

# Can Higher Body Mass Index Patients Save Blood Following On-pump Coronary Artery Bypass Grafting?

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## ABSTRACT

**Background:** The association of obesity with postoperative bleeding volume and transfusions after coronary artery bypass grafting (CABG) is not clear. We evaluated the effects of body mass index (BMI) on bleeding volume and transfusions in patients undergoing on-pump CABG.

**Methods:** We investigated 1,050 patients, aged 24 years to 83 years, who underwent isolated, primary CABG with cardiopulmonary bypass (CPB) at Fuwai Hospital, Chinese Academy of Medical Sciences, from September 2017 to July 2018. We recorded preoperative medical and laboratory coagulation parameters, intraoperative data, and postoperative bleeding volume for 24 hours following surgery. Primary endpoint was bleeding volume within 24 hours and transfusions after surgery. We analyzed the correlation between bleeding volume within 24 hours and transfusions after surgery and preoperative data with univariate and multivariate linear regression and logistic regression.

**Results:** Old age significantly increased postoperative transfusions (OR = 1.035 95% CI 1.013-1.058,  $P = .002$ ), whereas higher BMI (OR = 0.897 95% CI 0.848-0.949,  $P < .001$ ) and higher hemoglobin (HGB) (OR = 0.966 95% CI 0.954-0.978,  $P < 0.001$ ) decreased postoperative transfusions. And, BMI independently was correlated with bleeding volume after multivariate regression analysis ( $B = -0.257$ ,  $P < .001$ ).

**Conclusions:** Our findings suggest higher BMI may reduce postoperative bleeding volume and transfusion rate, thus such patients may save blood products during on-pump CABG.

## INTRODUCTION

Obesity is becoming a worldwide burden. By 2025, the percentage of obesity is expected to account for 18% in males

and more than 21% in females; severe obesity will be more than 6% in males and 9% in females [Collaboration NCDRF 2016]. Obesity is on the rise with mean BMI increasing 0.4-0.5 kg m<sup>-2</sup> annually worldwide [Finucane 2011]. BMI (BMI = weight height<sup>-2</sup>) is used to quantify obesity nowadays, but it's not a perfect measure because it fails to consider variations, such as muscle bulk and ethnicity. BMI does, however, correlate with percentage body fat in majority clinical situations [Hunt 2017].

Previous studies have revealed that obesity is a risk factor of diabetes mellitus, hypertension, and coronary artery disease [Simopoulos 1984]. However, there is much controversy regarding increased morbidity in obese patients undergoing CABG. A large sample study showed the risk of death increased with a higher BMI [Zheng 2011; Kuduvali 2002]. However, increased mortality after CABG also is associated with low BMI as underweight [Mariscalco 2017; Reeves 2003].

Severe postoperative bleeding after cardiac surgery can cause certain complications, such as stroke, acute kidney injury, perioperative myocardial infarction, and mortality [Dyke 2014; Ranucci 2013]. Meanwhile, transfusions can induce acute lung injury, postoperative low cardiac output, early and late mortality, and higher costs together with longer stays in the intensive care unit (ICU) [Murphy 2007; van Straten 2010]. Therefore, fewer blood transfusions and avoiding unnecessary transfusions in cardiac surgery are of great importance.

The relationship between obesity and non-obesity based on BMI, postoperative bleeding volume, and blood transfusion remains unclear. Nolan et al [Nolan 2011] reported that rate and amount of transfusion and total blood loss were reduced in obese individuals and indicated a linear correlation between BMI and postoperative bleeding volume. On the other hand, Gurm et al examined that the risk of postoperative bleeding complications does not differ between obese and non-obese patients [Gurm 2002]. Our previous study illustrated the linear correlation between BMI and postoperative bleeding volume in Chinese patients [Wang 2017]. However, no study confirmed its relationship with transfusions in Chinese as far as we know. So, we further explored whether higher BMI can reduce postoperative bleeding volume and transfusions after CABG.

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Table 1. Baseline Characteristics of the Patients (N = 1050)

Age (years)	60.6±8.33
Men (%)	810 (77.1)
Family history of CHD (%)	130 (12.4)
Hypertension (%)	675 (64.3)
Hyperlipidemia (%)	858 (81.7)
Diabetes (%)	369 (35.1)
Cerebrovascular events (%)	83 (7.9)
Myocardial infarction (%)	71 (6.8)
Interventional stent (%)	31 (3.0)
Heart failure (%)	5 (0.6)
Surgery history (%)	208 (19.8)
Medical therapy	
LMWH (%)	834 (79.4)
Aspirin (%)	280 (26.7)
Ticagrelor (%)	50 (54.8)
ACEI (%)	197 (18.8)
β-blocker (%)	115 (11.0)
LVEF (%)	58.5±11.5
BMI (kg m-2)	25.94±3.22
HGB (g L-1)	135.5±15.7
PLT count (×10 <sup>9</sup> L-1)	218.1±58.6
PCT (%)	0.23±0.06
PT (sec)	13.08±0.83
APTT (sec)	36.91±6.24
FIB (g L-1)	3.54±0.95
D-dimers (μg ml-1)	0.27 (0.22,0.40)
FDP (μg ml-1)	2.5 (2.5,2.5)
CPB time (min)	106.0±31.6
Aortic clamp time (min)	73.1±24.1
Number of anastomoses	3.50±0.8
Postoperative bleeding (mL 24h-1)	390 (300,500)
RBC transfusion (%)	208 (19.8)

CHD: coronary heart disease, LMWH: low molecular weight heparin, ACEI: angiotensin-converting enzyme inhibitors, LVEF: left ventricular ejection fraction, BMI: body mass index, HGB: hemoglobin, PLT: platelet, PCT: plateletcrit, PT: prothrombin time, APTT: activated partial thromboplastin time, FIB: fibrinogen, FDP: fibrinogen degradation product, CPB: cardiopulmonary bypass, RBC: red blood cell.

## MATERIALS AND METHODS

**Study population:** This was a retrospective study. Data was collected on 1,050 patients who underwent isolated primary on-pump CABG at Fuwai Hospital, from September 2017 to July 2018. Isolated primary on-pump CABG

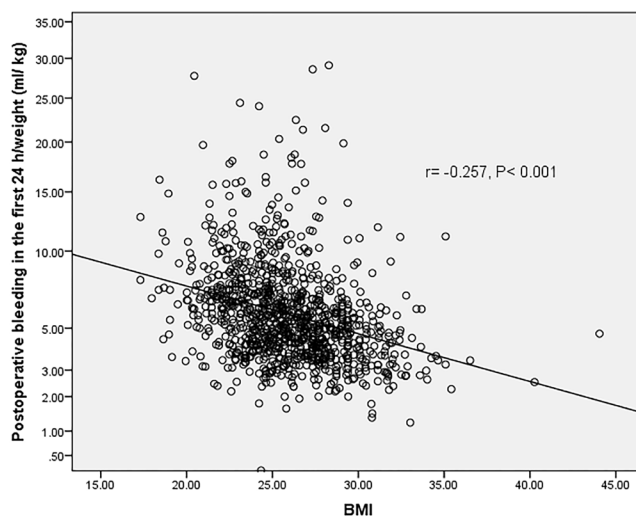


Figure 1. Correlation between BMI and postoperative bleeding. There was a significant correlation between the two factors ( $r = -0.257, P < .001$ ).

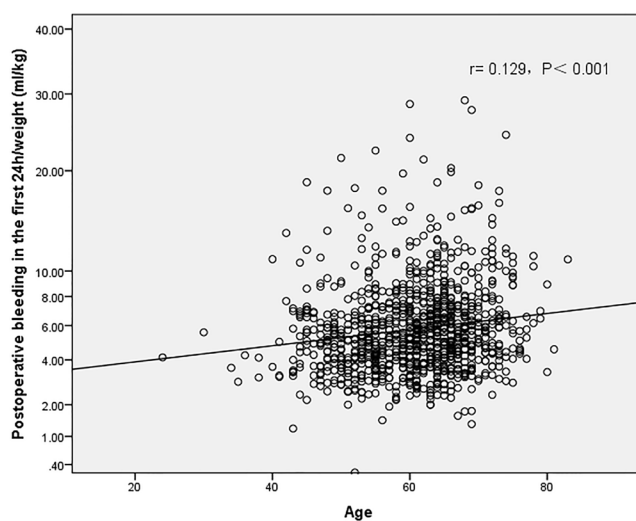


Figure 2. Correlation between age and postoperative bleeding. There was a correlation between the two factors ( $r = 0.129, P < .001$ ).

was defined as coronary artery bypass graft surgery for the first time with cardiopulmonary bypass. The study was approved by the Ethics Committee of Fuwai Hospital, and written informed consent was waived. We excluded patients of emergency CABG, off-pump CABG, concomitant surgical procedures, and patients with liver and kidney dysfunction.

**Data collection:** We collected preoperative medical therapy, laboratory coagulation parameters [platelet (PLT) count, plateletcrit (PCT), prothrombin time (PT), activated partial thromboplastin time (APTT), D-dimers, fibrinogen (fibrinogen (FIB), and fibrinogen degradation product (FDP)], intraoperative data and postoperative bleeding volume within 24 hours after surgery.

Table 2. Linear regression analysis for postoperative bleeding volume

Chest tube drainage in the first 24h/weight	Simple linear regression		Multiple linear regression	
	B	P	B	P
Age (years)	0.129	<.001	0.051	.175
Men (%)	-0.015	.631		
Family history of CHD (%)	-0.057	.066	-0.035	.338
Hypertension (%)	-0.048	.117		
Hyperlipidemia (%)	-0.026	.407		
Diabetes (%)	-0.040	.201		
Cerebrovascular events (%)	0.018	.568		
Myocardial infarction (%)	-0.030	.332		
Interventional stent (%)	-0.014	.653		
Heart failure (%)	0.001	.974		
Surgery history (%)	-0.011	.717		
Medical therapy				
LMWH (%)	0.040	.201		
Aspirin (%)	-0.012	.686		
Ticagrelor (%)	0.003	.932		
ACEI (%)	-0.016	.607		
β-blocker (%)	-0.001	.971		
LVEF (%)	-0.035	.217		
BMI( kg m-2 )	-0.257	<.001	-0.257	<.001
HGB (g L-1)	-0.088	.004	-0.039	.305
PLT count (×10 <sup>9</sup> L-1)	-0.087	.005-.008	0.942	
PCT (%)	-0.097	.002	-0.073	.500
PT (sec)	0.051	.103		
APTT (sec)	0.075	.037	0.064	.080
FIB (g L-1)	-0.093	.014	-0.073	.060
D-dimers (μg ml-1)	-0.018	.685		
FDP (μg ml-1)	-0.021	.703		
CPB time (min)	-0.046	.137		
Aortic clamp time (min)	-0.035	.258		
Number of anastomoses	0.003	.913		

CHD: coronary heart disease, LMWH: low molecular weight heparin, ACEI: angiotensin-converting enzyme inhibitors, LVEF: left ventricular ejection fraction, BMI: body mass index, HGB: hemoglobin, PLT: platelet, PCT: plateletcrit, PT: prothrombin time, APTT: activated partial thromboplastin time, FIB: fibrinogen, FDP: fibrinogen degradation product, CPB: cardiopulmonary bypass

Postoperative bleeding volume was defined as the total amount of chest tube drainage within 24 hours postoperatively, which was recorded by a nurse. We tried to eliminate interference by recording volume of chest tube drainage weight-1 rather than volume of chest tube drainage to prevent being affected by individual weight.

Statistical analysis: Categorical variables were expressed as numbers and percentage, and continuous variables were

expressed in the form of mean ± standard deviation (for normally distributed continuous variable comparisons between groups) or the median (IQR) (for abnormally distributed continuous variable comparisons between groups).

Simple linear regression and logistic regression were used to analyze the relationship between demographic data and postoperative bleeding volume and transfusion. A multiple linear regression model was used to identify the independent variable associated

Table 3. Multiple logistic regression analysis for postoperative transfusion

Postoperative transfusion	Adjusted OR	95% CI	P
Age (years)	1.035	1.013-1.058	.002
Men (%)	0.910	0.611-1.355	.643
BMI (kg m <sup>-2</sup> )	0.897	0.848-0.949	<.001
HGB (g L <sup>-1</sup> )	0.966	0.954-0.978	<.001
PLT count ( $\times 10^9$ L <sup>-1</sup> )	0.997	0.989-1.005	.437
PCT (%)	2.102	0.001-1.101	.865

BMI: body mass index, HGB: hemoglobin, PLT: platelet, PCT: plateletcrit

with postoperative bleeding volume, and multiple logistic regression analysis was used to identify the independent variable associated with postoperative transfusion. For both models, covariates were selected into the multiple linear regression models if the *P* value of any independent variable was less than 0.1 after univariate regression analysis.

All statistical analyses were performed with SPSS version 23.0 software (SPSS Inc., Chicago, IL, USA).

## RESULTS

Demographic and clinical data of the patients are presented in Table 1. It is obvious that postoperative bleeding volume significantly correlated with BMI (*P* < .001) (Figure 1), age (*P* < .001) (Figure 2), HGB (*P* < .01) (Figure 3), PLT count (*P* < .01), PCT (*P* < 0.01), APTT (*P* < 0.05), and FIB (*P* < .05). However, BMI was an independent predictor of postoperative bleeding volume by the multiple linear regression (*P* < .001) (Table 2).

Old age significantly increased the rate of postoperative transfusions (OR = 1.035 95% CI 1.013-1.058, *P* = .002), whereas higher BMI (OR = 0.897 95% CI 0.848-0.949, *P* < .001) and higher HGB (OR = 0.966 95% CI 0.954-0.978, *P* < .001) decreased postoperative transfusions (Table 3).

## DISCUSSION

Our study verified the correlation between BMI and postoperative bleeding volume and transfusion. We draw the conclusion that BMI, even within a normal range, can inhibit postoperative bleeding volume and a reduced transfusion rate can be considered as a biomarker to evaluate patients undergoing cardiac surgery.

This study demonstrated BMI is an independent preoperative indicator of postoperative bleeding volume. Although, some factors can contribute to postoperative bleeding volume, including amount of fluid left in the pleural cavity from intraoperative blood loss, for example. But there is evidence that chest-tube location does not affect

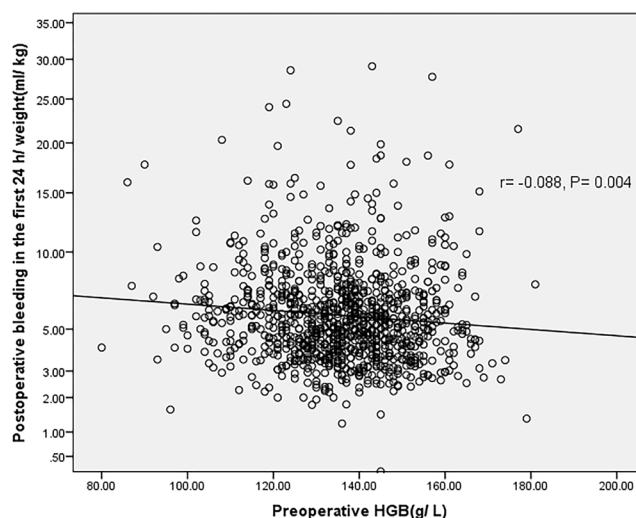


Figure 3. Correlation between HGB and postoperative bleeding. There was a correlation between the two factors ( $r = -0.088$ ,  $P = .004$ ).

output [Senoz 2011]. Chest tube drainage, therefore, is considered to be the only objective indicator of postoperative bleeding volume. As mentioned above, several studies [Gurm 2002; Nolan 2013] evaluated the correlation of BMI and postoperative bleeding volume and transfusions, which were similar with our findings that decreased postoperative bleeding volume and transfusions occurred in an obese group. However, the mechanisms were unexplored. Besides, there are some drawbacks of this grouping method, such as the BMI varying widely in each group, which may not reflect the effects of continuous BMI on postoperative bleeding volume and transfusions.

The link between BMI and postoperative bleeding volume and transfusions may relate to the procoagulant state. Obese patients have higher plasma concentrations of coagulation factor II (FVII), levels of thrombin and thrombin-antithrombin (TAT) complexes, and procoagulant activity of tissue factor (TF) [Samad 2013]. On the other hand, weight loss in morbidly obese patients significantly reduces thrombin generation potential and decreases levels of circulating TF, FVII [Ay 2010; Kopp 2012]. Obesity also is correlated with increased platelet activation [Santilli 2012].

Age previously has shown to be an independent risk factor for blood transfusion after cardiac surgery [Frankel 2005], which is in accordance with the results of our study.

Even though we tried our best, there are still several limitations. First, this study was conducted in a single center of ethnic Chinese patients which may not reflect other patients worldwide. Second, as a retrospective study, we could only collect postoperative data, thus, perioperative fluid management was not assessed.

In summary, this study illustrated blood loss and transfusions correlated with BMI. BMI may be used as an indicator to predict postoperative bleeding volume and transfusions. Therefore, we strongly recommended taking BMI into account in preoperative assessment, which will provide a more accurate preoperative prediction of CABG outcome.

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