Medical Complications of Obesity and Optimization of the Obese Patient for Colorectal Surgery

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ABSTRACT

Obesity is a medical epidemic with an enormous impact on disease prevalence and health care utilization. In the preoperative period, an awareness of medical issues associated with obesity is an important part of the planning for surgical procedures. The authors highlight the diagnostic and treatment options for medical conditions commonly affecting the obese patient including diabetes, hypertension, coronary artery disease, and deep venous thrombosis.

KEYWORDS: Obesity, preoperative care, diabetes, hypertension, cardiovascular disease

Objectives: On completion of this article, the reader should understand the scope of the obesity epidemic and should be able to summarize the diagnostic and treatment options for medical problems commonly associated with obesity.

The obesity epidemic has had an enormous impact on health care as a result of the increasing prevalence of obesity and medical expenditures related to its treatment and the treatment of associated comorbid conditions. The health care costs associated with obesity are staggering with an estimated \$147 billion spent in the United States in 2008.¹ From 1987 to 2001, diseases associated with obesity accounted for 27% of the increases in U.S. medical costs.² Medical problems associated with obesity include coronary heart disease, hypertension, stroke, type 2 diabetes, certain types of cancer, and premature death.³ Interestingly, obesity alone has not been universally identified as an independent risk factor for perioperative complications in patients undergoing major surgery.⁴⁻⁷ Nonetheless, identification

and management of medical comorbidities in the surgical patient is important to limit morbidity associated with major surgery. Here we will review the preoperative preparation and management of key medical issues associated with the obese patient.

DEFINITION OF OBESITY

Obesity is defined based on body mass index (BMI), calculated as weight in kilograms divided by the square of height in meters. According to the World Health Organization classification, normal BMI ranges from 18.5 to 25 kg/m², overweight ranges from 25 to 30 kg/m², and obesity is classified as a BMI greater than 30 kg/m². Obesity classification is further subdivided into three

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classes, with class 1 defined as BMI 30 to 35 kg/m², class 2 as BMI 35–40 kg/m², and class 3 as BMI greater than 40 kg/m². Based on the Centers for Disease Control (CDC) National Health and Nutrition Examination Survey, approximately one third of Americans were classified as obese in the 2007–2008 sample.⁸

DIABETES

The incidence of diabetes has increased dramatically over the past few decades, almost completely attributable to a rise in type 2 diabetes mellitus. According to data from the National Health Interview Survey, there was an increase in the incidence of diabetes by 41% between 1997 and 2003.⁹ Further, the National Health and Nutrition Examination Survey (NHANES) identified that in 2005 to 2006, 12.9% of the United States ambulatory population over age 20 had diabetes, with approximately an additional 30% having a prediabetic condition including impaired fasting glucose, impaired glucose tolerance, or gestational diabetes mellitus.¹⁰ Although the reason for the increase in incidence is multifactorial, obesity and inactivity, as well as the aging of the population, appear to be the most significant contributing factors.

The impact of diabetes in the management of the surgical patient is significant. Diabetes has been identified as an independent risk factor for postoperative morbidity, and diabetic patients can spend up to 50% more time in the hospital postoperatively compared with nondiabetic patients.¹¹ Additionally, patients coming to surgery may be diagnosed with diabetes at the time of their preoperative evaluation and blood work. A study of 7,310 patients presenting for coronary artery bypass surgery found that patients with undiagnosed diabetes more frequently required resuscitation and reintubation

and had a higher perioperative mortality compared with nondiabetic patients and known diabetics.¹² These results underscore the importance of identifying and managing the diabetic patient preoperatively.

Guidelines for screening individuals for diabetes have been established by both the U.S. Preventive Services Task Force (USPSTF) as well as the American Diabetes Association (ADA). The guidelines for the USPSTF recommend screening only for asymptomatic individuals with elevated blood pressure (>135/80); they are an evidence-based practice guideline.¹³ The ADA guidelines rely on evidence as well as expert opinion in determining their screening guidelines (see Table 1).¹⁴ Although the ADA guidelines are somewhat less rigorous, they provide broader recommendations that are probably more appropriate to the preoperative patient. These recommendations include screening for any overweight patient with a BMI greater than 25 kg/m² with an additional risk factor, or for the severely obese patient.

The diagnostic criteria for diabetes can be determined based on the results of blood testing. Currently accepted criteria for the diagnosis of diabetes includes a fasting blood glucose >126 mg/dL, an hemoglobin A1c (HbA1c) value >6.5%, a 2-hour blood glucose >200 mg/dL during administration of an oral glucose tolerance test, or a random blood glucose >200 mg/dL in a patient with classic symptoms of hyperglycemia. For the preoperative patient, the HbA1c is likely a more useful test as it evaluates the degree of hyperglycemia that red blood cells have been exposed to over the 120-day life span of the cell. However, rapid glycemic correction does have risks of increasing progression of retinopathy and in the Action to Control Cardiovascular Risk in Diabetes Study Group (ACCORD) trial, there was increased mortality seen in the group that had rapid correction

Table 1 ADA Diabetes Screening Guidelines

1. Testing should be considered in all adults who are overweight (BMI $\geq$ 25 kg/m²*) and have additional risk factors:
 - Physical inactivity
 - First-degree relative with diabetes
 - High-risk race/ethnicity (e.g., African American, Latino, Native American, Asian American, Pacific Islander)
 - Women who delivered a baby weighing >9 lb or were diagnosed with GDM
 - Hypertension (140/90 mm Hg or on therapy for hypertension)
 - High-density lipoprotein (HDL) cholesterol level <35 mg/dL (0.90 mmol/L) and/or a triglyceride level >250 mg/dL (2.82 mmol/L)
 - Women with polycystic ovarian syndrome (PCOS)
 - HbA1C 5.7%, IGT, or IFG on previous testing
 - Other clinical conditions associated with insulin resistance (e.g., severe obesity, acanthosis nigricans)
 - History of cardiovascular disease
2. In the absence of the above criteria, testing for diabetes should begin at age 45 years.
3. If results are normal, testing should be repeated at least at 3-year intervals, with consideration of more frequent testing depending on initial results and risk status.

ADA, American Diabetes Association; BMI, body mass index; GDM, gestational diabetes mellitus; IGT, impaired glucose tolerance; IFG, impaired fasting glucose.

*At-risk BMI may be lower in some ethnic groups.

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of their HbA1c, calling into question the safety of rapid glucose normalization.¹⁵ Additionally, correction of persistent hyperglycemia may result in unacceptable delays to surgery.¹⁶ Therefore, rapid correction of elevated HbA1c is not advocated for the preoperative patient. In contrast, short-term glucose control may be of benefit, although there are no prospective trials evaluating the effects of glucose control in the immediate preoperative period.

For patients with an established diagnosis of diabetes, preoperative management depends both on the type of diabetes, the antecedent metabolic control, and the time of surgery. The goal of glycemic management in the perioperative period is to avoid clinically significant hyperglycemia and hypoglycemia and ketosis. Type 1 diabetics are typically more difficult to manage due to the lack of endogenous insulin. Type 2 diabetics are much less likely to develop ketosis because they generally have enough insulin available to prevent the liver from initiating gluconeogenesis and ketosis. The average, compliant type 2 diabetic can generally be managed by continuing their medications preoperatively, checking pre- and postoperative glucose and then starting insulin and their regular regimen postoperatively once they resume eating, if necessary. In contrast, type 1 diabetics may be much more complicated and should be managed with their endocrinologist in the perioperative period.

Diabetic patients should be operated on in the morning whenever possible. Because of catecholamine and other counterregulatory hormone release and increase in circulating cytokines, the stress of surgery is a set up for issues with glycemic control. All diabetic patients should have dextrose in their intraoperative fluid to provide energy that will preclude lipolysis leading to ketosis if insulin levels are inadequate in opposing the actions of catecholamines and cytokines. The use of basal insulin will prevent lipolysis and ketoacidosis. Because of the shifts in glycemic control due to surgery, all diabetic patients presenting for outpatient procedures should be reminded about signs and symptoms of hyperglycemia with recommendations for contacting their physician should they experience symptoms.¹⁷

Diet Controlled

For patients with diet-controlled diabetes, no specific interventions are required preoperatively. These patients should have fingerstick testing performed the morning of surgery to evaluate their baseline blood glucose. Intraoperative blood glucose monitoring may be used in more lengthy operations to assure glycemic control. These patients may require supplemental short-acting subcutaneous insulin immediately postoperatively for hyperglycemia.¹⁸

Oral Medication

Most oral medications can be taken up until the day before surgery and are held the day of surgery when patients are fasting. A special case is metformin, which has been associated with a potential to cause a lactic acidosis in patients who develop acute tubular necrosis as a result of surgery. However, a recent Cochrane review of 70,000 patient years found no cases of lactic acidosis in patients taking metformin.¹⁹ Metformin is contraindicated in patients with renal dysfunction, classified as a creatinine greater than 1.4 mg/dL in males and greater than 1.3 mg/dL in females. The package insert states that metformin should be suspended temporarily at the time of surgery and restarted only once creatinine has normalized.²⁰ Although there is no clear consensus on the exact timing, holding metformin for 24 hours before surgery and restarting it following surgery once a postoperative creatinine has been evaluated is likely safe for these patients. Those patients who are only having minor surgery can continue to take metformin up until the morning of surgery.

Patients taking any oral medication for diabetes should have their blood glucose monitored both immediately before and after their surgery. If patients develop hyperglycemia when off their oral agents, supplemental insulin should be used to correct the elevated blood glucose.^{18,21} Patients with poorly controlled diabetes on oral therapy will likely require intravenous (IV) insulin and dextrose with more aggressive monitoring.

Insulin-Dependent Diabetics

Patients presenting for minor surgery who are treated with long-acting insulin should be continued on their medications up to the evening before surgery. Most insulin-dependent diabetics rely on both a short-acting and long-acting insulin to control their blood glucose levels. Typically, the basal insulin is either insulin glargine or insulin detemir with insulin aspart or insulin lispro used for short-acting control. Insulin glargine acts for 18 to 24 hours and has the benefit of less hypoglycemia over the duration of action. Insulin glargine should be continued through the preoperative period with short-acting insulin held the night before and morning of the procedure when the patient is fasting. There is some controversy in the well-controlled diabetic over whether to continue with the full dose of insulin glargine the night before surgery or change to half dose. Each approach has advantages and is the preference of the treating physician. Sliding-scale insulin can be used as an adjunct to correct hyperglycemia.

Most patients can be monitored at the start and end of surgery by checking the blood glucose level and treating appropriately. For poorly controlled diabetics, or when surgery is expected to be particularly stressful, intraoperative monitoring can be considered. In these

instances, regular glucose monitoring every 2 hours is recommended to assess the need for intervention. Additionally, electrolytes, specifically potassium, should be monitored especially in patients who are hyperglycemic.

Some have recommended separate infusions of glucose and insulin with IV insulin administered either by bolus technique or infusion. The advantage of this technique is rapid adjustment to compensate for hypo- or hyperglycemia intraoperatively.^{18,21} Insulin infusion rates are generally started at 0.5 to 1 unit/h for type 1 diabetics and 1 to 2 unit/h in type 2 diabetics.²¹ Intravenous therapy should be continued until oral intake is resumed. This regimen can be very time consuming and work intense with the current technology of glucose measurement. Maintenance of normotension and normocardia are probably more important intraoperative parameters to address.

HYPERTENSION

From 2005 to 2008, 68 million, or nearly one-third of all adults in the United States had hypertension.²² The association between hypertension and obesity has been well established by several studies, perhaps the most notable of which is the Framingham Heart Study. The Framingham Heart Study involved over 5,000 middle-aged men and women who were prospectively followed for 44 years. It investigated the development of cardiovascular disease with repeat measurements of weight and risk factor status over the course of the study. The study demonstrated a higher prevalence of hypertension with greater degree of obesity.²³ Moreover, a recent review of the Framingham Heart Study data showed that the multivariable-adjusted risk for developing hypertension in overweight males was 1.48 (95% confidence interval (CI), 1.24–1.75) and obese males was 2.23 (95% CI, 1.75–2.84). Similarly, the relative risk for developing hypertension in overweight females was 1.70 (95% CI, 1.48–1.94), and obese females was 2.63 (95% CI, 2.20–3.15).²⁴ Another longitudinal study, the Nurses' Health Study, also found a monotonic rise in the risk for hypertension with increasing BMI, both at 18 years of age and mid-life.²⁵

In addition to an increased risk of hypertension, obese individuals appear to have a greater risk of resistant hypertension. Resistant hypertension is defined as blood pressure that remains above goal despite the simultaneous use of three or more antihypertensive agents of different classes at optimal doses, with one of the agents ideally being a diuretic.^{26,27} Recently, data from NHANES from 2003 to 2008 showed that nearly 9% of all nonpregnant adults with hypertension met the criteria for resistant hypertension. Of those individuals, the mean BMI was 32.²⁸ A cross-sectional study of primary care patients in Germany also found that obesity

was a risk factor for poorly controlled blood pressure and that obese patients were more likely to be on more than one antihypertensive drug.²⁹

Pathophysiology

The mechanisms of obesity-related hypertension are not completely understood, but likely involve activation of the sympathetic nervous system (SNS) and renin-angiotensin-aldosterone system leading to renal sodium retention and rise in plasma volume expansion.^{30–33} Possible causes of increased sympathetic activity have been attributed to hyperinsulinemia, hyperleptinemia, and obstructive sleep apnea.^{32,33} Leptin, an adipocyte-derived hormone, promotes anorexia, increases metabolism, and has also been found to activate the SNS.^{34,35} Obese individuals have elevated levels of leptin, suggesting that they may have selective leptin resistance to its effect on appetite and metabolism, while preserving its renal/cardiovascular SNS activation.³⁶ The association between hyperinsulinemia and obesity-related hypertension is less clear. Although some studies have shown hyperinsulinemia may play a role in SNS activation, other human and animal studies did not find a link between hyperinsulinemia and hypertension.^{30,32,33} Obese individuals also have elevated levels of plasma renin, angiotensin II, angiotensinogen, and aldosterone. In addition, animal models have shown high circulating levels of adipocyte-derived angiotensinogen.^{30,33}

Evaluation

The diagnosis of hypertension is predicated on the average of two or more blood pressure readings on successive office visits. The proper technique of measuring blood pressure involves the subject being seated quietly in a chair for at least 5 minutes, resting their feet on the floor, and arm supported at heart level.²⁷ Equally as important is using an appropriately sized cuff, especially in obese individuals.

Once the diagnosis of hypertension has been established, the preoperative evaluation of obese individuals with hypertension is similar to that of nonobese subjects. It should start with a comprehensive history and physical examination, paying particular attention to identifying target organ damage and causes of hypertension. Elements of the history should include a history of angina or prior myocardial infarction, symptoms of heart failure, stroke or transient ischemic attack, claudication or symptoms of peripheral arterial disease, and thyroid disease. The physical examination should concentrate on a careful evaluation of the heart and lungs; auscultation of bruits in the carotid, abdominal, and femoral areas; thyroid examination; abdominal masses and unusual aortic pulsations; peripheral pulses and edema; and a thorough neurologic examination.²⁷

Table 2 Common Causes of Secondary Hypertension

Cause	Signs and Symptoms	Diagnostic Testing
Renovascular hypertension	Severe HTN in age > 55 years, abdominal bruit, history of diffuse atherosclerosis, acute rise in serum creatinine after starting ACEI/ARB, recurrent flash pulmonary edema	Renal artery duplex/Doppler, MR angiography, CT angiography
Chronic kidney disease	History of long-standing, uncontrolled HTN	Elevated serum creatinine, abnormal urinalysis, renal ultrasound
Pheochromocytoma	Paroxysmal elevations in BP, headache, palpitations, sweating, tachycardia, pallor	Plasma metanephrines, 24-hour urine catecholamines and metanephrines, CT or MRI abdomen and pelvic
Primary aldosteronism	Unexplained hypokalemia (including those on low-dose thiazides), metabolic alkalosis	Morning ambulatory plasma aldosterone/plasma renin ratio; oral sodium loading and 24-hour urine aldosterone; CT Adrenals
Coarctation of the aorta	Difference in systolic BP between upper and lower extremities, weak or absent femoral pulses	Echocardiography, CT or MR angiography of the thoracic and intracranial vessels
Cushing syndrome	History of corticosteroid use, "Moon" facies, central obesity, abdominal striae, proximal muscle weakness, hirsutism, ecchymoses, glucose intolerance	24-hour urinary cortisol excretion, dexamethasone suppression test
Obstructive sleep apnea	Snoring, witnessed apneic episodes, daytime somnolence, morning headache, difficulty concentrating, large neck circumference (> 17 inches in men and > 16 inches in women)	Polysomnography (sleep study)
Hypothyroidism/hyperparathyroidism	Enlarged thyroid, fatigue, cold intolerance, constipation, hypercalcemia	Serum thyroid-stimulating hormone, serum parathyroid hormone

HTN, hypertension; ACEI, angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor blocker; MR, magnetic resonance; MRI, magnetic resonance imaging; CT, computed tomography; BP, blood pressure.

Laboratory and other diagnostic testing in the preoperative testing also focuses on target organ damage and ascertaining other cardiovascular risk factors and comorbid diseases, such as diabetes mellitus, hyperlipidemia, and renal and hepatic insufficiency. Initial diagnostic testing should include an electrocardiogram (ECG). The presence of Q waves could indicate a prior myocardial event, and voltage criteria for left ventricular hypertrophy on the ECG have been associated with postoperative myocardial infarction or cardiac death.^{37,38} Occasionally, echocardiography may be needed if there are symptoms of heart failure or signs of cardiac valvular abnormalities. Laboratory testing includes a complete blood count, fasting blood glucose, serum electrolytes, and measurements of renal and hepatic function.³⁹ In cases of resistant hypertension or severely elevated blood pressure (> 180/120 mm Hg), with or without target organ damage, further diagnostic testing may be needed to exclude causes of secondary hypertension. Such causes of secondary hypertension include renovascular disease, primary aldosteronism, pheochromocytoma, Cushing syndrome, thyroid or parathyroid disease, coarctation of the aorta, and obstructive sleep apnea (see Table 2).^{27,40}

Treatment

The goal for treatment of hypertension in obese patients is the same as nonobese patients—to reduce cardiovascular disease complications. The target blood pressure is

< 140/90 mm Hg, except in patients with concurrent diabetes and renal disease, where the goal blood pressure is < 130/80 mm Hg.²⁷ Preoperative goals of blood pressure control must be dictated on a case-by-case basis. Previously, it had been recommended to delay surgery for blood pressure $\geq$ 180/110 mm Hg.⁴¹ A more recent study, however, found that there was no benefit to delaying surgery in patients with known hypertension with presenting diastolic blood pressures between 110 to 130 mm Hg and who had no prior myocardial infarction, unstable angina, renal failure, left ventricular hypertrophy, aortic stenosis, arrhythmias, stroke, conduction abnormalities, prior coronary revascularizations, or pregnancy-induced hypertension.⁴² Therefore, the latest guidelines state in cases of blood pressure > 180/110 mm Hg, "the potential benefits of delaying surgery to optimize the effects of antihypertensive medications should be weighed against the risk of delaying the surgical procedure."⁴³

Nonpharmacologic Treatment

If there is sufficient time in the preoperative setting, lifestyle modifications are the cornerstone for treatment of hypertension in the obese patient. Indeed, the Seventh Report of the Joint National Committee on the Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC-VII) focuses on emphasizing healthy behaviors in obese patients with hypertension.²⁷

Weight loss, although difficult to maintain, is the most effective treatment for lowering blood pressure in the obese patient, as much as 5 to 10 mm Hg.^{27,44} Other adjunctive measures include adoption of the DASH (Dietary Approaches to Stop Hypertension) diet, reduced sodium intake, and increasing physical activity.^{27,39,45,46} In addition to the above, tobacco cessation is paramount for the obese, hypertensive patient. Tobacco can raise blood pressure by as much as 10 mm Hg for 30 to 60 minutes.^{39,47} Even if adequate time does not exist to implement these measures prior to the planned surgery, reinforcing behavioral and lifestyle changes will help patients achieve long-term control of their disease process.

Pharmacologic Treatment

Despite the clear relationship between obesity and hypertension, there are few specific recommendations for the pharmacologic treatment of obesity-related hypertension. This is in large part due to the lack of prospective, randomized trials in this subset of patients. In fact, obese individuals are often excluded from major trials, either due to their weight or the presence of other comorbid diseases.⁴⁸ In view of this, the general guidelines for treatment of hypertension laid forth by the JNC-VII should be implemented for obese patients. Unless there is a compelling reason (such as heart failure or diabetes) for using a specific class of antihypertensive agents, these guidelines advocate the use of thiazide diuretics as initial therapy. In cases where the blood pressure is > 160/100 mm Hg, or is > 20 mm Hg above target blood pressure, then a two-drug combination, one being a thiazide diuretic, is recommended for initial therapy.²⁷ We will now review the major classes of antihypertensive agents and their potential implication on obese patients and the perioperative setting.

As mentioned previously, diuretics, especially thiazide diuretics, are the initial therapy of choice for most patients with hypertension. In addition they are particularly useful in patients with concurrent heart failure. Thiazide diuretics, however, have been implicated to increase insulin resistance and dyslipidemia.^{45,46,48,49} In obese patients, a randomized trial compared lisinopril with hydrochlorothiazide (HCTZ). This study found that both agents were equally as effective in lowering blood pressure, but lisinopril was more effective in younger white patients, whereas HCTZ was more effective in black patients. It also showed those taking HCTZ had increased plasma glucose, but insulin levels and lipid profiles did not differ between the two groups.⁵⁰ Other studies, though, have not linked thiazide diuretics with development of diabetes, especially in low doses.^{45,46,48,51,52} In those with heart failure or chronic kidney disease, loop diuretics may be needed instead of thiazide diuretics.²⁷

Beta-adrenergic receptor blockers (β -blockers) are also commonly used antihypertensive agents and have been shown to reduce cardiovascular morbidity and mortality. Beta-blockers are, therefore, indicated in patients with heart failure, certain tachyarrhythmias, postmyocardial infarction, and those who are at high risk for coronary artery disease.²⁷ With respect to obese individuals, β -blockers have also been shown to have some undesirable effects: They may cause weight gain or make weight loss more difficult as evident in several trials.^{53–55} The United Kingdom Prospective Diabetes Study showed that when compared with captopril, atenolol caused more weight gain and slightly increased HbA1c, but did not differ with respect to clinical endpoints.⁵⁴ Another study found that those taking β -blockers were 28% more likely to develop diabetes than those taking no medications.⁵¹ Beta-blockers may also cause alterations in lipid metabolism, leading to an increase in high-density lipoprotein cholesterol.⁵⁶ Given these findings, some authors suggest that β -blockers should not be used as first-line agents in obesity-related hypertension, unless other compelling indications exist.^{46,48}

Angiotensin-converting enzyme inhibitors (ACEI) and angiotensin receptor blockers (ARB) are indicated in patients with underlying heart failure, postmyocardial infarction, diabetes, and chronic kidney disease.²⁷ Some authors support ACEI and ARB as the ideal agents for obesity-related hypertension.^{45,46,48} ACEI are not associated with weight gain and have not been shown to have unfavorable effects on lipid metabolism.^{49–52} Several large, randomized trials actually demonstrated that ACEI and ARB confer a reduced risk of developing diabetes.^{57–60} There is some controversy regarding ACEI in the perioperative setting. Several small randomized and other observational studies have shown an increase in hypotension after induction of anesthesia when ACEI/ARB are administered on the day of noncardiac surgery.^{61,62} As a result, some authors recommend holding ACEI/ARB therapy on the day of surgery, except in the case of systolic dysfunction or uncontrolled hypertension where these agents may be carefully considered.^{38,63}

Calcium channel blockers (CCB) may be useful in certain patients with diabetes and coronary disease.²⁷ With respect to obese patients, CCB are not known to affect insulin sensitivity, glucose, or lipid metabolism.⁶⁴ In addition, they are not associated with an increased risk of developing diabetes.⁵¹ Therefore, CCB are potentially effective medications for the treatment of hypertension in obese individuals.^{45,46,48}

CARDIOVASCULAR DISEASE

The Framingham Heart Study found obesity to be an independent risk factor for cardiovascular disease, spe-

cifically, coronary disease, congestive heart failure, and sudden cardiac death.⁶⁵ Central obesity appears to be associated with highest risk in the obese population compared with BMI stratification.^{66,67} Additionally, cardiac arrhythmias, likely due to structural changes from increased work load result are more common in the obese patient. Specifically, atrial fibrillation has been found to be more prevalent in the obese population with obese patients having a nearly 50% increased risk of developing AF that increased with increasing BMI.⁶⁸

Preoperative evaluation of cardiac risk in the obese patient is difficult for several reasons. Although evaluation should begin with a thorough history and physical exam, deconditioning and symptoms that present in the obese population may be independent of cardiac disease. Due to body habitus, signs of cardiac disease may be overlooked because of distant heart sounds and the difficulty evaluating for signs, such as jugular venous distention. Electrocardiography can be an important preoperative test in the obese patient, however; some ECG changes are a result of obesity including displacement of the heart secondary to an elevated diaphragm in patients with large abdominal adiposity, increased cardiac workload, and increased distance of the electrodes to the heart because of subcutaneous and epicardial fat. These changes are represented on ECG as low QRS voltage, nonspecific flattening of the T waves, and evidence for left atrial abnormalities.^{69,70}

Due to a lack of literature related to the preoperative cardiovascular risk assessment of the obese patient, the 2009 American College of Cardiology/American Heart Association guidelines on perioperative cardiovascular evaluation should be utilized when preparing obese patients for colorectal surgery.⁴³ The updated guidelines suggest a stepwise approach to cardiac evaluation prior to noncardiac surgery. These steps are summarized below.

The first step is to determine the urgency of the surgery. Those requiring emergent surgery should proceed with the surgery. In these cases the patient should be monitored closely in the perioperative setting, and cardiac risk stratification and risk factor management would occur postoperatively.

The second step is to look for the presence of active cardiac conditions, or those entities that pose high surgical risk. These conditions include unstable coronary syndromes (unstable or severe, stable angina, and recent myocardial infarction), decompensated heart failure, significant arrhythmias (high-grade atrioventricular block; symptomatic ventricular arrhythmias; supraventricular arrhythmias, such as atrial fibrillation, symptomatic bradycardia; and newly diagnosed ventricular tachycardia), and severe valvular disease (aortic and mitral valve stenosis). The presence of any of these conditions should prompt further workup and treatment prior to undergoing surgery. Elective surgery may need to be delayed until these illnesses are fully evaluated and stabilized. Additional

measures range from maximizing medical therapy to procedural interventions, such as coronary angiography.

The next two steps involve determining the inherent risk of the planned surgery and the functional capacity of the patient. The guideline classifies surgical procedures with cardiac risk < 1% as low-risk (endoscopic, superficial, and ophthalmologic surgeries), 1 to 5% as intermediate-risk (intraperitoneal, intrathoracic, and orthopedic surgeries), and > 5% as high-risk (major vascular surgery). Most patients undergoing a low-risk surgical procedure may proceed without further diagnostic testing, even in those patients with known cardiac disease or clinical risk factors. Patients having intermediate or high-risk surgery should have their functional capacity established. Functional capacity can be expressed as metabolic equivalents (METs). Studies have shown that patients with poor functional capacity, < 4 METs, are at increased risk for perioperative cardiac events. METs may be determined by formal treadmill exercise testing, or by simply asking if patients are able to ambulate more than four blocks or two flights of stairs without symptoms.⁷¹ Asymptomatic patients with adequate functional capacity, or > 4 METs, may proceed with the intended surgery because additional cardiovascular testing will likely not change management.

In patients with poor or unknown functional capacity, the next step is to determine the presence of certain clinical risk factors for perioperative cardiac complications, based on the Revised Cardiac Risk Index.⁷² The clinical risk factors are a history of ischemic heart disease, a history of compensated or prior heart failure, a history of cerebrovascular disease, diabetes mellitus (especially insulin-requiring), and renal insufficiency (especially serum creatinine > 2 mg/dL). Those with no clinical risk factors are considered to be at low-risk, and therefore may proceed with the surgery. According to the guidelines, patients at intermediate-risk, or those with one to two clinical risk factors, may proceed with surgery with heart-rate control with β -blockers or "consider noninvasive testing if it will change management." Similarly, the guidelines also suggest to consider noninvasive testing, if it will change management, for high-risk patients (three or more clinical risk factors) undergoing high-risk vascular surgery. Recent randomized trials have elucidated important considerations regarding the use of perioperative β -blockade and coronary revascularization prior to surgery.

The emergence of new data highlights the controversy surrounding the use of β -blockers in the perioperative setting. Previous guidelines, based on the limited availability of randomized trials, had advocated the use of perioperative β -blockers in noncardiac surgery, especially for high-risk patients or those undergoing high-risk surgery (such as vascular surgery).⁴³ However, recent evidence has questioned those recommendations. The POISE trial is the largest randomized

trial to date that has evaluated the use of perioperative β -blockers. This trial evaluated more than 8,000 patients undergoing noncardiac surgery with known atherosclerotic disease or at risk for it, and randomized them to initiate therapy with a fixed-dose regimen of metoprolol succinate or placebo. The results demonstrated that metoprolol reduced the rate of myocardial infarctions, but it significantly increased total mortality and stroke.⁷³ These results and that of a subsequent meta-analysis suggest that the cardiovascular benefits of initiating prophylactic β -blockers in most patients undergoing noncardiac surgery may be outweighed by the increase in total mortality and strokes.^{73,74}

Some, however, have questioned the dose and timing of the β -blockers in the POISE trial, noting that the β -blockers were initiated on the day of surgery at high doses, resulting in increased episodes of hypotension and bradycardia.⁴³ A subsequent randomized study, the DECREASE-IV trial, evaluated the use of bisoprolol in more than a 1,000 intermediate-risk patients undergoing noncardiac surgery. Unlike the POISE trial, in this study β -blockers were initiated at a median of 34 days prior to surgery at a low dose and slowly titrated to achieve heart-rate control over 30 days. There was a significant decrease in the occurrence of cardiovascular death and nonfatal myocardial infarction in those patients receiving β -blockers. There was no difference in perioperative mortality or stroke, although the study was not adequately powered to detect these particular endpoints. This study suggests that β -blockers may have a cardioprotective effect for intermediate-risk patients when initiated well prior to the surgery and carefully titrated for heart-rate control.⁷⁵

Recent data has also provided new information regarding the utility of preoperative coronary revascularization. One of the first randomized trials to address this question was the Coronary Artery Revascularization Prophylaxis (CARP) Trial. Over 500 patients with stable coronary disease identified by coronary angiography undergoing elective vascular surgery were randomized to either coronary revascularization (coronary artery bypass grafting or percutaneous coronary intervention) or no revascularization. Within 30 days of the surgery, there was no difference in the incidence of myocardial infarction between the two groups. At a median of 2.7 years after randomization, there was no difference in mortality between the two groups.⁷⁶ The results of this trial and others suggest that coronary revascularization in patients with stable coronary artery disease prior to noncardiac surgery may not prevent perioperative cardiac events.⁴³

DEEP VENOUS THROMBOSIS/ PULMONARY EMBOLISM

Abdominal surgery and obesity are known risk factors for developing a deep venous thrombosis (DVT) or

venous thromboembolism (VTE). Postoperative pulmonary embolism is one the most common complications in patients undergoing gastric bypass surgery for morbid obesity.⁷⁷ There is no consensus for the best method of prophylaxis in the obese patient with variable regimens for DVT prophylaxis put forth by different authors.^{78–81} A Cochrane review of DVT prophylaxis in colorectal patients did find that treatment with heparin resulted in fewer DVT than in those untreated, and that compression stockings with heparin were also important in reducing risk. The same review found no difference in efficacy between low-molecular-weight heparin and unfractionated heparin.⁸² Obese patients planned for colorectal surgery should have preoperative DVT prophylaxis with either unfractionated heparin or low-molecular-weight heparin and compression stockings.

A second issue regarding DVT prophylaxis is the length of treatment postoperatively. Most protocols and studies refer to a treatment course within the inpatient setting. A recent large study of colorectal surgery patients using the National Surgery Quality Improvement Program (NSQIP) database assessed 52,555 patients for 30-day postoperative incidence of symptomatic thrombotic events. The incidence of DVT and PE in the postdischarge setting was found to be 0.67%, with obesity as an independent risk factor for development of an early postdischarge venous thrombotic event.⁸³ Further, another Cochrane review based on four studies found that prolonged treatment for DVT prophylaxis of one month in patients undergoing major abdominal or pelvic surgery significantly decreased the incidence of DVT from 14.3% in the in-hospital treatment group to 6.1%. Perhaps even more importantly, there was also a significant decrease in clinically significant DVT from 1.7% to 0.2% in the month-long treatment group.⁸⁴ Given the multiple risk factors for DVT in the obese patient presenting for colorectal surgery, strong consideration should be given to prolonged therapy with heparin.

Finally, there may be a role for placement of a retrievable inferior vena cava filter in select high-risk patients. In a small but suggestive study, Schuster found that some high risk patients including those with history of DVT/VTE, severe venous stasis disease, sleep apnea, and weight greater than 400 pounds may benefit from preoperative placement of a retrievable filter.⁸⁵

In conclusion, the colorectal surgery patient who is obese needs special consideration in the perioperative period. Most importantly, known comorbidities of obesity should be searched for and treated to prevent complicated operative and postoperative courses.

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