Am J Cardiovasc Dis 2025;15(2):85-99
www.AJCD.us /ISSN:2160-200X/AJCD0158053

Original Article

Impact of obesity on outcomes of transcatheter aortic valve implantation in patients with aortic stenosis: a systematic review and meta-analysis of real-world data

Farah Yasmin[1], Abdul Moeed[2], Farwa Zaidi[2], Mariam Adil[2], Salim Surani[3], M Chadi Alraies[4]

[1]Yale University School of Medicine, New Haven, CT 06511, USA; [2]Dow Medical College, Karachi 74200, Pakistan; [3]Texas A&M University, College Station, TX 77843, USA; [4]Detroit Medical Center, Cardiovascular Institute, Detroit, MI 48201, USA

Received May 25, 2024; Accepted February 25, 2025; Epub April 15, 2025; Published April 30, 2025

Abstract: Most recent large-scale global analyses on transcatheter aortic valve implantation (TAVI) for aortic stenosis (AS) showed favorable survival outcomes in patients with high body mass index (BMI). We performed a meta-analysis pooling all clinical studies to assess the validity of improved post-TAVI prognosis in obese patients. MEDLINE and Scopus were queried till January 2023 to identify studies comparing AS patients with BMI≥30 kg/m^2, and BMI 18.5 to <25 undergoing TAVI. Data were analyzed using a random-effects model to derive odds ratios (ORs) for all outcomes, and hazard ratios (HRs) for long-term overall survival with 95% confidence intervals. The primary outcomes of interest included 30-day all-cause mortality and long-term overall survival while secondary outcomes consisted of myocardial infarction (MI), major bleeding, major vascular events and acute kidney injury (AKI). A total of 24 studies comprising 38,743 patients were included in this meta-analysis. All-cause mortality at 30-days was significantly reduced in patients with BMI>30 kg/m^2 (OR 0.71, P<0.0001) vs. normal BMI. Every 1 kg/m^2 increase in BMI was associated with better overall survival (HR 0.96, P<0.0001). Obese patients had greater long-term overall survival (HR 0.87, P<0.00001) compared with non-obese patients. No significant differences in MI (OR 0.84, 95% CI 0.52-1.34), major bleeding (OR 0.94, 95% CI 0.72-1.21), major vascular events (OR 1.18, 95% CI 0.97-1.43) and AKI (OR 1.17, 95% CI 0.87-1.56) were observed between the two groups. Obese AS patients might have similar procedural complications, but reduced mortality, and increased overall survival in comparison with normal weight individuals.

Keywords: Obesity, transcatheter aortic valve implantation, aortic stenosis

Introduction

Aortic stenosis (AS) comprises the most frequent degenerative valvular heart disorders associated with significant disease burden owing to poor prognosis and reduced heart function [1-3]. The prevalence of severe AS increases with age, affecting around 4% of the elderly population (>75 years). Conventional surgical valve replacement, including cardiopulmonary bypass (C.B.P.) and sternotomy, has been the standard therapy. However, these techniques are met with post-operative complications such as stroke, acute respiratory distress syndrome, heart block and multisystem-organ failure in high-risk patients [4, 5]. The overall high complication rates associated with conventional treatments has led to the introduction of alternate, minimally invasive techniques such as transcatheter aortic valve implantation (TAVI) which involves the implantation of a valve percutaneously via the transfemoral (TF) or transapical (TA) route [6]. TAVI is recommended and considered a viable option mainly for treatment in severe AS patients deemed to be inoperable or at high-risk for surgical aortic valve replacement (SAVR) [7, 8]. Furthermore, between 2011 and 2014, there was a 25-fold rise in the rate of obese individuals undergoing TAVI in the United States, highlighting the rapidly growing indications for the procedure in patient profiles ranging from low to high surgical risk groups [9, 10]. Obese individuals, particularly morbidly obese (MO) patients (Body mass index (BMI) ≥40 kg/m^2), are underrepresented in clinical trials, and there is a lack

https://doi.org/10.62347/VTYE4110

of data regarding long-term results following TAVI in this specific population. MO patients present a distinct combination of complications, such as metabolic syndrome-related comorbidities, as well as respiratory and mobility issues, which may complicate their periprocedural recovery.

However, the validity of an "obesity paradox" in cardiovascular illness is still being contested, albeit this paradigm has lately been questioned in MO patients [11, 12]. Peri-procedural and long-term outcomes following TAVI in obese individuals have showcased contradictory results [13-15]. Single-center studies with small sample sizes, notably in the MO cohort, and a variety of BMI cutoff points utilized to determine patient groups further complicates the interpretation of these results [16]. Obesity is regarded as a significant and modifiable risk factor for cardiovascular morbidity and mortality, in both the general population as well as patients with cardiovascular disease (CVD) [17]. Despite their negative impact on overall health, intermediate and high-weight individuals proved to be protected throughout many cardiovascular procedures. This disparity was also discovered in individuals with severe AS who underwent TAVI [15, 18]. A previous meta-analysis conducted by Lv and colleagues [19] investigated the obesity paradox in patients undergoing TAVI. Since then, newer cohort studies with larger sample sizes comparing clinical outcomes in patients with vs. without obesity have shown inconsistent and conflicting results. A prospective cohort study [20] demonstrated no difference in overall-mortality between normal and obese patients, however, overweight patients had significantly lower mortality rates on multivariable analysis. Sharma and coworkers [13] evaluated the relationship between BMI and baseline and procedural characteristics from the Society of thoracic surgeons-American college of cardiology transcatheter valve therapy (STS/ACC TVT) Registry. They demonstrated overweight patients, and those with class I and class II obesity to have a decreased risk of one-year mortality compared with normal weight patients. Furthermore, among those with BMI≤30 kg/m^2, each 1-kg/m^2 increase was associated with a 2% and 4% decrease in the risk of 30-day and one-year mortality, respectively; for B.M.I.≥30 kg/m^2, a 1-kg/m^2 increase was associated with a 3% increased risk of 30-day mortality but not with one-year mortality. These conflicting findings in recently published clinical data warrants the conduction of an updated meta-analysis to showcase a comprehensive clinical evaluation of TAVI in obese individuals, and to confirm the validity of the improved outcomes with its therapy.

Methods

Our meta-analysis was conducted in accordance to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) guideline [21].

Data sources and search strategy

Two investigators (FY and AM) independently searched through the electronic databases PubMed (MEDLINE) and Scopus for relevant articles. All studies published from inception till January 2023 were reviewed. No restrictions were implemented based on geographical location, year of publication, publication type, and language of publication. The following keywords were used 'body mass index', 'BMI', 'obesity', 'transcatheter aortic valve replacement', 'transcatheter aortic valve implantation' and 'TAVI' alongside their MeSH (medical subject headings) terms incorporated with Boolean Operators "OR" and "AND". The detailed search strategy utilized for each database is given in Supplementary Table 1. Further, we manually searched through reference lists of review articles, pertinent editorials and original publications. Google scholar, medrix.org, and ClinicalTrials.gov were also searched to identify grey literature and preprints. We excluded case studies, reviews, conference abstracts, preclinical experiments and letters from this analysis.

Study selection and eligibility criteria

All relevant articles identified via systematic search were exported to EndNote X9 Reference Manager (Clarivate Analytics, Philadelphia, Pennsylvania) using which duplicates were removed among various online databases. Two independent investigators (FY and AM) performed initial screening of the remaining articles based on title and abstract to ensure they met the required eligibility criteria. Finally, full texts were evaluated for relevance. Any discrepancies were resolved by discussion with the

third investigator (FZ). The search was restricted to the following inclusion criteria: observational retrospective and prospective cohort studies of patients with aortic stenosis aged ≥18 years undergoing transcatheter aortic valve implantation, studies with an experimental group (obese patients) and a control group (normal patients), and studies that reported at least one of the outcomes of interest including 30-day all-cause mortality, long-term overall survival, myocardial infarction (MI), major bleeding, major vascular events, and acute kidney injury (AKI) as primary or secondary endpoints. Clinical outcomes and complications were recorded according to the Valve Academic Research Consortium-2 consensus definitions (VARC2) [22]. According to the definitions set by the World Health Organization (WHO), B.M.I. (kg/m^2) was categorized as underweight (<18.5), normal (18.5 to <25), overweight (25 to <30) and obese (≥30). In our study, the patients with B.M.I.≥30 kg/m^2 were labeled as obese, and the patients with 25-30 kg/m^2 were labeled as overweight.

Data extraction and study quality assessment

Two investigators (FY and AM) independently extracted data from the shortlisted articles using pre-specified collection forms. In addition to the population, and study characteristics, data on primary and secondary outcomes were also extracted. The data extracted included: study data including first author's last name, publication year, country of origin; experimental data including study design, study period, follow-up duration, cut offs of B.M.I., type of TAVI procedure, primary (30-day all-cause mortality and long-term overall survival) and secondary outcomes (myocardial infarction, major bleeding, major vascular events, and acute kidney injury); demographic data including total sample size, number of patients in the experimental and control groups, and major patient characteristics comprising mean age, male/female percentage, comorbidities, and statistical data including outcome statistics for the estimate of relative risk (R.R.s), odds ratio (O.R.s), and hazard ratios (H.R.s) and statistical method. Long-term overall survival was defined as survival recorded across at least one-year follow-up. The quality of each non-randomized study was assessed using the Newcastle-Ottawa Quality Assessment Scale (N.O.S.) [23]. The N.O.S utilizes a star scoring system comprising of eight items divided into three domains; selection, comparability and outcome or exposure. Each study was assigned a score from 0 to 9. Studies scoring seven or above were considered to be of high quality and thus at a low risk of bias whereas those scoring five or less were considered to be of poor quality.

Statistical analysis

We performed the statistical analysis using Review Manager (RevMan) V.5.3 Cochrane Collaboration, London, United Kingdom. A random-effects model was utilized to pool odds ratios (O.R.s) with 95% confidence intervals (C.I.s) that served as the appropriate estimate for evaluation of 30-day mortality and procedural complications extrapolated from either the demographic data or directly reported in the original studies. It was our first priority to integrate the OR statistics derived from multivariate analysis because of the adequate eliminations for confounding factors. Regarding the long-term overall survival, we used hazard ratios (H.R.s) with 95% CI as the summarized estimates, because the H.R. was the only appropriate statistic compatible for both censoring and time to event analysis. Similarly, incorporating the multivariate H.R. statistics would be considered first. In instances of a lack of multivariate statistic reporting, the H.R. value was extrapolated using published survival data with the log-rank *p* value as proposed by Tierney and coworkers [24]. Publication bias was ascertained for all clinical outcomes by generating a funnel plot and confirming the bias by Egger's regression test. The Higgins I-squared (I^2) statistical model was used to assess heterogeneity in the clinical outcomes of the included studies whereby a value of I^2=25%-50% was considered mild, 50%-75% as moderate, and greater than 75% as severe heterogeneity [25]. A *p* value of <0.05 was considered as statistically significant.

Results

Study characteristics and baseline demographics

The PRISMA flow chart summarizes the search and study selection process in **Figure 1**. The initial search retrieved a total of 844 relevant articles. After reviewing the titles and abstracts,

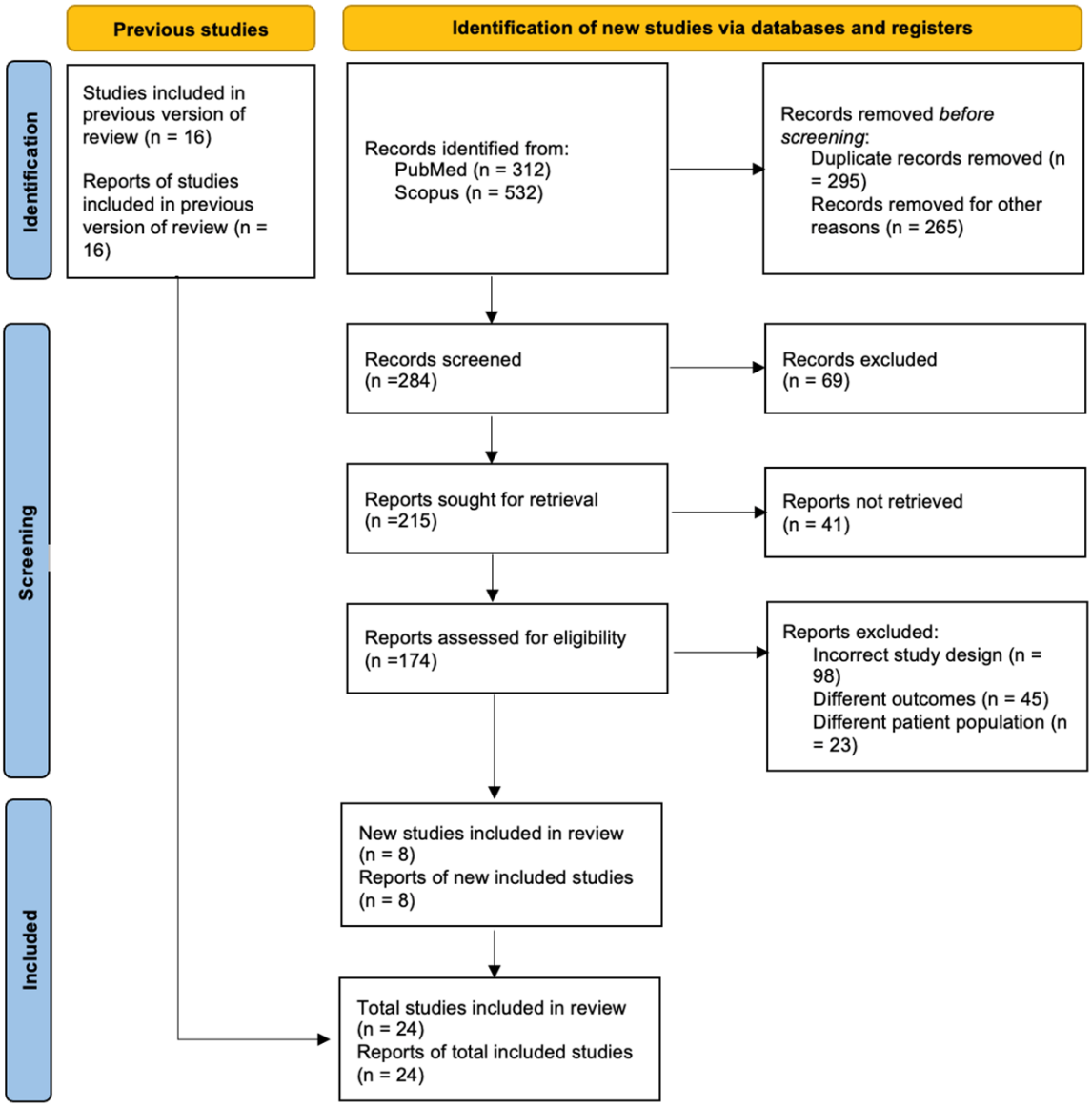


Figure 1. PRISMA flowchart diagram.

560 were removed due to duplication and irrelevance. From the finalized studies, 174 were assessed for eligibility on the basis of their full text. A total of 24 clinical studies were then included in this meta-analysis [13, 15-16, 20, 26-45]. From the included studies, n=10 reported the outcome of 30-day mortality, n=23 reported long-term overall survival as an outcome, and n=13 reported procedural complications. Six studies were prospective observational studies [15, 20, 27-29, 44] whereas 18 studies [13, 16, 26, 30-43, 45] were retrospective observational studies. A total of 38,743 patients who underwent TAVI were included in our study. 47.7% of the included participants were male, and the mean age of the included patients was 82.1 years. The follow-up period of the eligible studies ranged from 30 days to three years. The baseline characteristics of the included studies are presented in **Table 1**.

Quality assessment and publication bias

According to the Newcastle Ottawa Scale, seven studies were assigned the score seven, 14 studies were assigned the score eight, and three studies were assigned the score nine. Overall, all of the included studies were of good

Table 1. Baseline characteristics of included studies

Author, Year	Type of study	Country	Study Period	Sample size	Gender (male ratio)	Age (years)	Outcome reporting HR[a]/OR[b]	Type of TAVI procedure	Follow-up period, months	Outcomes reported
Abawi, 2017 [15]	Prospective observational	Netherlands	2008-2016	549			HR	Transfemoral, Transapical, Direct aortic	12	30-day mortality, long-term overall survival, procedural complication
Abramowitz, 2016 [26]	Retrospective observational	U.S.A.	2012-2015	805	484 (60.1%)	82.0 ± 8.8	H.R., OR	Transfemoral, Transapical, Transaortic, Subclavian	12	30-day mortality, long-term overall survival, procedural complication
Aung, 2013 [30]	Retrospective observational	U.K.	2007-2012	175	86 (49.1%)	83.0 ± 7.0	H.R.	Transfemoral, Transapical	12	Long-term overall survival
Beohar, 2014 [31]	Retrospective observational	U.S.A.	2007-2009	485	261 (53.8%)	N.A.	H.R.	Transfemoral, Transapical	12	Long-term overall survival
Boukhris, 2021 [43]	Retrospective observational	Canada	2009-2019	412			HR	Transfemoral, non-transfemoral	12	30-day mortality, long-term overall survival, procedural complication
Corcione, 2021 [27]	Prospective observational	Italy	2008-2018	3,705			HR	NA	NA	30-day mortality, long-term overall survival, procedural complication
Dvir, 2014 [32]	Retrospective observational	U.S.A.	2007-2009	1,108	603 (54.4%)	82.7 ± 7.2	H.R.	Transfemoral, Transapical	12	Long-term overall survival
Gonzalez-Ferreiro, 2017 [16]	Retrospective observational	Spain	2008-2015	770	332 (43.1%)	80.7 ± 6.3	H.R.	Transfemoral, Trans-axillary	36	Long-term overall survival, procedural complication
Iung, 2014 [33]	Retrospective observational	France	2010-2011	2,552	1288 (50.5%)	82.9 ± 7.2	OR	Transfemoral, Transapical, Subclavian	1	30-day mortality
Kamga, 2013 [29]	Prospective observational	Belgium	2009-2011	30	16 (53.3%)	86.0 ± 3.0	H.R.	Transfemoral	12	Long-term overall survival
Kische, 2016 [39]	Retrospective observational	Germany	2013-2015	172	100 (58.1%)	81.0 ± 5.5	OR	Transfemoral	12	30-day mortality, long-term overall survival
Koifman, 2016 [34]	Retrospective observational	U.S.A.	2007-2014	448	233 (52.0%)	82.9 ± 8.3	H.R.	Transfemoral	12	Long-term overall survival, procedural complication
Konigstein, 2015 [45]	Retrospective observational	Israel	2009-2013	409	173 (42.3%)	82.0 ± 5.7	H.R., OR	Transfemoral	12	30-day mortality, long-term overall survival, procedural complication
Marzo, 2021 [28]	Prospective observational	Italy	2014-2019	645			OR	Transfemoral	6	30-day mortality, long-term overall survival, procedural complication
Mok, 2013 [36]	Retrospective observational	Canada	2005-2009	319	147 (46.1%)	80.0 ± 8.0	H.R.	Transfemoral, Transapical, Transaortic	12	Long-term overall survival
Nieuwkerk, 2021 [41]	Prospective observational	U.S.A., Brazil, Israel, European countries	2007-2018	12,381			HR, OR	Transfemoral	12	30-day mortality, long-term overall survival
Quine, 2020 [20]	Prospective observational	U.S.A., Australia	2008-2019	634			HR	Transfemoral, Transapical, Subclavian, Direct aortic, Subclavian and Transfemoral	12	30-day mortality, long-term overall survival, procedural complication

Salizzoni, 2016 [38]	Retrospective observational	Italy	2007-2012	1,904	757 (39.8%)	81.7 ± 6.2	H.R.	Transfemoral, Transapical, Transaortic, Trans axillary	24	Long-term overall survival
Seiffert, 2014 [37]	Retrospective observational	Germany	2008-2011	845	413 (48.9%)	80.9 ± 6.5	H.R.	Transfemoral, Transapical, Subclavian	12	Long-term overall survival
Sharma, 2020 [13]	Retrospective observational	U.S.A.	2011-2015	31,929			HR	Transfemoral, Transapical, Transaortic, Subclavian	12	30-day mortality, long-term overall survival, procedural complication
Tokarek, 2019 [35]	Retrospective observational	Finland	2008-2015	148			HR	Transfemoral, Transapical, Transaortic, Subclavian	12	30-day mortality, long-term overall survival, procedural complication
Van der Boon, 2013 [41]	Retrospective observational	Netherlands	2005-2011	940	506 (53.8%)	81.0 ± 7.0	H.R., OR	Transfemoral, Transaortic	12	30-day mortality, long-term overall survival, procedural complication
Yamamoto, 2013 [42]	Retrospective observational	France	2010-2011	3,072	1564 (50.9%)	82.8 ± 7.2	H.R., OR	Transfemoral, Transapical, Subclavian	12	30-day mortality, long-term overall survival, procedural complication
Yoon, 2016 [40]	Retrospective observational	Korea	2010-2014	848	396 (46.7%)	81.8 ± 6.6	H.R.	Transfemoral, Transapical, Transaortic, Subclavian	24	Long-term overall survival

a: Hazards ratio, b: Odds ratios.

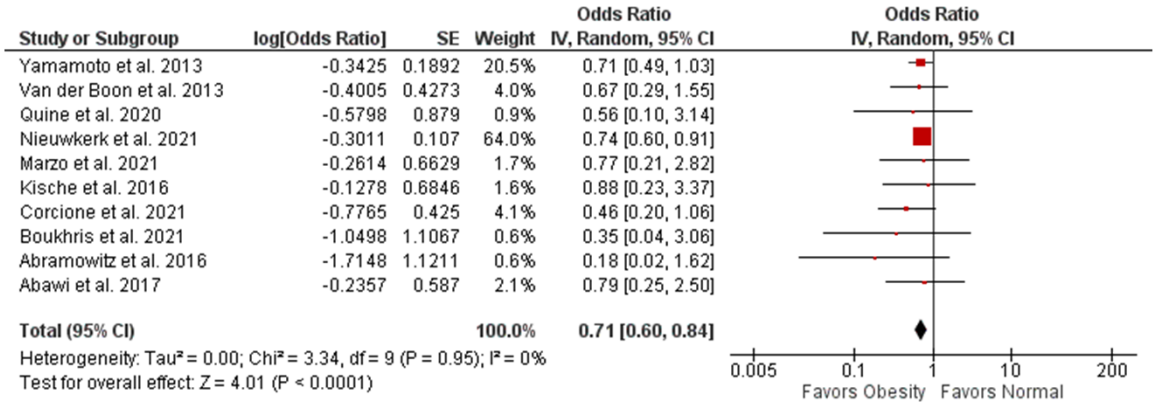


Figure 2. Forest plot of 30-day mortality and its association with obesity.

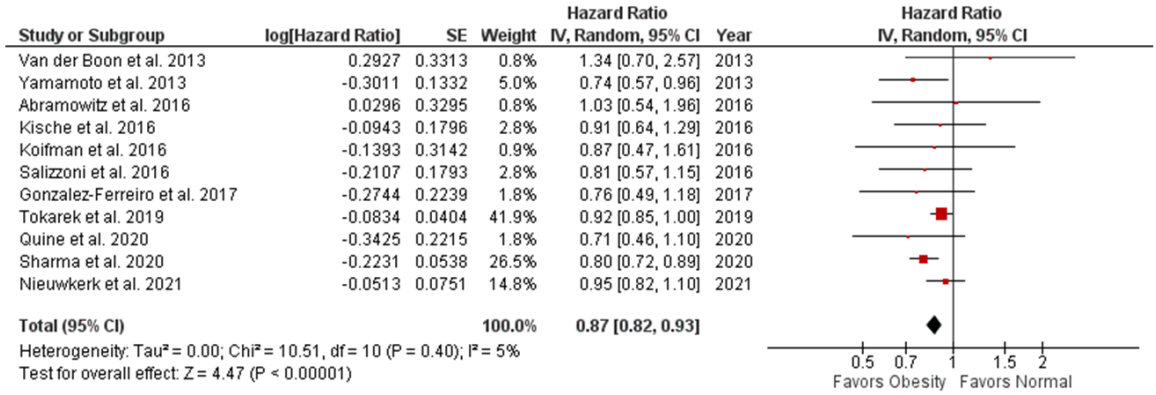


Figure 3. Forest plot of long-term overall survival and its association with obesity.

quality owing to their robust methodology as shown in Supplementary Table 2. Funnel plots were created for 30-day mortality, A.K.I., major bleeding, vascular complications, and long-term overall survival as shown in Supplementary Figures 1, 2, 3, 4, 5, 6. All of the aforementioned outcomes were subjected to some degree of asymmetry. Egger's regression test was used to confirm the risk of publication bias. Upon confirmation, only overall survival with 1 kg/m^2 increase in B.M.I. had some degree of publication bias as shown in Supplementary Table 3.

30-day mortality

10 studies compared 30-day mortality between obese patients and normal patients. Upon analysis, a significant decrease could be observed in 30-day mortality among obese patients (OR 0.71, 95% CI 0.60-0.84, P< 0.0001; I^2=0%) as shown in **Figure 2**.

Long-term overall survival

11 studies compared the long-term overall survival between obese and normal patients, and their pooled estimates based on a random-effects model (HR 0.87, 95% CI 0.82-0.93, P<0.00001; I^2=5%) indicated that obesity could be predictive of better prognosis among TAVI patients (**Figure 3**). Comparably, a significant improvement could be seen for long-term overall survival with every 1 kg/m^2 increase in BMI (HR 0.96, 95% CI 0.94-0.98, P<0.0001; I^2=45%) (**Figure 4**).

Procedural complications

Seven studies reported an incidence of MI. No significant difference was observed between obese and normal patients in MI (OR 0.84, 95% CI 0.52-1.34, P=0.66; I^2=0%) as given in **Figure 5**. Similarly, pooled data of 11 studies showed no significant difference for major bleeding (OR 0.94, 95% CI 0.72-1.21, P=0.02; I^2=54%) and

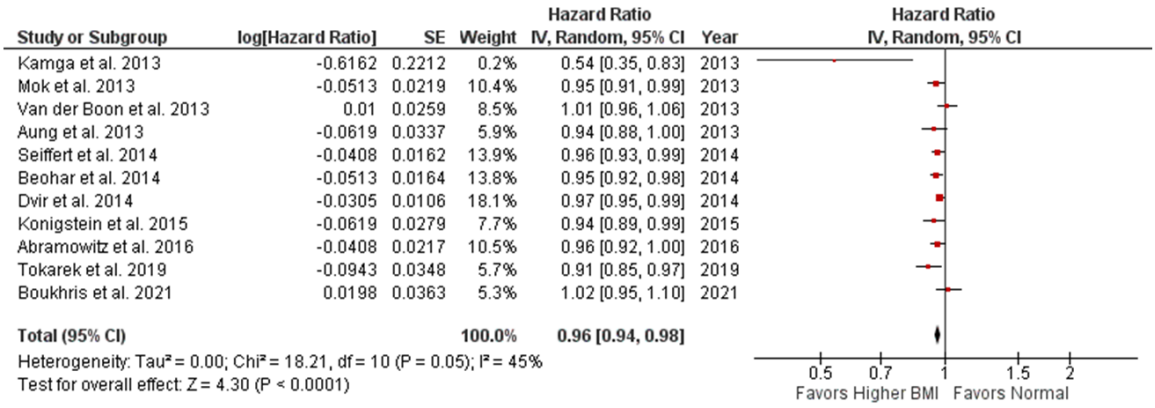


Figure 4. Forest plot of long-term overall survival and its association with B.M.I.

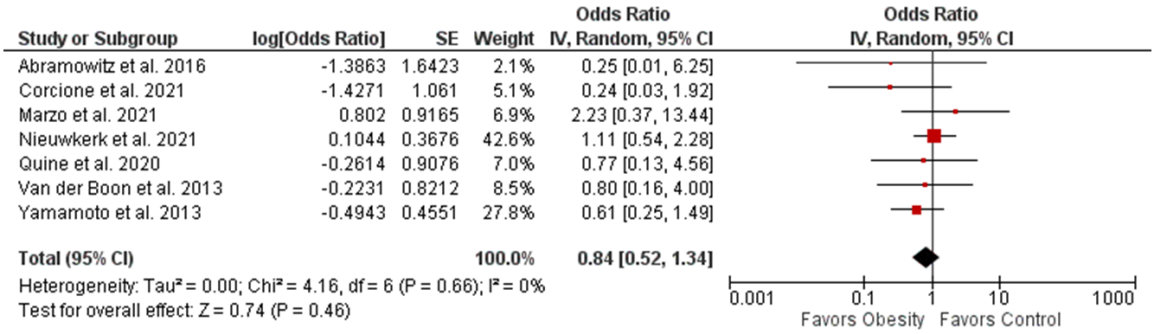


Figure 5. Forest plot of myocardial infarction and its association with obesity.

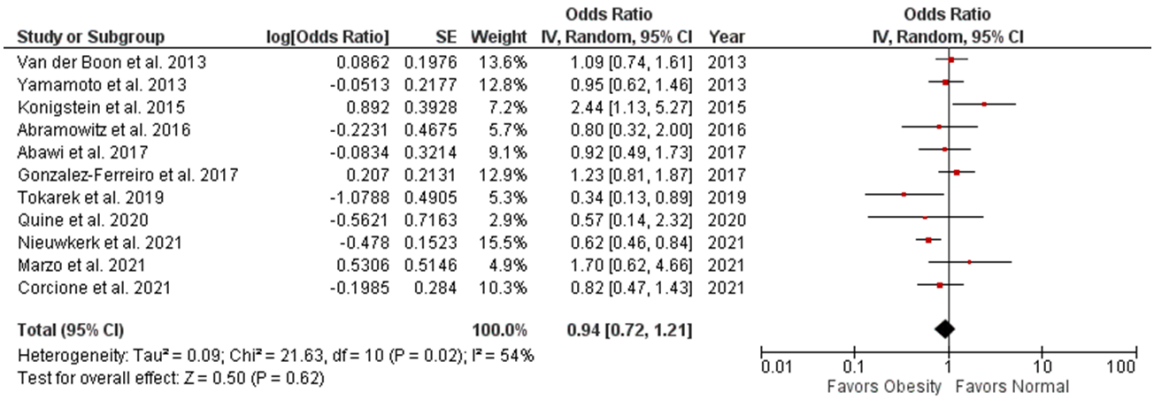


Figure 6. Forest plot of major bleeding and its association with obesity.

major vascular events (OR 1.18, 95% CI 0.97-1.43, P=0.51; I^2=0%) (**Figures 6** and **7**). Moreover, analysis of 10 studies revealed no difference between obese and normal patients suffering from A.K.I. following TAVI (OR 1.17, 95% CI 0.87-1.56, P=0.12; I^2=36%) as shown in **Figure 8**.

Discussion

Our meta-analysis evaluated the existence of the obesity paradox in clinical outcomes among patients undergoing TAVI. The results of our analysis revealed obesity to be significantly associated with reduced 30-day mortality, and

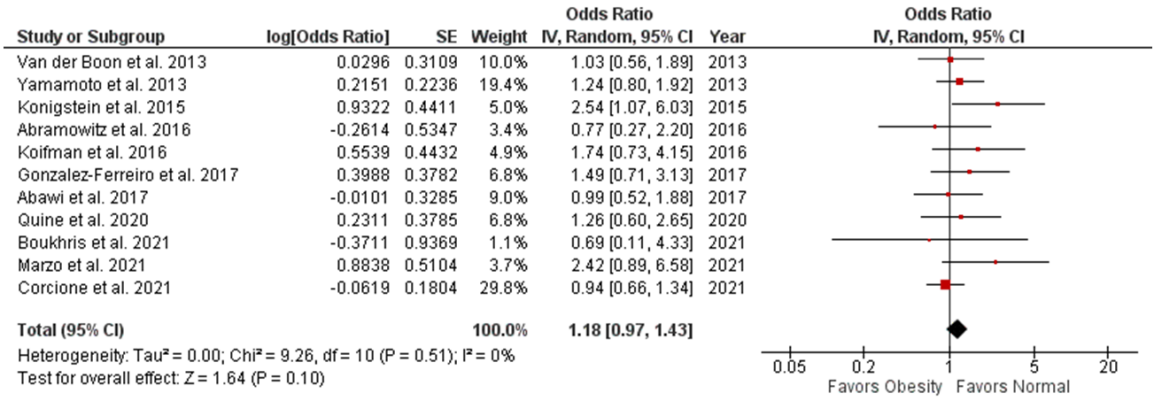


Figure 7. Forest plot of major vascular complications and its association with obesity.

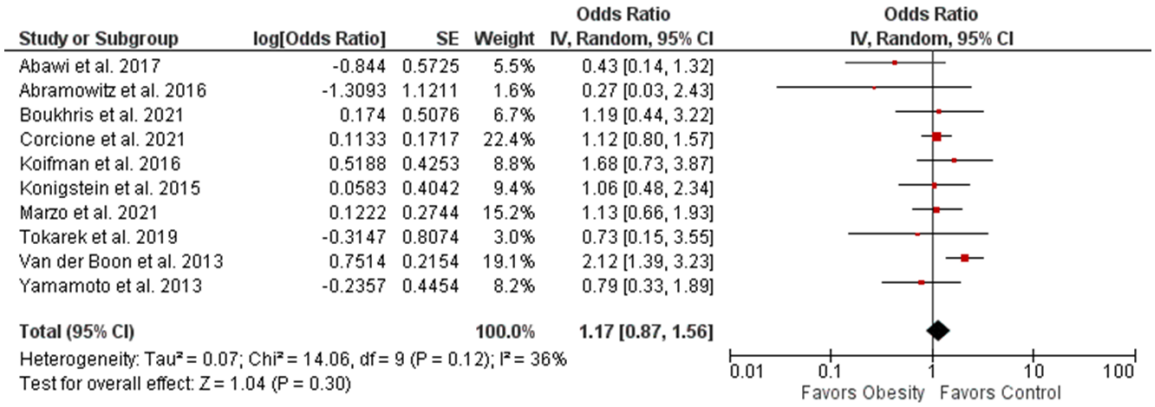


Figure 8. Forest plot of A.K.I. and its association with obesity.

better overall long-term survival with no significant differences in the incidence of MI, major bleeding, A.K.I. and major vascular events in either of the two groups. Obesity has a strong correlation with metabolic diseases, hypertension and dyslipidemia, making it a strong risk factor for the occurrence of major cardiovascular events. However, recent evidence has highlighted that obese individuals may have a better prognosis following cardiovascular surgical interventions. A meta-analysis of 26,842 heart failure patients conducted by Khan and coworkers [46] showed that obese individuals (BMI≥30 kg/m) receiving left ventricular assist device (LVAD) implantation had significantly improved short-term (≤1 year) survival rates when compared with non-obese patients. A retrospective study including 865 candidates undergoing aortic valve replacement for AS found that a BMI in the lower 30 s resulted in lower risks of 30-day and long-term mortality [47]. Furthermore, another investigation revealed significantly reduced bleeding complications and incidence of stroke in obese patients compared with their counterpart (P<0.001 and P<0.03, respectively) [48].

The results of our analysis can be validated with findings from several other investigations. A meta-analysis of 12,330 patients conducted by Lv and coworkers [19] revealed a favorable prognosis in terms of 30-day and long-term mortality (P=0.024 and P<0.001, respectively) in obese individuals in comparison with non-obese patients. Furthermore, similar to our findings, they also observed that with every increase of 1 kg/m^2 in BMI the rates of 30-day mortality significantly reduced. Similarly, another investigation sought to analyze 221,000 patients from the National Inpatient Sample Database found obese (P<0.001) and MO (P< 0.001) TAVI patients to be significantly associated with reduced in-hospital mortality when compared with normal-weight individuals [49],

further substantiating our results. Gupta and coworkers [50] assessed the obesity paradox in a total of 99,829 participants and ascertained the obese group to be significantly corelated with a lower risk of short and long-term mortality. However, unlike our results, they determined that obese patients were at significantly higher odds of developing AKI (P=0.01) compared to their normal-weight counterparts. It is important to emphasize that certain studies reported no significant differences in mortality rates across varying BMI categories [39, 41]. For example, Abramowitz and coworkers [26] included a total of 805 patients and upon multivariate analysis found mortality rates to be comparable in both the cohorts. However, most of these investigations were limited by their small sample sizes which may account for the discrepancies with our findings.

The incidence of AS is generally more prevalent in obese patients than in non-obese patient [51]. Several factors that may elucidate the reasoning behind positive surgical outcomes in obese patients undergoing interventions for cardiovascular diseases should be discussed. According to Hayashida and coworkers [52] major vascular complications, which included access site related injuries leading to death, blood transfusions or surgical interventions, were found to be predictors of 30-day mortality in patients who underwent TAVI (P=0.049). Perhaps having a higher body surface area (BSA) and a larger vasculature serves to protect obese patients in acquiring vascular injuries during procedures. Zafrir and coworkers [53] analyzed data from the heart failure long-term registry of the Heart Failure Association of the European Society of Cardiology and found a progressive inverse relationship between all-cause mortality and BSA levels. Although our analysis stated no significant differences in bleeding and major vascular complications between the two cohorts, this may be attributed to the limited number of studies reporting on these outcomes.

Furthermore, age should also be considered a vital confounder in establishing the relationship between B.M.I. and mortality in TAVI patients. Older patients tend to be weaker and leaner compared to younger individuals and are associated with several accompanying comorbidities [54]. A study of 7099 patients revealed increasing age to be significantly associated with poor 30-day mortality outcomes in participants undergoing TAVI [55]. Obesity has become increasingly prevalent in the younger populations [56] and these individuals are also diagnosed earlier than their regular weight counterparts. Hence, it can be concluded that timely diagnosis, increased tolerance to surgical procedures and aggressive pharmacological intervention for several comorbidities may put obese patients at an advantage and likely result in fewer mortality rates, as observed in our analysis.

Moreover, adipokine physiology plays a crucial role in the improved survival rates of obese patients. An increased fat distribution in obesity offers a more extensive energy reserve to compensate for the increased catabolic demands in patients with cardiovascular disease [57]. Increased levels of adipocytes and lipoproteins might be beneficial as they bind to and neutralize bacterial toxin [58]. An elevated adiponectin level and a more rigorous catecholamine response to stress are also reported in patients with lower BMI [59] which may provide plausible reasonings for our results. Lastly, amongst the varying BMI categories reported in most studies, underweight patients carry the greatest risk of the mortality burden following TAVI. Studies suggest that cachexia is strongly interrelated with neuroendocrine and immunologic abnormalities [60] leading to adverse outcomes post-surgical procedures [61].

Body Mass Index (BMI) is widely utilized for assessing adiposity and categorizing individuals by weight classifications, encompassing underweight, normal weight, overweight, and obese categories. Nonetheless, its use as the sole measure of obesity has been questioned due to inherent limitations. BMI relies solely on weight and height, failing to distinguish between lean mass (muscle, bone) and fat mass. Moreover, BMI does not indicate fat distribution across the body, distinguishing between central (abdominal) and peripheral fat deposition [62]. Central obesity is particularly linked to heightened metabolic risks compared to peripheral fat. To address these limitations, alternative tools offer improved assessments of obesity. Waist circumference and waist-to-hip ratio measure abdominal fat distribution, which is metabolically active and strongly associated with obesity-related health risks [63].

Furthermore, advanced techniques such as dual-energy X-ray absorptiometry (DXA), bioelectrical impedance analysis (BIA), and underwater weighing provide more precise evaluations of body fat percentage and distribution than BMI [64]. These alternative measures contribute to a more comprehensive understanding of adiposity and its implications for health.

Our study comprises a few limitations that should be discussed. Firstly, most of the studies included in this analysis are retrospective, resulting in potential recall bias. Our meta-analysis could not conduct a subgroup analysis concerning factors such as TAVI access sites, race differences and severity of AS, as most investigators did not report on these parameters. Future investigations are encouraged to assess the impact of these factors to produce more concrete results. Secondly, our analysis comprised some studies that utilized univariate O.R.s to report their results, which might diminish the accuracy of our outcome. Lastly, since the incidence of comorbidities like hypertension, diabetes, and coronary heart disease is greater in obese patients compared to non-obese patients, it is imperative to adjust these factors when analyzing the overall effect of obesity on outcomes like mortality and complications associated with TAVI.

Conclusion

The results of this meta-analysis verify the concept of the 'obesity paradox' in the context of interventions such as TAVR in patients suffering from AS. Obesity and a high BMI significantly improved short and long-term overall mortality in patients of TAVI. However, no significant decrease was observed when analyzing complications of major bleeding, major vascular events, MI and AKI in the obese group.

Disclosure of conflict of interest

None.

Address correspondence to: Farah Yasmin, Yale University School of Medicine, New Haven, CT 06511, USA. E-mail: farah.yasmin@yale.edu

References

[1] Nkomo VT, Gardin JM, Skelton TN, Gottdiener JS, Scott CG and Enriquez-Sarano M. Burden of valvular heart diseases: a population-based stud. Lancet 2006; 368: 1005-1011.

[2] Iung B, Baron G, Butchart EG, Delahaye F, Gohlke-Bärwolf C, Levang OW, Tornos P, Vanoverschelde JL, Vermeer F, Boersma E, Ravaud P and Vahanian A. A prospective survey of patients with valvular heart disease. Eur Heart J 2003; 24: 1231-1243.

[3] Otto CM and Prendergast B. Aortic-valve stenosis--from patients at risk to severe valve obstruction. N Engl J Med 2014; 371: 744-756.

[4] Thourani VH, Ailawadi G, Szeto WY, Dewey TM, Guyton RA, Mack MJ, Kron IL, Kilgo P and Bavaria JE. Outcomes of surgical aortic valve replacement in high-risk patients: a multiinstitutional study. Ann Thorac Surg 2011; 9: 49-56.

[5] Liu J, Li X, Xie W, Wang Y, Xu Z, Bai YX, Zhou Q and Wu Q. Risk factors and short-term outcomes of postoperative pulmonary complications in elderly patients after cardiopulmonary bypass. Clin Interv Aging 2024; 19: 31-9.

[6] Makkar RR, Fontana GP, Jilaihawi H, Kapadia S, Pichard AD, Douglas PS, Thourani VH, Babaliaros VC, Webb JG, Herrmann HC, Bavaria JE, Kodali S, Brown DL, Bowers B, Dewey TM, Svensson LG, Tuzcu M, Moses JW, Williams MR, Siegel RJ, Akin JJ, Anderson WN, Pocock S, Smith CR and Leon MB; PARTNER Trial Investigators. Transcatheter aortic-valve replacement for inoperable severe aortic stenosis. N Engl J Med 2012; 366: 1696-1704.

[7] Mesnier J, Panagides V, Nuche J and Rodés-Cabau J. Evolving indications of transcatheter aortic valve replacement-where are we now, and where are we going. J Clin Med 2022; 11: 3090.

[8] Beckmann E, Martens A, Alhadi FA, Ius F, Koigeldiyev N, Fleissner F, Stiefel P, Kaufeld T, Haverich A and Shrestha M. Is bentall procedure still the gold standard for acute aortic dissection with aortic root involvement? Thorac Cardiovasc Surg 2016; 64: 116-123.

[9] Ando T, Akintoye E, Trehan N, Telila T, Briasoulis A, Takagi H, Grines CL and Afonso L. Comparison of in-hospital outcomes of transcatheter aortic valve implantation versus surgical aortic valve replacement in obese (Body Mass Index ≥ 30 Kg/M2) Patient. Am J Cardiol 2017; 120: 1858-1862.

[10] Siontis GC, Praz F, Pilgrim T, Mavridis D, Verma S, Salanti G, Søndergaard L, Jüni P and Windecker S. Transcatheter aortic valve implantation vs. surgical aortic valve replacement for treatment of severe aortic stenosis: a meta-analysis of randomized trials. Eur Heart J 2016; 37: 3503-3512.

[11] Wolny R, Maehara A, Liu Y, Zhang Z, Mintz GS, Redfors B, Madhavan MV, Smits PC, Von

Birgelen C, Serruys PW, Mehran R, Leon MB and Stone GW. The obesity paradox revisited: body mass index and -long-term outcomes after PCI from a large pooled patient-level database. EuroIntervention 2020; 15: 1199-1208.

[12] Sharma A, Vallakati A, Einstein AJ, Lavie CJ, Arbab-Zadeh A, Lopez-Jimenez F, Mukherjee D and Lichstein E. Relationship of body mass index with total mortality, cardiovascular mortality, and myocardial infarction after coronary revascularization: evidence from a meta-analysis. Mayo Clin Proc 2014; 89: 1080-1100.

[13] Sharma A, Lavie CJ, Elmariah S, Borer JS, Sharma SK, Vemulapalli S, Yerokun BA, Li Z, Matsouaka RA and Marmur JD. Relationship of body mass index with outcomes after transcatheter aortic valve replacement: results from the national cardiovascular data-STS/ACC TVT registry. Mayo Clin Proc 2020; 95: 57-68.

[14] González-Ferreiro R, Muñoz-García AJ, López-Otero D, Avanzas P, Pascual I, Alonso-Briales JH, Trillo-Nouche R, Pun F, Jiménez-Navarro MF, Hernández-García JM, Morís C and González Juanatey JR. Prognostic value of body mass index in transcatheter aortic valve implantation: a "J"-shaped curve. Int J Cardiol 2017; 232: 342-347.

[15] Abawi M, Rozemeijer R, Agostoni P, van Jaarsveld RC, van Dongen CS, Voskuil M, Kraaijeveld AO, Doevendans PAFM and Stella PR. Effect of body mass index on clinical outcome and all-cause mortality in patients undergoing transcatheter aortic valve implantation. Neth Heart J 2017; 25: 498-509.

[16] González Ferreiro R, López Otero D, Álvarez Rodríguez L, Iglesias Álvarez D, Cid Menéndez A, Antúnez Muiños PJ, Cid Álvarez B, Sanmartín Pena XC, Cruz-González I, Trillo Nouche R and González Juanatey JR. Transcatheter aortic valve replacement in patients with morbid obesity: procedure outcomes and medium-term follow-up. JACC Cardiovasc Interv 2019; 12: 1192-1193.

[17] Das SR, Alexander KP, Chen AY, Powell-Wiley TM, Diercks DB, Peterson ED, Roe MT and De Lemos JA. Impact of body weight and extreme obesity on the presentation, treatment, and in-hospital outcomes of 50,149 patients with ST-segment elevation myocardial infarction results from the NCDR (national cardiovascular data registry). J Am Coll Cardiol 2011; 58: 2642-2650.

[18] Bundhun PK, Li N and Chen MH. Does an obesity paradox really exist after cardiovascular intervention?: a systematic review and meta-analysis of randomized controlled trials and observational studies. Medicine (Baltimore) 2015; 94: e1910.

[19] Lv W, Li S, Liao Y, Zhao Z, Che G, Chen M and Feng Y. The "obesity Paradox" does exist in patients undergoing transcatheter aortic valve implantation for aortic stenosis: a systematic review and meta-analysis. Interac Cardiovas Thora Surg 2017; 25: 633-642.

[20] Quine EJ, Dagan M, William J, Nanayakkara S, Dawson LP, Duffy SJ, Stehli J, Dick RJ, Htun NM, Stub D and Walton AS. Long-term outcomes stratified by body mass index in patients undergoing transcatheter aortic valve implantation. Am J Cardiol 2020; 137: 77-82.

[21] Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, Shamseer L, Tetzlaff JM, Akl EA, Brennan SE, Chou R, Glanville J, Grimshaw JM, Hróbjartsson A, Lalu MM, Li T, Loder EW, Mayo-Wilson E, McDonald S, McGuinness LA, Stewart LA, Thomas J, Tricco AC, Welch VA, Whiting P and Moher D. The PRISMA 2020 statement: an updated guideline for reporting systematic review. BMJ 2021; 372: n71.

[22] Kappetein AP, Head SJ, Généreux P, Piazza N, van Mieghem NM, Blackstone EH, Brott TG, Cohen DJ, Cutlip DE, van Es GA, Hahn RT, Kirtane AJ, Krucoff MW, Kodali S, Mack MJ, Mehran R, Rodés-Cabau J, Vranckx P, Webb JG, Windecker S, Serruys PW and Leon MB; Valve Academic Research Consortium (VARC)-2. Updated standardized endpoint definitions for transcatheter aortic valve implantation: the Valve Academic Research Consortium-2 consensus document (VARC-2). Eur J Cardiothorac Surg 2012; 42: S45-60.

[23] Wells G, Shea B, O'Connell D and Peterson J. The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomised studies in meta-analyses. Available online: http://www.ohri.ca/programs/clinical_epidemiology/oxford.asp (accessed on 15 January 2022).

[24] Tierney JF, Stewart LA, Ghersi D, Burdett S and Sydes MR. Practical methods for incorporating summary time-to-event data into meta-analysis. Trials 2007; 8: 16.

[25] Higgins JPT and Green S. Cochrane handbook for systematic reviews of interventions. Version 5.1.0. Available online: www.cochrane-handbook.org.

[26] Abramowitz Y, Chakravarty T, Jilaihawl H, Cox J, Sharma RP, Mangat G, Nakamura M, Cheng W and Makkar RR. Impact of body mass index on the outcomes following transcatheter aortic valve implantation. Catheter Cardiovasc Interv 2016; 88: 127-134.

[27] Corcione N, Testa A, Ferraro P, Morello A, Cimmino M, Albanese M, Giordano S, Bedogni F, Iadanza A, Berti S, Regazzoli D, Trani C, Pepe M, Frati G, Biondi Zoccai G and Giordano A; Registro Italiano GISE sull'impianto di Valvola

Aortica Percutanea (RISPEVA) Study Investigators. Baseline, procedural and outcome features of patients undergoing transcatheter aortic valve implantation according to different body mass index categories. Minerva Med 2021; 112: 474-482.

[28] De Marzo V, Crimi G, Benenati S, Buscaglia A, Pescetelli F, Vercellino M, Della Bona R, Sarocchi M, Canepa M, Ameri P, Balbi M and Porto I. BMI and acute kidney injury post transcatheter aortic valve replacement: unveiling the obesity paradox. J Cardiovasc Med (Hagerstown) 2021; 22: 579-585.

[29] Kamga M, Boland B, Cornette P, Beeckmans M, De Meester C, Chenu P, Gurné O, Renkin J and Kefer J. Impact of frailty scores on outcome of octogenarian patients undergoing transcatheter aortic valve implantation. Acta Cardiol 2013; 68: 599-606.

[30] Aung N, Dworakowski R, Byrne J, Alcock E, Deshpande R, Rajagopal K, Brickham B, Monaghan MJ, Okonko DO, Wendler O and Maccarthy PA. Progressive rise in red cell distribution width is associated with poor outcome after transcatheter aortic valve implantation. Heart 2013; 99: 1261-1266.

[31] Beohar N, Zajarias A, Thourani VH, Herrmann HC, Mack M, Kapadia S, Green P, Arnold SV, Cohen DJ, Généreux P, Xu K, Leon MB and Kirtane AJ. Analysis of early out-of hospital mortality after transcatheter aortic valve implantation among patients with aortic stenosis successfully discharged from the hospital and alive at 30 days (from the Placement of Aortic Transcatheter Valves Trial). Am J Cardiol 2014; 114: 1550-1555.

[32] Dvir D, Waksman R, Barbash IM, Kodali SK, Svensson LG, Tuzcu EM, Xu K, Minha S, Alu MC, Szeto WY, Thourani VH, Makkar R, Kapadia S, Satler LF, Webb JG, Leon MB and Pichard AD. Outcomes of patients with chronic lung disease and severe aortic stenosis treated with transcatheter versus surgical aortic valve replacement or standard therapy: insights from the PARTNER trial (Placement of AoRTic TraNscathetER Valve). J Am Coll Cardiol 2014; 63: 269-279.

[33] Iung B, Laouénan C, Himbert D, Eltchaninoff H, Chevreul K, Donzeau-Gouge P, Fajadet J, Leprince P, Leguerrier A, Lièvre M, Prat A, Teiger E, Laskar M, Vahanian A and Gilard M; FRANCE 2 Investigators. Predictive factors of early mortality after transcatheter aortic valve implantation: individual risk assessment using a simple score. Heart 2014; 100: 1016-1023.

[34] Koifman E, Kiramijyan S, Negi SI, Didier R, Escarcega RO, Minha S, Gai J, Torguson R, Okubagzi P, Ben-Dor I, Satler LF, Pichard AD and Waksman R. Body mass index association with survival in severe aortic stenosis patients undergoing transcatheter aortic valve replacement. Catheter Cardiovasc Interv 2016; 88: 118-124.

[35] Tokarek TA, Dziewierz A, Sorysz D, Bagieński M, Rzeszutko Ł, Krawczyk-Ożóg A, Dudek D and Kleczyński P. The obesity paradox in patients undergoing transcatheter aortic valve implantation: is there any effect of body mass index on survival? Kardiol Pol 2019; 77: 190-197.

[36] Mok M, Nombela-Franco L, Dumont E, Urena M, Delarochellière R, Doyle D, Villeneuve J, Côté M, Ribeiro HB, Allende R, Laflamme J, DeLarochellière H, Laflamme L, Amat-Santos I, Pibarot P, Maltais F and Rodés-Cabau J. Chronic obstructive pulmonary disease in patients undergoing transcatheter aortic valve implantation: insights on clinical outcomes, prognostic markers, and functional status change. JACC Cardiovasc Interv 2013; 6: 1072-1084.

[37] Seiffert M, Sinning JM, Meyer A, Wilde S, Conradi L, Vasa-Nicotera M, Ghanem A, Kempfert J, Hammerstingl C, Ojeda FM, Kim WK, Koschyk DH, Schirmer J, Baldus S, Grube E, Möllmann H, Reichenspurner H, Nickenig G, Blankenberg S, Diemert P, Treede H, Walther T, Werner N and Schnabel RB. Development of a risk score for outcome after transcatheter aortic valve implantation. Clin Res Cardiol 2014; 103: 631-640.

[38] Salizzoni S, D'Onofrio A, Agrifoglio M, Colombo A, Chieffo A, Cioni M, Besola L, Regesta T, Rapetto F, Tarantini G, Napodano M, Gabbieri D, Saia F, Tamburino C, Ribichini F, Cugola D, Aiello M, Sanna F, Iadanza A, Pompei E, Stefàno P, Cappai A, Minati A, Cassese M, Martinelli GL, Agostinelli A, Fiorilli R, Casilli F, Reale M, Bedogni F, Petronio AS, Mozzillo RA, Bonmassari R, Briguori C, Liso A, Sardella G, Bruschi G, Fiorina C, Filippini C, Moretti C, D'Amico M, La Torre M, Conrotto F, Di Bartolomeo R, Gerosa G and Rinaldi M; TAVI Team. Early and mid-term outcomes of 1904 patients undergoing transcatheter balloon-expandable valve implantation in italy: results from the italian transcatheter balloon-expandable valve implantation registry (ITER). Eur J Cardiothorac Surg 2016; 50: 1139-1148.

[39] Kische S, D'Ancona G, Agma HU, El-Achkar G, Dißmann M, Ortak J, Öner A, Ketterer U, Bärisch A, Levenson B and Ince H. Transcatheter aortic valve implantation in obese patients: overcoming technical challenges and maintaining adequate hemodynamic performance using new generation prostheses. Int J Cardiol 2016; 220: 909-913.

[40] Yoon SH, Ahn JM, Hayashida K, Watanabe Y, Shirai S, Kao HL, Yin WH, Lee MK, Tay E, Araki

M, Yamanaka F, Arai T, Lin MS, Park JB, Park DW, Kang SJ, Lee SW, Kim YH, Lee CW, Park SW, Muramatsu T, Hanyu M, Kozuma K, Kim HS, Saito S and Park SJ; Asian TAVR Investigators. Clinical outcomes following transcatheter aortic valve replacement in Asian population. JACC Cardiovasc Interv 2016; 9: 926-933.

[41] van Der Boon RM, Chieffo A, Dumonteil N, Tchetche D, Van Mieghem NM, Buchanan GL, Vahdat O, Marcheix B, Serruys PW, Fajadet J, Colombo A, Carrié D, van Domburg RT and de Jaegere PP; PRAGMATIC-Plus Researchers. Effect of body mass index on short- and long-term outcomes after transcatheter aortic valve implantation. Am J Cardiol 2013; 111: 231-236.

[42] Yamamoto M, Mouillet G, Oguri A, Gilard M, Laskar M, Eltchaninoff H, Fajadet J, Iung B, Donzeau-Gouge P, Leprince P, Leuguerrier A, Prat A, Lievre M, Chevreul K, Dubois-Rande JL and Teiger E; FRANCE 2 Registry Investigators. Effect of body mass index on 30- and 365-day complication and survival rates of transcatheter aortic valve implantation (from the FRench Aortic National CoreValve and Edwards 2 [FRANCE 2] registry). Am J Cardiol 2013; 112: 1932-1937.

[43] Boukhris M, Forcillo J, Potvin J, Noiseux N, Stevens LM, Badreddine M, Gobeil JF and Masson JB. Does "obesity paradox" apply for patients undergoing transcatheter aortic valve replacement? Cardiovasc Revasc Med 2022; 38: 1-8.

[44] van Nieuwkerk AC, Santos RB, Sartori S, Regueiro A, Tchétché D, Mehran R and Delewi R; CENTER collaboration. Impact of body mass index on outcomes in patients undergoing transfemoral transcatheter aortic valve implantation. JTCVS Open 2021; 6: 26-36.

[45] Konigstein M, Havakuk O, Arbel Y, Finkelstein A, Ben-Assa E, Leshem Rubinow E, Abramowitz Y, Keren G and Banai S. The obesity paradox in patients undergoing transcatheter aortic valve implantation. Clin Cardiol 2015; 38: 76-81.

[46] Khan MS, Yuzefpolskaya M, Memon MM, Usman MS, Yamani N, Garan AR, Demmer RT and Colombo PC. Outcomes associated with obesity in patients undergoing left ventricular assist device implantation: a systematic review and meta-analysis. ASAIO J 2020; 66: 401-408.

[47] Roberts WC, Roberts CC, Vowels TJ, Ko JM, Filardo G, Hamman BL, Matter GJ, Henry AC and Hebeler RF Jr. Effect of body mass index on survival in patients having aortic valve replacement for aortic stenosis with or without concomitant coronary artery bypass grafting. Am J Cardiol 2011; 108: 1767-1771.

[48] Einarsdóttir FH, Gunnarsdóttir ELT, Gunnarsdóttir SLX, Jensen EM, Viktorsson SA, Ingvarsdóttir IL, Larusdottir KJ, Heitmann LA and Gudbjartsson T. The effect of obesity on the outcome of surgical aortic valve replacement for aortic stenosis. Laeknabladid 2023; 109: 235-42.

[49] Patel E, Varghese JJ, Garg M, Yacob O, Sánchez JS and Garcia-Garcia HM. Comparison of body mass index (four categories) to in-hospital outcomes in patients who underwent transcatheter aortic valve implantation. Am J Cardiol 2023; 192: 190-5.

[50] Gupta R, Mahmoudi E, Behnoush AH, Khalaji A, Malik AH, Sood A, Bandyopadhyay D, Zaid S, Goel A, Sreenivasan J, Patel C, Vyas AV, Lavie CJ and Patel NC. Effect of BMI on patients undergoing transcatheter aortic valve implantation: a systematic review and meta-analysis. Prog Cardiovasc Dis 2023; 78: 58-66.

[51] Larsson SC, Wolk A, Hakansson N and Back M. Overall and abdominal obesity and incident aortic valve stenosis: two prospective cohort studies. Eur Heart J 2017; 38: 2192-2197.

[52] Hayashida K, Lefevre T, Chevalier B, Hovasse T, Romano M, Garot P, Mylotte D, Uribe J, Farge A, Donzeau-Gouge P, Bouvier E, Cormier B and Morice MC. Transfemoral aortic valve implantation new criteria to predict vascular complications. JACC Cardiovasc Interv 2011; 4: 851-858.

[53] Zafrir B, Salman N, Crespo-Leiro MG, Anker SD, Coats AJ, Ferrari R, Filippatos G, Maggioni AP, Mebazaa A, Piepoli MF, Ruschitzka F, Paniagua-Martin MJ, Segovia J, Laroche C and Amir O; Heart Failure Long-Term Registry Investigators. Body surface area as a prognostic marker in chronic heart failure patients: results from the heart failure registry of the heart failure association of the european society of cardiology. Eur J Heart Fail 2016; 18: 859-868.

[54] Gurm HS, Whitlow PL and Kip K; BARI Investigators. The impact of body mass index on short- and long-term outcomes inpatients undergoing coronary revascularization. Insights from the bypass angioplasty revascularization investigation (BARI). J Am Coll Cardiol 2002; 39: 834-840.

[55] Attinger-Toller A, Ferrari E, Tueller D, Templin C, Muller O, Nietlispach F, Toggweiler S, Noble S, Roffi M, Jeger R, Huber C, Carrel T, Pilgrim T, Wenaweser P, Togni M, Cook S, Heg D, Windecker S, Goy JJ and Stortecky S. Age-related outcomes after transcatheter aortic valve replacement: Insights From the SwissTAVI Registry. JACC Cardiovasc Interv 2021; 14: 952-60.

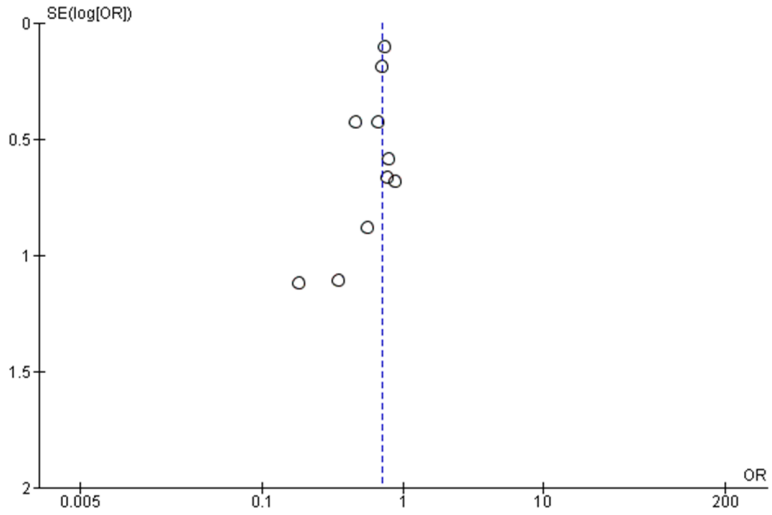
[56] Wilson PW, D'Agostino RB, Sullivan L, Parise H and Kannel WB. Overweight and obesity as determinants of cardiovascular risk: the framingham experience. Arch Intern Med 2002; 162: 1867-1872.
[57] Fonarow GC, Srikanthan P, Costanzo MR, Cintron GB and Lopatin M; ADHERE Scientific Advisory Committee and Investigators. An obesity paradox in acute heart failure: analysis of body mass index and inhospital mortality for 108,927 patients in the acute decompensated heart failure national registry. Am Heart J 2007; 153: 74-81.
[58] Csige I, Ujvárosy D, Szabó Z, Lorincz I, Paragh G, Harangi M and Somodi S. The impact of obesity on the cardiovascular system. J Diabetes Res 2018; 2018: 3407306.
[59] Weber MA, Neutel JM and Smith DHG. Contrasting clinical properties and exercise responses in obese and lean hypertensive patients. J Am Coll Cardiol 2001; 37: 169-174.
[60] Mano A, Fujita K, Uenomachi K, Kazama K, Katabuchi M, Wada K, Terakawa N, Arai K, Hori Y, Hashimoto S, Nakatani T and Kitamura S. Body mass index is a useful predictor of prognosis after left ventricular assist system implantation. J Heart Lung Transplant 2009; 28: 428-433.
[61] Li S, Wang Z, Huang J, Fan J, Du H, Liu L and Che G. Systematic review of prognostic roles of body mass index for patients undergoing lung cancer surgery: does the 'obesity paradox' really exist? Eur J Cardiothorac Surg 2017; 51: 817-828.
[62] Etchison WC, Bloodgood EA, Minton CP, Thompson NJ, Collins MA, Hunter SC and Dai H. Body mass index and percentage of body fat as indicators for obesity in an adolescent athletic population. Sports Health 2011; 3: 249-252.
[63] Ravensbergen HR, Lear SA and Claydon VE. Waist circumference is the best index for obesity-related cardiovascular disease risk in individuals with spinal cord injury. J Neurotrauma 2014; 31: 292-300.
[64] Duren DL, Sherwood RJ, Czerwinski SA, Lee M, Choh AC, Siervogel RM and Cameron Chumlea W. Body composition methods: comparisons and interpretation. J Diabetes Sci Technol 2008; 2: 1139-1146.

Supplementary Table 1. Detailed search strategy used in each database

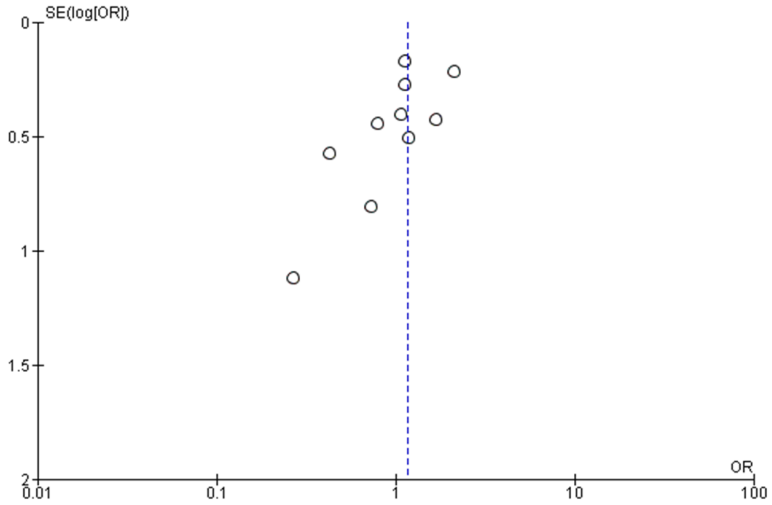
PubMed	("BMI"[All Fields] OR "body mass index"[All Fields] OR "obesity"[All Fields]) AND ("TAVI"[All Fields] OR "TAVR"[All Fields] OR "transcatheter aortic valve implantation"[All Fields])
Scopus	("BMI" OR "body mass index" OR "obesity") AND ("TAVI" OR "TAVR" OR "transcatheter aortic valve implantation")

Supplementary Table 2. Newcastle-Ottawa Scale for observational studies

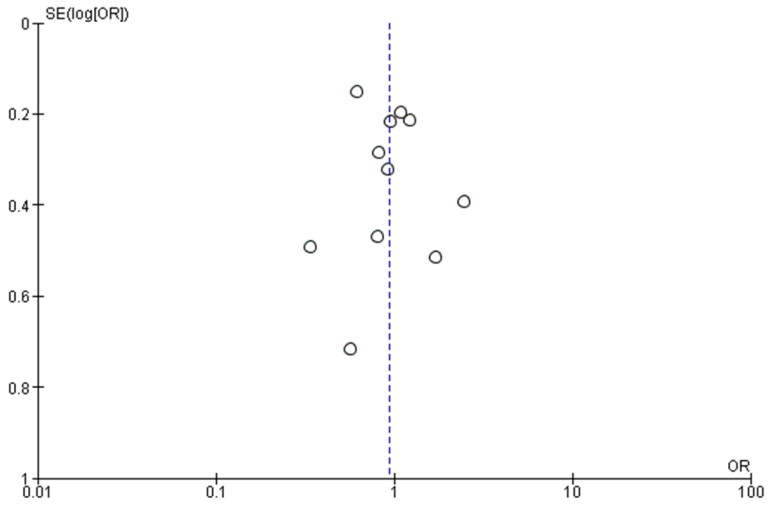
Study, Year	Selection				Comparability		Outcome			Total Score
	S1	S2	S3	S4	C		O1	O2	O3	
Abawi, 2017	*	*	*	*	*	*	*		*	8
Abramowitz, 2016	*	*	*	*	*		*		*	7
Astrid, 2021	*	*	*	*	*	*	*		*	8
Aung, 2013	*	*	*	*	*	*	*		*	8
Beohar, 2014	*	*	*	*	*	*	*		*	8
Boukhris, 2021	*	*	*	*	*		*		*	7
Corcione, 2021	*	*	*	*	*		*		*	7
Dvir, 2014	*	*	*	*	*	*	*		*	8
Gonzalez-Ferreiro, 2017	*	*	*	*	*	*	*	*	*	9
Iung, 2014	*	*	*	*	*		*		*	7
Kamga, 2013	*	*	*	*	*	*	*		*	8
Kische, 2016	*	*	*	*	*		*		*	7
Koifman, 2016	*	*	*	*	*	*	*		*	8
Konigstein, 2015	*	*	*	*	*	*	*		*	8
Marzo, 2021	*	*	*	*	*	*	*		*	8
Mok, 2013	*	*	*	*	*		*		*	7
Quine, 2020	*	*	*	*	*	*	*	*	*	9
Salizzoni, 2016	*	*	*	*	*	*	*		*	8
Seiffert, 2014	*	*	*	*	*	*	*		*	8
Sharma, 2020	*	*	*	*	*	*	*		*	8
Tokarek, 2019	*	*	*	*	*		*		*	7
Boon, 2013	*	*	*	*	*	*	*		*	8
Yamamoto, 2013	*	*	*	*	*	*	*		*	8
Yoon, 2016	*	*	*	*	*	*	*	*	*	9



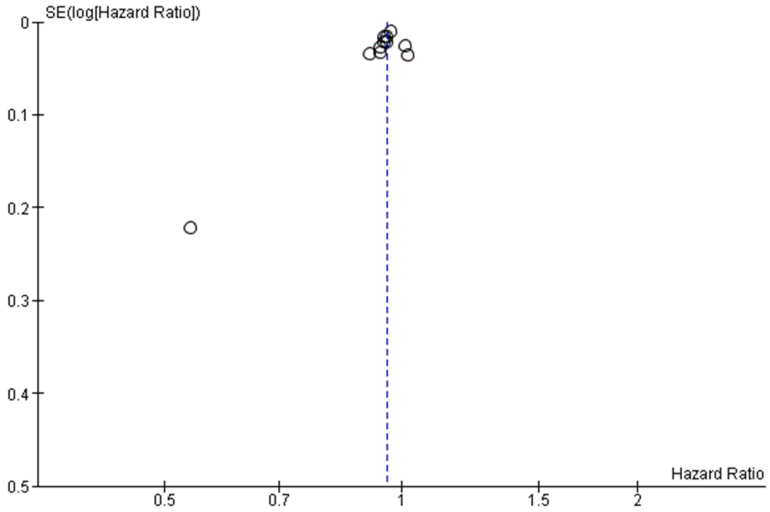
Supplementary Figure 1. 30-day mortality funnel plot.



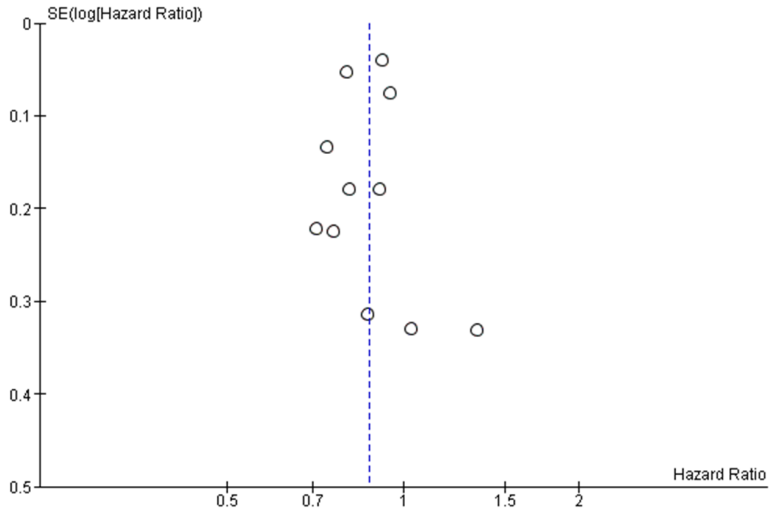
Supplementary Figure 2. Acute kidney injury funnel plot.



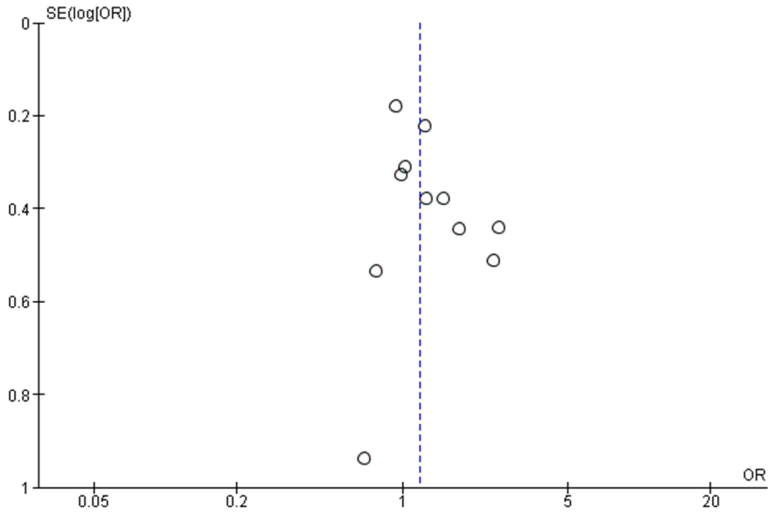
Supplementary Figure 3. Major bleeding funnel plot.



Supplementary Figure 4. Long-term overall survival associated with BMI funnel plot.



Supplementary Figure 5. Long-term overall survival associated with obesity funnel plot.



Supplementary Figure 6. Vascular complications funnel plot.

Supplementary Table 3. Egger's regression test for publication bias

Outcome	Egger's *P*-value
30-day mortality	0.0844
Overall survival with BMI	0.0034
Overall survival with obesity	0.7471
Acute kidney injury	0.1092
Major bleeding	0.6286
Vascular complications	0.2350