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Racial disparities in inferior vena cava filter use in metabolic and bariatric surgery patients: Nationwide insights from the MBSAQIP database

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ABSTRACT

Background: Prophylactic inferior vena cava (IVC) filter use in bariatric surgery patients is a physician- and patient-dependent practice pattern with unclear safety and efficacy. Factors that mediate physicians' decisions for IVC filter placement preoperatively remain unclear. The role of race in decision-making also remains unclear.

Methods: From the 2015–2016 MBASQIP database, patient characteristics leading to IVC filter use and outcomes after IVC filter placement were compared between Black and White primary bariatric surgery patients.

Results: Prophylactic IVC filter was used in 0.66% of Black and White patients. IVC filter use was three-fold higher in Black patients, despite this cohort having a lower venous thromboembolism (VTE) risk profile than White counterparts. Black race was an independent predictor for IVC filter placement on multivariate analysis. After receiving an IVC filter, Black patients had higher rates of 30-day adverse outcomes.

Conclusions: In this study, Black race was independently associated with the likelihood of receiving a prophylactic IVC filter, despite lower rates of VTE risk factors and lack of recommendations for its use. Further research is needed to explore why this disparity in clinical practice exists.

Introduction

Obesity remains a growing epidemic in the United States (US)[1–6] and is associated with a significant obesity-related disease burden, impaired quality of life and shortened life expectancy.[7] Metabolic and bariatric surgery (MBS) has repeatedly been shown to be a safe and effective treatment modality for severe obesity, resulting in sustained long-term weight loss and remission of obesity-related comorbidities.[8–12] In a recent meta-analysis of randomized and observational studies by Chang *et al.*, overall early and late mortality rates following MBS were low at 0.08%–0.22% and 0.31%–0.35%, respectively.[7] Significant remission of diabetes (86–92%), dyslipidemia (68–76%), hypertension (75%) and obstructive sleep apnea (89–96%) were also reported. Several randomized trials have highlighted the advantages of MBS in the remission of type-2 diabetes compared to medical therapy.[11–14]

Despite the excellent safety profile of MBS, these procedures are not without patient risk. Previously reported incidence of deep vein thromboses (DVT) and pulmonary emboli (PE) following MBS were 0–5.4% and 0.6–4%, respectively[15]; however, most contemporary studies have consistently reported a venous thromboembolism (VTE) rate of less than 1%.[15–20] In a recent review of over 270,000 patients in the 2015–2016 Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program (MBSAQIP) database, Dang et al. reported an overall VTE rate of 0.4%, including

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a PE rate of 0.02%.[21] Although a rare occurrence, VTE remains the most common cause of mortality following MBS, with a reported VTE-related mortality rate of 19–30%.[15,21] The current American Association of Clinical Endocrinologists, the Obesity Society, and American Society for Metabolic and Bariatric Surgery Medical Guidelines for Clinical Practice for the Perioperative Nutritional, Metabolic, and Nonsurgical Support of the Bariatric Surgery Patient (AACE/TOS/ASMBS guidelines) recommend prophylaxis against DVT for all bariatric surgery patients.[22] However, ongoing controversy remains regarding VTE risk factors, optimal prophylactic measures and duration of prophylaxis to reduce the rate of VTE following MBS. This has resulted in ongoing practice variability.[23–25] In a recent survey, Pryor et al. reported that over 90% of surgeons use preoperative and postoperative chemoprophylaxis (with variability in the medication used), over 40% used extended chemoprophylaxis (variability in the medication used and duration of therapy) and over 20% elected to place preoperative inferior vena cava (IVC) filters in a subset of patients.[25]

The data behind the indication, use, and potential impact of prophylactic IVC filter use in MBS patients have evolved. Some studies have reported that prophylactic IVC filter is protective in high-risk MBS patients[26,27]; however, there is no consensus on patient characteristics that constitutes high-risk for VTE. Other studies have reported higher rates of adverse outcomes with IVC filter use,[28–31] including higher rates of PE (odds ratio (OR) 2.0), DVT (OR 3.3), serious complications (OR 1.6), permanent disabling complications (OR 4.3) and death (OR 7.0).[28] ASMBS guidelines state for bariatric surgery in general, “filter placement may be considered with chemical and mechanical prophylaxis for selected high-risk patients in whom the risks of VTE are determined to be greater than the risks of filter-related complications”. In the 2017 ASMBS care pathway for laparoscopic sleeve gastrectomy (SG), Telem et al. concluded that routine use of IVC filter is not recommended based on current evidence.[32]

Some studies have suggested Black race to be an independent risk factor for VTE.[20,21,33–35] However, the use of IVC filters in MBS patients by racial cohorts is largely unexplored. The purpose of this study was to primarily determine practice patterns in the utilization of prophylactic IVC filters in non-Hispanic Black and White MBS patients. Secondarily, we sought to determine the impact of IVC filter use practice patterns on bariatric surgery outcomes.

Material and methods

The MBSAQIP participant user file

Data from the 2015 and 2016 Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program Participant Use Files (MBSAQIP-PUF) database were retrospectively reviewed to examine the utilization of prophylactic inferior vena cava (IVC) filter among racial groups and its impact on outcomes following primary MBS. The MBSAQIP is responsible for the accreditation of bariatric surgical facilities in the US. Among the requirements for certification, surgical facilities are required to report bariatric surgical outcomes to the MBSAQIP, a Health Insurance Portability and Accountability Act (HIPAA)-compliant data file registry; the database contains prospectively entered, risk-adjusted, clinically rich data using standardized definitions for preoperative, intraoperative, and postoperative variables that are specific to metabolic and bariatric surgical care. Data points are abstracted at participating institutions by Bariatric Certified Reviewers who are audited for accuracy of performance.

Inclusion and exclusion criteria

For the purposes of this analysis, criteria for inclusion were limited to patients undergoing either Roux-en-Y gastric bypass (RYGB) or sleeve gastrectomy (SG), (Current Procedural Terminology (CPT) codes 43644, 43645 and 43775), and had a prophylactic IVC filter placed prior to MBS. Exclusion criteria included age <18 years, cases without an IVC filter, cases with missing data, and a surgical approach other than conventional laparoscopic or robotic-assisted. For our primary analysis, additional exclusions included cases with a pre-existing IVC filter and those in which the timing of IVC filter placement prior to MBS was classified as unknown. Cases in the resulting cohort were then stratified by race (non-Hispanic White and non-Hispanic Black). A subgroup analysis was also performed of cases with pre-existing IVC filter, stratified by race. A flow diagram of inclusion and exclusion criteria is outlined in Fig. 1. Descriptive statistics (patient demographics and preoperative comorbidities) of Black and White patients with a prophylactic IVC filter were also compared to Black and White patients without a prophylactic IVC filter.

Data collection and statistical analysis

Collected data included patient demographic factors such as age, gender, pre-operative body mass index (BMI), health summary status variables including the American Society of Anesthesiologists' (ASA) classification, and pre-operative comorbidities such as history of myocardial infarction (MI), hypertension requiring medication, hyperlipidemia, renal insufficiency, renal failure requiring dialysis, vein thrombosis requiring therapy, history of pulmonary embolism (PE), diabetes, smoking history, chronic renal disease, dialysis-dependence, obstructive sleep apnea, history of chronic obstructive pulmonary disease and oxygen dependence.

Primary outcome measures included 30-day overall mortality and VTE complications (DVT, PE, and anticoagulation for presumed VTE). Secondary outcomes included postoperative length of stay, operative duration, transfusion requirement, 30-day adverse outcomes (reoperation, readmission, intervention and intensive care unit admission) and aggregate complications, as defined in Appendix 1, including rates of composite leak, bleeding, cardiovascular, renal, pulmonary and infection complications, and total morbidity.

Descriptive statistics and outcome measures in the IVC filter cohorts were compared by univariate analyses using Pearson χ 2 test for categorical variables and independent sample t-tests for normally distributed continuous variables. In order to determine independent predictors of IVC filter use, a binary logistic regression analysis was performed. Independent variables included demographic factors, comorbid conditions, health summary variables and operative choice. A backward Wald method was employed to develop a predictive model of prophylactic IVC filter use. All statistical analysis was performed with SPSS version 25 (IBM Corporation). A p-value < 0.05 was considered statistically significant.

Results

Baseline characteristics

Of the 355,765 cases in the 2015 and 2016 MBSAQIP database, 0.8% (n = 2834) had an IVC filter in place at the time of their MBS. Overall, prophylactic IVC filter was used in 0.66% of non-Hispanic Black and non-Hispanic White patients. We excluded 215 cases for incomplete data. Of the remaining cohort (n = 2619), 66.9% (n = 1751) of IVC filters were placed specifically for their MBS, while 22.6% (n = 591) had a pre-existing IVC filter. Prophylactic IVC filter

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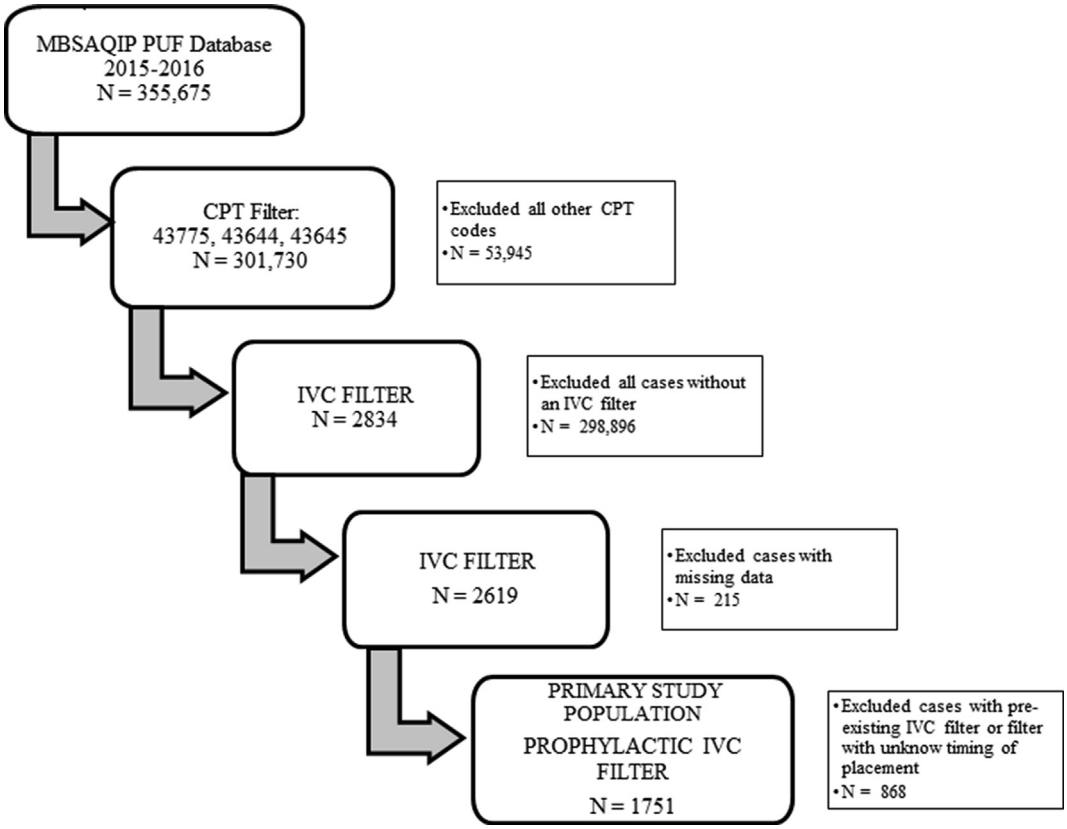

Fig. 1. Flow diagram of inclusion and exclusion criteria.
MBSAQIP = Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program, PUF = Participant Use Database, CPT = Current Procedure Terminology, PMH = Past Medical History, IVC = Inferior Vena Cava.

use was 3.2-fold higher in Black compared to White patients (1.52% vs. 0.48%, $p < 0.001$) (Table 1).

Descriptive statistics of racial cohorts with prophylactic IVC filter use are detailed in Table 2. Patient demographics were significantly different between the two racial cohorts, including more advanced age (50-years vs. 43.5-years, $p < 0.001$), a higher prevalence of male patients (36% vs. 17.9%, $p < 0.001$) and higher ASA classification (3.1 vs. 3.0, $p < 0.001$) among White patients. Preoperative BMI (55.2 kg/m^2 vs. 53.9 kg/m^2, $p = 0.02$) and the proportion of sleeve gastrectomy cases performed (78.7% vs. 62.7%, $p < 0.001$) were higher in Black patients.

Most preoperative comorbid diseases were also significantly different between White and Black prophylactic IVC filter cohorts. White patients had a higher prevalence of most comorbid diseases, including, higher rates of limited ambulation (38.7% vs. 24.6%, $p < 0.001$), total dependence (1.5% vs 0.28%, $p = 0.01$), DVT (27.5% vs. 14.0%, $p < 0.001$), PE (22.4% vs. 9.9%, $p < 0.001$), anticoagulation for presumed or confirmed VTE (25.2% vs. 10.2%, $p < 0.001$) and venous stasis (10.6% vs. 2.9%, $p < 0.001$). A history of smoking (13.9% vs. 9.4%, $p = 0.005$) was significantly higher in the Black patient cohort. Even though renal disease was more prevalent in Black patients, the difference was not significant (chronic kidney disease, $p = 0.5$; dialysis-dependent, $p = 0.09$) compared to White patients. All other preoperative comorbid conditions were either similar between racial cohorts or significantly higher in White patients (Table 2).

Demographics and characteristics of patients with and without IVC filter use, within racial groups, were also compared. For Black patients, those who received an IVC filter (n = 717) had higher rates of reported VTE risk factors preoperatively, compared to Black patients who did not receive an IVC filter (n = 45,595) (Table 3a). Black patients who received a prophylactic IVC filter were more

Table 1
IVC filter use in metabolic and bariatric surgery patients.

Prophylactic				
	White	Black	Ratio	**P-value**
IVC Filter use as a percent of total non-Hispanic cohort population				
IVC Filter (n)	861/180,530	717/46,342		
IVC Filter (%)	0.48%	1.5%	3.2	<0.001
Pre-existing				
IVC Filter use as a percent of total non-Hispanic cohort population				
IVC Filter (n)	444/180,551	147/47,068		
IVC Filter (%)	0.25%	0.31%	1.3	<0.001

IVC = inferior vena cava.

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Table 2
Patient demographics and comorbid conditions (prophylactic IVC filter cohort).

	White [n = 861]	Black [n = 717]	Ratio	P-value
Patient Demographics				
Mean Age (years ± sd)	50.0 ± 12.0	43.5 ± 10.9	0.9	<0.001*
Male Gender (%)	36.0	17.9	0.5	<0.001*
Mean BMI (Highest) (kg/m^2)	56.7 ± 11.5	57.38 ± 11.3	1.0	0.300
Mean BMI (OR Closest)	53.9 ± 10.7	55.2 ± 11.0	1.0	0.020**
ASA class	3.1 ± 0.4	3.0 ± 0.4	0.9	<0.001
Sleeve gastrectomy (%)	62.7	78.7	1.3	<0.001**
Preoperative Comorbid Conditions (%)				
GERD	38.7	24.6	0.6	<0.001
Limited ambulation	12.1	5.4	0.5	<0.001*
History of MI	4.0	1.4	0.4	0.002*
History of PCI	5.7	1.5	0.3	<0.001*
Cardiac surgery	2.3	0.8	0.4	0.020*
Hypertension	66.4	65.4	1.0	0.700
Hyperlipidemia	36.6	22.7	0.6	<0.001*
DVT	27.5	14.0	0.5	<0.001*
Venous stasis	10.6	2.9	0.3	<0.001*
Dialysis-dependent	0.2	0.8	4.0	0.090
Chronic kidney disease	1.5	2.0	1.3	0.500
Anticoagulation	25.2	10.2	0.4	<0.001*
Diabetes	36.7	29.7	0.8	0.003*
Insulin use	15.2	11.9	0.8	0.050
Smoker	9.4	14.0	1.5	0.005**
Partial dependence	4.9	3.4	0.7	0.100
Total dependence	1.5	0.3	0.2	0.010*
COPD	7.3	2.9	0.4	<0.001*
Oxygen-dependent	3.6	1.4	0.4	0.006*
History of PE	22.4	9.9	0.4	<0.001*
Obstructive sleep apnea	60.3	49.8	0.8	<0.001*
Chronic steroid use	2.6	1.5	0.6	0.020*

IVC = inferior vena cava, sd = standard deviation, BMI = body mass index, OR = operation, ASA = American Society of Anesthesiology, GERD = gastroesophageal reflux disease, MI = myocardial infarction, PCI = percutaneous coronary intervention, VTE = venous thromboembolic event, COPD = chronic obstructive pulmonary disease, PE = pulmonary embolism, * = demographic and comorbid conditions significantly higher in white patients, ** = demographic and comorbid conditions significantly higher in black patients.

Table 3a
Patient demographics and comorbid conditions, no IVC filter vs. prophylactic IVC filter in Black patients.

Black Race	No Filter [n = 45,595]	Filter [n = 717]	Ratio	P-value
Patient Demographics				
Mean Age (years ± sd)	43.1 ± 10.8	43.5 ± 10.9	1.0	0.185
Male Gender (%)	13.5	17.9	1.3	<0.001
Mean BMI (Highest) (kg/m^2)	46.4 ± 11.5	57.38 ± 11.3	1.2	<0.001
Mean BMI (OR Closest) (kg/m^2)	44.6 ± 10.7	55.2 ± 11.0	1.2	<0.001
ASA class	2.8 ± 0.4	3.0 ± 0.4	1.1	<0.001
Sleeve gastrectomy (%)	75.6	78.7	1.0	0.140
Preoperative Comorbid Conditions (%)				
GERD	26.3	24.6	1.0	0.516
Limited ambulation	1.8	5.4	3.1	<0.001
History of MI	1.0	1.4	1.4	0.002
History of PCI	1.4	1.5	1.0	0.602
Cardiac surgery	0.8	0.8	1.0	0.916
Hypertension	54.7	65.4	1.2	<0.001
Hyperlipidemia	19.7	22.7	1.2	0.035
DVT	1.2	14.0	11.3	<0.001
Venous stasis	0.6	2.9	4.8	<0.001
Dialysis-dependent	0.7	0.8	1.1	0.721
Chronic kidney disease	1.1	2.0	1.6	0.056
Anticoagulation	1.8	10.2	5.7	<0.001
Diabetes	26.1	29.7	1.1	0.013
Insulin use	8.6	11.9	1.3	0.004
Smoker	7.7	14.0	1.8	0.001
Partial dependence	0.7	3.4	4.5	<0.001
Total dependence	0.3	0.3	1.0	0.810
COPD	1.5	2.9	2.0	<0.001
Oxygen-dependent	0.4	1.4	2.9	0.001
History of PE	1.1	9.9	9.4	<0.001
Obstructive sleep apnea	34.2	49.8	1.4	<0.001
Chronic steroid use	1.7	1.5	0.8	0.057

IVC = inferior vena cava, sd = standard deviation, BMI = body mass index, OR = operation, ASA = American Society of Anesthesiology, GERD = gastroesophageal reflux disease, MI = myocardial infarction, PCI = percutaneous coronary intervention, DVT = deep vein thrombosis, COPD = chronic obstructive pulmonary disease, PE = pulmonary emboli.

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commonly male patients with a higher mean preoperative BMI (55.2 kg/m^2 vs. 44.6 kg/m^2, $p < 0.001$) and ASA classification (3.0 vs. 2.8, $p < 0.001$). They also had significantly higher rates of impaired ambulation ($p < 0.001$), partial dependence ($p < 0.001$), venous stasis ($p < 0.001$), anticoagulation for presumed history of VTE ($p < 0.001$), DVT ($p < 0.001$), PE ($p < 0.001$) and smoking ($p = 0.001$). White patients who received an IVC filter ($n = 861$) similarly had higher mean preoperative BMI (53.9 kg/m^2 vs. 44.1 kg/m^2, $p < 0.001$) and ASA classification (3.1 vs. 2.8, $p < 0.001$)., as well as higher rates of reported VTE risk factors, compared to White patients who did not receive an IVC filter ($n = 179{,}669$) (Table 3b). When compared to racial cohorts without IVC filter use, the likelihood of preoperative VTE risk factors in Black patients receiving a prophylactic IVC filter were less than in White patients receiving a prophylactic IVC filter. For instance, White patients who received a prophylactic IVC filter were 17.7, 22, 9.7, 9.2, 8.1 and 3.8 times more likely to have a preoperative history of DVT, PE, anticoagulation for presumed VTE, venous stasis, partial and total dependence, respectively, compared to White patients without an IVC filter. In comparison, Black patients who received a prophylactic IVC filter were only 11.3, 9.4, 5.7, 4.8, 4.5 times more likely to have a preoperative history of DVT, PE, anticoagulation for presumed VTE, venous stasis and partial dependence, compared to Black patients who did not receive a prophylactic IVC filter. There was no difference in age between Black IVC filter and no IVC filter cohorts ($p = 0.185$); however, White IVC filter patients were significantly older than White patients without an IVC filter ($p < 0.001$).

Outcomes were compared between White and Black patients with prophylactic IVC filters (Table 4). Most hospital outcomes were similar between racial cohorts, except for a significantly higher postoperative length of stay (LOS) (2.3 days vs. 1.9%, $p = 0.002$) and transfusion requirement (0.8% vs. 0.3%, $p = 0.004$) among White patients. Aggregate complications, including leak, bleeding, and cardiac, pulmonary, renal, VTE and infection complications were similar between cohorts. Overall VTE (DVT, PE or anticoagulation for presumed or confirmed VTE) rate in Black and White patients were 3.11% and 2.86%, respectively. Even though aggregate VTE was higher in Black compared to White patients (OR 1.3), the difference was not significantly different ($p = 0.4$). Black patients had worse thirty-day adverse outcomes, including higher rates of readmission (9.6% vs. 5.3%, $p = 0.001$), intervention (12.1% vs. 7.4%, $p = 0.002$) and mortality (1.0% vs. 0.2%, $p = 0.05$). The reasons for thirty-day readmission, intervention and reoperation are outlined in Table 5. Total VTE-related readmission (21.25% vs. 11.48%), intervention (8.74% vs. 5.13%) and reoperation (21.74% vs. 3.57%) were higher in Black compared to White patients.

Binary logistic regression was performed to determine the strongest predictors of prophylactic IVC filter use in racial cohorts of MBS patients (Table 6). On binary logistic regression, Black race was identified as one of the strongest independent predictors for receiving a prophylactic IVC filter (OR = 3.24, $p < 0.001$), superseded only by a history of deep vein thrombosis (DVT) (OR = 5.85, $p < 0.001$) and a history of pulmonary embolism (PE) (OR = 4.62, $p < 0.001$). Other significant independent predictors that were less strongly associated than Black race with prophylactic IVC filter use included a history of venous stasis (OR = 2.07, $p < 0.001$), limited ambulation (OR = 2.03, $p < 0.001$), anticoagulation for presumed VTE (OR = 1.83, $p < 0.001$), COPD (OR = 1.45, $p = 0.005$), smoking (OR = 1.40, $p < 0.001$), ASA score (OR = 1.27/point, $p < 0.001$), OSA (OR = 1.21, $p = 0.001$), hypertension (OR = 1.16, $p = 0.02$) and increasing BMI (OR = 1.05/point, $p < 0.001$). The model had an overall predictive R^2 of 0.192, suggesting a fairly weak predictive

Table 3b
Patient demographics and comorbid conditions, no IVC filter vs. prophylactic IVC filter in White patients.

	No IVC Filter [n = 179,669]	IVC Filter [n = 861]	Ratio	P-value
Patient Demographics				
Mean Age (years ± sd)	46.2 ± 12.1	50.0 ± 12.0	1.1	<0.001
Male Gender (%)	22.0	36.0	1.6	<0.001
Mean BMI (Highest) (kg/m^2)	44.6 ± 13.9	56.7 ± 11.5	1.3	<0.001
Mean BMI (OR Closest) (kg/m^2)	44.1 ± 8.6	53.9 ± 10.7	1.2	<0.001
ASA class	2.8 ± 5	3.1 ± 0.4	1.1	<0.001
Sleeve gastrectomy (%)	69.4	62.7	0.9	<0.001
Preoperative Comorbid Conditions (%)				
GERD	35.0	38.7	1.1	0.013
Limited ambulation	1.8	11.9	6.5	<0.001
History of MI	1.5	4.0	2.4	<0.001
History of PCI	2.5	5.7	2.2	<0.001
Cardiac surgery	1.3	2.3	1.8	0.005
Hypertension	49.5	66.4	1.3	<0.001
Hyperlipidemia	26.9	36.6	1.3	<0.001
DVT	1.5	27.5	17.7	<0.001
Venous stasis	1.1	10.6	9.2	<0.001
Dialysis-dependent	0.2	0.2	1.3	0.670
Chronic kidney disease	0.5	1.5	3.0	<0.001
Anticoagulation	2.6	25.2	9.7	<0.001
Diabetes	25.8	36.7	1.4	<0.001
Insulin use	8.7	15.2	1.7	<0.001
Smoker	9.0	9.4	1.0	<0.001
Partial dependence	0.6	4.9	8.1	<0.001
Total dependence	0.4	1.5	3.8	<0.001
COPD	1.9	7.3	3.6	<0.001
Oxygen-dependent	0.8	3.6	4.3	<0.001
History of PE	1.0	22.4	22.0	<0.001
Obstructive sleep apnea	39.3	60.3	1.5	<0.001
Chronic steroid use	1.7	2.6	1.6	0.044

IVC = inferior vena cava, sd = standard deviation, BMI = body mass index, OR = operation, ASA = American Society of Anesthesiology, GERD = gastroesophageal reflux disease, MI = myocardial infarction, PCI = percutaneous coronary intervention, DVT = deep vein thrombosis, COPD = chronic obstructive pulmonary disease, PE = pulmonary embolism.

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Table 4
Hospital and 30-day outcomes, and aggregate complications.

	White [n = 861]	Black [n = 717]	Ratio	P-value
Hospital Outcomes				
Post-operative LOS (days ± sd)	2.3 ± 2.9	1.9 ± 1.9	0.8	0.002*
Total LOS (days ± sd)	2.4 ± 3.0	2.0 ± 1.9	0.8	0.001*
Surgery length (minutes ± sd)	107.4 ± 59.5	103.3 ± 59.4	1.0	0.200
ICU Admission (%)	2.9	2.4	0.8	0.500
Transfusion (%)	0.8	0.3	0.4	0.004*
Intubation (%)	0.4	0.8	2.0	0.200
Pulmonary emboli (%)	0.0	0.3	–	0.200
Anticoagulation (%)	2.7	1.8	0.7	0.600
30-day Outcomes (%)				
Intervention	7.4	12.1	1.6	0.002**
Reoperation	2.1	2.5	1.2	0.600
Readmission	5.3	9.6	1.8	0.001**
Mortality	0.2	1.0	5	0.050**
Aggregate Complications (%)				
Leak	0.6	0.4	0.7	0.600
Bleed	1.2	0.4	0.4	0.100
Cardiac	0.1	0.4	4.0	0.200
Pulmonary	0.9	1.1	1.2	0.700
Renal	0.6	0.6	1.0	0.900
VTE	2.8	3.1	1.3	0.400
Wound Infection	1.7	1.4	0.8	0.600
Other Infection	1.4	0.7	0.5	0.600

IVC = inferior vena cava filter, LOS = length of stay, sd = standard deviation, ICU = intensive care unit, VTE = venous thromboembolism, * = outcome measures significantly higher in White patients, ** = outcome measures significantly higher in Black patients.

value. This is in contrast to the multivariate regression analysis of strongest predictors of pre-existing IVC filter in MBS patients, where Black race had a weaker predictive value (OR = 1.63, $p < 0.001$) in the context of a stronger predictive model in general ($R^2 = 0.353$) (Appendix 2).

Discussion

While venous thromboembolism remains a rare postoperative event, it is the most common cause of mortality following bariatric surgery.[21] Recent studies have suggested IVC filter use is less cost-effective and associated with more adverse outcome versus benefit.[28,31] In a matched cohort analysis of 2144 high-risk patients using the Michigan Bariatric Surgery Collaborative (MBSC) database, Birkmeyer et al. compared outcomes in MBS patients with and without an IVC filter. They reported higher rates of DVT (1.2% vs. 0.37%, OR 3.3), PE (0.84% vs. 0.46%, OR 2.0), serious complications (5.8% vs. 3.8%, OR 1.6), permanently disabling complications (1.2% vs 0.37%, OR 4.3) and mortality (0.7% vs. 0.09%, OR 7.0) in the IVC filter cohort.[28] In a meta-analysis by Kaw et al., preoperative IVC filter use was associated with higher rates of DVT and mortality, without a significant preventative impact on PE rates.[36] In a more recent review of the 2005–2013 National Inpatient Sample (NIS) database, Reddy et al. compared outcomes in matched MBS cohorts with and without prophylactic IVC filter use, and similarly reported higher rates of adverse outcomes with IVC filter use.[31] This included higher rates of DVT (1.8% vs. 0.3%, OR 6.3) and PE (1.0% vs. 0.1%, OR 10), as well as higher total median hospital charges. They also noted that patients with a history of VTE who received a prophylactic IVC filter had a higher rate of postoperative PE (1.11% vs. 0.19%, p = 0.02), compared to those with a history of VTE who did not receive a prophylactic IVC filter.[31]

Even though IVC filter may be considered for some high-risk patients, there are inconsistencies across studies and risk calculators regarding which variables are most predictive for post-operative VTE (Table 7)[18,20,21,37–45] Based on current evidence, practice guidelines and care pathways do not recommend routine use of IVC filter in bariatric surgery patients.[15,32] This is further highlighted by the fact that current VTE risk stratification tools or calculators, such as BariClot,[21] the Caprini Risk Score,[46] and the MBSC VTE Risk Calculator,[18] do not recommend routine IVC filter use in patients stratified as high VTE risk. In spite of this, over 20% of surgeons report using IVC filters in patients deemed to be at a high-risk for VTE.[25,30]

While studies have reported that Black race is an independent predictor for VTE,[20,21,33–35] little is reported on the use of IVC filter for VTE prophylaxis in Black patients compared to other racial cohorts. This is the first study using the MBSAQIP database to evaluate IVC filter use practice pattern between racial cohorts and potential impact on outcomes. In this study, we found that for both Black and White patient cohorts, those who received a prophylactic IVC filter, had higher rates of preoperative risk factors for VTE (i.e. male gender, higher BMI, history of DVT, PE, smoking and impaired ambulatory state). In comparing both Black and White patient

Table 5
VTE-related 30-day adverse outcomes.

% (n)	Readmission		Intervention		Reoperation	
	Black	White	Black	White	Black	White
PE	2.5% (2)	0% (0)	0.97% (1)	1.28% (1)	0	0
DVT Requiring Therapy	18.75% (15)	11.48% (7)	7.77% (8)	3.85% (3)	21.74% (5)	3.57% (1)
Total VTE-Related 30-Day Adverse Outcomes	21.25% (17)	11.48% (7)	8.74% (9)	5.13% (4)	21.74% (5)	3.57% (1)
Leak	6.25% (5)	8.2% (5)	2.91% (3)	6.41% (5)	8.7% (2)	14.29% (4)
Bleeding	3.75% (3)	12.1% (8)	1.94% (2)	2.56% (2)	0	17.86%

VTE = venous thromboembolism, PE = pulmonary embolism, DVT = deep vein thrombosis.

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Table 6
Predictors of prophylactic IVC filter use in metabolic and bariatric surgery patients.

	Wald	df	P-value	OR	95% CI - Lower	95% CI - Upper
Black vs. White Race	**437.42**	1	<0.001	3.24	2.91	3.62
History of DVT	**369.86**	1	<0.001	5.85	4.89	7.00
History of PE	**250.62**	1	<0.001	4.62	3.82	5.58
Highest BMI	**73.13**	1	<0.001	1.05	1.04	1.06
Limited Ambulation	**45.87**	1	<0.001	2.03	1.66	2.50
Anticoagulation	**41.55**	1	<0.001	1.83	1.52	2.20
Venous Stasis	**37.45**	1	<0.001	2.07	1.64	2.62
BMI Closest to Surgery	**19.83**	1	<0.001	1.03	1.01	1.04
Smoking History	**15.77**	1	<0.001	1.40	1.19	1.66
ASA Class	**14.51**	1	<0.001	1.27	1.12	1.43
OSA	**10.66**	1	0.001	1.21	1.08	1.35
Age	**8.64**	1	0.003	1.01	1.00	1.01
COPD	**7.91**	1	0.005	1.45	1.12	1.89
Hypertension	**5.48**	1	0.019	1.16	1.02	1.31
Oxygen Dependent	**5.32**	1	0.021	0.64	0.44	0.94
GERD	**4.67**	1	0.031	0.88	0.78	0.99

Df = degrees of freedom, OR = odds ratio, CI = confidence interval, DVT = deep vein thrombosis, PE = pulmonary embolism, BMI = body mass index, ASA = American Society of Anesthesiology, OSA = obstructive sleep apnea, COPD = chronic obstructive pulmonary disease, GERD = gastroesophageal reflux disease.

cohorts, with and without IVC filter use, we found that those variables commonly considered to be most predictive for VTE occurred at a higher ratio in White versus Black patients. This suggests that a higher proportion of White patients had a higher VTE risk profile that should have predisposed them to a higher rate of IVC filter utilization. Even though White patients in this study had a higher VTE risk profile, the use of a prophylactic IVC filter was three-fold higher in Black patients, suggesting a racial disparity in this clinical practice pattern. While several studies have stratified Black race as a high VTE risk predictor,[20,21,33,34,47] it is unclear how Black race is weighted in clinical decision-making regarding risk for VTE following bariatric surgery. The reasons for this disparity remain uncertain and could not be determined from this study.

The risks associated with IVC filter use continues to evolve, with more contemporary studies suggesting greater harm than benefit. While Haskins et al. found no difference in VTE rate between those with and without an IVC filter,[33] the recent review by Reddy et al. reported a ten-fold and six-fold higher rates of PE and DVT, respectively, with IVC filter use in bariatric surgery patients.[31] Prior studies evaluating outcomes in bariatric patients with and without an IVC filter have not focused on racial cohorts. In our study, VTE was 30% more likely in Black patients, even though the difference in VTE rate was not statistically significant between Black and White patients. Among Black patients, IVC filter use was associated with significantly higher rates of VTE-related thirty-day adverse outcomes, including 1.6 and 1.8-fold higher rates of intervention and readmission, respectively. In contrast to the findings by Haskins et al. that reported no mortality impact of IVC filter use in bariatric patients ($p = 0.21$),[33] we found that mortality was five-fold higher in Black compared to White patients who received a prophylactic IVC filter ($p = 0.05$). The mortality difference noted in our study may be multifactorial. As other complications known to be risk factors for postoperative VTE, including leak, bleeding and transfusion requirement, were more prevalent in White patients, we suspect the noted higher rate of VTE-related complications were associated with the racial disparate use of IVC filters. The five-fold higher mortality rate in the Black patient cohort may also be related to differences in VTE rates, as other complications were more prevalent in White patients. This would be consistent with the recent study by Dang et al., reporting a VTE-related mortality odds ratio of 40 following bariatric surgery.[21] While this study found racial disparity in prophylactic IVC filter use in bariatric surgery patients, with potential differential impact on outcomes, further studies are needed to validate our findings and to determine causality.

There are several limitations to our study. First, this is a retrospective dataset that is subject to the potential biases that are associated with any retrospective analysis of a multi-institutional clinical database. While missingness is low for most variables and likely did not impact our findings, as with all such retrospective studies, results are limited by the completeness and integrity of data entry. While the MBSAQIP program offers training and

Table 7
Risk factors for venous thromboembolism in metabolic and bariatric surgery patients.

Study	Outcome	Previous VTE	Male	Prolonged procedure	BMI	Age	Procedure type	Other Risk Factors
Steele et al., Obes Surg, 2011	VTE	+	+			+		Smoking
Winegar et al., Surg Obes Relat Dis. 2011	VTE	+	+		+	+	+	Pulm HTN, Edema, Black Race
Masoomi et al. Am Surg. 2011	VTE		+				+	CHF, Lung disease, EtOH, Renal failure
Fink et al. Ann Surg 2012		+	+	+	+	+	+	+
Rezvani et al. Surg Obes Relat Dis. 2013	VTE (DS)			+				Prolonged hospital stay
Chan et al. Surg Obes Relat Dis. 2013	PE			+	+			
Haskins et al. Surg Obes Relat Dis. 2015	DVT		+		+			HTN, CHF
Aminian et al. Ann Surg. 2017	VTE		+	+	+	+	+	Prolonged hospital stay, reop, CHF, paraplegia
Helm et al., Am J Surg. 2017	VTE							Bleeding Leak Sepsis
Halawani et al. Surg Obes Relat Dis. 2017	VTE			+				Prolonged hospital stay
Nielsen et al., Surg Endosc 2018	VTE							Bleeding
Dang et al. Surg Endosc 2019	VTE	+	+	+	+			Black Race, Poor Functional Satus
Haskins et al. Surg Obes Relat Dis. 2019	PE		+		+	+		COPD, CHF, Black Race

VTE - venous thromboembolism, DVT = deep venous thrombosis, HTN = hypertension, EtOH = alcohol, CHF = congestive heart failure, COPD = chronic obstructive pulmonary disease.

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oversight including auditing to ensure accuracy, variations in coding between institutions cannot be fully excluded as a source of bias. Secondly, while a large clinical database, the IVC filter sample size remains expectedly small compared to the overall database. The relatively small IVC filter cohort may have impacted our findings. Third, the dataset provides no insight about VTE risk stratification and clinical decision-making about IVC filter use. It is unclear if a VTE risk calculator or score was used in VTE risk stratification and subsequent decision regarding IVC filter use. The database also lacks granularity about chemoprophylaxis or contraindications to chemoprophylaxis that may have impacted clinical decision-making about IVC filter use. It is possible that there were clinical variables not accounted for in the database that impacted the disparity noted in IVC filter use between Black and White patients. Finally, while IVC filter seems to be disproportionately used in Black MBS patients with a lower VTE risk profile, it remains unclear if adverse outcomes that were significantly higher in Black patients were directly related to the IVC filter placement or other patient and/or operative characteristics. For both the disparate use of IVC filter and outcomes in Black patients, causality could not be established.

Conclusion

VTE is the most significant cause of mortality following MBS. VTE prevention is critical to the continued improvement in quality and outcomes of MBS patients. Prophylactic IVC filters are not considered standard of care and its routine use is not recommended in MBS patients. Their use is left to surgeon and/or program discretion. Current literature suggests that IVC filter use may be associated with more adverse outcomes compared to the potential benefit of VTE prevention. While Black race may be a predictor of high VTE risk, it does not justify the disparity in IVC filter use between Black and White MBS patients noted in this study. Whether inherent biases or variables unaccounted for by our data, the reasons for the higher rate of prophylactic IVC filter use in Black MBS patients who appear to have a lower VTE risk profile remain unclear. Further study of this phenomenon and its clinical impact will be important.

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Appendix 1. Definitions of aggregate complications

Aggregate Complication	Composite Variables
Leak	Reoperation with Suspected Reason: Leak
	Readmission with Suspected Reason: Leak
	Intervention with Suspected Reason: Leak
	Drain present over 30 days
	Complication: Organ space SSI
Bleeding	Reoperation with Suspected Reason: Bleeding
	Readmission with Suspected Reason: Bleeding
	Intervention with Suspected Reason: Bleeding
Cardiac/CVA	Reoperation with Suspected Reason: Cardiac NOS, CVA, or MI
	Readmission with Suspected Reason: Cardiac NOS, CVA, or MI
	Intervention with Suspected Reason: Cardiac NOS, CVA, or MI
	Complication of CVA
	Complication of MI
Pulmonary	Reoperation with Suspected Reason: Shortness of Breath, Pneumonia, or Other Respiratory Failure
	Readmission with Suspected Reason: Shortness of Breath, Pneumonia, or Other Respiratory Failure
	Intervention with Suspected Reason: Shortness of Breath, Pneumonia, or Other Respiratory Failure
	Complication: On Ventilator >48 h
	Complication: Unplanned Intubation
	Complication: Pneumonia
Renal	Reoperation with Suspected Reason: Renal Insufficiency
	Readmission with Suspected Reason: Renal Insufficiency
	Intervention with Suspected Reason: Renal Insufficiency
	Complication: Progressive Renal Insufficiency
	Complication: Acute Renal Failure
DVT or PE	Reoperation with Suspected Reason: Vein Thrombosis Requiring Therapy or Pulmonary Embolism
	Readmission with Suspected Reason: Vein Thrombosis Requiring Therapy or Pulmonary Embolism
	Intervention with Suspected Reason: Vein Thrombosis Requiring Therapy or Pulmonary Embolism
	Complication: Vein Thrombosis Requiring Therapy
	Complication: Pulmonary Embolism
	Complication: Anticoagulation initiated of presumed/confirmed vein thrombosis/PE
Wound infection	Reoperation with Suspected Reason: Wound Infection or Other Abdominal Sepsis
	Readmission with Suspected Reason: Wound Infection or Other Abdominal Sepsis
	Intervention with Suspected Reason: Wound Infection or Other Abdominal Sepsis
	Complication: Post-Op Superficial Incisional SSI occurrence
	Complication: Post-Op Deep Incisional SSI occurrence
Other Infection	Reoperation with Suspected Reason: Infection/Fever
	Readmission with Suspected Reason: Infection/Fever,
	Intervention with Suspected Reason: Infection/Fever

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(*continued*)

Aggregate Complication	Composite Variables
	Complication: Post-Op Sepsis Occurrence
	Complication: Post-Op Septic Shock Occurrence
	Complication: Post-Op Pneumonia occurrence
	Complication: Post-Op Urinary Tract Infection occurrence
Total Infection	Wound Infection, as above
	Other Infection, as above
Total Morbidity	Mortality within 30 Days
	Need for Intervention within 30 Days
	Need for Readmission within 30 Days
	Need for Reoperation within 30 Days
	Unplanned ICU Transfer within 30 Days

SSI = surgical site infection, NOS = not otherwise specified, CVA = cerebrovascular accident, MI = myocardial infarction, DVT = deep venous thrombosis, PE = pulmonary emboli, ICU = intensive care unit.

Appendix 2. Predictors of pre-existing IVC filter use in metabolic and bariatric surgery patients

	Wald	df	Sig.	OR	95% CI - Lower	95% CI - Upper
History of DVT	**469.52**	1	<0.001	14.03	11.05	17.81
History of PE	**361.57**	1	<0.001	9.23	7.34	11.61
Therapeutic Anticoagulation	**112.15**	1	<0.001	3.49	2.77	4.40
Age	**24.54**	1	<0.001	1.02	1.01	1.03
Black vs. White Race	**19.83**	1	<0.001	1.63	1.31	2.02
Pre-Op BMI, Highest	**15.02**	1	<0.001	1.02	1.01	1.03
History of Cardiac Surgery	**8.88**	1	0.003	1.85	1.24	2.78
Limited Ambulation Status	**7.69**	1	0.006	1.62	1.15	2.28
Diabetes Mellitus	**6.41**	1	0.011	1.28	1.06	1.55
Dialysis	**5.50**	1	0.019	2.54	1.17	5.52
Sleeve Gastrectomy	**4.97**	1	0.026	0.80	0.66	0.97
Total Functional Dependence	**4.83**	1	0.028	2.41	1.10	5.27
Venous Stasis	**3.13**	1	0.077	1.37	0.97	1.94
ASA Class	**3.06**	1	0.08	1.21	0.98	1.50

Df = degrees of freedom, Sig. = statistical significance, OR = odds ratio, CI = confidence interval, DVT = deep vein thrombosis, PE = pulmonary emboli, BMI = body mass index, ASA = American Society of Anesthesiology.

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