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ORIGINAL RESEARCH

Impact of Racial Disparities in Preoperative Cardiovascular Evaluation and Surgical Outcomes in Patients Undergoing Metabolic and Bariatric Surgery: A Retrospective Cohort Analysis

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BACKGROUND: We investigated preoperative referral patterns, rates of cardiovascular testing, surgical wait times, and postoperative outcomes in White versus Black, Hispanic, or other racial or ethnic groups of patients undergoing metabolic and bariatric surgery.

METHODS AND RESULTS: This was a single center retrospective cohort analysis of 797 consecutive patients undergoing metabolic and bariatric surgery from January 2014 to December 2018; 86% (n=682) were Black, Hispanic, or other racial or ethnic groups. White versus Black, Hispanic, or other racial or ethnic groups had similar baseline comorbidities and were referred for preoperative cardiovascular evaluation in similar proportion (65% versus 68%, *P*=0.529). Black, Hispanic, or other racial or ethnic groups of patients were less likely to undergo preoperative cardiovascular testing (unadjusted odds ratio [OR], 0.56; 95% CI, 0.33–0.95; *P*=0.031; adjusted for Revised Cardiac Risk Index OR, 0.59; 95% CI, 0.35–0.996; *P*=0.049). White patients had a shorter wait time for surgery (unadjusted hazard ratio [HR], 0.7; 95% CI, 0.58–0.87; *P*=0.001; adjusted HR, 0.7; 95% CI, 0.56–0.95; *P*=0.018). Reduction in body mass index at 6 months was greater in White patients (12.9 kg/m^2 versus 12.0 kg/m^2, *P*=0.0289), but equivalent at 1 year (14.9 kg/m^2 versus 14.3 kg/m^2, *P*=0.330).

CONCLUSIONS: White versus Black, Hispanic, or other racial or ethnic groups of patients were referred for preoperative cardiovascular evaluation in similar proportion. White patients underwent more preoperative cardiac testing yet had a shorter wait time for surgery. Early weight loss was greater in White patients, but equivalent between groups at 12 months.

Key Words: cardiovascular risk stratification ■ metabolic and bariatric surgery ■ preoperative evaluation ■ racial disparities

Racial disparities in health care delivery are well-described globally across medical and surgical subspecialties.[1,2] Black and Hispanic patients experience longer surgical wait times,[3,4] have increased dropout rates before surgery,[5] and undergo both life-saving procedures and elective interventions at lower rates than their White counterparts.[6,7] Racial inequality has also been demonstrated in postoperative outcomes, with Black patients having worse clinical outcomes as compared with White patients.[8,9] Despite an increased focus on racial disparities in health care, significant differences along racial and ethnic lines still exist.[10–12]

The obesity epidemic, in particular, has disproportionately affected Black and Hispanic patients, with a higher prevalence of obesity in Black patients as

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CLINICAL PERSPECTIVE

What Is New?

- There are currently no society guidelines indicating which patients should be referred for preoperative cardiovascular evaluation before metabolic and bariatric surgery.
- Despite similar medical comorbidities, baseline surgical risk, and referral for cardiovascular evaluation in similar proportion, White patients undergo more preoperative cardiovascular testing yet paradoxically have a shorter wait time for metabolic and bariatric surgery as compared with Black, Hispanic, or other racial or ethnic groups of patients.
- Body mass index reduction was similar across racial and ethnic groups at 12 months.

What Are the Clinical Implications?

- Further research should be aimed at understanding the basis for these racial inequalities to formulate society guidelines for standardized preoperative cardiovascular evaluation and to develop sustainable, systems-based solutions to minimize racial and ethnic disparities in care.

Nonstandard Abbreviations and Acronyms

MBS	metabolic and bariatric surgery
RCRI	Revised Cardiac Risk Index

compared with White patients, and with Black women having the highest odds of obesity of all racial and sex groups.[13,14] Black and Hispanic patients not only have a higher prevalence of obesity, but also an increased prevalence of cardiovascular disease—for which obesity is an independent, modifiable risk factor.[15,16]

Metabolic and bariatric surgery (MBS), with attendant significant weight loss, is an effective strategy to decrease the risk of developing incident cardiovascular disease and to induce remission of the metabolic syndrome.[17] As the prevalence of obesity has increased globally, the number of patients undergoing MBS has increased as well.[18,19] Yet, Black and Hispanic patients undergo weight loss reduction surgery at lower rates and experience a higher rate of postoperative complications than their White counterparts.[20,21] There remains a paucity of data examining racial disparities in preoperative cardiovascular evaluation before MBS and the impact of such disparities on perioperative outcomes. Identifying discrete points of inequality along the continuum of care is paramount to improving clinical outcomes for vulnerable populations.

We investigated preoperative referral patterns to cardiology, rates of cardiovascular testing, surgical wait times, and postoperative outcomes in White versus Black, Hispanic, or other racial or ethnic groups of patients undergoing MBS at an urban, academic center.

METHODS

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Study Population

We identified consecutive patients who underwent MBS at our urban campus from January 2014 to December 2018. All patients who underwent a first-time weight reduction surgery during this time frame were included in the analysis. The study was approved by the institutional review board at our hospital in compliance with HIPAA regulations and informed consent was waived.

Data Collection and Measurement

Detailed clinical information was abstracted from the electronic medical record (Epic Systems, Madison, WI), including baseline patient demographics, self-reported race and ethnicity, zip code of primary residence, primary insurance provider, medical comorbidities at the time of MBS, and preoperative laboratory values. Self-reported race data were available for all patients in the cohort and were categorized as either White, Black, Hispanic, or other racial or ethnic groups. The "other" categorization was used for Asian patients, Indian patients, and patients who did not self-identify as White, Black, Hispanic, Asian, or Indian. These patients were grouped with the Black and Hispanic patients for comparison with White patients and were excluded from the post hoc analysis comparing Black and Hispanic patients separately to White patients, as they were too few in number to analyze separately. We heretofore refer to them as “other racial or ethnic groups.” Hispanic ethnicity was reported in our electronic medical record separately from race, but as mutually exclusive, and thus self-reported Hispanic ethnicity supersedes race in our model. The median income data for each patient were determined by using the zip code of primary residence and correlating with the US Census Bureau data for median household income for each specific zip code.[22] Poverty was defined as annual income <$26 200, as per the US Department of Health and Human Services poverty guidelines.[22] The Revised Cardiac Risk Index (RCRI) score was calculated for each patient retrospectively to compare estimated preoperative cardiac risk.

Statistical Analysis

Normally distributed continuous variables were reported as means±SD and were compared using Student *t*-test. Non-normally distributed continuous variables were compared using Mann-Whitney test and were reported as medians with interquartile ranges. Categorical variables were reported as proportions and were compared using the Chi-square test.

Proportions of White versus Black, Hispanic, or other racial or ethnic groups of patients referred to cardiology for preoperative evaluation were compared using the Chi-square test. Among those referred to cardiology, separate models examining the association of any preoperative testing and race and ethnicity (specifically, stress testing and race and ethnicity) were performed using univariable and multivariable logistic regression models, adjusting for RCRI score. In a secondary analysis, the associations between income category (above or below poverty line) and insurance provider with referral or not to cardiology were examined using adjusted logistic regression models.

Time from index cardiology appointment to MBS date was reported as a median with interquartile range and comparisons between White versus Black, Hispanic, or other racial or ethnic groups of patients were performed using adjusted Cox regression models. Adjustments were made for age, sex, baseline body mass index, insurance provider, income category, referral to cardiology, and whether the patient was referred for preoperative cardiac testing. Mean change in body mass index (BMI) post MBS, at 6- and 12-month follow-up intervals, was compared between White and Black, Hispanic, or other racial or ethnic groups of patients using Student *t*-test.

A 2-tailed *P* value of <0.05 was considered statistically significant. All analyses were performed using STATA 15.1 Statistical Software (StataCorp, College Station, Texas).

RESULTS

There were 797 patients who underwent MBS during the study period, with baseline characteristics listed in Table 1. The large majority of patients were Black, Hispanic, or of other racial or ethnic groups (86.0%, n=682). Of the Black, Hispanic, or other racial or ethnic groups of patients, there were approximately equal proportions of Black patients (49.9%) and Hispanic patients (47.9%). The majority of patients were women (86.2%, n=687). White and Black, Hispanic, or other racial or ethnic groups of patients had similar prevalence of baseline medical comorbidities, including hypertension, hyperlipidemia, type 2 diabetes, chronic obstructive pulmonary disease, atrial fibrillation, and heart failure (systolic and diastolic), as well as severe obesity (BMI >50 kg/m^3). White patients had a higher median income than Black, Hispanic, or other racial or ethnic groups of patients, on average, and were less likely to live in neighborhoods where poverty was prevalent. RCRI score at the time of surgery was similar for White versus Black, Hispanic, or other racial or ethnic groups of patients, and most patients were low risk for a major cardiac event (ie, RCRI score of 0).

A similar proportion of White versus Black, Hispanic, or other racial or ethnic groups of patients were referred to cardiology for preoperative evaluation (65% versus 68%, *P*=0.529; Figure – Panel A). However, Black, Hispanic, or other racial or ethnic groups of patients were less likely to undergo further preoperative cardiovascular testing as compared with White patients, an association that was reduced after adjustment for RCRI (unadjusted odds ratio [OR], 0.56; 95% CI, 0.33–0.95; *P*=0.031; adjusted for RCRI OR 0.59, 95% CI, 0.35–0.996; *P*=0.049). The disparity in testing was primarily driven by a lower number of stress tests ordered for Black, Hispanic, or other racial or ethnic groups of patients compared with their White counterparts (unadjusted OR, 0.51; 95% CI, 0.29–0.92; *P*=0.025; adjusted for RCRI OR, 0.54; 95% CI, 0.30–0.98; *P*=0.044; Figure – Panel B). As there was no statistical difference in the odds of White versus Black, Hispanic, or other racial or ethnic groups of patients referred to cardiology, no post hoc analysis differentiating by race and ethnicity within Black, Hispanic, or other racial or ethnic groups of patients was performed. However, regarding further testing ordered among those referred to cardiology, we did perform a post hoc analysis comparing Black versus Hispanic patients. Patients who were categorized in other racial or ethnic groups (n=15) were excluded from this post hoc analysis, as their numbers were too few from which to draw meaningful conclusions. We found that there was no statistically significant difference between the number of stress tests ordered between groups (unadjusted OR of Hispanic patients undergoing testing relative to Black patients 0.80, 95% CI, 0.52–1.24; *P*=0.325; adjusted for RCRI OR, 0.81; 95% CI, 0.52–1.26; *P*=0.349). In our secondary analysis, there was no difference in referral pattern for preoperative cardiovascular evaluation based on income category defined as living above or below the poverty line (OR, 1.08; 95% CI, 0.8–1.45; *P*=0.619). There was also no difference in referral pattern for preoperative cardiovascular evaluation based on insurance provider, as defined by private insurance versus Medicare or Medicaid (OR, 0.8; 95% CI, 0.55–1.16; *P*=0.242).

Despite more preoperative cardiac testing, White patients paradoxically had shorter wait times for surgery compared with Black, Hispanic, or other racial or ethnic groups of patients (unadjusted HR, 0.7; 95% CI, 0.58–0.87; *P*=0.001), a difference that remained significant after adjustment (adjusted hazard ratio [HR],

Table 1. Baseline Patient Characteristics

	White (n=115)	Black, Hispanic, or other (n=682)	*P* value
Race or ethnicity			<0.001
Asian (Non-Indian)	…	1 (0.1%)	
Black	…	340 (49.9%)	
Hispanic	…	327 (47.9%)	
Indian	…	1 (0.1%)	
Other*	…	13 (1.9%)	
White	115 (100.0%)	…	
Age, y, mean (±SD)	44.6 (±12.9)	41.4 (±11.1)	0.006
Sex			<0.001
Women	83 (72.2%)	604 (88.6%)	
Men	32 (27.8%)	78 (11.4%)	
Hypertension	79 (68.7%)	447 (65.5%)	0.510
Diabetes			0.017
Prediabetes	32 (27.8%)	251 (36.8%)	
Type 1 diabetes	2 (1.7%)	2 (0.3%)	
Type 2 diabetes	30 (26.1%)	202 (29.6%)	
Hyperlipidemia	34 (29.6%)	185 (27.1%)	0.590
End-stage renal disease	1 (0.9%)	9 (1.3%)	0.690
Chronic obstructive pulmonary disease	7 (6.1%)	23 (3.4%)	0.160
Systolic heart failure (EF <45%)	1 (0.9%)	14 (2.1%)	0.390
Heart failure with preserved ejection	2 (1.7%)	14 (2.1%)	0.820
Atrial fibrillation	4 (3.5%)	17 (2.5%)	0.540
Cerebrovascular accident	5 (4.3%)	24 (3.5%)	0.660
Smoking			0.560
Current smoker	10 (8.7%)	43 (6.3%)	
Former smoker	38 (33.0%)	215 (31.5%)	
Never	67 (58.3%)	424 (62.2%)	
Very severe obesity†	31 (27.0%)	211 (30.9%)	0.390
Type of metabolic and bariatric surgery			0.260
Roux-en-Y gastric bypass	47 (40.9%)	230 (33.7%)	
Laparoscopic adjustable gastric band	1 (0.9%)	3 (0.4%)	
Sleeve gastrectomy	67 (58.3%)	449 (65.8%)	
Household income in dollars, median (IQR)	44 641 (28 726; 66 610)	27 914 (22 654; 33 966)	<0.001
Below poverty line	23 (20.0%)	334 (49.0%)	<0.001
Revised Cardiac Risk Index score			0.360
0	92 (80.0%)	588 (86.2%)	
1	19 (16.5%)	74 (10.9%)	
2	4 (3.5%)	16 (2.3%)	
3	0 (0%)	3 (0.4%)	
4	0 (0%)	1 (0.1%)	

EF indicates ejection fraction; and IQR interquartile range.
*"Other" refers to patients who did not self-identify as White, Black, Hispanic, Asian, or Indian.
†Defined as body mass index >50 kg/m^2.

0.7; 95% CI, 0.56–0.95; *P*=0.018) (Table 2). Reduction in BMI at 6 months was greater in White patients (12.9 kg/m^2 versus 12.0 kg/m^2, *P*=0.029), but equivalent at 1 year for White versus Black, Hispanic, or other racial or ethnic groups of patients (14.9 kg/m^2 versus 14.3 kg/m^2, *P*=0.330) (Table 3).

DISCUSSION

We found that among patients undergoing MBS at an urban, academic health system, White versus Black, Hispanic, or other racial or ethnic groups of patients with comparable comorbidities and baseline surgical

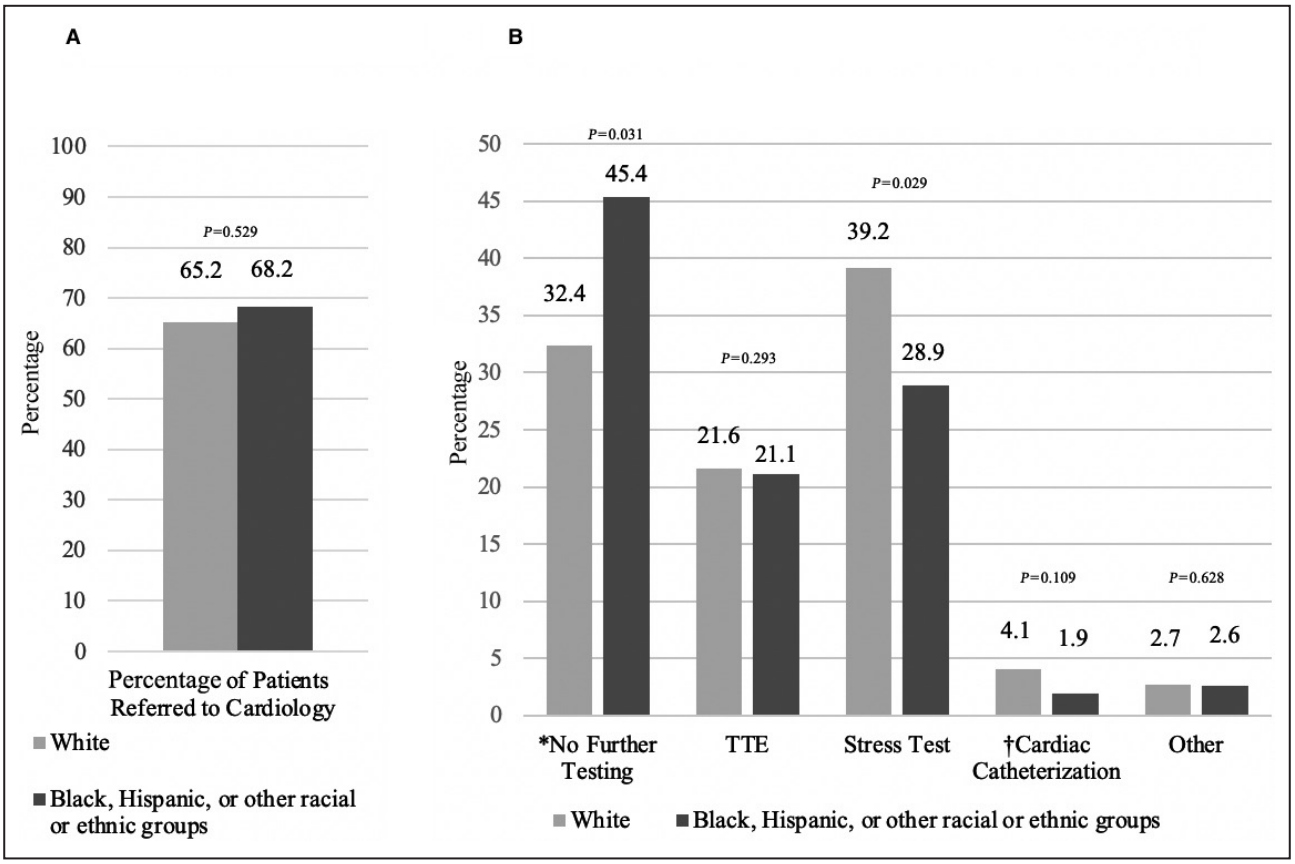

Figure . **Cardiology referral pattern and preoperative cardiac testing. A, Percentage referred to cardiology. B, Percentage of preoperative cardiac testing ordered.**
A, Percentage of White vs Black, Hispanic, or other racial or ethnic groups of patients referred to cardiology for preoperative evaluation. **B**, Percentage of specific preoperative cardiac tests ordered for White vs Black, Hispanic, or other racial or ethnic groups of patients. TTE, Transthoracic echocardiogram. *Patients who were seen by a cardiologist in whom no further tests were ordered. Comparisons were made via a Chi-squared analysis. †Cardiac catheterizations were performed as a result of positive stress tests.

risk were referred for preoperative cardiovascular evaluation in similar proportion, yet White patients underwent more preoperative cardiac testing than Black, Hispanic, or other racial or ethnic groups of patients and had a paradoxically shorter wait time for surgery. Although total BMI reduction was greater in White patients at 6 months post surgery, it was equivalent between groups at 12 months.

Both groups were referred in equal proportion for preoperative cardiovascular evaluation. Our MBS population was predominately Black, Hispanic, or other racial or ethnic groups, and Black, Hispanic, or other racial or ethnic groups of patients had lower neighborhood income and were more likely to live in zip codes where poverty was more prevalent than their White counterparts. This population differs from the overall United States MBS population, which is disproportionately White.[23] In examining the patients who were referred to cardiology in our population, the majority had an RCRI score of 0, indicating a low surgical risk. Despite predominately low RCRI scores and low inherent surgical risk of minimally invasive MBS, a general

Table 2. **Comparisons of Time from Index Appointment to Metabolic and Bariatric Surgery, by Race**

	White	Black, Hispanic, or other racial or ethnic groups	HR	*P* value
Time (mo) from index appointment to surgery, median (IQR)	7.7 (5.3–9.9)	9.1 (6.6–14.2)	Unadjusted HR, 0.7; 95% CI, 0.58–0.87 Adjusted HR, 0.7; 95% CI, 0.56–0.95	Unadjusted: 0.001* Adjusted: 0.018†

Index appointment defined as the first visit with bariatric surgery. HR indicates hazard ratio; and IQR, interquartile range.
*Unadjusted analysis.
†Adjusted analysis with adjustment made for age, sex, baseline body mass index, insurance provider, income category, referral to cardiology, and whether the patient was referred for preoperative cardiac testing.

Table 3. Reduction in Body Mass Index at 6 Months and 12 Months Postoperatively, by Race

Postoperative BMI change	White	Black, Hispanic, or other racial or ethnic groups	*P* value
6 mo, mean (±SD)	13.0 (±5.3)	12.0 (±4.0)	0.029
12 mo, mean (±SD)	14.9 (±5.4)	14.3 (±4.9)	0.330

BMI indicates body mass index.

pattern of nearly uniform referral to cardiology for preoperative risk assessment may have superseded any potential racial bias.

Inequities were apparent in preoperative cardiovascular testing when comparing White versus Black, Hispanic, or other racial or ethnic groups of patients, despite similar baseline medical comorbidities and similarly low surgical risk. Despite this relatively objective equivalence in preoperative cardiovascular risk, cardiologists ordered more preoperative cardiovascular testing for White patients, driven by an increased number of preoperative stress tests. Few studies have examined racial differences in preoperative cardiac testing. Our findings differ from a cross-sectional prevalence study of all ambulatory visits in the United States spanning the years 1993 to 2010 which found equivalent proportions of White and Black patients being referred for cardiac stress tests, but did find that fewer Hispanic patients were referred.[24] Conversely, and more consistent with our findings, Black patients with chest pain presenting to emergency rooms are less likely to be referred for follow-up stress testing compared with matched White counterparts.[25] Delineating the cause of these racial disparities and identifying actionable methods to mitigate them remains challenging. Prior research has suggested that there are both racial and sex preferences in cardiac testing, with Black patients preferring less invasive cardiovascular testing and women more likely to refuse invasive cardiac testing.[26] Our results suggest there may be unmeasured cultural variables, provider bias, patient preference, and variables in the patient-doctor relationship contributing to the differences observed in preoperative cardiovascular testing. Either way, evaluating disparities in the realm of diagnostic testing remains important, as it underscores race- or ethnicity-based differences in clinical management on the basis of subjective decision making.

Despite more preoperative cardiac testing, White patients paradoxically had a shorter wait time for surgery, including after adjustment. Prior research has demonstrated what one would expect – longer wait times in patients who undergo preoperative cardiology evaluation, which was independent of race.[27] Both racial differences and socioeconomic factors may interact to affect access to MBS and overall wait time. Although we adjusted for insurance provider and income in our analysis, there may be disproportionate, unmeasured impediments to receiving health care services in a timely fashion for Black, Hispanic, or other racial or ethnic groups of patients. These unmeasured variables that may be tied to race and affect surgical wait time are unlikely to be unique to our specific patient population.

Although prior literature has demonstrated less favorable outcomes in Black, Hispanic, or other racial or ethnic groups of patients compared with White patients, we found equivalence in the specific outcome of weight loss.[20,21] The initial postoperative weight loss was greater in White patients at 6 months, however both groups had a similar degree of BMI reduction at 12 months. Racial differences in the rate of weight reduction after MBS have not been extensively studied. In our population, it is not clear what would drive this early difference in weight loss, that later evened. Both racial groups had a similar breakdown of surgeries (Roux-en-Y versus sleeve gastrectomy) and similar baseline comorbidities. Explanations for this early difference could include acute or subacute racial differences in metabolic response to surgery, as have been identified in at least 1 prior study[28]; differences in postsurgical follow-up, as have been observed after other surgical interventions[29]; or other racial differences in immediate postoperative management. That the racial difference in weight loss evened at 12 months may belie an as-of-yet unidentified opportunity in the weeks postoperatively to improve postoperative weight loss for Black, Hispanic, or other racial or ethnic groups of patients. Our findings suggest there may be unexplored differences among racial groups that contribute to the overall rate of weight loss after MBS.

The goal of traditional preoperative risk calculators is to assess the role of patient and surgery-specific characteristics in order to estimate overall operative risk and determine if further cardiovascular testing is warranted. Although estimation of surgical risk is fairly standardized given the availability of multiple surgical risk calculators, further testing as a result of risk calculation remains predominately at the discretion of the ordering physician and may not be based on calculated risk alone. The American College of Cardiology and American Heart Association guidelines recommend that for patients with low combined clinical and surgical risk based on standardized risk calculators, no further preoperative cardiac testing should be performed.[30] However, there is established and emerging data suggesting that obesity itself is a risk-enhancing factor for cardiovascular disease that is not captured in traditional risk calculators.[31] Within the MBS literature, there are no specific society guidelines indicating which patients should be referred to a cardiologist for evaluation. The American Society of Metabolic and

Bariatric Surgery guidelines only state that "noninvasive cardiac testing beyond an electrocardiogram is determined on the basis of the individual risk factors and findings on history and physical examination."[32] The overemphasis on preoperative cardiac evaluation before MBS leads to overutilization of this resource when often not needed. Given the lack of standardization and uniformly morbid population in question, decision-making on whom to order further testing invites myriad forms of bias, including along racial and ethnic lines. Our findings highlight the need for a more standardized approach to minimize potential bias and disparities in care as well as overuse of preoperative cardiovascular testing on low-risk patients.

There are several limitations to this study. The single hospital system study population may limit generalizability. However, our hospital system draws from patients across socioeconomic strata, as well as across both urban and suburban settings. The retrospective study design may result in selection bias and the presence of unmeasured variables that would affect the measured associations, although our combination of a large sample size and granular data on individual patient characteristics for adjustment may have mitigated these biases. Because this is an observational study, identified relationships should be interpreted as associations, and no inference on causation can be made. The study population only included those patients who went forward with surgery and did not examine those who were referred for cardiology evaluation but did not ultimately undergo surgery. Although our analysis adjusted for income, there may be unmeasured socioeconomic factors which may have affected expedient access to care and engagement with the health system. Given the retrospective nature of the study, income data was based on reported mean income by zip code, rather than personal income. Additionally, in our data analysis we recorded BMI at the initial MBS appointment. Since Black, Hispanic, or other racial or ethnic groups of patients waited longer for surgery as compared with White patients, their BMI may have been lower at the time of surgery, and their initial weight loss may not have been as substantial as a result of this, affecting the results. This may be because patients at our institution must be on a regimented weight loss program designed by the bariatric surgery team before surgery. It may be that with longer wait times and more time in this program, the weight of Black, Hispanic, or other racial or ethnic groups of patients was lower. We did not adjust for patients who may have received one or greater than one test after referral to cardiology. Finally, as there were multiple a priori hypotheses in the methods of this study, there is an increased risk of type-I error. There was no adjustment made for testing multiple hypotheses.

In conclusion, we found that White and Black, Hispanic, or other racial or ethnic groups of patients at our institution have similar medical comorbidities, baseline surgical risk, and are referred in similar proportion to cardiology for risk stratification before MBS. Yet, despite surgical risk equivalence, White patients undergo more preoperative cardiovascular testing and paradoxically have a shorter wait time for MBS. Postoperative weight loss was greater in White patients at 6 months but was comparable between White and Black, Hispanic, or other racial or ethnic groups of patients at 12 months. Further research should be aimed at understanding the basis for these racial inequalities to develop sustainable, systems-based solutions.

ARTICLE INFORMATION

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