Perioperative Assessment and Management of Patients with Heart Failure

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Abstract

In noncardiac surgery, a preexisting diagnosis of heart failure (HF) serves as a significant risk factor for major adverse cardiac events. Among elderly patients, this risk is heightened, where the risk of operative mortality and hospital readmission for the same operative procedure has been found to be greater in HF patients than it is for patients with coronary artery disease. In this review, we summarize the requisite preoperative evaluation and management of HF patients undergoing noncardiac surgery and highlight the important perioperative monitoring and management considerations.

Introduction

Globally, an estimated 313 million patients undergo noncardiac surgery every year.1 Heart failure (HF) represents a significant comorbidity that impacts nearly one in every five patients undergoing a major surgical procedure.2 The rising incidence of HF coupled with the advancement in therapies has resulted in a growing cohort of HF patients undergoing noncardiac surgery.3

Underlying HF portends significant perioperative risk for adverse cardiac events. A prior diagnosis of HF, even among those with preserved ejection fraction and those...
dyspnea), and current New York Heart Association functional class. Functional capacity can further be estimated in metabolic equivalents (METs), whereby one MET is the resting or basal oxygen consumption of a 40-year-old, 70 kg male. Perioperative cardiac risk has been shown to be increased when >4 METs of work can be performed during daily activity, and has been strongly associated with postoperative cardiovascular events. 7,8 Activities greater than four METs include walking up a hill, climbing a flight of stairs, and carrying out heavy house work. 7 Although the ACC/AHA guidelines have noted functional capacity to be a component of the preoperative cardiac risk, the CCS has not included a formal recommendation on the use of self-reported functional capacity for risk stratification.

A thorough physical examination should be undertaken in tandem, specifically focusing on the patient’s hemodynamic and volume or congestion status. Assessment of blood pressure, heart rate, rhythm, and oxygen saturation, along with weight, examination of the jugular venous waveform, precordial examination, lung auscultation, and assessment of the abdomen and extremities are essential.

Preoperative Evaluation

The Canadian Cardiovascular Society (CCS) Guidelines on the Perioperative Cardiac Risk Assessment and Management (2017) recommends that all patients aged 45 years or older and those who are 18–44 years old with a significant cardiovascular disease (including HF) warrant preoperative cardiac assessment.6 The initial strategy is guided by the timing of the surgery. Emergency surgery does not allow for any additional preoperative cardiac assessment. If the surgery is urgent or semi-urgent, evaluation should be undertaken only if a high-risk cardiac condition is suspected (e.g., severe obstructive intracardiac abnormality, severe pulmonary hypertension, or an unstable cardiovascular condition). If the surgery is elective, cardiac risk stratification is advised.

Cardiac Investigations

The role and validity of special cardiac investigations preoperatively in patients with HF remain as an area of ongoing study.

Cardiac biomarkers
Brain natriuretic peptide (BNP) and the N-terminal pro-BNP are produced by the myocardium and released in response to left ventricular stretching or wall tension.9 A baseline NT-proBNP/BNP is advised in all patients who are 65 years and older, in the age range 45–64 years old with significant cardiovascular disease, or have a Revised Cardiac Risk Index (RCRI, discussed below) ≥ 1.6,10–12 Therefore, all patients with a diagnosis of HF should have a preoperative NT-proBNP/BNP drawn where available. Patients with an established diagnosis of HF will typically have elevated natriuretic peptide values at baseline as an independent marker of risk; relative increases or decreases in natriuretic peptide values can provide additional information about clinical stability in advance of surgery.

Electrocardiogram
According to the 2014 ACC/AHA Guideline on Perioperative Cardiovascular Evaluation and Management of Patients
Undergoing Noncardiac Surgery, a preoperative resting 12-lead ECG is reasonable in patients with established structural heart disease (ACC/AHA Class IIA) and may be considered in asymptomatic patients (ACC/AHA Class IIB) for any non-low-risk surgery. It can offer insight into any abnormalities (e.g., pathological Q waves, bundle branch blocks, ST depression, LV hypertrophy, and QTc prolongation), although the prognostic implication of specific ECG abnormalities remains poorly defined. More importantly, the preoperative ECG provides a useful baseline for comparison for any ECG changes in the postoperative phase.

Transthoracic 2-D echocardiography
Routine resting echocardiography is not recommended in the preoperative risk assessment. If a patient is suspected to have a severe undiagnosed obstructive intracardiac abnormality (i.e., valvular lesion, hypertrophic obstructive cardiomyopathy), or an undiagnosed cardiomyopathy, echocardiography should be acquired in consideration of the urgency of the surgery. In patients with HF, an echocardiogram is reasonable in those with deteriorating shortness of breath or an alteration in clinical status (ACC/AHA Class IIA).

Chest radiograph
A routine chest radiograph is not required, and only indicated if patients have suspected pulmonary edema or any other pulmonary pathology.

Special investigations
There is no role for routine additional cardiac testing, including exercise stress testing, cardiopulmonary exercise testing, pharmacological stress echocardiography, or stress radionuclide imaging. The value of such testing in reclassifying cardiac risk beyond the clinical evaluation with biomarker testing remains unclear and is thus not routinely recommended for all patients.

Risk Assessment

Clinical risk models
The risk of major adverse cardiac events (MACE) is dependent on the nature of the procedure, and a patient’s underlying characteristics. Procedures associated with major fluid shifts and hemodynamic stresses are typically of higher risk. Several tools have been developed to perform perioperative cardiac risk stratification, of which two of them are commonly used in contemporary medicine. The RCRI, developed and validated by Lee et al. in 1999, is the most validated preoperative risk stratification tool comprising of six variables (Table 1) predicting risk for major cardiac complications (myocardial infarction, pulmonary edema, complete heart block, ventricular fibrillation, or primary cardiac arrest). A score of zero or one is associated with a low risk of MACE, while patients with a score of ≥2 are deemed to be at an elevated risk of MACE. This risk index discriminates moderately well for major cardiac events after noncardiac surgery.

The combination of RCRI and functional capacity (in METs) has a combined C-statistic of 0.70 for MACE.

The National Surgical Quality Improvement Program (NSQIP) Myocardial Infarction and Cardiac Arrest (MICA) model and American College of Surgeons (ACS) NSQIP was developed in 2011 from large databases to predict perioperative myocardial infarction or cardiac arrest. These indices have demonstrated superior discrimination to the RCRI. However, given the lack of systemic perioperative troponin level measurement within the studies, they are believed to have underestimated cardiac risk. As such, the CCS has opted for the use of the RCRI for cardiac risk prediction.

### Table 1. Revised Cardiac Risk Index

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Definition</th>
<th>Points</th>
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<tbody>
<tr>
<td>Ischemic heart disease</td>
<td>History of myocardial infarctionHistory of a positive exercise test Current complaint of chest pain considered to be secondary to myocardial ischemia Use of nitrate therapy ECG with pathological Q waves</td>
<td>1</td>
</tr>
<tr>
<td>Congestive heart failure</td>
<td>History of congestive heart failure Pulmonary edema Paroxysmal nocturnal dyspnea Physical examination showing bilateral rales or S3 gallop Chest radiograph showing pulmonary vascular redistribution</td>
<td>1</td>
</tr>
<tr>
<td>Type of surgery</td>
<td>High risk (intraperitoneal, intrathoracic, or suprainguinal vascular)</td>
<td>1</td>
</tr>
<tr>
<td>Cerebrovascular disease</td>
<td>TIA or stroke</td>
<td>1</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>Preoperative treatment with insulin</td>
<td>1</td>
</tr>
<tr>
<td>Renal function</td>
<td>Creatinine level &gt; 177 μmol/L</td>
<td>1</td>
</tr>
</tbody>
</table>


TIA, transient ischemic attack.
Patient characteristics
Assessment of risk can be further informed by a patient’s HF phenotype. The stage and severity of HF influence the perioperative outcomes and long-term cardiovascular mortality.4,19 Progressively lower left ventricular ejection fraction has been correlated with a higher postoperative mortality.4 The presence of preexisting right ventricular dysfunction has also been associated with higher cardiac postoperative complications and longer hospital stay, irrespective of left ventricular function.20,21

Surgical characteristics
Any operation deemed to be urgent or emergent intrinsically carries a higher perioperative cardiovascular risk, independent of a patient’s baseline cardiovascular function.22

Preoperative Management

Medications
Patients with HF and reduced ejection fraction (HFrEF) are usually on guideline-directed therapies, which may include beta-blockers, renin–angiotensin system inhibitors, mineralocorticoid receptor antagonists, and more recently, sodium–glucose cotransporter-2 (SGLT2) inhibitors. They may also be on aspirin, in the setting of underlying coronary artery disease. Table 2, adopted from the CCS 2017 Guidelines, outlines the recommended management of common therapies for HF for optimization of perioperative cardiac risk.

Table 2. Management of Heart Failure Pharmacotherapy for Optimization of Cardiac Risk6

<table>
<thead>
<tr>
<th>Medication</th>
<th>Recommendation</th>
</tr>
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<tbody>
<tr>
<td>Aspirin</td>
<td>Withhold at least 3 days before surgery and restart ASA when the risk of bleeding related to surgery has passed (i.e., 8–10 days after major noncardiac surgery)</td>
</tr>
<tr>
<td>β-Blocker</td>
<td>Continue the β-blocker during the perioperative period; however, if a patient’s systolic blood pressure is low before surgery, physicians should consider decreasing or holding the dose of the beta-blocker before surgery.</td>
</tr>
<tr>
<td>ACEI/ARB (or ARNI)</td>
<td>Withhold ACEI/ARB/ARNI 24 h before noncardiac surgery and restart ACEI/ARB/ARNI on Day 2 after surgery, if the patient is hemodynamically stable.</td>
</tr>
<tr>
<td>SGLT2 Inhibitor</td>
<td>Hold 48 h before surgery.</td>
</tr>
<tr>
<td>Statin</td>
<td>Continue during perioperative period.</td>
</tr>
</tbody>
</table>


Devices
In patients who have a permanent pacemaker or implantable cardioverter-defibrillator (ICD), consultation with a cardiologist or an institution’s cardiac implantable device team should be made prior to elective procedures. The patient’s underlying rhythm and appropriate functioning of the device should be confirmed preoperatively. For ICDs, interrogation is recommended if not performed within the prior 6 months; for conventional low-voltage pacemakers, interrogation should be performed if not done within the past 12 months.23 As a general principle, device-programming changes should be limited as much as possible in the perioperative setting; it is often easier to apply a magnet to the device, secured intraoperatively by the anesthesia team, in settings where electrocautery is anticipated to inhibit device function. For example, a magnet placed over an ICD will prevent inappropriate shocks that may result from oversensing electrical activity, whereas a magnet placed over a conventional pacemaker prevents unwanted pacing inhibition from external electrical activity. The cardiology or specialized device team can provide further specialized guidance on the programming of the devices, as needed, based on underlying rhythm, and procedural characteristics.

Intraoperative Management

Monitoring
HF patients are at risk of decompensating in the intraoperative period, where physiologic changes to blood pressure and heart rate result in greater metabolic demand, ultimately requiring an augmentation of heart rate and stroke volume to ensure an adequate cardiac output.24 The intraoperative management of hemodynamic changes can be a dynamic process, and routinely facilitated through heart rate monitoring via continuous electrocardiography, and often invasive blood pressure measurement via intra-arterial catheter.25

Pulmonary Artery Catheterization
The routine use of pulmonary artery catheterization (PAC) for continuous invasive monitoring has not been recommended for patients with preexisting HF undergoing noncardiac surgery.26 While prior investigations have not found a reduction in mortality among patients who were treated using PAC,27–29 observational studies in postoperative and intensive care unit (ICU) settings have shown that PAC use provides information that changes clinical management in 30–60% of cases.30–32
It should be acknowledged that, however, the quality of the evidence for PAC use in ICU settings postoperatively is poor, limited by lack of standardization, randomization, and adequate control for confounding factors. A large, prospective observational study has suggested that among patients undergoing noncardiac surgery, those monitored with PAC had increased morbidity and mortality; however, these patients had more severe underlying illness, reflecting potential selection bias. A review of the published data therefore provides incomplete information about the indication, utility, and effectiveness of PAC in the HF patient undergoing noncardiac surgery, and as a result, evidence does not support the routine use of PAC. However, patient clinical factors (i.e., severe uncorrected and hemodynamically significant valvular disease, shock, acute decompensated HF in the perioperative period), the nature of the surgical procedure, and anesthetists’ experience with the theoretical, technical, and practical aspects of PAC often inform appropriate indication in the intraoperative setting. Some centers may also supplement hemodynamic assessment with a combination of PAC and intraoperative echocardiography, depending on local expertise. A discussion of noninvasive cardiac output monitoring strategies used by some centers is beyond the scope of this review.

**Echocardiography**

According to the American Society of Echocardiography and the Society of Cardiovascular Anesthesiologists (2013), the indications for an intraoperative transesophageal echocardiogram (TEE) include all open heart (i.e., valvular) and thoracic aortic surgical procedures, some coronary artery bypass graft surgeries, and in noncardiac surgery when patients have known or suspected cardiovascular pathology which may impact outcomes. Intraoperatively, the TEE is particularly helpful in the assessment of global left and right ventricular function, recognizing the development of regional wall motion abnormalities or valvular dysfunction as a consequence of the surgical intervention, and ascertaining of volume status with serial measurement of LV end-diastolic dimension and systemic vascular resistance. For HF patients undergoing noncardiac surgery, one of the major considerations for intraoperative TEE use includes surgical procedures that involve significant hemodynamic shifts related to fluid and/or blood loss (i.e., thoracic surgery, solid organ transplantation) in the absence of absolute contraindications (perforated viscus, esophageal stricture, esophageal tumor, esophageal perforation or laceration, esophageal diverticulum, active upper GI bleed). Importantly, in both prospective and retrospective studies, the use of intraoperative TEE has been found to impact patient management, including the modification of blood product use and/or inotropic or vasopressor support.

**Hemodynamic Management**

Intraoperatively, the use of inotropes and vaspressors are guided by acute physiologic changes necessitating their use. Inotropic therapy augments cardiac output by enhancing cardiac contractility, which increases stroke volume, while decreasing left ventricular end-systolic volume. Vasopressor therapy increases peripheral vasoconstriction, thereby increasing the systemic vascular resistance, while increasing blood pressure and mean arterial pressure. In the setting of vasopressor use, stroke volume in vulnerable HF patients may be reduced, and the left ventricular end-systolic volume may increase. Intraoperatively, an increase in ventricular preload by fluid and/or blood product administration results in an increase in the stroke volume, but excessive volume resuscitation may not be well tolerated by patients with poor ventricular function. Conversely, a maladaptive reduction in ventricular preload may be the result of reduced blood volume (i.e., significant blood loss or hemorrhage intraoperatively), impaired atrial contraction secondary to atrial arrhythmia (such as atrial fibrillation or atrial flutter), or an excessive increase in heart rate in preload-dependent patients. For HFrEF patients who are deemed high-risk surgical candidates, these hemodynamic effects may prove to be more significant, thereby necessitating expert consultation with HF clinicians and/or referral to a center that offers advanced HF management and mechanical circulatory support in the perioperative period.

Noting these hemodynamic factors, maintenance of euvolemia in the HF patient becomes particularly important during the intraoperative period, with the goal of ensuring adequate preload for effective cardiac output and perfusion, while simultaneously avoiding unnecessary volume resuscitation that may increase filling pressures, which would result in intravascular volume overload and pulmonary edema. With respect to anemia and blood loss, clinical practice guidelines recommend a hemoglobin target of 80g/L in HF patients. Intraoperative management of atrial and ventricular tachyarrhythmias and bradyarrhythmias typically follow standardized Advanced Cardiac Life Support (ACLS) algorithms. For patients who develop atrial fibrillation intraoperatively with evidence of hemodynamic instability...
Postoperative Management

Monitoring and management of postoperative decompensated heart failure

Given the heightened risk of postoperative morbidity and mortality in HF patients, close clinical monitoring in the postoperative period is essential.5 Particular attention should be paid to blood pressure, heart rate, heart rhythm, volume status, and end organ function. Intensity of monitoring should be informed by the patient’s underlying risk profile, including the type of surgery, and the intraoperative course. Table 3 summarizes an approach to selecting an appropriate level of monitoring based on clinical, biochemical, electrocardiographic, and imaging findings.

Initial management considerations for acute decompensated HF in the postoperative period include rapid assessment of hemodynamic status, and the application of appropriate interventions based on the patient’s HF hemodynamic profile (Figure 1).46 Postoperatively, patients can be “warm and dry,” indicating compensated hemodynamics that require titration of oral therapy. Mild to moderate acute decompensated HF can present postoperatively with evidence of volume overload on clinical exam (i.e., elevated jugular venous pulse [JVP], crackles, peripheral edema), but the patient remains normotensive or hypertensive, and warm peripherally. In this setting, the patient is deemed “warm and wet,” and would benefit from diuretics and oral afterload reduction.

<table>
<thead>
<tr>
<th>Features</th>
<th>Routine monitoring (Ward)</th>
<th>Step-down setting</th>
<th>Critical care setting</th>
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<tbody>
<tr>
<td>HF history</td>
<td>History of mild–moderate HF previously</td>
<td>Recent worsening of HF requiring intravenous diuretics; high risk of requiring noninvasive ventilatory support</td>
<td>Advanced HF, listed or being evaluated for LVAD therapy or cardiac transplantation; recent cardiogenic shock; known severe left ventricular dysfunction; recent ventricular arrhythmias requiring defibrillation</td>
</tr>
<tr>
<td>Physical exam</td>
<td>Warm, well-perfused</td>
<td>Warm, well-perfused, moderately volume overloaded</td>
<td>Hypotensive, evidence of end-organ dysfunction or hypoperfusion, gross volume overload</td>
</tr>
<tr>
<td>Rhythm</td>
<td>Normal sinus rhythm; chronic stable atrial arrhythmias Consider telemetry when high risk for new or symptomatic atrial arrhythmias</td>
<td>Atrial or ventricular rhythm disturbances (i.e., non-sustained VT, atrial fibrillation with rapid ventricular response causing worsening symptoms Arrhythmias requiring continuous infusions</td>
<td>Atrial or ventricular rhythm disturbances (i.e., non-sustained VT, atrial fibrillation with rapid ventricular response causing hypotension); need for defibrillation or cardioversion, continuous antiarrhythmic infusions Prolonged pauses, Mobitz II or 3rd degree AV block with potential temporary pacing requirements</td>
</tr>
<tr>
<td>Biochemistry</td>
<td>Stable renal function Baseline biomarker values (natriuretic peptide levels, troponin)</td>
<td>Very high or increasing troponin, natriuretic peptides Worsening renal function. Potential need for frequent lab work, including arterial or venous gases and lactate monitoring as needed</td>
<td>Very high or increasing troponin, natriuretic peptides Worsening renal function Anticipated frequent lab work, including arterial or venous gases and lactate monitoring as needed</td>
</tr>
<tr>
<td>Radiology</td>
<td>Absence of pulmonary edema</td>
<td>Evidence of pulmonary edema, pleural effusions</td>
<td>Severe pulmonary edema, large pleural effusions</td>
</tr>
</tbody>
</table>

LVAD, left ventricular assist device; VT, ventricular tachycardia.
Patients with evolving cardiogenic shock typically develop hypotension (systolic blood pressure <90 mmHg), cool extremities, and signs of pulmonary congestion (i.e., the “cold and wet” hemodynamic phenotype), which reflects a reduced cardiac index, increased systemic vascular resistance, and an increased pulmonary capillary wedge pressure that may require initiation of inotropic therapy in addition to diuretic/decongestive therapy. Less often, postoperative patients can present as “cold and dry,” which reflects hypovolemia on clinical examination, and hypoperfusion. Right-sided HF can also present postoperatively because of an abrupt increase in right ventricular (RV) afterload (i.e., pulmonary embolism, hypoxia, acidemia, acute pulmonary hypertension, acute respiratory distress syndrome), or because of decreased RV contractility (i.e., RV ischemia). In these instances, collaboration with cardiology and critical care services would be indicated for more invasive monitoring and therapy. Importantly, postoperative myocardial infarction or ischemia is a common contributor to worsening HF in the perioperative period; in turn, the clinical, biochemical (i.e., serial troponin), electrocardiographic, and echocardiographic assessment for acute coronary syndrome is warranted in this clinical setting.

Management of Postoperative Atrial Fibrillation

Atrial fibrillation (AF) is common in the postoperative period, with 0.4–3% of patients affected after noncardiac surgery. It can occur as a consequence of several factors, such as atrial stretch, ischemia, inflammation, hypoxemia, high sympathetic tone, and electrolyte disturbances. Given that atrial fibrillation disrupts normal atrioventricular synchrony and can result in a 15–25% reduction in cardiac output, its management becomes particularly important in the HF patient. The 2020 CCS offer guidelines for management of postoperative atrial fibrillation, including the continuation or initiation of beta-blockers in patients without significant contraindications, the use of amiodarone for patients with a contraindication to beta-blocker therapy, and the use of prophylactic therapy (intravenous magnesium, colchicine) in patients who have contraindications to beta-blocker therapy and amiodarone. The CCS guidelines recommend withholding anticoagulation therapy for the first 72 h after cardiac surgery, or as precluded by surgical risk of bleeding. Further, current guidelines recommend clinical reevaluation of all patients with perioperative atrial fibrillation in 6–12 weeks for reassessment of anticoagulation, rate, and/or rhythm control. Perioperative atrial fibrillation has a high likelihood of being self-limited and may not require long-term therapy.

Reinitiation of Guideline Directed Medical Therapy and Discharge Planning

Guideline-directed medical therapy for HF should be reinitiated postoperatively when there are no hemodynamic or biochemical contraindications. Observational studies have
demonstrated an increased 30-day mortality in patients who do not have their ACE or ARB restarted within 48 h or 2 weeks after surgery; however, these studies are not limited to patients with HF, and residual confounding variables are not excluded. Given that patients who develop decompensated HF postoperatively are at an increased risk of morbidity and mortality, and readmission, a multidisciplinary approach to outpatient follow-up with the surgical team, as well as the patient’s outpatient cardiologist or internist will ensure appropriate volume status assessment, medication titration, and early intervention in the event of worsening clinical status related to the operative procedure.

Conclusion

A diagnosis of HF confers a significant perioperative risk of adverse cardiac events. A comprehensive evaluation, with completion of the requisite preoperative testing as directed by the patient’s clinical status and as augmented by ancillary testing, coupled with an intraoperative and postoperative monitoring and management plan, can assist in ensuring the safety of HF patients undergoing noncardiac surgery. In instances where the clinical scenario requires considerations for advanced therapies, management of decompensated HF manifesting as cardiogenic shock, and/or hemodynamically significant arrhythmias, collaboration with the cardiology service will provide the necessary support to facilitating the next steps in the patient’s care or management plan. At the time of discharge, a detailed summary of the patient’s course in hospital, medications (with specific commentary on reduced doses of medications, or held medications), as well as requested timelines for patient reassessment can be helpful to the receiving provider who will continue their management as an outpatient.

References


