Body Mass Index and Operating Times in Vascular Procedures

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INTRODUCTION

The increasing prevalence of obesity is well documented. Obesity, conventionally defined as a body mass index (BMI; calculated as weight [kg] divided by height [m^2]) > 30, is associated with an increased incidence of many chronic diseases, including diabetes mellitus, hypertension, and dyslipidaemia, which are all associated with atherosclerotic vascular disease.

The effect of BMI on operating times has previously been examined. In general surgery it has been shown that operating times for procedures such as cholecystectomy, unilateral mastectomy, and colectomy are significantly higher in obese patients than in patients of normal weight. Moreover, a large multi-institutional database study has revealed that obesity increases both operating time and risk of wound infection for elderly vascular surgery patients. The largest difference between operating times for the six weight classes was 18 minutes (p = .02).

This last mentioned study, however, focused primarily on the impact of BMI on operating times in general, and did not stratify patients into specific vascular procedures, which could potentially have influenced their results.

The objective of this analysis was to investigate the association between BMI and operating times (defined as time from incision to skin closure) in a large national cohort of consecutive patients, subdivided into three procedures: carotid endarterectomy (CEAs), central vascular procedures, and peripheral bypass procedures.

MATERIALS AND METHODS

Patients and database

An analysis of prospectively enrolled data in the National Danish Vascular Registry between January 1983 and February 2012 was performed. The registry covers all Danish vascular procedures performed at nine vascular surgery departments in Denmark and has been systematically validated. Patient consent was not obtained, as data were anonymised. Ethical approval was therefore not required for this study.

Data collection

Data on the following open vascular procedures were collected: (1) CEA; (2) aortic/iliac bypass and open surgery for infrarenal abdominal aortic aneurysm, collated under one group category as central vascular procedures; and (3) peripheral infragenital bypass. Only patients undergoing their first vascular procedure were included. Those having
secondary and redo procedures were excluded. Patients with missing data pertaining to the primary variables in the database, including BMI, type, and time of the surgical procedure were excluded. Grouping of BMI was according to the World Health Organisation (WHO) categories, that is, <18.5, 18.5–25, 25–30, 30–35, >35.

Statistical analysis

Basic descriptive statistics included median, minimum, maximum, and interquartile ranges (IQRs) of operating times for the three types of surgical procedures. Pairwise comparisons of BMI groups with regard to operating times using the independent samples Kruskall–Wallis test for each type of surgical procedure were carried out. Median operating times for normal weight patients (BMI 18.5–24.99) were used as the reference values. To adjust for the influence of confounders, linear and multi-adjusted linear regressions were conducted, adjusting for age, sex, creatinine, heart disease, diabetes, hypertension, and smoking. A p value of <.05 was considered statistically significant. All p values were adjusted for multiple comparisons. Statistical analyses of data were performed using SPSS version 21 (IBM SPSS Statistics 21).

RESULTS

Patient characteristics

The distribution of patients according to BMI and surgical procedure is shown in Fig. 1. The median patient obesity class was overweight (BMI 25.0–29.99) and 14% of the patients were obese (BMI >30.0). At the extremes, 620 (4%) patients were underweight (BMI <18.5) and 387 (3%) were severely obese (BMI >35.0). Sixty-seven percent of the patients were male, and the median age of the patients was 69 years (IQR 62–75 years) for men and 70 years (IQR 63–77 years) for women (Table 1). There was no difference between the age of men and women.

Operating time

CEA. In total, 3,255 patients were included for analysis. The median operating time increased from 71 minutes (IQR 64–90 minutes) for patients with BMI <18.5–88 minutes (IQR 73–101 minutes) for patients with BMI >35.0. The median operating time for obese patients (BMI 30.0–34.99) was 5 minutes longer than the median operating time for patients of normal weight (BMI 18.5–24.99), representing a 7% (i.e., 5/75 [7%]) increase in median operating time ($p = .001$) (Fig. 2, upper panel). In a univariate and multivariate linear regression model, there was a significant correlation between BMI and operating time ($p < .001$ [$R^2 = .015$] and $p < .001$ [$R^2 = .035$]).

Central vascular procedures. In total, 6,885 patients were included for analysis. The median operating time increased from 150 minutes (IQR 120–185 minutes) for patients with BMI <18.5–180 minutes (IQR 140–221 minutes) for patients with BMI >35.0. The median operating time for obese patients (BMI 30.0–34.99) was 15 minutes longer than the median operating time for patients of normal

Figure 1. Distribution of patients according to surgical procedure and body mass index (BMI).
Table 1. Patient characteristics.

| Surgical characteristics | All     | CEA   | Aortic surgery | Infrainguinal bypass |
|--------------------------|---------|-------|----------------|----------------------|
| Sex                      |         |       |                |                      |
| Female                   | 4,862 (33) | 1,074 (33) | 1,938 (28) | 1,850 (41)           |
| Male                     | 9,766 (67) | 2,181 (67) | 4,947 (72) | 2,638 (59)           |
| Age (y)                  |         |       |                |                      |
| Female                   | 70 (63–77) | 67 (60–74) | 68 (61–74) | 75 (67–81)           |
| Male                     | 69 (62–75) | 68 (61–74) | 69 (63–74) | 70 (62–77)           |
| BMI (<18.5)              | 620 (4.2) | 56 (1.7) | 286 (4.2) | 278 (6.2)           |
| 20.0–24.99               | 6,491 (44.4) | 1,283 (39.4) | 3,056 (44.4) | 2,152 (48.0) |
| 25.0–29.99               | 5,468 (37.4) | 1,400 (43.0) | 2,609 (37.9) | 1,459 (32.5) |
| 30.0–34.99               | 1,662 (11.4) | 408 (12.5) | 766 (11.1) | 488 (10.9)           |
| ≥35.0                    | 387 (2.6) | 108 (3.3) | 168 (2.4) | 111 (2.5)           |
| Creatinine               | 87 (73–105) | 87 (75–100) | 86 (72–105) | 87 (71–110) |
| Smoking (current)        | 2,755 (49.6) | 1,413 (43.4) | 3,664 (53.2) | 2,178 (48.5) |
| Hypertension             | 7,792 (53.3) | 1,953 (60.0) | 3,471 (50.4) | 2,368 (52.8) |
| Heart disease            | 4,268 (29.2) | 794 (24.3) | 2,057 (29.9) | 1,417 (31.6) |
| Diabetes                 | 2,300 (15.8) | 458 (14.1) | 567 (8.2) | 1,275 (28.4) |

Note. Categorical variables are presented as n (%). Continuous variables are presented as median (interquartile range). Heart disease defined as ischaemia, arrhythmia, or congestive heart failure. Cerebrovascular disease defined as amaurosis fugax, transient ischaemic attack or stroke. Diabetes defined as type I or II. Hypertension defined as blood pressure >140/90 mmHg and/or antihypertensive medication. CEA = carotid endarterectomy; BMI = body mass index.

weight (BMI 18.5–24.99), representing a 10% increase in median operating time \( (p = .001) \) (Fig. 2, middle panel). In a univariate and multivariate linear regression model, there was a significant correlation between BMI and operating time \( (p < .001 \ [R^2 = .012]) \) and \( p < .001 \ [R^2 = .021]) \). **Peripheral bypass.** In total, 4,488 patients were included for analysis. The median operating time increased from 150 minutes (IQR 120–190 minutes) for patients with BMI <18.5–165 minutes (IQR 125–200 minutes) for patients with BMI ≥35.0. The median operating time for obese patients (BMI 30.0–34.99) was 5 minutes longer than the median operating time for patients of normal weight (BMI 18.5–24.99), representing a 3% increase in median operating time \( (p > .05) \) (Fig. 2, lower panel). In a univariate linear regression model, there was a significant correlation between BMI and operating time \( (p < .048 \ [R^2 = .001]) \); however, after multivariate adjustment the correlation was not present \( (p < .947 \ [R^2 = .023]) \).

**DISCUSSION**

Operating time increases with increasing BMI for CEA and central vascular procedures. The differences between median operating times for normally weighted and obese patients were between 5 and 15 minutes. For patients undergoing peripheral bypass, there was no significant difference in time between obese and patients of normal weight, neither when patients were analysed according to the WHO grouping nor in a linear multivariate adjusted regression.

The findings mirror those found in previous studies. Obesity (BMI >30) significantly increased operating times when compared with normal or overweight patients in the general surgery setting,\(^5\) as well as in elderly vascular surgery patients.\(^\text{\textsuperscript{5}}\) There are, however, some studies that show conflicting results.\(^\text{\textsuperscript{6}}\) The discrepancies among these studies might partially be explained by low statistical power due to small sample sizes, heterogeneity between studies (method of the study and types of surgery included), and a missing subdivision according to surgical procedures (central vs. peripheral).

Previous studies have shown that obese patients had a higher rate of post-operative wound infections than non-obese patients.\(^\text{\textsuperscript{4,7}}\) \(^\text{\textsuperscript{9}}\) Prolonged operating time has been suggested to be an independent predictor of subsequent wound infection.\(^\text{\textsuperscript{10}}\) A prolonged median operating time was found for obese patients undergoing CEA and central vascular procedures in which the differences between median operating times for normal weight and obese patients were 5 and 15 minutes. Prolonged operating times expose the open wound to a greater risk of either direct or airborne contamination, which could be an explanation for part of the increased incidence of wound infection among obese patients. However, another important risk factor of infection in obese patients is the presence of excessive fat tissue, which has low regional oxygen tension, and therefore predisposes to impaired wound healing and infection in the presence of concomitant factors such as haematoma.

The present data confirm that there is a significant but hardly clinically relevant difference in median operating times between obese and normally weighted patients, at any rate for those undergoing either a CEA or a central vascular procedure. Although these differences in time satisfy tests for statistical significance, it is less persuasive to suggest that these differences are of real world clinical significance.

An important limitation of the present study is the issue of unobservable confounders, which may bias the estimates
Figure 2. Box plots present operating times (min) for each body mass index (BMI) group for the three vascular procedures. Note. TEA = thrombo-endarterectomy. *Statistically significant difference between the median operating time of this BMI group and the median operating time of normal weight patients (BMI 18.5 – 24.99) undergoing the same vascular procedure when using pairwise comparison of independent sample Kruskall–Wallis test ($p < .05$) adjusted for multiple comparisons.
of association between obesity and operating times. Surgeon experience, for example, was not accounted for, which certainly would have some impact on operating times, as well as the complexity of the procedure, operating facilities, and transfusions. It is worth noting that this increase in operating time may arguably have little consequence in logistical concerns. That is, the increased operating time may not necessarily affect either the perceived surgical workload or actual time set aside for the procedure. The increased time implies, however, an undeniable increase in the time of wound exposure and therefore should not be ignored.

CONCLUSION

Obesity significantly increased the operating times in CEAs and central vascular procedures. The differences, however, were a maximum of 15 minutes in median operating times. This may have ramifications on individual operating stress but not necessarily on logistical operating planning.

CONFLICT OF INTEREST

None.

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