1.2%)	0.648
Permanent pacemaker	9 (0.5%)	4 (0.8%)	2 (0.2%)	3 (0.7%)	0.250
Ventricular arrhythmias	7 (0.2%)	1 (0.2%)	1 (0.1%)	5 (1.2%)	0.008
Overall complications	217 (11.9%)	58 (11.6%)	96 (10.6%)	63 (15.3%)	0.049
Death	83 (4.6%)	25 (5.0%)	39 (4.3%)	19 (4.6%)	0.951
Combined events	300 (16.5%)	83 (16.6%)	135 (14.9%)	82 (19.9%)	0.077
(death + complications)					

CABG: Coronary artery bypass grafting

\*Percent calculated exclusively for coronary artery surgery



Fig. 1.– Overall postoperative complications observed in patients undergoing all types of cardiac surgery according to their body mass indexes (BMI). BMI showed a near quadratic relationship with the risk of postoperative complications (R<sup>2</sup> = 0.923)



Fig. 2.– In-hospital mortality, *EuroSCORE* II mortality risk and observed-to-expected mortality ratio of patients undergoing all types of cardiac surgery according to their body mass indexes (BMI). BMI showed a near quadratic (reverse J-shaped) association with in-hospital mortality risk (R<sup>2</sup> = 0.912)

expected mortality for each individual BMI group; nevertheless, the expected mortality risk according to *EuroSCORE* II was significantly different among BMI groups (ANOVA F = 2.98, p = 0.018; Tukey's test p = 0.046 for post hoc comparison between normal and overweight groups), with the normal-weight group showing the highest expected risk.

After adjusting by propensity score, a total of 806 patients for normal versus overweight comparison and 460 patients for normal versus obese comparison showed no systematic differences in the distribution of covariates.

Differences in in-hospital mortality rates were preserved, and complications rates became similar after propensity score-matched normal versus overweight groups were compared (mortality rate 4.2% versus 3.5%, OR: 1.22, 95% CI: 0.59-2.52, p = 0.583, and complications 8.4% versus 8.4%, OR: 1.00, 95% CI: 0.61-1.64, p = 1.000). Conversely, when comparing normal versus obese groups, differences in in-hospital mortality and complications rates were preserved after propensity score matching (mortality rate 3.5% versus 2.2%, OR: 1.62, 95% CI: 0.52-5.03, p = 0.399, and complications 6.5% versus 11.7%, OR: 0.52, 95% CI: 0.27-1.01, p = 0.052).

Out of 4410 initial independent references obtained through various search strategies comprising cardiac surgery and obesity, 30 eligible cohort observational studies were identified and included in the meta-analysis<sup>11, 12, 17-19, 22, 29, 31-53</sup>. When the data from our study before and after propensity score matching were included, the final meta-analysis population comprised 451 300 patients for the

normal/overweight comparison (32 studies), and 289 214 patients for the normal/obese comparison (20 studies). The meta-analysis demonstrated the obesity paradox. Compared with overweight patients, the random observed global OR was 0.71 (95% CI, 0.66-0.77) for normal-weight individuals (Fig. 3.a), whereas compared with obese patients, the random observed global OR was 0.73 (95% CI, 0.65-0.83) for normal-weight patients (Fig. 3.b). Funnel plots revealed no evidence of publication bias in both mortality comparisons (Begg test Z = 0.60, p = 0.549 for overweight versus normal groups, and Z = 0.29, p = 0.770for obese versus normal groups). Between-study heterogeneity was statistically significant in the analysis of both overweight versus normal-weight patients ( $I^2 = 61.0\%$ , Q = 62.0, p = 0.0008) and in obese versus normal-weight patients ( $I^2 = 74.4\%$ , Q = 44.3, p = 0.0009).

#### Discussion

The initial unadjusted comparison of in-hospital mortality rates after cardiac surgery between the different BMI groups revealed the incipient reverse J-shaped distribution described in the obesity paradoxical effect, with overweight and class I obese patients showing the lowest mortalities. Nevertheless, the higher mortality rate found in patients with normal BMI can be easily explained by a greater expected risk according to *EuroSCORE* II. This expected risk was significantly higher than that predicted for the

			Overwei	ight	Normal				Type of
Study (Year) n	0005 1800 CT (95,0%)		even	t total	event	total	OR	95% CI	surgery
Gurm [44] (2002) 945	•		9	683	6	262	0.57	0.20-1.62	CABG
Reeves [38] (2003) 3336	· · · ·		18	2170	11	1166	0.88	0.41-1.87	CABG
Orhan [53] (2004) 950	·		12	632	6	318	1.01	0.37-2.71	CABG
Brat [48] (2005) 3126	·		51	2139	29	987	0.81	0.51-1.28	All
Jin [40] (2005) 10158	· · ·		129	6683	108	3475	0.61	0.47-0.80	CABG
Pan [39] (2006) 6441	·		125	4257	103	2184	0.61	0.47-0.80	CABG
Wagner [45] (2007) \$2193	·		1090	34063	725	18130	0.79	0.72-0.87	CABG
Rahmanian [47] (2007) 4330	·] _+_		75	2289	64	2041	1.05	0.75-1.47	Combine
Shirzad [50] (2009) 7988			34	4809	29	3179	0.77	0.47-1.27	CABG
Sun [46] (2009) 9313			228	5551	218	3762	0.70	0.58-0.84	All
van Straten [37] (2010) 8130			105	5234	73	2896	0.79	0.59-1.07	CABG
Le-Bert [34] (2011) 302	•		7	167	8	135	0.69	0.25-1.97	CABG
Stamou [11] (2011) 1521	<b>↓</b> • ↓		17	965	26	556	0.37	0.20-0.68	Combine
Atalan [51] (2012) 530	<u>}</u> +		12	371	9	159	0.56	0,23-1,35	CABG
Zalewska-Adamiec [52] (2012) 109	<b>}</b> •		7	72	7	37	0.46	0.15-1.43	CABG
Vaduganathan [49] (2012) 1885	· · · · · · · · · · · · · · · · · · ·		25	1020	40	865	0.52	0.31-0.86	Valve
Ho [29] (2013) 1462	1 —	•	14	924	5	538	1.64	0.59-4.58	AII
van Straten [42] (2013) 1313			23	829	20	484	0.65	0.36-1.22	Valve
Chang [32] (2013) 295	·		4	130	12	165	0.40	0.13-1.29	AII
Zittermann [18] (2014) 6491	·] _•		107	3937	81	2554	0.85	0.64-1.14	All
Cemerlic-Adjic [43] (2014) 544	•		. 8	389	3	155	1.03	0.28-4.05	CABG
Benedetto [33] (2014) 9931	· · ·		133	6662	125	3269	0.51	0.40-0.66	CABG
Allama [22] (2014) 2205	·		22	1261	33	944	0.49	0.28-0.85	CABG
Caliskan [35] (2014) 2793			40	1802	15	991	1.48	0.81-2.69	CABG
Ranucci [41] (2014) 4054	1 -		65	2086	59	1968	1.04	0.73-1.49	AII
Lopez-Delgado [19] (2015) 1673	·		51	1150	27	523	0.85	0.53-1.38	All
Johnson [12] (2015) 51759	·		356	34597	256	17162	0.69	0.58-0.81	CABG
Gao [17] (2016) 2918	· _ • _		43	1774	45	1144	0.61	0.40-0.93	All
Hartrumpf [36] (2017) 10242			344	6608	254	3634	0.73	0.62-0.86	AII
Mariscalco [31] (2017) 242147	•		4283	150769	4014	91378	0.64	0.61-0.66	All
Current study (2017) 1410	1		39	908	25	502	0.86	0.51-1.43	AII
Current (porpensity) (2017) 806	·		14	403	17	403	0.82	0.40-1.68	All
GLOBAL (Fixed Eff.) 451300			7490	285334	6453	165966	0.67	0.65-0.70	
GLOBAL (Random Eff.) 451300			7490	285334	6453	165966	0.71	0.66-0.77	
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a. Overweight versus OR: Odds ratio; CI: (	normal	2 3 4	Coronary	v artery b	oypass	graftin	ıg		
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a. Overweight versus OR: Odds ratio; CI: (	normal	ż ż ź	Coronary	v artery b	oypass	graftin	ŋg		Type of
a. Overweight versus OR: Odds ratio; CI: (	normal Confidence interval,	żżź	Coronary	v artery b	oypass	graftin	ng	95% CI	Type of surgery
a. Overweight versus OR: Odds ratio; CI: ( Study (Year) n Reeves [38] (2000) 1913	normal Confidence interval,	2 3 4	Coronary	v artery b	total	graftin or 0.85	ng 	95% CI 31-2.31	Type of surgery CABG
a. Overweight versus <i>OR: Odds ratio; CI:</i> ( Study (Year) n Reeves (38) (2005) 1913 Jin (40) (2005) 9445		2 3 4	Coronary total 747 5970	Normal event 11 108	total 1166 3475	graftin or 0.85 0.62	<i>ng</i> 	95% CI 31-2.31 47-0.81	Type of surgery CABG CABG
a. Overweight versus OR: Odds ratio; CI: ( Study (Year) n Reeves [30] (2003) 1913 JR (40] (2006) 1914 JR (40] (2006) 5005	s normal Confidence interval, srato cr (95,9%) 	2 3 4 CABG: C Obese event 6 116 115	Coronary total 747 5970 3421	Normal event 11 108 103	total 1166 3475 2184	<b>OR</b> 0.85 0.62 0.70	<i>ng</i> 0. 0. 0.	95% CI 31-2.31 47-0.81 54-0.92	Type of surgery CABG CABG CABG
a. Overweight versus OR: Odds ratio; CI: ( Sudy (Vear) n Reeves (38) (2003) 1913 Jan (40) (2005) 9445 Pan 190 (2006) 9452	s normal Confidence interval, s rate ct (95.0%)	2 3 4 CABG: C Obese event 6 116 115 41	total 747 5370 3421 1686	Normal event 11 108 103 73	total 1166 3475 2184 2896	<b>OR</b> 0.85 0.62 0.70 0.96	<i>ng</i> 0. 0. 0. 0. 0.	95% Cl 31-2.31 47-0.81 54-0.92 65-1.42	Type of surgery CABG CABG CABG CABG
a. Overweight versus <i>OR: Odds ratio; CI: (</i> Study (Year) n Reeves (38) (2005) 1913 Jin (40) (2005) 9445 Pan 191 (2006) 5665 van Straten (51) (2011) 1475	s rormal Confidence interval,	2 3 4 CABG: C event 6 115 115 41 34	Coronary total 747 5970 3421 1686 919	Normal event 11 105 73 26	total 1166 3475 2184 2896 556	<b>or</b> 0.85 0.62 0.70 0.96 0.78	<i>ig</i> 0. 0. 0. 0. 0. 0.	95% CI 47-0.81 54-0.92 65-1.42 46-1.32	Type of surgery CABG CABG CABG CABG CABG Combine
a. Overweight versus OR: Odds ratio; CI: ( Study (Year) n Reves [30] (2003) 1913 Jan (40) (2006) 1945 Pan [39] (2006) 5505 van Straten [37] (2016) 4552 Statem (17) (2011) 4552 Statem (17) (2011) 1475	s normal Confidence interval, srato ct (95,0%) 	2 3 4 CABG: C 0bese event 6 115 115 115 41 34 4	Coronary total 747 5570 3421 1685 919 94 342	Normal event 108 108 73 26 8	total 1166 3475 2184 2896 556 135	<b>graftin</b> 0.85 0.62 0.70 0.96 0.78 0.72	<i>ig</i> 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.	95% CI 31-2.31 47-0.81 54-0.92 65-1.42 46-1.32 21-2.41	Type of surgery CABG CABG CABG CABG CABG CABG
a. Overweight versus OR: Odds ratio; CI: ( Study (Year) n Reeves (38) (2003) 1913 Jai (40) (2005) 9445 Pan 190 (2006) 9445 Van Straten (37) (2016) 4562 Stamou (11) (2015) 4565 Van Straten (37) (2016) 4562 Stamou (11) (2015) 229 Chang (23) (2013) 229 Chang (23) (2013) 229	In normal Confidence interval, Is ratio CI (95,0%) 	CABG: C CABG: C event 6 115 41 34 4 3 0	Coronary total 747 5570 3421 1686 919 94 133 66	Normal event 11 105 73 26 8 12 5	total 1166 3475 2184 2896 135 165 556	<b>OR</b> 0.85 0.62 0.70 0.96 0.72 0.29	9 <b>9</b> 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.	95% Cl 31-2.31 47-0.81 54-0.92 65-1.42 46-1.32 21-2.41 08-1.07	Type of surgery CABG CABG CABG CABG CABG CABG CABG CABG
a. Overweight versus OR: Odds ratio; CI: ( Study (Year) n Reves [38] (2003) 1913 Jn (c0] (2005) 94-5 Pan [39] (2006) 5565 Van Strate (J2) (2019) 94-5 Stamou (11) (2011) 1475 Le-Bert [24] (2013) 1287 Htte [22] (2013) 1287	Is ratio ct (95.0%)	CABG: C CABG: C Cobese event 6 116 115 41 34 4 3 9 9 68	Coronary total 747 5970 3421 1686 919 94 133 669 919 2359	Normai event 11 108 103 26 8 12 5 5	total 1166 3475 2184 2896 556 135 165 538 2556	<b>OR</b> 0.85 0.62 0.70 0.96 0.78 0.72 0.29 1.45	1 <b>g</b> 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.	55% C1 31-2.31 54-0.92 65-1.42 46-1.32 21-2.41 88-1.07 48-4.36	Type of surgery CABG CABG CABG CABG CABG CABG All All All
a. Overweight versus OR: Odds ratio; CI: ( Study (Year) n Reves [38] (2003) 1913 Jin (40 (2005) 1914 Pan [39] (2006) 5005 van Straten [37] (2016) 4522 Staterou [17] (2016) 4522 Chang [32] (2013) 298 He (28) (2013) 1267 Zittermann [18] (2014) 4923 Benedicti 21 (2014) 4923	is normal Confidence interval, is ratio CI (95,0%)	CABG: C CABG: C Cobese event 6 115 115 115 41 34 4 3 9 68 86	total 747 5970 3421 919 94 1685 919 94 333 669 2369 2369	Normai event 11 108 108 108 108 108 108 108 108 5 8 125	total 1166 3475 2184 2896 556 135 558 165 538 2554 3259	<b>OR</b> 0.85 0.62 0.76 0.78 0.78 0.72 0.29 1.45 0.90	9 <b>9</b> 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.	95% CI 31-2.31 47-0.81 54-0.92 65-1.42 46-1.32 21-2.41 08-1.07 48-4.36 65-1.25	Type of surgery CABG CABG CABG CABG CABG CABG AII AII AII AII CABG
a. Overweight versus OR: Odds ratio; CI: ( Study (Year) n Reeves (30) (2003) 1913 Ja (40) (2005) 1945 Pan 193 (2005) 5955 van Straten (77) (2010) 4562 Stamou (11) (2011) 1475 Le-Bert (20) (2013) 298 He (29) (2013) 1297 Zterman (18) (2014) 4292 Benedetto (33) (2014) 7090 Albama (22) (2014) 7090	s normal Confidence interval, s rate ct (95,0%) 	Obese event 6 116 115 41 34 4 3 9 88 86 86 86	Coronary total 747 5970 3421 1686 919 94 133 669 2369 3821 94 133 669 2369 3821 971	Normal event 11 108 103 73 26 8 12 5 81 125 33	total 1166 3475 2184 2896 135 165 556 135 165 538 2554 3269 944	<b>OR</b> 0.85 0.62 0.76 0.96 0.78 0.72 0.29 1.45 0.90 0.58	99 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.	95% CI 31-2.31 47-0.81 54-0.92 65-1.42 21-2.41 08-1.07 48-4.36 65-1.25 44-0.77	Type of surgery CABG CABG CABG CABG Combine CABG All All All CABG
a. Overweight versus OR: Odds ratio; CI: ( Study (Year) n Reeves (38) (2003) 1913 Jn (40) (2005) 9445 Pan (39) (2006) 5665 Pan (39) (2006) 5665 Van Staten (31) (2010) 4562 Stamou (11) (2011) 1475 Le Beft (12) (2013) 298 Ho (29) (2013) 1207 Zterman (11) (2011) 1275 Lebent (15) (2011)	Is ratio ct (95.0%)	CABG: C CABG: C event 6 116 115 41 34 4 3 9 68 86 88 68 86 12	Coronary total 747 5970 3421 1886 919 94 133 669 2369 3821 971 971 705	Normal event 108 109 73 26 8 122 5 81 125 33 15	total 1166 53475 2184 2896 556 135 165 538 2554 3269 944 991	<b>or</b> 0.85 0.62 0.70 0.96 0.72 0.29 1.45 0.90 0.58 0.35	ng 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.	95% CI 31-2.31 47-0.81 65-1.42 46-1.32 21-2.41 68-1.07 48-4.36 65-1.25 44-0.77 18-0.67	Type of surgery CABG CABG CABG CABG CABG All All CABG CABG CABG
a. Overweight versus OR: Odds ratio; CI: ( Study (Year) n Reves [30] (2003) 1913 Jin (ed) (2006) 1913 Le Bert (Ed) (2011) 229 Chang (22) (2013) 229 Ho (22) (2013) 229 Ho (22) (2013) 229 Jin (ed) (2014) 4923 Benedetto (23) (2014) 4923 Benedetto (23) (2014) 1915 Catalan (23) (2014) 1915 Catalan (23) (2014) 1915 Catalan (23) (2014) 1915	In normal Confidence interval, In raise CI (95,0%) In raise CI	Cobese event 6 115 115 41 34 4 3 9 68 86 12 14	total total 747 7570 3421 1685 669 919 94 133 669 92369 971 708 8866	Normal event 11 108 108 108 126 8 12 5 8 12 5 5 8 125 33 15 5 9	total 1166 3475 2184 556 135 556 135 558 165 538 2554 3269 944 991 1968	<b>OR</b> 0.85 0.62 0.70 0.96 0.78 0.72 0.29 1.45 0.90 0.58 0.35 1.31	9g 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.	95% Cl 31-2.31 47-0.81 54-0.92 65-1.42 46-1.32 21-2.41 46-1.32 21-2.41 46-1.32 44-0.77 18-0.67 63-2.74	Type of surgery CABG CABG CABG CABG CABG CABG CABG CABG
a. Overweight versus OR: Odds ratio; CI: ( Study (Year) n Reeves (30 (2003) 1913 Jn (40 (2005) 1913 Jn (40 (2005) 1913 Jn (40 (2005) 1945 Pan (19) (2006) 9465 Van Straten (17) (2010) 4562 Stamou (11) (2011) 1475 Le-Bert (12) (2014) 1475 Ztterman (18) (2014) 4923 Benedetto (33 (2014) 7090 Alama (15) (2014) 1699 Raucci (41 (2014) 2834 Loeeze-Belgo (19) (2015) 1147	s normal Confidence interval, s rato ct (95,0%) 	Obese event 6 115 41 34 4 3 9 68 86 88 86 83 80 21 14 25 34	total 747 5970 3421 1686 919 94 133 669 2369 3821 708 866 824	Normal event 11 108 103 73 26 8 12 5 81 125 81 125 33 15 59 27	total 1166 3475 2184 2896 556 135 165 538 2554 3269 944 991 1968 523	OR 0.85 0.62 0.70 0.96 0.78 0.72 0.29 1.45 0.90 0.58 0.35 1.31 0.96	9g 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.	95% Cl 31-2.31 54-0.92 65-1.42 46-1.32 21-2.41 08-1.07 48-4.36 65-1.25 44-0.77 18-0.67 18-0.67 44-0.77	Type of surgery CA8G CA8G CA8G CA8G CA8G All All All CA8G CA8G CA8G CA8G CA8G CA8G CA8G All All
a. Overweight versus OR: Odds ratio; CI: ( Sudy (Year) n Reeves (38) (2003) 1913 Jin (40) (2005) 9445 Pan 190 (2006) 9445 Van Straten (37) (2016) 4582 Stamou (11) (2011) 1475 Le.Bert (18) (2014) 129 Chang (12) (2013) 129 Ho (29) (2013) 129 Zterreman (18) (2014) 1915 Calskan (53) (2014) 1915 Calskan (51) (2015) 1147 Lobez-Delgado (19) (2015) 1147 Johnsen (12) (2015) 1147	s ratio ci (95.0%)	CABG: C CABG: C event 6 116 115 41 34 4 3 9 68 86 12 14 25 34 4 25 34	total 747 5970 3421 133 669 919 94 133 669 2369 3821 971 3321 971 971 971 971 971 971 971 971 971 97	Normal event 108 108 108 108 103 73 26 8 122 5 8 1125 33 15 559 27 255	total 1166 3475 2184 2896 556 135 165 538 2554 3269 944 991 1968 523 17162	<b>or</b> 0.86 0.62 0.70 0.96 0.78 0.72 0.29 1.45 0.90 0.58 0.35 1.31 0.35 1.31 0.66 0.26	2 <b>9</b> 	95% CI 31-2.31 47-0.81 54-0.92 65-1.42 46-1.32 21-2.41 08-1.07 48-4.36 65-1.25 65-1.25 65-1.25 65-1.25 65-1.77 18-0.67 63-2.74 60-1.55 63-1.78	Type of surgery CABG CABG CABG CABG AII AII CABG CABG AII CABG CABG AII AII CABG CABG CABG
a. Overweight versus OR: Odds ratio; CI: ( Study (Year) n Reves [30] (2003) 1913 Jin (40) (2005) 1943 Pan [39] (2006) 5055 van Straten [37] (2016) 4522 Stamou [11] (2011) 1475 Le-Bert [34] (2011) 229 Chang [32] (2013) 229 Ho [29] (2013) 1207 Ztermann [18] (2014) 4923 Benedetto [32] (2014) 1915 Catalan [32] (2015) 1147	In normal Confidence interval,	Cobese event 6 115 115 41 4 3 4 4 3 9 68 86 12 14 4 25 34 49	total 747 5570 3421 1686 669 919 94 133 3821 971 708 8821 971 708 8821 971 708 866 662 4 18147 708	Normal event 11 108 108 108 108 108 108 108 108 108	total 1166 3475 2184 2896 355 155 558 2554 3269 944 991 1968 523 17162 523 17162	<b>OR</b> 0.85 0.65 0.70 0.76 0.78 0.78 0.78 0.78 0.78 0.58 0.35 1.31 0.96 1.06 0.62 0.72	99 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0	55% C1 31-2.31 31-2.31 54-0.92 65-1.42 21-2.41 08-1.02 21-2.41 08-4.36 65-1.25 44-0.77 63-2.74 60-1.55 51-0.75 51-0.75	Type of surgery CABG CABG CABG CABG CABG CABG CABG CABG
a. Overweight versus OR: Odds ratio; CI: ( Study (Year) n Reeves [20] (2003) 1913 Jn (60] (2005) 1943 Pan (19) (2006) 5965 van Straten (17) (2010) 4582 Stamou (11) (2011) 1425 Le-Bert (24) (2013) 289 Ho (29) (2013) 1207 Zttermann (18) (2014) 4923 Benedette (13) (2014) 1959 Ranueci (41) (2014) 1959 Hot Yung (20) 3359 Gao (17) (2016) 2964 Hartung (12) (2017) 2815	s normal Confidence interval, srato ct (95,9%) 	Obese event 6 115 41 34 4 3 9 68 86 68 86 68 86 68 22 14 12 14 23 34 49 334	total 747 5970 3421 1886 659 2369 3821 708 865 654 18147 1760 4881	Normal event 11 108 103 73 26 8 12 5 8 1 25 5 8 1 125 33 15 59 27 256 45 254	total 1166 2184 2284 155 165 155 165 155 165 155 165 135 2554 2554 2554 2554 2554 2554 2554 25	08 082 082 082 082 082 082 082 082 082 0	9 <b>9</b>	85% Cl 31-2.31 54-0.92 65-1.42 21-2.41 08-1.07 48-4.36 48-4.36 63-2.74 60-1.55 63-1.75 46-1.06 75 46-1.06 75 46-1.06	Type of surgery CABG CABG CABG CABG CABG CABG AII AII CABG CABG CABG AII CABG AII CABG AII AII AII CABG AII AII
a. Overweight versus OR: Odds ratio; CI: ( Sudy (Year) n Reeves (30) (2003) 1913 Jn (40) (2005) 9445 Pan 190 (2006) 9445 Pan 190 (2006) 9445 Van Straten (37) (2010) 4562 Van Straten (37) (2010) 4562 Van Straten (37) (2010) 4562 Chang (22) (2013) 1207 Chang (22) (2014) 1207 Zterman (18) (2014) 1915 Catskan (35) (2015) 13539- Cat (17) (2016) 2934- Maringcato (21) (2017) 196649-	s relie ci (95.0%)	CABG: C CABG: C event 6 116 115 41 34 4 3 9 68 88 68 88 12 14 25 34 49 9 314 2928	Coronary 747 5970 3421 133 669 919 94 133 669 919 93 2369 3821 971 770 885 624 18147 1760 865 624 18147 1708 885 18147	Normal event 108 108 103 73 26 8 12 5 5 8 125 33 15 5 9 27 255 45 254 4014	total 1166 13475 2184 2886 556 135 135 135 538 23269 944 991 1988 2032 2554 23269 991 1988 2032 554 991 1988 523 523 523 523 523 523 523 523 523 523	<b>OR</b> 0.85 0.85 0.70 0.70 0.29 1.45 0.29 1.45 0.29 0.29 1.45 0.58 0.58 0.58 0.58 0.58 0.58 0.58 0.5	9g 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.	95% CI 31-2.31 47-0.81 54-0.92 65-1.42 46-1.32 21-2.41 48-4.36 65-1.25 65-1.25 63-1.77 18-0.67 63-2.74 63-2.74 63-1.78 51-0.75 51-0.75 51-0.75 50.0 67	Type of surgery CABG CABG CABG CABG CABG AII AII CABG CABG AII AII AII AII AII AII AII
a. Overweight versus OR: Odds ratio; CI: ( Study (Year) n Reves [38] (2003) 1913 Jin (ed) (2005) 1945 Pan [39] (2006) 5665 van Straten [37] (2110) 4562 Stateu [17] (210) 4562 Stateu [12] (211) 229 Chang [12] (2013) 1207 Ztermann [18] (2014) 4923 Benedetto [20] (2015) 1207 Ztermann [18] (2014) 4923 Benedetto [20] (2015) 1147 Catalan [22] (2015) 1147 Johnsen [12] (2015) 1359 Os [11] (2015) 1359 Os [11] (2115) 1685- Mariscack [20] (2017) 9815- Mariscack [21] (2017) 9815-	normal Confidence interval,	Cobese event 6 116 115 41 3 9 9 68 86 12 14 4 3 9 9 68 86 12 14 14 3 4 9 9 68 86 12 14 14 15 14 15 14 15 14 15 14 15 14 15 14 15 14 15 14 15 14 15 14 15 14 15 14 15 14 14 15 14 14 15 14 14 14 14 15 14 14 14 15 14 14 14 14 14 14 14 14 14 14 14 14 14	total total 747 5570 3421 1666 569 919 94 3821 971 708 866 629 18147 1760 4881 1760 4881 1760 4881 1760 4881 1760 488 1760 1	Normal event 11 108 108 108 108 108 108 108 108 108	toral 1166 3475 2184 2856 135 556 155 558 558 558 558 558 558 558 558 558	<b>or</b> 08 0.62 0.70 0.96 0.72 0.99 0.58 0.35 1.45 0.90 0.58 0.35 1.31 0.96 0.62 0.70 0.62 0.70 0.90 0.62 0.70 0.90 0.62 0.72 0.95 0.55 0.55 0.55 0.55 0.55 0.55 0.55	99 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.	55% CI 31-2.31 47-0.81 47-0.81 47-0.82 65-1.42 21-2.41 08-1.05 65-1.42 21-2.41 08-1.05 65-1.25 44-0.67 63-2.74 60-1.55 51-0.75 46-1.06 59-0.65 50-1.70	Type of surgery CABG CABG CABG CABG CABG CABG CABG CABG
a. Overweight versus OR: Odds ratio; CI: ( Study (Year) n Recess [30] (2003) 1913 Jn (40) (2005) 1943 Pan [30] (2006) 5656 vas Straten [37] (2010) 4582 Statu (1) (2011) 125 Chang [21] (2013) 288 Ho [22] (2013) 287 Ztterman [18] (2014) 4923 Benedeto [31] (2014) 1267 Ztterman [18] (2014) 4923 Benedeto [31] (2014) 1059 Ranucci (41] (2014) 4923 Losez-Delgado [10] (2015) 1147 Johnson [12] (2015) 35399 Gas (11] (2017) 1955 Liamscalo [31] (2017) 1955 Current usy (2017) 495	s normal Confidence interval,	CABG: C CABG: C CABG: C C CABG: C C C C C C C C C C C C C C	Coronary total 747 747 3421 1686 669 919 94 133 669 92369 3821 971 708 865 6624 18147 105271 708 865 624 18147 10565 4981 105251 230	Normai event 11 108 103 73 26 8 11 25 8 11 25 8 1 125 33 15 5 9 27 255 45 27 254 401 425 8	total 1166 3475 2284 2896 185 556 135 558 2554 3269 944 991 1988 523 17762 239 944 991 1782 239 17762 230	08 0.85 0.82 0.70 0.96 0.72 0.29 0.45 1.45 0.90 0.58 0.35 1.31 0.96 0.62 0.70 0.62 0.70 0.62 0.70 0.90 0.62 0.70 0.90 0.62 0.70 0.90 0.62 0.70 0.62 0.70 0.52 0.70 0.52 0.70 0.52 0.70 0.52 0.70 0.52 0.70 0.52 0.70 0.52 0.52 0.70 0.52 0.52 0.52 0.52 0.52 0.52 0.52 0.5	ng 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.	55% C1 31-2,31 47-0,81 54-0.92 65-1.42 21-2,41 08-1.07 63-1.25 44-0.77 63-2.74 60-1.55 63-1.75 46-1.06 75-1.06 75-1.06 59-0.65 50-1.70	Type of surgery CA8G CA8G CA8G CA8G CA8G CA8G CA8G CA8G
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Fig. 3.– Forest plots of studies estimating 30-day-in-hospital mortality post-cardiac surgery. Comparison between overweight and normal groups (a), and between obese and normal groups (b) other BMI groups, and even the observed-to-expected mortality ratio of the normal BMI cohort was closer to one. Therefore, this observation plus outcomes obtained from the propensity score analysis helped to question a clear obesity paradoxical effect on mortality when contrasting matched data of normal and overweight groups. Nonetheless, after propensity score analysis, obese patients presented a lower mortality rate compared with normal patients, but a higher complication rate. In short, relative to non-obese patients, overweight and obese individuals showed comparable or lower in-hospital mortality rates after cardiac surgery. On the contrary, the overall complication rates were similar in overweight and higher in obese patients compared with normal-weight individuals.

Evaluation relative to previous research becomes difficult because some studies bring together overweight and normal-weight patients in a single set of data<sup>20, 21, 23, 25, 28,</sup> <sup>30</sup>, and adjustment by confounders was rarely done. The analysis of 4172 patients from the ARIAM registry<sup>21</sup> demonstrated that after adjusting for severity and perfusion time, obese patients had mortality rate, complication rate, and length-of-stay similar to non-obese patients (BMI < 30 kg/m<sup>2</sup>). Ho el al.<sup>29</sup> did not observe any "obesity paradox" in mortality rate assessment after adjusting data for the principal confounders. In a short series of 637 patients, obesity did not increase in-hospital mortality; however, it increased pulmonary and gastrointestinal complications after adjusting for age, sex, and comorbidities<sup>30</sup>. Conversely, in a cohort analysis with propensity score matching of 2440 patients, Stamou el al.11 communicated that overweight patients had a lower operative mortality than normal BMI patients (OR: 0.4, 95% CI: 0.2-0.9), whereas obese individuals had a comparable risk with respect to normal-weight patients.

As in other studies<sup>12, 19, 22</sup>, we found that overweight and obese patients were younger and with higher rates of male sex and diabetes compared with normal-weight patients. However, the higher rates of heart failure, pulmonary hypertension and valve endocarditis found in normal-weight patients had not been previously observed or considered.

Some considerations must be taken into account to evaluate the obesity paradox effect. Firstly, a normal BMI in a healthy person might be protective in a public health setting in which mortality is assessed in the long-term<sup>54</sup>. By contrast, an overweight or obese BMI might be protective in critical illnesses when comorbidities are frequent because mortality is high and is assessed in the short-term rather than years<sup>55-57</sup>. It is important to consider additional sources of bias for the "obesity paradox" phenomenon. Obese patients consistently undergo revascularization surgical procedures at a younger age than their non-obese counterparts and, consequently, may present with lower risk coronary anatomy<sup>58</sup>. Outcomes of the present study were consistent with this last observation, since obese patients were significantly younger, and coronary surgery was more common. On the other hand, the paradox may be due to selection bias if only a subgroup of the "healthiest" obese patients were selected for cardiac surgery<sup>59-60</sup>.

The present systematic review of observational studies suggested that overweight and obesity were associated with a neutral or beneficial effect on all-cause mortality after cardiac surgery. Meanwhile, pooled analysis of the 32 studies in the meta-analysis demonstrated a definite protective effect of overweight and obesity in general, on 30-day-in-hospital mortality rates post-cardiac surgery. Though moderate to high statistical heterogeneity was found in the analyses of overweight or obese versus normal-weight patients, nearly all studies reported a neutral or protective effect of higher BMI levels on mortality, providing supportive evidence that the summary effect sizes were the product of consistent results. Nevertheless, the pooled effect size found in the meta-analysis should be considered small (OR > 0.66)<sup>61</sup>.

Previously, two other meta-analyses reported similar outcomes. Oreopoulos et al.<sup>62</sup> analyzed the effect of BMI only after coronary artery bypass grafting in 12 observational studies (nearly 75 000 patients). After coronary surgery, both overweight and obese patients had lower in-hospital mortality risks compared with normal-weight individuals (OR: 0.70, 95% CI: 0.63-0.77 and OR: 0.63, 95% CI: 0.56-0.71, respectively). Recently, Mariscalco et al.<sup>31</sup> studied approximately 558 000 patients undergoing all types of cardiac surgery in 26 observational studies. They reported lower in-hospital mortality in overweight (OR: 0.79, 95% CI: 0.76-0.83), obese class I (OR: 0.81, 95% CI: 0.76-0.86) and obese class II (OR: 0.83; 95% CI: 0.74-0.94) patients relative to normal-weight individuals.

This study has some limitations. Since in most patients, BMI was calculated from self-reported weight and height, a systematic bias may arise when comparing with BMI calculated from objectively measured data. Nevertheless, in large studies<sup>54</sup>, self-reported and measured BMI differed on average by only 3%, with a 95% correlation coefficient between them. It is possible that overweight or obese patients with a more severe profile of comorbidities and considered at high risk for a cardiac operation were excluded from surgery. Isolated BMI used as a marker of obesity also has limitations, since other aspects of body composition such as visceral fat distribution were not explored in this study. Finally, early reductions in mortality observed in obese patients may not be sustained in the mid- and long-term.

In conclusion, this study showed that overweight and obese patients had similar or slightly lower in-hospital mortality rates after cardiac surgery compared with normalweight individuals. Conversely, postoperative complication rates systematically increased with higher BMI levels. Most observational studies included in the systematic review showed that overweight and obese patients had at least the same mortality rate as normal-weight patients, or even a lower death risk. Pooled-data of the meta-analysis provided evidence on the association between higher BMI levels and a lower all-cause in-hospital mortality rate after cardiac surgery.

Conflict of interests: None to declare

## References

- Logue J, Murray HM, Welsh P, et al. Obesity is associated with fatal coronary heart disease independently of traditional risk factors and deprivation. *Heart* 2011; 97: 564-8.
- Global Burden of Metabolic Risk Factors for Chronic Diseases Collaboration (BMI Mediated Effects), Lu Y, Hajifathalian K, et al. Metabolic mediators of the effects of body-mass index, overweight, and obesity on coronary heart disease and stroke: a pooled analysis of 97 prospective cohorts with 1⋅8 million participants. *Lancet* 2014; 383: 970-83.
- De Pergola G, Silvestris F. Obesity as a major risk factor for cancer. J Obes 2013; 2013: 291546.
- 4. Zhang X, Lerman LO. Obesity and renovascular disease. *Am J Physiol Renal Physiol* 2015; 309: F273-9.
- Pulgarón ER. Childhood obesity: a review of increased risk for physical and psychological comorbidities. *Clin Ther* 2013; 35: A18-32.
- Adams KF, Schatzkin A, Harris TB, et al. Overweight, obesity, and mortality in a large prospective cohort of persons 50 to 71 years old. *N Engl J Med* 2006; 355: 763-78.
- McAuley PA, Blair SN. Obesity paradoxes. J Sports Sci 2011; 29: 773-82.
- 8. Chen Z, Yang G, Offer A, et al. Body mass index and mortality in China: a 15-year prospective study of 220 000 men. *Int J Epidemiol* 2012; 41: 472-81.
- 9. Amundson DE, Djurkovic S, Matwiyoff GN. The obesity paradox. *Crit Care Clin* 2010; 26: 583-96.
- Klasen J, Junger A, Hartmann B, et al. Increased body mass index and peri-operative risk in patients undergoing non-cardiac surgery. *Obes Surg* 2004; 14: 275-81.
- Stamou SC, Nussbaum M, Stiegel RM, et al. Effect of body mass index on outcomes after cardiac surgery: is there an obesity paradox? Ann Thorac Surg 2011; 91: 42-7.
- Johnson AP, Parlow JL, Whitehead M, Xu J, Rohland S, Milne B. Body Mass Index, and mortality following cardiac surgery in Ontario, Canada. *J Am Heart Assoc* 2015; 4: e0022140.
- Parlow JL, Ahn R, Milne B. Obesity is a risk factor for failure of "fast track" extubation following coronary artery bypass surgery. *Can J Anesth* 2006; 53: 288-94.
- Engel AM, McDonough S, Smith JM. Does an obese body mass index affect hospital outcomes after coronary artery bypass graft surgery? *Ann Thorac Surg* 2009; 88: 1793-800.
- Tyson GH, Rodriguez E, Elci OC, et al. Cardiac procedures in patients with a body mass index exceeding 45: outcomes and long-term results. *Ann Thorac Surg* 2007; 84: 3-9.
- 16. Nashef SA, Roques F, Sharples LD, et al. EuroSCORE II. Eur J Cardiothorac Surg 2012; 41: 734-44.
- 17. Gao M, Sun J, Young N, et al. Impact of Body Mass Index on outcomes in cardiac surgery. *J Cardiothorac Vasc Anesth* 2016; 30: 1308-16.
- Zittermann A, Becker T, Gummert JF, Börgermann J. Body mass index, cardiac surgery and clinical outcome. A

single-center experience with 9125 patients. *Nutr Metab Cardiovasc Dis* 2014; 24: 168-75.

- Lopez-Delgado JC, Esteve F, Manez R, et al. The influence of body mass index on outcomes in patients undergoing cardiac surgery: does the obesity paradox really exist? *PLoS One* 2015; 10: e0118858.
- Baslaim G, Bashore J, Alhoroub K. Impact of obesity on early outcomes after cardiac surgery: experience in a Saudi Arabian center. *Ann Thorac Cardiovasc Surg* 2008; 14: 369-75.
- Curiel-Balsera E, Muñoz-Bono J, Rivera-Fernández R, Benitez-Parejo N, Hinojosa-Pérez R, Reina-Toral A; en representación de los investigadores del proyecto ARIAM de cirugía cardiaca de adultos de Andalucía. Consequences of obesity in outcomes after cardiac surgery. Analysis of ARIAM registry. *Med Clin (Barc)* 2013; 141: 100-5.
- 22. Allama A, Ibrahim I, Abdallah A, et al. Effect of body mass index on early clinical outcomes after cardiac surgery. *Asian Cardiovasc Thorac Ann* 2014; 22: 667-73.
- Yap CH, Mohajeri M, Yii M. Obesity and early complications after cardiac surgery. *Med J Aust* 2007; 186: 350-4.
- Rehman SM, Elzain O, Mitchell J, et al. Risk factors for mediastinitis following cardiac surgery: the importance of managing obesity. *J Hosp Infect* 2014; 88: 96-102.
- Dişcigil G, Ozkisacik EA, Badak MI, Güneş T, Dişcigil B. Obesity and open-heart surgery in a developing country. *Anadolu Kardiyol Derg* 2008; 8: 22-6.
- Moulton MJ, Creswell LL, Mackey ME, Cox JL, Rosenbloom M. Obesity is not a risk factor for significant adverse outcomes after cardiac surgery. *Circulation* 1996; 94 (9 Suppl): II87-92.
- Rockx MA, Fox SA, Stitt LW, et al. Is obesity a predictor of mortality, morbidity and readmission after cardiac surgery? *Can J Surg* 2004; 47: 34-8.
- Virani SS, Nambi V, Lee VV, et al. Obesity: an independent predictor of in-hospital postoperative renal insufficiency among patients undergoing cardiac surgery? *Tex Heart Inst J* 2009; 36: 540-5.
- 29. Ho KM, Bertenshaw C, Same S, et al. Differential associations between body mass index and outcomes after elective adult cardiac surgery: a linked data cohort study. *Anaesth Intensive Care* 2013; 41: 573-83.
- Demir A, Aydınlı B, Güçlü ÇY, et al. Obesity and postoperative early complications in open heart surgery. *J Anesth* 2012; 26: 702-10.
- Mariscalco G, Wozniak MJ, Dawson AG, et al. Body Mass Index and mortality among adults undergoing cardiac surgery: A Nationwide Study With a Systematic Review and Meta-Analysis. *Circulation* 2017; 135: 850-863.
- Chang CH, Lee FY, Wang CC, et al. An obesity paradox of Asian body mass index after cardiac surgery: arterial oxygenations in duration of mechanic ventilation. *Scientific World Journal* 2013; 2013: 426097
- Benedetto U, Danese C, Codispoti M. Obesity paradox in coronary artery bypass grafting: myth or reality? *J Thorac Cardiovasc Surg* 2014; 147: 1517-23.
- 34. Le-Bert G, Santana O, Pineda AM, Zamora C, Lamas GA, Lamelas J. The obesity paradox in elderly obese patients undergoing coronary artery bypass surgery. *Interact Cardiovasc Thorac Surg* 2011; 13: 124-7.
- Caliskan E, Güsewell S, Seifert B, et al. Does body mass index impact the early outcome of surgical revascularization? A comparison between off-pump and on-pump coronary artery bypass grafting. *Interact Cardiovasc Thorac Surg* 2014; 19: 749-55.
- Hartrumpf M, Kuehnel RU, Albes JM. The obesity paradox is still there: a risk analysis of over 15 000 cardiosurgical

patients based on body mass index. Interact Cardiovasc Thorac Surg 2017; 25: 18-24.

- van Straten AH, Bramer S, Soliman Hamad MA, et al. Effect of body mass index on early and late mortality after coronary artery bypass grafting. *Ann Thorac Surg* 2010; 89: 30-7.
- Reeves BC, Ascione R, Chamberlain MH, Angelini GD. Effect of body mass index on early outcomes in patients undergoing coronary artery bypass surgery. *J Am Coll Cardiol* 2003; 42: 668-76.
- Pan W, Hindler K, Lee VV, Vaughn WK, Collard CD. Obesity in diabetic patients undergoing coronary artery bypass graft surgery is associated with increased postoperative morbidity. *Anesthesiology* 2006; 104: 441-7.
- Jin R, Grunkemeier GL, Furnary AP, Handy JR Jr. Is obesity a risk factor for mortality in coronary artery bypass surgery? *Circulation* 2005; 111: 3359-65.
- Ranucci M, Ballotta A, La Rovere MT, Castelvecchio S; Surgical and Clinical Outcome Research (SCORE) Group. Postoperative hypoxia and length of intensive care unit stay after cardiac surgery: the underweight paradox? *PLoS One* 2014; 9: e93992.
- van Straten AH, Safari M, Ozdemir HI, Elenbaas TW, Hamad MA. Does the body mass index predict mortality after isolated aortic valve replacement? *J Heart Valve Dis* 2013; 22: 608-14.
- Cemerlić-Adjić N, Pavlović K, Jevtić M, Velicki R, Kostovski S, Velicki L. The impact ofn early mortality after coronary artery bypass grafting. *Vojnosanit Pregl* 2014; 71: 27-32.
- 44. Gurm HS, Whitlow PL, Kip KE; BARI Investigators. The impact of body mass index on short- and long-term outcomes in patients undergoing coronary revascularization: insights from the Bypass Angioplasty Revascularization Investigation (BARI). J Am Coll Cardiol 2002; 39: 834-40.
- Wagner BD, Grunwald GK, Rumsfeld JS, et al. Relationship of body mass index with outcomes after coronary artery bypass graft surgery. *Ann Thorac Surg* 2007; 84: 10-6.
- Sun X, Hill PC, Bafi AS, Garcia JM, Haile E, Corso PJ, Boyce SW. Is cardiac surgery safe in extremely obese patients (body mass index 50 or greater)? *Ann Thorac Surg* 2009; 87: 540-6.
- Rahmanian PB, Adams DH, Castillo JG, Chikwe J, Bodian CA, Filsoufi F. Impact of body mass index on early outcome and late survival in patients undergoing coronary artery bypass grafting or valve surgery or both. *Am J Cardiol* 2007; 100: 1702-8.
- Brát R, Kolek M. Is obesity a real risk factor in cardiosurgical procedures? *Rozhl Chir* 2005; 84: 342-5.
- 49. Vaduganathan M, Lee R, Beckham AJ, et al. Relation

of body mass index to late survival after valvular heart surgery. *Am J Cardiol* 2012; 110: 1667-78.

- Shirzad M, Karimi A, Armadi SH, et al. Effects of body mass index on early outcome of coronary artery bypass surgery. *Minerva Chir* 2009; 64: 17-23.
- Atalan N, Fazlioğulları O, Kunt AT, et al. Effect of body mass index on early morbidity and mortality after isolated coronary artery bypass graft surgery. *J Cardiothorac Vasc Anesth* 2012; 26: 813-7.
- Zalewska-Adamiec M, Bachorzewska-Gajewska H, Malyszko J, et al. Impact of diabetes on mortality and complications after coronary artery by-pass graft operation in patients with left main coronary artery disease. *Adv Med Sci* 2014; 59: 250-5.
- 53. Orhan G, Biçer Y, Aka SA, et al. Coronary artery bypass graft operations can be performed safely in obese patients. *Eur J Cardiothorac Surg* 2004; 25: 212-7.
- Global BMI Mortality Collaboration. Body-mass index and all-cause mortality: individual-participant-data meta-analysis of 239 prospective studies in four continents. *Lancet* 2016; 388: 776-86.
- Hogue CW Jr, Stearns JD, Colantuoni E, et al. The impact of obesity on outcomes after critical illness: a metaanalysis. *Intensive Care Med* 2009; 35: 1152-70.
- Oliveros H, Villamor E. Obesity and mortality in critically ill adults: a systematic review and meta-analysis. *Obesity* 2008; 16: 515-21.
- Pepper DJ, Sun J, Welsh J, Cui X, Suffredini AF, Eichacker PQ. Increased body mass index and adjusted mortality in ICU patients with sepsis or septic shock: a systematic review and meta-analysis. *Crit Care* 2016; 20: 181.
- Rubishtein R, Halon DA, Jaffe R, Shahla J, Lewis BS. Relation between obesity and severity of coronary artery disease in patients undergoing coronary angiography. *Am J Cardiol* 2006; 87: 1277-90.
- Yancy WS Jr, Olsen MK, Curtis LH, et al. Variations in coronary procedure utilization depending on body mass index. *Arch Int Med* 2005; 165: 1381-7.
- King KM, Southern DA, Cornuz J, Knudtson ML, Ghali WA. Elevated body mass index and access to coronary revascularization following cardiac catheterization. *Can J Cardiol* 2006; 22(Suppl D): 290.
- Sullivan GM, Feinn R. Using Effect Size or Why the P value is not enough. J Grad Med Educ 2012; 4: 279-82.
- Oreopoulos A, Padwal R, Norris CM, Mullen JC, Pretorius V, Kalantar-Zadeh K. Effect of obesity on short- and long-term mortality postcoronary revascularization: A meta-analysis. *Obesity* 2008; 16: 442-50.