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REVIEW ARTICLE

Does Body Mass Index Affect Mortality in Coronary Surgery?

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Abstract:

Introduction:

The Body Mass Index (BMI) quantifies nutritional status and classifies humans as underweight, of normal weight, overweight, mildly obese, moderately obese or morbidly obese. Obesity is the excessive accumulation of fat, defined as BMI higher than 30 kg/m^2. Obesity is widely accepted to complicate anaesthesia and surgery, being a risk factor for mediastinitis after coronary artery bypass grafting (CABG). We sought the evidence on operative mortality of CABG between standard BMI groups.

Materials and Methodology:

A simple literature review of papers presenting the mortality of CABG by BMI group: Underweight (BMI ≤ 18.49 kg/m^2), normal weight (BMI 18.5–24.9 kg/m^2), overweight (BMI 25.0–29.9 kg/m^2), mild obesity (BMI 30.0–34.9 kg/m^2), moderate obesity (BMI 35.0–39.9 kg/m^2), or morbid obesity (BMI ≥ 40.0 kg/m^2).

Results:

We identified 18 relevant studies with 1,027,711 patients in total. Their variability in size of samples and choice of BMI groups precluded us from attempting inferential statistics. The overall cumulative mortality was 2.7%. Underweight patients had by far the highest mortality (6.6%). Overweight patients had the lowest group mortality (2.1%). The group mortality for morbidly obese patients was 3.44%.

Discussion:

Patients with extreme BMI's undergoing CABG (underweight ones more than morbidly obese) suffer increased crude mortality. This simple observation indicates that under nutrition and morbid obesity need be further explored as risk factors for coronary surgery.

Keywords: Body Mass Index, Coronary Artery Bypass, Evidence based medicine, Mortality, Obesity, Risk stratification.

INTRODUCTION

The standard expression of nutritional status in human subjects is the Body Mass Index (BMI).The World Health Organisation (WHO) has defined subgroups of BMI [1] as follows:

- Underweight (BMI ≤ 18.49 kg/m^2)
- Normal weight (BMI 18.50–24.9 kg/m^2),
- Overweight (BMI 25.0–29.9 kg/m^2),
- Mild obesity (BMI 30.0–34.9 kg/m^2),

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- Moderate obesity (BMI 35.0–39.9 kg/m^2), or
- Morbid obesity (BMI ≥ 40.0 kg/m^2)

Obesity, is a rising global epidemic affecting over 10% of the world's adult population [1, 2]. It is known to complicate anaesthesia and surgery with lethal and non- lethal events: Many anaesthetists and surgeons empirically encourage obese patients to lose weight prior to planned surgery.

Specifically after coronary artery bypass grafting (CABG), Obesity is a strong risk factor for mediastinitis and death [3]. Although often demonised by surgeons, obesity does consensus on the impact of nutritional status on the operative mortality after CABG (OM-CABG). Neither the current European (EuroSCORE II) or North American (STS PROM) risk scores applicable to risks of CABG directly interrogate for obesity or BMI. Importantly, risk stratification (and perhaps litigation) issues may arise by accepting that obesity does not increase the risk of *death* after CABG, should such association exist (type II error).

This lack of confirmation of an association of obesity with OM-CABG is baffling, taking into account its proven association to the often lethal complication of mediastinitis [3]. Empirical explanations of such paradox may be:

- Unsatisfactory matching of obese and non-obese groups in comparing mortalities
- A physiologically unexplainable protective effect of obesity in established mediastinitis

We sought the cumulative evidence on association of BMI, as a reliable surrogate of nutritional status, and OM-CABG. Contrary to many previous clinical studies, we included underweight (under-nourished) patients for a complete picture of the BMI spectrum.

MATERIALS AND METHODOLOGY

Ethical issues were not raised, therefore ethical approval was not sought.

We performed a simple PubMed search in the English language for studies reporting on obesity and OM-CABG till 31 December 2010. Searching keywords was limited to "human subjects." Articles were also identified using the function "related articles" in PubMed and cross-validated by hand search. The sole outcome was mortality.

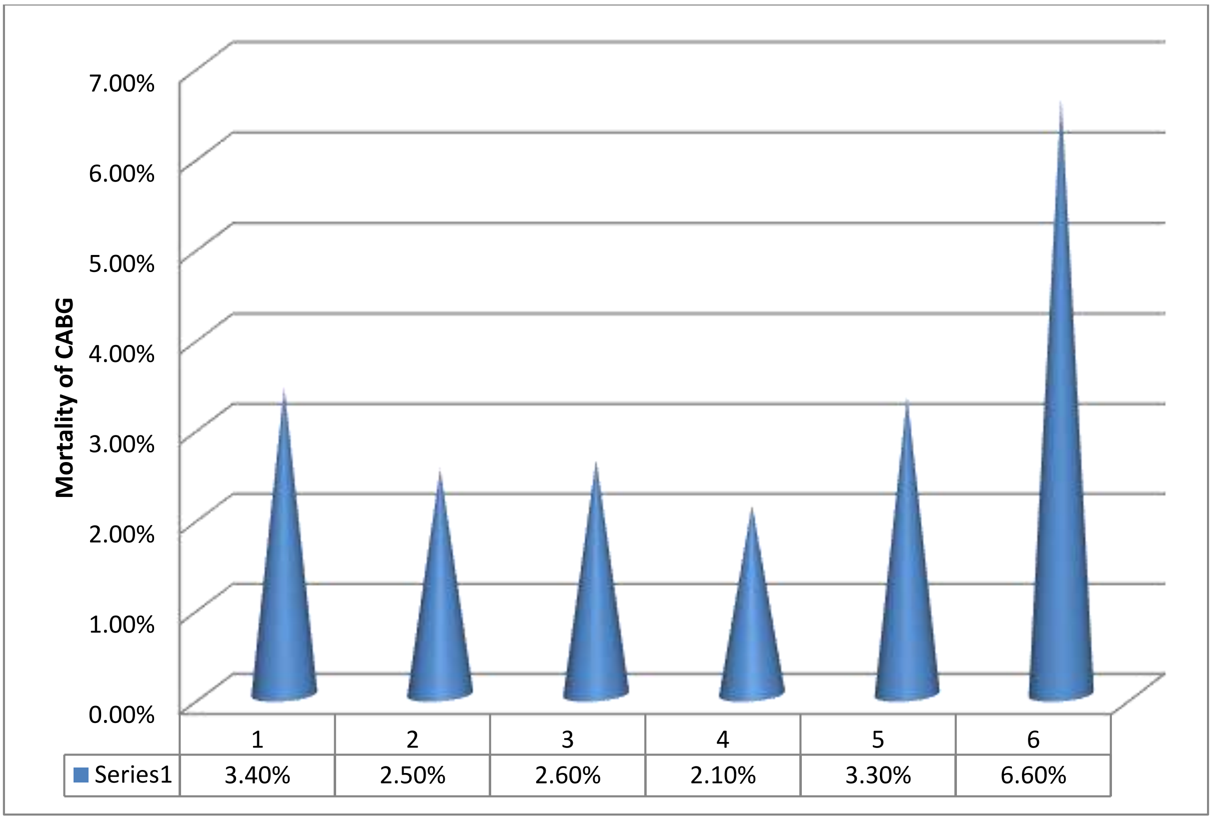
Table 1. Tabulation of mortality of CABG by BMI groups in individual series.

<table>
<tr><th rowspan="3">First author</th><th rowspan="3">Number of patients</th><th colspan="6">Mortality</th></tr>
<tr><th colspan="4">Overnourished</th><th>Well nourished</th><th>Undernourished</th></tr>
<tr><th>Morbidly (Severely) obese</th><th>Moderately obese</th><th>Mildly obese</th><th>Overweight</th><th>Normal weight</th><th>Underweight</th></tr>
<tr><td>Prasad</td><td>500</td><td colspan="4">0.80%</td><td>0.80%</td><td>n/a</td></tr>
<tr><td>Tolpin</td><td>10,863</td><td colspan="3">3.30%</td><td colspan="2">3.60%</td><td>n/a</td></tr>
<tr><td>Kuduvalli</td><td>4,713</td><td colspan="2">3.10%</td><td>2.70%</td><td colspan="3">2.80%</td></tr>
<tr><td>Pan</td><td>9,862</td><td>3.90%</td><td>3.50%</td><td>3.20%</td><td>2.90%</td><td>4.70%</td><td>n/a</td></tr>
<tr><td>Habib</td><td>4,557</td><td colspan="2">1.30%</td><td>2.50%</td><td colspan="2">1.7%</td><td>n/a</td></tr>
<tr><td>Birkmeyer</td><td>11,101</td><td colspan="2">3.10%</td><td>3.30%</td><td colspan="3">3.30%</td></tr>
<tr><td>Engel</td><td>10,590</td><td>1%</td><td colspan="2">2%</td><td colspan="2">2%</td><td>7%</td></tr>
<tr><td>Brandt</td><td>500</td><td colspan="3">4%</td><td colspan="3">3.60%</td></tr>
<tr><td>Kim</td><td>6,728</td><td colspan="3">1%</td><td>2%</td><td colspan="2">2%</td></tr>
<tr><td>Lindhout</td><td>1,130</td><td colspan="3">1%</td><td colspan="3">3.40%</td></tr>
<tr><td>Syrakas</td><td>13,139</td><td colspan="3">2%</td><td colspan="3">2.80%</td></tr>
<tr><td>Schwann</td><td>3,560</td><td>3,2%</td><td>2.60%</td><td>2.40%</td><td>2.20%</td><td>2.20%</td><td>5.30%</td></tr>
<tr><td>Prabhakar</td><td>559,004</td><td>3.10%</td><td>2.50%</td><td colspan="4">2.60%</td></tr>
<tr><td>Edwards</td><td>344,913</td><td>3.60%</td><td colspan="5">2.72%</td></tr>
<tr><td>Clough</td><td>27,239</td><td colspan="2">3.10%</td><td>2.47%</td><td colspan="3">3.10%</td></tr>
<tr><td>Perrotta</td><td>4,749</td><td colspan="2">2.70%</td><td>2.00%</td><td colspan="2">1.70%</td><td>6.20%</td></tr>
<tr><td>Reeves</td><td>4,372</td><td colspan="2">0.60%</td><td>0.80%</td><td>0.80%</td><td>0.90%</td><td>6.70%</td></tr>
<tr><td>Shirzad</td><td>10,191</td><td colspan="3">0.80%</td><td>0.70%</td><td>0.90%</td><td>3%</td></tr>
<tr><td>Total</td><td>1,027,711</td><td colspan="6"></td></tr>
</table>

n/a: no available data

The variability in size of samples from n=500 to n=559.004 and the arbitrary choice of BMI groups (Table **1**) precluded us from attempting inferential statistics. Plain descriptive and summary statistics were therefore performed. Denominators were related to actual data. Missing data were not defaulted.

We stratified OM-CABG to the 6 groups of BMI [1]: Underweight, normal weight, overweight, mildly obese, moderate obese and morbidly obese (Table **1**). Subsequently, we pooled therefore the raw mortality data from all studies and defined cumulative mortalities by BMI group (Fig. **1**) by adding up the available data from each paper: in simple terms, we divided the total number of reported operative deaths in each BMI group by the number of total patients in the same group. That gave us the cumulative surgical mortalities by group.



1: Morbidly (severely) obese: BMI ≥ 40.0 kg/m^2; 2: Moderately obese: BMI 35.0–39.9 kg/m^2; 3: Mildly obese: BMI 30.0–34.9 kg/m^2; 4: Overweight: BMI 25.0–29.9 kg/m^2; 5: Normal weight BMI 18.0–24.9 kg/m^2; 6: Underweight: BMI ≤ 18.49

Fig. (1). A simple graph of mortality from CABG in decreasing order of BMI.

RESULTS

18 relevant clinical reports [4 - 20] were identified, comprising 1,027,711 prospectively and retrospectively studied patients and spanning from 1991-2010 (Table **1**). Two large papers [16, 21] overlap around the year 1997. At least two smaller studies have also cohort overlap [8, 15], yet their relevant results are so different that we tabulated them separately. There were two propensity matched trials [8, 20]; the other series report on unmatched cohorts.

The cumulative mortalities by BMI group are presented in Fig. (**1**) and the mortalities per series, divided again by BMI group, in Table **1**.

The cumulative OM-CABG was 2.7%. Underweight patients had by far the highest individual group mortality (6.6%) (Fig. **1**). The severely (morbidly) obese patients followed them with an OM-CABG of 3.44%. Interestingly, the overweight patients had the lowest individual group mortality (2.1%).

DISCUSSION

Our overarching findings were in summary that (a) underweight patients coming to coronary surgery had by far the highest mortality and (b) the groups at both extremes of BMI had increased mortality (Fig. **1**).

These findings mirror previous findings on BMI –related morbidity after CABG [8]. We have also confirmed to an extent the conclusions of Edwards [21], who had interrogated a database, one-third the size of our sample, for the Society of Thoracic Surgery (STS): Edwards had identified the overweight as the safest CABG candidates, and both very high- and very low-BMI patients as the high-risk. A more recent and even larger cohort STS study, half in size to ours, confirmed the higher risk for the morbidly obese, yet did not capture results for underweight subjects [16]. We note again with interest that many authors ignore the underweight patients when seeking outcomes of CABG (Table **1**).

No mechanisms are immediately evident to explain the skewed U-shape in mortality after CABG Fig. (**1**): We note the previous suggestion that underweight patients fare worse after CABG due to proportionally increased heamodilution during extracorporeal circulation [8]: This alludes to cardiopulmonary bypass/perfusion protocols for adults being often rigid in the amount of non-sanguineous primer. An interesting further question is: does beating heart coronary revascularisation, without heamodilution from extracorporeal circulation offer better outcomes in underweight subjects? A paper with 4,372 patients from an off-pump centre answered' no' [20]. However, we agree in principle with the authors [8] in the need for stringent quantification of 'primer' in the circuits of cardiopulmonary bypass, in the manner of paediatric protocols that maintain perioperative haemoglobin by strict control of heamodilution and modified ultrafiltration.

We note in most papers [4 - 9, 11 - 21] that other potential risk factors have not been interrogated against BMI, with the exception of a paper by Engel [10]: Engel declares, at multivariable analysis, an association of mortality to undernourishment (additional to female gender, non –Caucasian race, chronic obstructive pulmonary disease and renal failure. These risk factors are now, with the exception of race, incorporated in EuroSCORE II. A robust comparison of outcomes for various BMI groups would require data from equally matched groups for Euro SCORE II or STS PROM, with controlling established risk factors regressed to the BMI).

CONCLUSION

Patients undergoing CABG with extreme BMI (underweight ones more than morbidly obese) have increased crude mortality compared to their peers. This simple observation indicates that under nutrition and morbid obesity need be explored as risk factors for coronary surgery: If either or both were thus implicated, a strategy of relevant dietary manipulation towards an optimal BMI would be relevant prior to CABG (as is currently exercise and smoking cessation).

LIMITATIONS

Our study is subject to the standard limitations of literature searches, especially in possible variation of the definition of surgical mortality and BMI grouping between series.

BMI is a given characteristic that somewhat precludes prospective trials to connect it to outcomes [8].

Analysis of raw data without pairing /matching for other risk factors (Euro SCORE II, STS PROM or other scoring system) breeds risk of Type I and Type II Errors. Specifically relating BMI to OM-CABG hazards the residual confounding effects of covariates such as diabetes mellitus, venous thromboembolism and sleep apnoea, all common in the obese population.

The relationship between underweight patients and mortality in the absence of any index of malnutrition such as albumin can be misleading.

We had no data on glycaemic control that may directly impact on the risk of mediastinitis-driven mortality.

CONFLICT OF INTEREST

The author confirms that this article content has no conflict of interest.

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Declared none.

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