PERIOPERATIVE RISK ASSESSMENT AMONG PATIENTS WITH CONGESTIVE HEART FAILURE: A CALL FOR GUIDELINES

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Overview

Each year, more than 10 million major noncardiac surgical procedures are performed in the United States. Current perioperative risk assessment focusing on ischemic heart disease and adherence to practice guidelines reduces morbidity and mortality. An estimated 10 million people in the United States suffer from ventricular dysfunction (class B), and half are symptomatic (class C), despite medical therapy. Individuals with heart failure who undergo surgical procedures are at higher risk for perioperative complications than those with ischemic heart disease. Currently, there are no consensus statements on the best approaches to risk-stratify individuals with heart failure who undergo surgical procedures.

This manuscript reviews the current literature regarding risk assessment and perioperative management of patients with heart failure undergoing noncardiac surgical procedures. The authors will support the widespread use of two-dimensional echocardiogram with Doppler along with clinical criteria as the foundation of risk assessment. A simple algorithm will be discussed to help unify concepts and set the foundations for further research.

Introduction

Heart failure afflicts nearly five million Americans; and, with 550,000 new cases diagnosed annually, experts believe these number will continue to rise and afflict a disproportionate number of individuals over the age of 65 (1/1000).[1] Despite significant strides in the treatment strategies for chronic heart failure, hospitalizations have topped one million, attributable deaths approach 265,000, and in 2007 direct cost estimates were $34 billion.[2] Heart failure is common, particularly in the elderly, and predominantly treated by general internal medicine or family practice physicians. Unfortunately, unless specific hospital or practice-based interventions are established to optimize treatment, compliance with basic medical therapies documented to reduce morbidity and mortality are generally no higher than 30%.[3,4]

The epidemiology of noncardiac surgical procedures has changed over the last 15 years.[5-7] In 2000, there were 40 million procedures performed in the United States, of which 10 million were major noncardiac surgical procedures. Individuals over age 65 account for four million major noncardiac surgical procedures every year.[7,8] Undoubtedly, a significant number of individuals undergoing major surgical procedures have occult or established left-ventricular (LV) dysfunction.

Published data among patients with heart failure who undergo major noncardiac surgery have reported a wide range of morbidity and mortality.[8,9] Most recently, Hernandez and colleagues determined that individuals with an antecedent diagnosis of heart failure who underwent major surgery have a 30-day readmission and mortality rate of 20% and 11.7% respectively (Figure 1). These rates are significantly worse than individuals diagnosed with either ischemic heart disease (14.2% and 6.6%) or age-matched controls (11% and 6.2%).[10]

Generally speaking, perioperative risk is based on four categories: urgency of surgery, complexity of procedures involved, extent of medical comorbidities, and severity of underlying heart disease. Each factor carries important independent prognostic information and therefore assigning cardiovascular risk requires investigation of each of these parameters. In 2002, the American College of Cardiology, the American Heart Association, and the American College of Physicians put forth guidelines for managing cardiac patients undergoing noncardiac surgery. The identification, risk assessment, and treatment strategies for ischemic heart disease are emphasized within these guidelines while the section on heart failure is minimal and does not

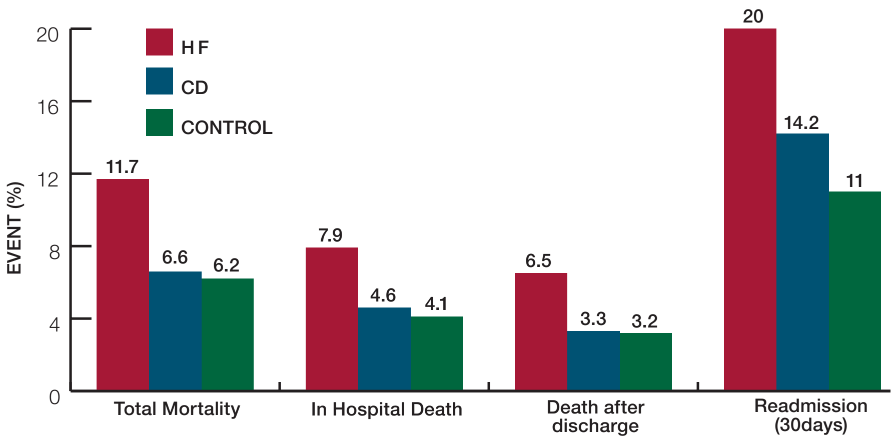

Figure 1. Risk-adjusted event rates among patients undergoing noncardiac surgery. Statistically significant higher rates were observed among patients with a diagnosis of heart failure (HF) compared with either coronary artery disease (CAD) or control.[10]

include specific treatment protocols; in fact, the guidelines dedicate a total of two paragraphs to heart failure.[11] Specifically, the authors appropriately point out that "little information is available" and state that every effort must be made to "detect unsuspected heart failure," recognizing its important prognostic implications. However, no specific risk assessment paradigm or management strategy is presented.

Present Models of Operative Risk and Limitations

All current models of preoperative risk assessment include a cardiovascular-directed history and physical examination. Various permutations of the original concepts of Goldman[12] and later Detsky[13] have been modified by Lee and colleagues and are known as the revised cardiac risk index (RCRI).[14] The use of the RCRI (Table 1) has been validated prospectively, utilized at a number of large clinical centers, and recently implemented in the design of major clinical investigations.[15,16] The intended focus of the RCRI is to stratify cardiovascular risk, and it relies on two major cardiovascular disease entities: ischemic cardiovascular disease and congestive heart failure. Among the specific clinical factors that carried the highest risk for perioperative cardiovascular events are signs, symptoms, or a history of heart failure. In fact, the physical findings of a cardiac S3 or jugular venous distension were the most significant predictors of perioperative events in the original Goldman risk index.[12] Furthermore, the RCRI found that chest radiographic findings of pulmonary edema carried a 4.3-fold increase in major perioperative cardiovascular complications.[13]

The challenge associated with the diagnosis of heart failure is apparent on review of available literature. Earlier single-center risk assessments such as the Goldman criteria relied on physical examination and interpretation of radiographic studies by a limited group of physicians, thereby minimizing intraobserver variability while limiting multicenter reproducibility. In contrast, later efforts simply documented a "history of heart failure" as a significant risk factor, thereby achieving greater reproducibility. While either definition carries sufficient power to assign risk, applying the later

Table 1. Revised cardiac risk index (RCRI).

RISK FACTOR	DEFINITION	POINTS
Ischemic heart disease	Any of History of MI History of positive exercise test result Current chest pain Nitrate use ECG with Q wave	1
Congestve heart failure	Any of History of HF Pulmonary edema PND Bilateral rales S3 gallop CXR with pulmonary vascular redistribution	1
Type of surgery	High risk (intraperitoneal, intrathoracic, or suprainguinal vascular)	1
Cerebrovascular disease	TIA or stroke	1
Diabetes mellitus	Preoperative treaatment with insulin	1
Renal function	Creatinine level >2.0 mg/dL (>177 µmol/L)	1

criteria identifies a nonmodifiable risk factor while the former criteria lends itself to understanding the pathophysiological state of a patient with heart failure and thereby allows for potential treatment paradigms.

While current ACC/AHA standards[5] defining congestive heart failure include a combination of signs and symptoms as well as response to established therapy (i.e., diuretics, vasodilators, etc.), no published risk indices include the complete definition of CHF. Furthermore, heart failure can be segregated by cardiac function and assigned broadly to two groups: systolic heart failure (impaired systolic function) and diastolic heart failure (preserved systolic function), each with variable intrinsic risk. Although the phenotypes of these two categories are very disparate, they share a common underlying pathophysiology. The congestive, or symptomatic, aspect of heart failure irrespective of systolic function implies that the heart is unable to adequately maintain the metabolic demands of the organism during either rest or exercise in association with a significant rise in ventricular diastolic pressure. Therefore, congestive heart failure mandates a rise in diastolic pressure that may manifest as classic signs (S3, rales, peripheral edema, etc.) and symptoms (orthopnea, dyspnea, etc.) and furthermore would be expected to respond to established therapies (diuretics, vasodilators, etc.). Signs and symptoms of heart failure can be elicited by a carefully targeted history and physical examination; however, they are late manifestations of elevated ventricular diastolic pressures and carry high intraobserver variability and low reproducibility. Symptoms of heart failure carry particular prognostic information and are used to risk stratify patients with chronic heart failure.[3] History of heart failure is graded by NYHA classification into four classes of severity: from class I to class IV.[5] A higher class of heart failure corresponds to more restricted physical activity and higher surgical risk. Heart failure of NYHA grade IV is an independent factor to signal caution for surgery irrespective of the type of surgery.[7] In fact, the presence of pulmonary edema by radiography or physical examination within one week of anticipated surgery carried the highest odds/risk ratio for major cardiac complications.[14-16] If the clinical manifestations of elevated ventricular filling pressure are symptoms, and symptoms are important to stratify risk among patients with heart failure, then an objective measure of ventricular diastole (more importantly left ventricular filling pressure) would be advantageous.

Potential Role of Doppler Echocardiography for Risk Stratification

The gold standard for the assessment of cardiac structure and function is echocardiography. The last 20 years of Doppler cardiac ultrasound has revolutionized our understanding of both ventricular systole and diastole. Advancements have allowed for the accurate quantification of ventricular filling irrespective of systolic function. Investigators have been able to segregate the impact of diastolic abnormalities with regards to clinical outcome. Furthermore, Nagueh and colleagues have developed regression equations utilizing specific Doppler indices to estimate diastolic filling pressures.[17] Validations of these estimates have been performed across multiple centers and have now been incorporated into the design of clinical investigations specifically intended to alter diastolic properties and filling pressure *(personal communi-*

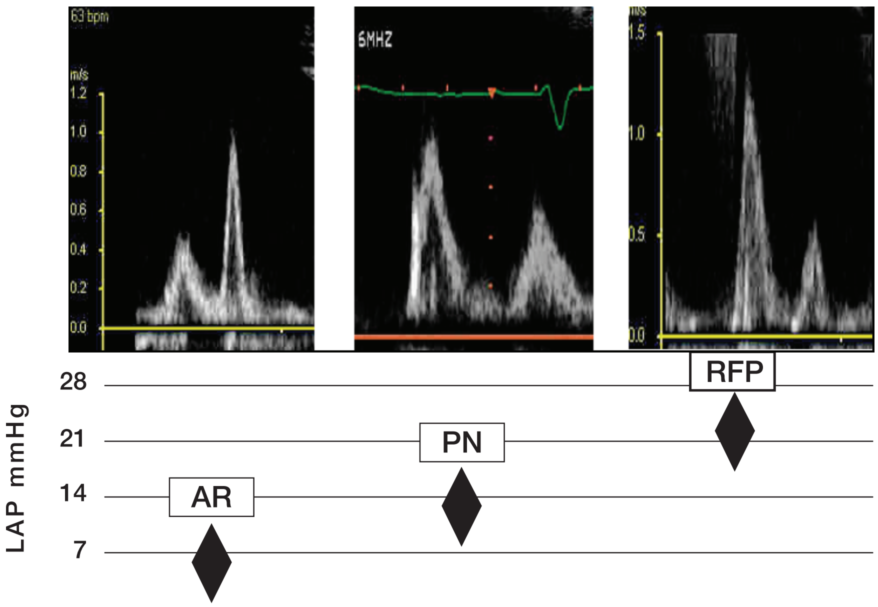

Figure 2. Doppler mitral inflow pattern in patients with systolic dysfunction (LVEF < 35%) and its relation to left atrial pressure. AR: abnormal relaxation, PN: pseudo-normal, RFP: restrictive filling pattern.

cation with Alteon Inc. and Encysive Pharmaceuticals Inc.).

It is beyond the scope of this text to provide a comprehensive technical and interpretive understanding of the Doppler characterization of ventricular diastole (see Naqvi[18]). However, a few general observations are pertinent for our discussion.

1) Hearts of patients with systolic dysfunction have prolonged myocardial relaxation and decreased compliance and therefore uniformly have diastolic dysfunction *(substrate)*.
2) The specific Doppler pattern of mitral inflow observed in patients with systolic dysfunction is influenced by a number of factors, among the more critical being left atrial pressure and the crossover pressure between the LA and LV at the onset of mitral valve opening *(stimulus)*.
3) Correlating symptoms *(reaction)* to isolated and serial transmitral Doppler assessments of patients with systolic dysfunction has helped define our understanding of the interaction between *substrate* and *stimulus.*

In general, three patterns of mitral inflow have been observed (Figure 2), and each correlate with the clinical spectrum of systolic heart failure.[19] Relevant investigations have assigned risk by segregating patients into groups with either the presence or absence of the restrictive filling pattern (RFP) or the ability to reverse the RFP. While the definition of RFP varies, in general it is accepted that the ratio of early (E) and the atrial (A) wave be greater than 2.0 and the deceleration time (DT) of the mitral E wave be less than 140 ms.

Static measurement of mitral inflow among patients with systolic dysfunction have demonstrated that the presence of an RFP predicts worse NYHA functional class[18] and exercise capacity[20] despite similar demographics, LV diastolic dimension, fractional shortening, and right heart catheterization data. Xie et al. extended these observations and found that the presence of RFP among ambulatory patients with LVEF < 40% was the single best discriminator of mortality, conferring event rates of 5% versus 19% ($p<0.05$) at one year and 5% versus 51% ($p<0.01$) at two years (RFP versus non RFP, respectively).[21] Further discriminatory power of the transmitral inflow pattern was documented among 311 patients being evaluated for heart transplantation and MVO_2 values less than 14 mL/min/kg. The presence of an RFP added important prognostic information and was associated with a significantly higher mortality compared to patients with non RFP (48% versus 20%). Not surprisingly, those subjects with MVO_2 values greater than 14 mL/min/kg had a significantly better survival; however, the detection of an RFP among patients in this group was associated with three times the mortality as compared to those without an RFP (20% versus 6%).[22]

As alluded to earlier, the Doppler mitral inflow pattern is strongly influenced by alterations in preload. As such, therapies that reverse the RFP improve prognosis among patients with systolic heart failure. Traversi et al. optimized medical treatment over six months for 98 patients with an initially restrictive filling pattern (E/A > 1 and DT < 130 ms) and performed serial studies with echo-Doppler, cardiopulmonary testing, and hemodynamic at six months. Among the 19 patients with an initial RFP who reverted to non RFP, a highly significant reduction in pulmonary wedge pressure (from 25 +/- 7 mm Hg to 11 +/- 3 mm Hg) and an increase in exercise capacity was observed, while those six patients who reverted to an RFP had marked deterioration of these parameters. More importantly, those patients with persistent RFP after six months of medical therapy had a 35% event rate (mortality or transplantation) over the following year as opposed to those who either reverted or remained in a non RFP (event rate 5% and 4% respectively).[23,24]

Concordant data published by Pinamonti et al. report that a persistent RFP after three months of optimized medical therapy was associated with a 35% one-year mortality, while reversion of the initial RFP was associated with a 0% event rate.[25] In fact, simply evaluating mitral filling patterns prior to discharge among patients admitted for decompensated heart failure (n=115) reveals that the presence of an RFP (n=27) is associated with a 38% all-cause mortality and 41% CHF rehospitalization rate at one year, while those patients with a non RFP have much lower event rates (17.4% mortality and 15.4% CHF rehospitalization).[26]

We have used the mitral filling pattern as one measure for optimizing patients with advanced heart failure. Patients who either develop or persist in having an RFP even with an apparent compensated clinical state should undergo further pharmacologic optimization. In particular, carvedilol therapy optimized among a subset of heart failure subjects with an RFP was demonstrated to successfully reverse this pattern in 72% of those treated.[27] The clinical implications of diastolic filling among patients with systolic heart failure are established.[19] To date there are no clinical investigations establishing the role that diastolic filling may play in evaluating perioperative risk among patients with systolic heart failure undergoing noncardiac surgery. The absence of data is fertile ground for speculation from clinical observation, hypothesis generation, and subsequent testing.

If diastolic filling among patients with chronic systolic heart failure has significant clinical implications with regard to symptoms and objective measures of functional capacity and can be correlated with central hemodynamics, then evaluation with preoperative 2D echocardiogram and Doppler may allow further stratification of risk among patients with known systolic heart failure. Currently, a retrospective chart review is underway at Wake Forest Baptist Hospital evaluating patients who underwent nonemergent, nonthoracic vascular surgery with a diagnosis of heart failure. Information will be used to estimate risk and subsequent sample size calculations with the hope of conducting a larger prospective clinical investigation. The algorithm provided (Figure 3) serves as the basis of an ongoing clinical investigation but may help to manage individuals with established systolic heart failure. We have employed a protocol incorporating echocardiographic measures of hemodynamics in order to optimize cardiac risk. Among patients with systolic heart failure who undergo evaluation for major noncardiac surgery, a detailed history identifies the current state of symptoms. A follow-up echocardiogram with Doppler is used to estimate central hemodynamics, emphasizing left ventricular filling pressure. If the symptoms state is greater than moderate with concomitant elevated filling pressures, then elective surgery is delayed and medical therapy is initiated with an emphasis on reversing the restrictive filling pattern. Again, validation of this paradigm prospectively has not been compared with the standard of care; however, we believe that overwhelming data from patients with chronic heart failure provides adequate impetus to test this concept. If noncardiac major surgical intervention is deemed urgent and cannot be delayed, then we advocate placing a preoperative Swan-Ganz catheter and using appropriate medical (vasodilators, beta-blockers, diuretics, etc.) or mechanical therapy (intra-aortic balloon counterpulsation or percutaneous ventricular device implantation) in an effort to optimize central hemodynamics (i.e., normalize pulmonary wedge pressure).

Conclusion

Established paradigms for identifying and managing patients with systolic heart failure undergoing major noncardiac surgery are lacking. Information available from retrospective data indicates high cardiac complication rates (i.e., a two-fold increase) among individuals with an antecedent diagnosis of congestive heart failure. Signs and symptoms are late manifestations of heart failure, carry significant intraobserver variability, and have low reproducibility.

Objective measure of cardiac function correlating with symptoms, central hemodynamics, and prognosis may be ideal for estimating cardiac risk; in this regard, simple Doppler echocardiography can be incorporated into a clinical risk assessment model in order to define risk and manage patients with heart failure. Future investigations utilizing focused clinical evaluation along with cardiac imaging and relevant biomarkers are needed to prospectively evaluate cardiac risk among patients with heart failure. Consensus statements and guidelines rely on a clinical

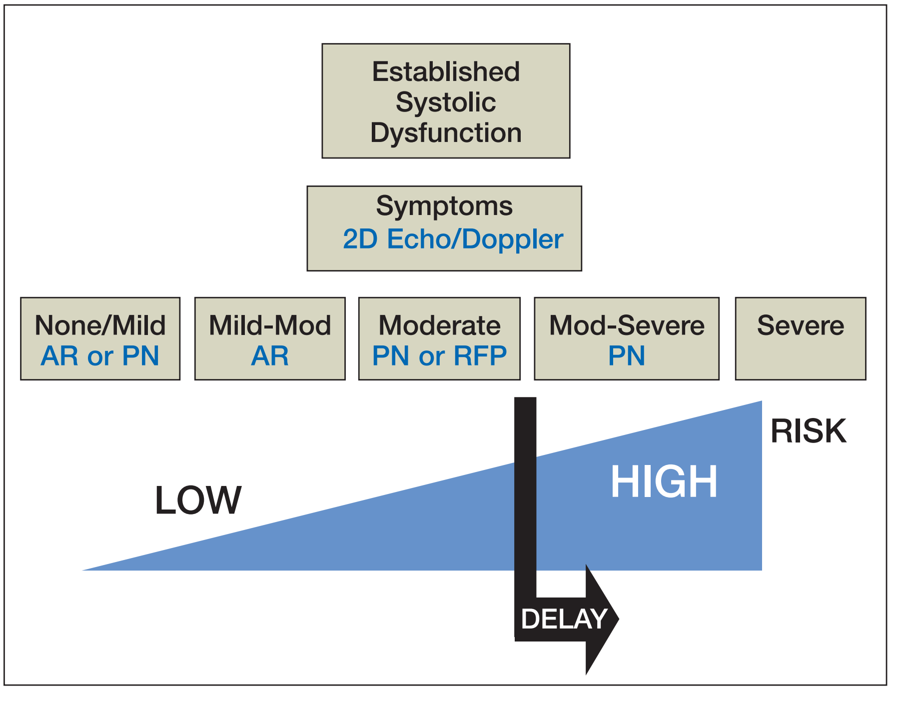

Figure 3. Algorithm incorporating Doppler indices to assign perioperative risk for cardiac events. Anticipated surgery is elective and noncardiac. This model does not account for other established risk factors for perioperative outcome. AR: abnormal relaxation, PN: pseudonormal, RFP: restrictive filling pattern.

compendium of data to endorse a treatment or diagnostic strategy. At this stage, whatever statements can be made regarding the evaluation and management of perioperative risk among patients with heart failure would have a "C" level of evidence.

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