# Impact of the second internal thoracic artery on short- and long-term outcomes in obese patients: A propensity score matched analysis

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**Objectives:** A limited number of patients undergoing coronary artery bypass grafting (CABG) currently receive bilateral internal thoracic arteries (BITA) as a consequence of lack of evidence on survival benefit and concerns about sternal wound complications. This study was undertaken to determine the impact of BITA grafting on short- and long-term outcomes in obese patients.

**Methods:** Propensity score matching for short- and long-term outcomes was conducted for 1522 obese (body mass index $\geq$30 kg/m$^2$) patients undergoing CABG using BITA (n = 229, 15.0%) or a single internal thoracic artery (SITA, n = 1293, 85.0%).

**Results:** Propensity score matching created 229 matching sets. In the matched sample, operative mortality (within 30 days) occurred in 3 (1.3%) and 4 (1.7%) patients in the BITA and SITA groups, respectively ($P$ = 1). Deep sternal wound infection occurred in 6 (2.6%) and 2 (0.9%) patients ($P$ = .2) in the BITA and SITA group, respectively. After a median follow-up of 4.5 ± 3.3 years, the use of BITA was associated with an improved late survival (hazard ratio [HR], 0.35; 95% confidence interval [CI], 0.13-0.97; $P$ = .03) and a reduced need for repeat revascularization (HR, 0.45; 95% CI, 0.23-0.85; $P$ = .01).

**Conclusions:** BITA grafting can be safely offered to obese patients with significant long-term advantages without substantial additional risk of operative complications including deep sternal wound infection. (J Thorac Cardiovasc Surg 2015;149:841-7)

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See related commentary on pages 848-9.

Supplemental material is available online.

With the prevalence of overweight and obese individuals estimated at 68%, the significance of obesity in western countries has become a focus of increasing attention.[1] The impact of high body mass index (BMI) on late outcomes after coronary artery bypass grafting (CABG) has been investigated by several studies.[2-6] Although the results are conflicting with a few studies suggesting a protective relationship[2] and others showing no effect,[3-5] obesity has been consistently associated with increased operative morbidity and poorer long-term survival.[3-7] The detrimental effect of obesity on long-term survival after CABG has been attributed to the progression of earlier atherogenic grafts observed in patients with higher BMI, which may lead to a greater risk of clinical events at long-term follow-up.[8]

The use of a second internal thoracic artery over saphenous vein grafts (SVG) has been consistently reported to improve long-term outcomes after CABG, including overall survival.[9,10] The main reason for the long-term benefit from the use of a second internal thoracic artery has been attributed to its better patency rate,[11] secondary to the reduced susceptibility to atherosclerosis compared with SVG.[12] Although such a benefit is expected to be enhanced in patients with higher BMI,[11,13] surgeons continue to be reluctant to perform bilateral internal thoracic artery (BITA) grafting in obese patients,[14] because of the lack of evidence of a long-term benefit in such a high-risk group. Furthermore, concerns still exist regarding the detrimental effect of this strategy on operative outcomes, including the potential vulnerability for sternal wound complications in such a high-risk group.[5,14-16] Therefore, there is an urgent need to validate the safety and efficacy of BITA grafting for obese patients requiring CABG. We undertook a single-center propensity matched outcomes analysis to evaluate the impact of BITA compared with single internal thoracic artery (SITA) on short- and long-term outcomes in obese patients.

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**Abbreviations and Acronyms**

BITA = bilateral internal thoracic arteries
BMI = body mass index
CABG = coronary artery bypass grafting
COPD = chronic obstructive pulmonary disease
CVA = cerebrovascular accident
DSWI = deep sternal wound infection
HR = hazard ratio
LAD = left anterior descending
LVEF = left ventricular ejection fraction
NYHA = New York Heart Association
PCI = percutaneous coronary intervention
POAF = postoperative atrial fibrillation
PVD = peripheral vascular disease
RRT = renal replacement therapy
SITA = single internal thoracic artery
SMD = standardized mean difference
SVG = saphenous vein grafts



## METHODS

### Study Population

The study was conducted in accordance with the principles of the Declaration of Helsinki. The local ethical committee approved the study, and the requirement for individual patient consent was waived. We retrospectively analyzed prospectively collected data from the institutional surgical database (PATS; Dendrite Clinical Systems, Ltd, Oxford, UK) from April 2001 to May 2013. The PATS database captures detailed information on a wide range of preoperative, intraoperative, and hospital postoperative variables (including complications and mortality) for all patients who underwent CABG surgery in our institution. The data are collected and reported in accordance with the Society for Cardiothoracic Surgery in Great Britain & Ireland database criteria. The database is maintained by a team of full-time clinical information analysts, who are responsible for continuous prospective data collection as part of a continuous audit process. Data collection is validated regularly. We classified anyone with a BMI of 30 kg/m$^2$ and higher as obese, in line with the National Heart Lung and Blood Institute classification of obesity.[17] All patients who met the following criteria were included in the analysis: (1) first time isolated CABG; (2) BMI greater than or equal to 30 kg/m$^2$; (3) 2 or more grafts received; (4) surgical strategies included SITA to left anterior descending (LAD) artery and additional SVG for non-LAD targets (SITA group) or BITA with or without additional SVG (BITA group). All patients included were eligible for the use of BITA and the choice of BITA was based on the surgeon's preference.

The study population consisted of 1522 obese patients who received CABG using BITA (n = 229, 15.0%) or SITA (n = 1293, 85.0%). Median BMI was 33 (interquartile range, 31-35; maximum 50). In the BITA group, the right internal thoracic artery was used as in situ retrosternal conduit to the LAD in 135 cases (in these cases, the left internal thoracic artery was used as in situ conduit to graft the diagonal branch in 11 cases and the circumflex territory in 124), as an in situ retroaortic conduit to the circumflex territory in 61 cases, as a Y graft to the circumflex territory in 21 cases, to graft to the right coronary artery in 12 cases (6 cases in situ conduit, 6 cases as free conduit). A total of 145 of 229 (63%) patients in the BITA group received at least an SVG. BITA were harvested as skeletonized conduits in 100 of 229 (43%).

### Pretreatment Variables and Study End Points

The effect of BITA was adjusted for 18 pretreatment variables: age, female gender, New York Heart Association (NYHA) functional class III-IV, previous myocardial infarction, previous percutaneous coronary intervention (PCI), diabetes mellitus, current smoking, chronic obstructive pulmonary disease (COPD), previous cerebrovascular accident (CVA), peripheral vascular disease (PVD), preoperative atrial fibrillation, left main stem disease, number of vessels diseased, left ventricular ejection fraction (LVEF) less than 50%, renal impairment defined as a serum creatinine level more than 200 mmol/L, urgent/emergency indication, preoperative use of an intra-aortic balloon pump, and the use of cardiopulmonary bypass.

The short-term outcomes investigated were the incidence of deep sternal wound infection (DSWI) as defined by the Centers for Disease Control and Prevention,[18] postoperative CVA, need for renal replacement therapy (RRT), reintubation for acute respiratory failure, reexploration for bleeding, postoperative atrial fibrillation (POAF), prolonged length of hospital stay ($\geq$8 days corresponding to the 75th percentile), and operative mortality (within 30 days).

Long-term outcomes investigated were all-cause late mortality and freedom from repeat revascularization including the need for PCI or redo CABG. All-cause death is the most robust and unbiased index because no adjudication is required, thus avoiding inaccurate or biased documentation and clinical assessments.[19] Information about death from any cause is obtained regularly from the General Register Office approximately 1 week after the event and data on repeat revascularization are obtained from the national surgical and interventional database.

### Statistical Analysis

For baseline characteristics, variables are summarized as the mean for continuous variables and the proportion for categorical variables.

Multiple imputation using a bootstrapping-based expectation-maximization algorithm was used to address missing data. The fraction missing ranged from 0% (age) to 0.6% (number of vessels diseased). Patterns of missingness in the data were 23 and rows after listwise deletion were 1456. Rows after imputation were 1522 and the imputation models showed normal expectation-maximization convergence.[20]

To control for measured potential confounders in the data set, a propensity score was generated for each patient from a multivariable logistic regression model based on 18 pretreatment covariates as independent variables with treatment type (BITA vs SITA) as a binary dependent variable.[21] The resulting propensity score represented the probability of a patient undergoing CABG with BITA grafting (C statistic, 0.77). Pairs of patients receiving BITA and SITA were derived using greedy 1:1 matching with a caliper of width of 0.20 standard deviation of the logit of the propensity score. The quality of the match was assessed by comparing selected pretreatment variables in propensity score matched patients using the standardized mean difference (SMD), by which an absolute standardized difference of greater than 10% is suggested to represent meaningful covariate imbalance. Analytical methods for the estimation of the treatment effect in the matched sample included the McNemar test to compare proportions. Kaplan-Meier survival curves between treated and untreated patients in the matched sample were compared using a test described by Austin and Therneau.[22,23] Baseline characteristics and outcomes were also reported for the unmatched SITA patients (Tables E1 and E2, Figures E1 and E2).

R version 3.1.0 was used for the statistical analysis.[24]

## RESULTS

### Propensity Score Matching

Table 1 summarizes for each pretreatment variable, the unmatched and matched prevalence for the treatment group