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Impact of BMI on Outcomes after Mesenteric Revascularization for Chronic Mesenteric Ischemia

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Abstract

Objective—Historically, patients with chronic mesenteric ischemia (CMI) are underweight with a low body mass index (BMI). However, with the recent obesity epidemic many of these patients now are overweight with a high BMI. We evaluated the impact of BMI on outcomes after mesenteric revascularization for CMI.

Methods—A retrospective chart review of patients undergoing open or endovascular mesenteric revascularization for CMI between January 2000 and June 2015 was performed. Demographics, co-morbidities, BMI, Society for Vascular Surgery (SVS) combined co-morbidity score, treatment modality, post-operative complications, reintervention, and all-cause mortality were analyzed. The primary endpoint for the study was all-cause mortality at 5 years. Patients were stratified using World Health Organization (WHO) BMI criteria. Univariate, Kaplan-Meier (KM) survival, and multivariate analyses were performed.

Results—In the study period, 104 unique patients underwent mesenteric revascularization for CMI, for 77 of whom BMI information was available. Of these 77, 30 patients were treated by endovascular revascularization and 47 patients were treated by open revascularization. Overall, 27 (35.1%) were overweight or obese with a BMI ≥ 25 . Median follow-up time was 41 months. High BMI patients were less likely to have weight loss at the time of surgery ($P=0.004$). Stratified by BMI <25 vs BMI ≥ 25 , 5-year survival for patients treated by open revascularization was 90% vs 50% ($P=.02$; survival for patients treated by endovascular revascularization was 27% vs 53% ($P=.37$). Multivariate survival analysis identified active smoking, hypertensive chronic kidney disease, open repair with use of venous conduit instead of prosthetic conduit ($P<0.001$), and history of

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DISCLOSURES

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peripheral arterial disease (PAD) ($P=.002$), as independent predictors of increased all-cause mortality.

Conclusions—BMI needs to be considered in assessing and counseling patients on outcomes of mesenteric revascularization for CMI, as a BMI over 25 is associated with poorer long term survival after open revascularization. Smoking, hypertensive chronic kidney disease, PAD, and open repair with use of venous conduit are independent predictors of long-term mortality after mesenteric revascularization independent of BMI.

Keywords

chronic mesenteric ischemia; mesenteric revascularization; obesity; BMI

1. INTRODUCTION

Chronic mesenteric ischemia (CMI) is an uncommon condition caused by reduced blood flow to the gut that fails to meet its metabolic requirement. Without mesenteric revascularization, it is universally fatal. This condition is classically marked by the triad of postprandial abdominal pain, “food fear,” and weight loss. However, with the obesity epidemic there is a significant proportion of patients with an elevated body mass index (BMI) who require mesenteric revascularization for CMI.[1, 2] This is counterintuitive to the disease pathophysiology. Recent studies have shown worse outcomes in patients at the extremes of BMI undergoing vascular surgery.[3] The studies that have examined CMI in obese patients have only evaluated open revascularizations or only looked at short-term outcomes.[2, 3]

The purpose of this study was to identify the proportion of overweight or obese patients undergoing mesenteric revascularization for CMI, evaluate the effect of BMI on post-operative outcomes, and identify other risk factors for poor patient outcomes in patients with high BMI undergoing revascularization for CMI. We hypothesized that overweight and obese patients have worse morbidity and poorer long term survival compared to non-obese patients after revascularization for CMI.

2. METHODS

2.1 Study Design

This study was a single center retrospective review. All patients were seen and evaluated at a single academic tertiary medical center and were treated by members of the same vascular surgery group practice -- all board certified vascular and endovascular surgeons. Included were all patients undergoing open or endovascular mesenteric revascularization for atherosclerotic chronic mesenteric ischemia from January 2000 to June 2015. Excluded were patients with acute mesenteric ischemia, patients with history of connective tissue disease or median arcuate ligament syndrome, patients of age less than 18 years, cases of iatrogenic CMI, or CMI due to aortic or mesenteric vessel dissection. Primary outcome was 5-year survival, secondary outcomes included post-operative complications such as access site complications, myocardial infarction, respiratory failure, stroke, pneumonia, length of ICU

stay and re-intervention. Approval for this study was granted after institutional board review and patient consent was waived.

2.2 Data Collection

Data were collected through an institutional Enterprise Data Warehouse based search and accuracy was confirmed with manual chart review. Data collected included age, BMI calculated by WHO criteria, co-morbidities, weight loss and nutritional data, pre-operative imaging, treatment modality, intraoperative information, post-operative information, and complications.

The Society for Vascular Surgery (SVS) combined co-morbidity score, originally described by Chaikof and colleagues, was utilized as a raw score of 1-9.[4] Based on the objective functional status of their cardiac, pulmonary, and renal systems, patients were assigned a score of 0-3 for each system; the sum of these three scores was used as their composite score with 0 as the best and 9 as the worst. A score of 0-3 indicated low risk, 4-6 indicated intermediate risk, and 7-9 indicated high risk.

2.3 Statistical Analysis

Continuous data are reported as means $\pm$ standard deviation of the means and medians with ranges. Categorical data is reported as frequencies and percentages. Patients were stratified using World Health Organization (WHO) BMI criteria: underweight BMI <18.5 , normal weight 18.5-24.9, and overweight or obese ≥ 25 . The Fisher's exact test was used for 3-level BMI categories and for open vs. endovascular revascularizations. Survival estimates were obtained via the Kaplan-Meier (KM) method and differences were assessed via the log-rank test was performed to compare survival after open and endovascular revascularization for BMI categories. Multivariate analysis was completed for BMI groups and other significant factors using a Cox regression model, which controlled for all other covariables. Significant covariables were determined by stepwise selection. Significance was assumed at $P<0.05$. All statistical analyses were performed using SAS 9.4 software (SAS Inc., Cary, NC).

3. RESULTS

3.1 Patients Included and Demographics

In the study period, 104 unique patients underwent mesenteric revascularization for CMI. There were 77 of these patients with BMI and treatment information available; of those, 27 (35.1%) were overweight or obese with a BMI of 25 or greater. There were 30 patients treated endovascularly and 47 patients treated with open revascularization. Overall median follow-up time was 41 months (range 0-136 months), and mean age was 66.1 years (SD 11.4 years). Patients with BMI <18.5 were more likely to be active smokers ($P=.048$) and have a history of recent weight loss ($P=.004$). There were more patients with hypertension in the BMI ≥ 25 group ($P=.02$). There was no difference in SVS combined co-morbidity scores or other co-morbidities between all groups including nutritional status as measured by serum albumin. There were no significant differences in the rates of endovascular and open revascularization between BMI groups (Table I).

If treated endovascularly, patients with BMI <25 were more likely to have percutaneous puncture for access. Patients with BMI ≥25 were more likely to have cut down and open puncture for access (Table II). There were no differences in intraoperative factors such as OR time, ASA class, EBL, or contrast volume between groups (Table III).

3.2 Survival Analysis

For our primary outcome of 5-year survival, 12 of the 77 patients had no follow-up information after discharge and, therefore, there were 65 patients included in our survival analysis. Overall 5-year survival was 57%. Stratified by underweight vs normal weight vs overweight/obese, KM 5-year survival was 100% (95% CI 100%-100%), 55.8% (95% CI 33.9%-73.0%), and 47.5% (95% CI 18.1%-72.3%) in patients with BMIs <18.5, 18.5-24.9, and ≥25, respectively ($P=0.19$) (Figure 1). When stratified as overweight or obese (BMI ≥25) compared to those who were underweight or of normal weight (BMI <25), the Kaplan-Meier 5-year survival in the overweight or obese group was 47.5% (95% CI 18%-72%) compared to 61% (95% CI 40%-77%) in the underweight or normal weight group ($P=0.3$) (Figure 1).

Next, patients were further stratified by open vs endovascular revascularization. Five-year survival for patients treated with endovascular revascularization with BMI ≥25 was 53.3% (95% CI 6.8-83.3%), and for patients treated with endovascular revascularization with BMI <25, 27.0% (95% CI 7.0-52.4%) ($p=0.37$). Five-year survival for patients treated with open revascularization with BMI ≥25 was 50% (95% CI 13.4%-78.7%), and for patients treated with open revascularization with BMI <25 was 90% (95% CI 65.6%-97.4%, $P=0.02$, Figure 2). Patients with a low SVS score demonstrated a 5-year survival after mesenteric revascularization of 60.8% (95% CI 44.7-73.5%), versus 0% for the high scoring group ($P<0.001$, Figure 3).

3.3 Multivariate analysis

Cox regression analysis identified active smoking within 6 months of intervention (HR 11.0, 95% CI 2.3-52.0), hypertensive chronic kidney disease (HR 6.4, 95% CI 2.4-17.3), open repair with use of venous conduit as opposed to PTFE or Dacron (HR 5.1, 95% CI 1.8-14.1), and peripheral arterial disease (HR 5.1, 95% CI 3.1-70.6) as independent predictors of increased 5-year mortality (Table V).

4. DISCUSSION

The results of our study demonstrate a complex relationship between BMI and comorbid conditions in patients undergoing mesenteric revascularization for CMI. While obesity did not significantly correlate with decreased 5-year survival in patients undergoing mesenteric revascularization overall, when stratified by BMI, overweight or obese patients had poorer survival after open revascularization compared to their normal or underweight counterparts. Independent of BMI, certain co-morbidities such as smoking, hypertensive chronic kidney disease, and peripheral arterial disease (PAD), as well as having an overall high SVS comorbidity score, correlated with poor long-term survival. Furthermore, the use of venous conduit in open revascularization was also an independent predictor of mortality; this was

likely due to its preferential use in contaminated fields. However, data on bowel necrosis, intra-abdominal contamination, or necessity of “second look” operations was not available to explore this finding. Interestingly, there were no differences in pre-operative nutrition status of patients based on BMI as measured by serum albumin.

The role of BMI in post-operative outcomes after mesenteric revascularization has been the subject of limited study but is increasingly pertinent given the increasing prevalence of obese patients.[3] The absence of the archetypal body habitus of patients with CMI cannot be used to exclude the diagnosis of CMI because, as previously reported, 1/3 of these patients are now overweight or obese, which was also observed in this study with 35% of the cohort having a BMI ≥ 25 . [2] This highlights the need for maintaining a high index of suspicion for CMI as the traditional clinical picture may be confounded by this shifting patient population. This also necessitates evaluation and clarification of the role patient BMI plays in clinical decision making for mesenteric revascularization.

For other vascular surgery operations, there has been a demonstrated “obesity paradox” whereby obesity confers a protective effect. Pitan et al demonstrated a survival advantage conferred by obesity class I-II (BMI 30-39.9) for lower extremity revascularization. This survival advantage was lost in patients with morbid obesity (BMI ≥ 40). [5] In carotid endarterectomy, class II-III obesity (BMI 35-39.9 and BMI ≥ 40) exerted a protective effect against perioperative stroke. [6] This protective effect of obesity has not been demonstrated in the endovascular counterparts to these procedures.

Conversely, Khandanpour demonstrated that patients with class II obesity and high BMI (>35) undergoing open AAA repair had longer operative times and higher rates of wound infections. [7] As reported by Johnson, obese VA patients were more likely to incur infectious, cardiac, and renal post-operative complications. [6] Furthermore, several additional studies have demonstrated increased surgical site infections in obese patients (BMI >30) undergoing lower extremity bypass surgery, as well as an overall increased risk of death and cardiac complications after lower extremity bypass surgery in obese patients. [8-10]

This possible “obesity paradox” was also partly observed in this study with a trend toward improved long term survival for obese patients undergoing endovascular revascularization, but it was not statistically significant. Being overweight, as opposed to the traditionally underweight CMI patients, may represent better baseline nutritional status, making these patients better optimized for major open surgery, as has been seen in critically ill patients and in major open operative patients in cardiac, abdominal, and lung cancer surgery. [11-14] Although there was no significant difference in the serum albumin between the underweight, normal weight, and overweight/obese groups in this study, the number of patients included may not be large enough to detect a significant difference. The observed trends for obese patients may be related to selection bias with patients presenting with more complex comorbid conditions being preferentially treated with endovascular revascularization. The role of BMI and obesity in the treatment of vascular disease will continue to be a growing area of interest with the shift in the population.

A limitation of this study is that it was a retrospective review in a single academic center, with a small patient population. Additionally, as this was a nonrandomized study, patients with more complex co-morbid conditions may have been preferentially treated with endovascular revascularization. Furthermore, this study does not cover outcomes in patients who did not undergo mesenteric revascularization, and it also excludes patients treated for acute mesenteric ischemia. Additionally, we were unable to obtain data regarding clinical outcomes of mesenteric revascularization, aside from survival, such as symptom relief or weight gain.

Nonetheless, this study provides insight into the influence of BMI on post-operative outcomes after mesenteric revascularization. BMI ≥ 25 may be associated with a survival advantage after endovascular revascularization but may be disadvantageous after open revascularization. Co-morbidities including smoking, hypertensive chronic kidney disease, and PAD predict poor long term outcomes, as does high SVS co-morbidity scores. Additionally, the use of venous conduit in open revascularization is associated with poor long term survival. These findings add long term results to the role BMI plays in patients undergoing mesenteric revascularization for CMI, and suggests that BMI has a mixed influence on long-term survival, varying with the method of mesenteric revascularization and the complexity of co-morbid conditions.

5. CONCLUSIONS

BMI should be considered when assessing and counseling patients on outcomes of mesenteric revascularization for CMI as overweight and obese patients have a poorer long term survival after open revascularization than normal or underweight patients. High SVS combined co-morbidity score was also associated with worse long term outcomes. Smoking, hypertensive chronic kidney disease, PAD, and open repair with use of venous conduit are independent predictors of long-term mortality after mesenteric revascularization.

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Figure 1.

Kaplan-Meier 5-year survival analysis of CMI revascularization by BMI groups. (A) BMI <18.5, 18.5-25, and 25+ and (B) BMI less than vs greater than or equal to 25.

A

Open, BMI < 25	27	28	20	17	13	11	8	7	4	2
Open, BMI ≥ 25	10	7	7	7	6	4	3	3	2	1

B

Endo, BM < 25	18	9	5	4	4	4	3	2	
Endo, BM ≥ 25	7	2	2	2	1	1	1	1	1

Figure 2.

Kaplan-Meier 5-year survival analysis of CMI revascularization by BMI groups stratified by (A) open and (B) endovascular treatment.

Figure 3.
Kaplan-Meier 5-year survival analysis of CMI revascularization of all participants by Society for Vascular Surgery (SVS) combined co-morbidity score.

Table I

Participants Included

	All Patients	BMI <18.5	BMI 18.5-24.9	BMI ≥25	p-value
Patients	N=77	N=11	N=39	N=27	
Age	67 (42-85)	67 (49-84)	66 (42-85)	68 (42-84)	0.95
BMI	22.7 (14.1-37.0)	16.5 (14.1-18.4)	21.5 (18.5-24.8)	27.5 (25.2-37.0)	<0.0001
SVS Combined Score	1.2 ± 1.5	0.6 ± 0.8	1.4 ± 1.5	1.2 ± 1.8	0.25
ASA Score	2.9 ± 0.7	2.9 ± 0.7	2.9 ± 0.7	2.9 ± 0.6	0.99
Endovascular	30 (39.0%)	2 (18.2%)	16 (41.0%)	12 (44.4%)	0.31
Open	47 (61.0%)	9 (81.8%)	23 (59.0%)	15 (55.6%)	0.31
Female	54 (70.1%)	10 (90.9%)	25 (64.1%)	19 (70.4%)	0.25
Active Smoker	28 (36.4%)	7 (63.6%)	15 (35.9%)	7 (25.9%)	0.048
Prior Smoker	57 (74.0%)	8 (72.7%)	30 (76.9%)	19 (70.4%)	0.68
Diabetes	15 (19.5%)	0 (0.0%)	7 (18.0%)	8 (29.6%)	0.12
Hypertension	58 (75.3%)	6 (54.6%)	27 (69.2%)	25 (92.6%)	0.02
CHF	10 (13.0%)	1 (9.1%)	7 (18.0%)	2 (7.4%)	0.52
Renal Insufficiency	16 (20.8%)	1 (9.1%)	9 (23.1%)	6 (22.2%)	0.69
COPD	12 (15.6%)	1 (9.1%)	8 (20.5%)	3 (11.1%)	0.62
PAD	37 (48.1%)	5 (45.5%)	19 (48.7%)	13 (48.2%)	0.99
Prior MI	11 (14.3%)	1 (9.1%)	7 (18.0%)	3 (11.1%)	0.67
Any Prior Mesenteric Stent	9 (11.7%)	1 (9.1%)	4 (10.3%)	4 (14.8%)	0.89
Abdominal Pain	74 (96.1%)	11 (100%)	39 (100%)	24 (88.9%)	0.09
Nausea/Vomiting	30 (39.0%)	5 (45.5%)	17 (43.6%)	8 (29.6%)	0.50
Weight Loss	44 (57.2%)	10 (90.9%)	25 (64.1%)	9 (33.3%)	0.004
Albumin	3.3 ± 0.8	3.1 ± 0.4	3.1 ± 0.8	3.6 ± 0.8	0.13
Total Bilirubin	0.7 ± 0.5	0.5 ± 0.1	0.7 ± 0.4	0.9 ± 1.0	0.46
Lactate	1.2 ± 0.9	1.1 ± 0.5	1.2 ± 1.0	1.2 ± 0.7	0.96
WBC	7.8 ± 3.2	8.0 ± 3.4	7.4 ± 3.2	8.4 ± 3.0	0.27
Creatinine	1.3 ± 1.8	0.7 ± 0.3	1.5 ± .4	1.2 ± 0.9	0.054

Table II

Treatment Modality Data by BMI Category

	BMI <18.5	BMI 18.5-24.9	BMI 25	p-value
Endovascular				
Patients	N=2	N=16	N=12	
SMA Stent	2 (100.0%)	15 (93.8%)	10 (83.3%)	0.65
Celiac Stent	0 (0.0%)	1 (6.3%)	0 (0.0%)	0.99
SMA & Celiac Stent	0 (0.0%)	0 (0.0%)	1 (8.3%)	0.47
Femoral Approach	2 (100%)	9 (56.3%)	6 (50.0%)	0.62
Radial Approach	0 (0.0%)	0 (0.0%)	1 (8.3%)	0.47
Brachial Approach	0 (0.0%)	4 (25.0%)	4 (33.3%)	0.84
Open Puncture	0 (0.0%)	1 (6.3%)	6 (50.0%)	0.02
Perc Puncture	2 (100%)	14 (87.5%)	5 (41.7%)	0.02
Open				
Patients	N=9	N=23	N=15	
SMA Revascularized	5 (55.6%)	9 (39.1%)	8 (53.3%)	0.59
Celiac Revascularized	2 (22.2%)	2 (8.7%)	1 (6.7%)	0.57
SMA & Celiac Revascularized	1 (11.1%)	12 (52.2%)	5 (33.3%)	0.08
Inflow: Supraceliac	5 (55.6%)	17 (73.9%)	8 (53.3%)	0.37
Inflow: Iliac	4 (44.4%)	3 (13.0%)	7 (46.7%)	0.04
Conduit: PTFE	8 (88.9%)	22 (95.7%)	12 (80.0%)	0.32
Conduit: Vein	1 (11.1%)	1 (4.4%)	3 (20.0%)	0.32

Table III

Intraoperative Data by BMI Category

	BMI <18.5	BMI 18.5-24.9	BMI 25	p-value
Patients	N=11	N=39	N=27	
OR Time	253 ± 164	259 ± 159	305 ± 173	0.21
ASA Class				
1	0 (0.0%)	0 (0.0%)	1 (3.7%)	0.66
2	3 (27.2%)	7 (17.9%)	3 (11.1%)	
3	4 (36.4%)	15 (38.5%)	12 (44.4%)	
4	1 (9.1%)	4 (10.3%)	1 (3.7%)	
EBL	453 ± 225	359 ± 295	564 ± 797	0.46

Table IV

Postoperative Complications by BMI Category

	BMI <18.5	BMI 18.5-24.9	BMI ≥ 25	p-value
Patients	N=11	N=39	N=27	
Any Post-Op Complication	5 (45.5%)	14 (35.9%)	15 (55.6%)	0.27
Access Complication	0 (0.0%)	3 (7.7%)	3 (11.1%)	0.73
UTI	2 (18.2%)	2 (5.1%)	2 (7.4%)	0.35
ARF	0 (0.0%)	1 (2.6%)	4 (14.8%)	0.13
ARF Requiring RRT	0 (0.0%)	0 (0.0%)	1 (3.7%)	0.50
MI	0 (0.0%)	2 (5.1%)	2 (7.4%)	0.99
Stroke	1 (9.1%)	0 (0.0%)	0 (0.0%)	0.14
Pneumonia	2 (18.2%)	3 (7.7%)	2 (7.4%)	0.56
Intubation (hrs)	43.7 ± 91.7	15.7 ± 61.4	47.2 ± 96.8	0.11
Intubation >2 Days	2 (18.2%)	2 (5.1%)	6 (22.2%)	0.09
Unplanned Return to OR	3 (27.3%)	3 (7.7%)	7 (25.9%)	0.07
ICU Days	2.7 ± 5.4	3.1 ± 4.1	3.3 ± 5.0	0.66
Surgical Site Infection	1 (9.1%)	0 (0.0%)	0 (0.0%)	0.15
Open Reintervention	1 (9.1%)	2 (5.1%)	6 (22.2%)	0.09
Endo Reintervention	1 (9.1%)	2 (5.1%)	5 (18.5%)	0.18

Table V

Multivariate Analysis of Independent Predictors of Mortality

Parameter	Hazard Ratio and 95% Confidence Interval	P
Smoking Within 6 Months of Intervention	11.0 (2.3-52.0)	0.003
Hypertensive Chronic Kidney Disease	6.4 (2.4-17.3)	0.0002
PAD	5.1 (1.8-14.1)	0.002
Venous Conduit (vs Prosthetic)	14.9 (3.1-70.6)	0.0007