Effect of Body Mass Index on Early and Late Mortality After Coronary Artery Bypass Grafting

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Background. **The effect of obesity on the long-term outcome after coronary artery bypass graft surgery (CABG) remains controversial. We analyzed data of patients undergoing CABG in a single center, to determine the predictive value of body mass index in combination with comorbidities on early and late mortality.**

Methods. **Early and late mortality of consecutive patients undergoing isolated CABG from January 1998 until December 2007 were determined. Patients were classified into five groups according to preoperative body mass index: underweight, normal weight, overweight, obese, and morbidly obese.**

Results. **After excluding 122 patients who were lost to follow-up and 236 patients with missing preoperative body mass index, 10,268 patients were studied. Multivariate logistic regression analyses showed that underweight was associated with higher early mortality (hazard ratio 2.63; 95% confidence interval: 1.13 to 6.11, $p = 0.025$). Multivariate Cox regression analyses did reveal morbid obesity as an independent predictor of late mortality (hazard ratio 1.67, 95% confidence interval: 1.15 to 2.43, $p = 0.007$).**

Conclusions. **Among patients undergoing isolated CABG, underweight is an independent predictor for early mortality, and morbid obesity is an independent predictor for late mortality.**

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Obesity in the Western world has achieved alarming proportions and is related to morbidity such as diabetes mellitus, hypertension, and coronary artery disease, reduced life expectancy, impaired quality of life, and increased health care costs [1-4]. However, it remains controversial whether obesity is related to increased long-term mortality after coronary artery bypass graft surgery (CABG) [5-10]. In a recent meta-analysis, Oreopoulos and colleagues [11] showed that overweight and obesity are associated with a neutral or even beneficial effect on all-cause mortality after coronary revascularization. This controversial finding is described as the "obesity paradox." Because obesity is a potentially treatable condition, the identification of obesity as a risk factor for reduced life expectancy after CABG is an important issue.

The objective of this study was to determine the effect of body mass index (BMI) on early and late mortality after CABG.

Patients and Methods

Patients

This study was performed after permission from the local Medical Ethics Committee. We analyzed data from patients undergoing isolated CABG in a single center in the Netherlands between January 1998 and December 2007. Clinical data, including demographics, risk factors, and complications, were prospectively collected in our database. We were not able to determine ethnicity in our patient groups, but the Dutch population is mostly Caucasian. Patients were placed into five groups based on BMI [9, 12–15]: underweight (BMI $<$ 20 kg/m^2), normal weight (BMI 20.0 to 24.9 kg/m^2), overweight (BMI 25.0 to 29.9 kg/m^2), obese (BMI 30.0 to 34.9 kg/m^2), and morbidly obese (BMI $>$ 34.9 kg/m^2). Because most studies comparing BMI to early and late death after CABG used a limit of 20 kg/m^2 for defining underweight, we decided not to use the cutoff point of 18.5 defined by the National Institution of Health [16].

Operative Techniques

All patients received short-acting anesthetic drugs to facilitate early extubation. Normothermic extracorporeal circulation used nonpulsatile flow. Cold crystalloid cardioplegia (St Thomas solution) or warm blood cardioplegia was used to induce and maintain cardioplegic arrest,

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Abbreviations and Acronyms

BMI = body mass index
CABG = coronary artery bypass graft surgery
CI = confidence interval
COPD = chronic obstructive pulmonary disease
CrCl = creatinine clearance
EF = ejection fraction
HR = hazard ratio
OR = odds ratio
PVD = peripheral vascular disease

according to the surgeon's preference. Patients undergoing CABG with extracorporeal circulation received low-dose aprotinin (2 million kallikrein inactivating units) during extracorporeal circulation, administered in the prime solution.

Follow-Up

Follow-up data concerning mortality were gathered using databases of health insurance companies. The data of 9% of the patient group could not initially be retrieved from these databases. We therefore contacted the patients' general practitioners or, if necessary, the authorities of the cities in which the patients lived at the time of the operation. In this way, we retrieved information about mortality for 99% of patients. Early mortality was defined as death within 30 days postoperatively or death at anytime if the patient did not leave the hospital or a transfer tertiary hospital alive; late mortality was defined as any-cause mortality more than 30 days postoperatively.

Statistical Analysis

Discrete variables were compared with the χ^2 test and presented as numbers and percentages. Continuous variables were compared with the t test and analysis of variance and presented as mean ± SD. Univariate and multivariate logistic regression analyses were performed to investigate the impact of potential risk factors on early mortality. Cox proportional hazard regression analyses were performed to investigate the impact of potential risk factors on late mortality. Univariate analyses tested the potentially confounding effects of risk factors on mortality. If significant at p less than 0.05, confounders were included in the multivariable logistic and Cox regression analyses, in addition to the BMI groups (reference group: normal weight). Given the pronounced difference in sex distribution between the BMI groups, sex was included in the multivariate models as well. The cumulative long-term survival was estimated according to the Kaplan-Meier method, comparing differences between groups with the log-rank test. Survival was also estimated using the same method adjusted for other risk factors. The zero time point indicates the time of CABG. Odds ratios (OR) and hazard ratios (HR) with 95% confidence intervals (CI) are reported. A p value less than 0.05 was used for all tests to indicate statistical significance. All statistical analyses were performed using the SPSS statistical software (Statistical Product and Services Solutions, version 15.0; SPSS Inc, Chicago, IL).

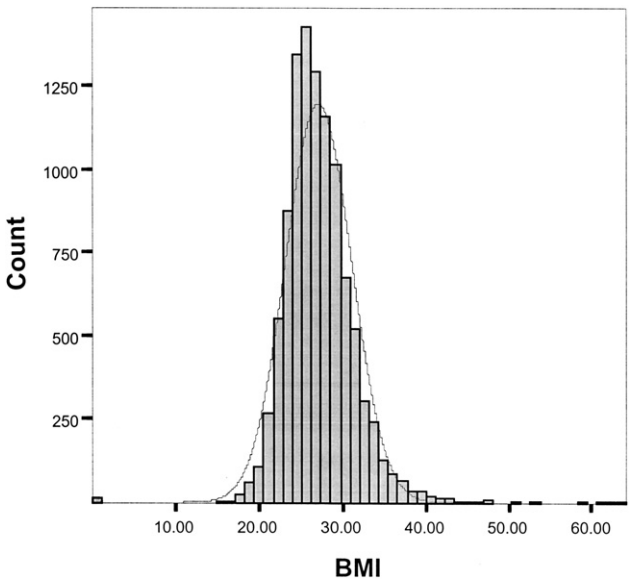

Fig 1. Distribution of body mass index (BMI [kg/m^2]) in 10,268 patients before coronary artery bypass graft surgery (CABG).

Results

During a 10-year period (January 1998 to December 2007), 10,626 patients underwent isolated CABG at our institution. After excluding 122 patients who were lost to follow-up and 236 patients with missing preoperative BMI, 10,268 patients were studied. Almost all patients who were lost to follow-up were foreigners or living abroad. Zero days were recorded for intraoperative deaths; minimum follow-up for surviving patients was 2 months. Mean follow-up was 65.5 ± 34.2 months (maximum follow-up was 123.6 months). Mean BMI of the study group was 27.1 ± 3.7 kg/m^2 (range, 15.4 to 58.8 kg/m^2). Distribution of BMI is shown in Figure 1. Baseline characteristics stratified by BMI groups are shown in Table 1. Morbidly obese patients were younger, and patients with underweight or morbid obesity were more often women than were normal weight, overweight, and obese patients. Diabetes mellitus and hypertension were associated with overweight, obesity, and morbid obesity. Patients who were underweight were more likely to have estimated left ventricular ejection fraction (EF) less than 35% and creatinine clearance (CrCl) less than 60 mL/min. Reexploration for any cause was more frequent in patients with underweight.

Early and late mortality were higher among patients who were underweight compared with patients who were normal weight, overweight, obese, or morbidly obese, as shown in Table 2. Risk factors for early mortality identified by univariate and multivariate logistic regression analyses are shown in Table 3. Univariate logis-