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PREOPERATIVE EVALUATION (BJ SWEITZER, SECTION EDITOR)

Recommendations for Preoperative Assessment and Shared Decision-Making in Cardiac Surgery

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Abstract

Purpose of Review Recommendations about shared decision-making and guidelines on preoperative evaluation of patients undergoing non-cardiac surgery are abundant, but respective recommendations for cardiac surgery are sparse. We provide an overview of available evidence.

Recent Findings While there is currently no consensus statement on the preoperative anesthetic evaluation and shared decision-making for the adult patient undergoing cardiac surgery, evidence pertaining to specific organ systems is available.

Summary We provide a comprehensive review of available evidence pertaining to preoperative assessment and shared decision-making for patients undergoing cardiac surgery and recommend a thorough preoperative workup in this vulnerable population.

Keywords Anesthesia · Cardiac surgery · Guideline · Preoperative evaluation · Shared decision-making · Cardiovascular risk factors

Introduction

Patients undergoing cardiac surgery are older and more medically complex. Clinical cardiovascular risk factors for major perioperative adverse cardiovascular and cerebral events (MACCE) include reduced functional status (< 4 metabolic equivalent of task), age > 60 years, arterial and pulmonary hypertension, heart failure (HF), acute coronary syndrome (ACS), ischemic heart disease, cardiomyopathy, severe valvular heart disease, significant arrhythmias, peripheral vascular disease, thoracic aortic atheroma, diabetes mellitus requiring insulin, renal insufficiency, chronic pulmonary disease, neurological disease, anemia, previous cardiac surgery [1–4], previous mediastinal radiation therapy [5, 6], and body mass index (BMI) > 35 kg/m^2 or < 20 kg/m^2. Shared decision-making among the patient, surgeon, and anesthesiologist before surgery regarding risks, benefits, and patient's goals of care, expectations, and values may improve outcome [7••].

Frailty is associated with adverse perioperative events such as hemodynamic instability [8], increased postoperative pain [9], and postoperative cognitive decline [10]. Phenotypic criteria initially defined to quantify women's aging and health status (Fried criteria) used on other cohorts such as those having cardiac surgery are shown in Table 1 [11]. Normalizing potentially modifiable risk factors with shared decision-making preoperatively can improve outcomes [12••, 13••].

Multiple guidelines on the preoperative evaluation of adults undergoing non-cardiac surgery have been published and have been widely accepted and adopted in practice. While there is currently no consensus statement on the preoperative anesthetic evaluation of the adult patient undergoing cardiac surgery, we provide an overview of available evidence

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Table 1 Fried criteria to assess frailty (adapted from Graham et al.) [11]

Dimension	Measure
Activity	Minnesota Leisure Time Activity Questionnaire revealing energy expenditure < 383 kcal/week (men) or < 270 kcal/week (women) respectively.
Self-reported exhaustion	"I could not get going in the last week" or "I felt that everything I did was an effort in the last week"
Slowness	Walking < 15 ft in 6–7 s
Weakness	BMI and gender-stratified cutoffs
Weight loss	Unintentional loss of > 10 lbs over the past year

kcal kilocalories, *BMI* Body Mass Index

from a multidisciplinary perspective aimed at making collaborative decisions on the timing of the surgery and how optimizing the patient before surgery can improve outcomes.

Risk Scores and Risk Assessments

Substantial efforts must be made to try to optimize the patient' physiology to minimize risk. Current risk models such as the Society of Thoracic Surgeons (STS) score (https://www.sts.org/resources/risk-calculator) or the European System for Cardiac Operative Risk Evaluation (EuroSCORE II and EuroSCORE I, http://www.euroscore.org/calc.html) ascertain a patient's risk of complications [14–16] with good predictive value [17, 18]. However, none of these models takes physical capability and frailty into consideration.

As defined by Joseph et al., frailty is a complex systemic syndrome associated with, but distinct from, aging, disability, and multi-morbidity, and is marked by impaired physiological reserves and weakness. Frailty is strongly linked to adverse outcomes and increased mortality in adults undergoing cardiac surgery [19–21, 22••, 23•]. Models for identifying frailty emerged in 2001 [24]. Joseph et al. adapted these models for HF patients [23•]. Bentov et al. recently described that frailty assessments in high-risk surgical patients may provide better prognostic information than the American Society of Anesthesiologists classification [25].

The Model for End-stage Liver Disease (MELD) score (https://www.thecalculator.co/health/MELD-Calculator-421.html) and Child-Pugh classification [26] (Table 2), originally designed for risk stratification of cirrhotic patients, were found to also predict morbidity and mortality in patients with HF, ventricular assist devices, and in those undergoing heart transplantation [27, 28].

Especially in vulnerable and frail patients, the optimal decision-making process is multidisciplinary, involves the patient's values and preferences, and facilitates patient control over decision making as defined by the concept of shared decision-making. Understanding the risks involved requires shared planning, assessment, and coordination among the patient, their family, surgeon, anesthesiologist, and other medical specialists [7••, 29•, 30••, 31••, 32••].

Heart Failure

Morbidity and mortality in cardiac surgery cohorts increase in patients with HF and are accentuated in decompensated HF [33, 34]. Improving fluid and nutritional status and end-organ function before cardiac surgery improves outcomes and should be directed at every elective patient with shared decision-making embracing comprehensive and easy to follow nutritional advice [30••, 35••]. Medication management needs to be aligned with established recommendations for patients undergoing non-cardiac surgery. A brain natriuretic peptide (BNP) < 300 pg/mL or at the "lowest individual value in the previous year" indicates successful optimization of HF [35••]. These measures help to restore liver and renal function, with the goal of albumin concentrations ≥ 30 g/L and hemoglobin concentrations ≥ 100 g/L.

Kidney and Liver Function

Acute kidney injury (AKI) remains a common complication in patients undergoing cardiac surgery [36, 37]. In patients older than 75 years, the comorbidity profile is often extensive, including chronic kidney disease (CKD).

Table 2 Child-Pugh classification, adapted from Pugh et al. [26]

Assessment	1 point	2 points	3 points
Ascites	No ascites	Mild	Moderate–severe
Hepatic encephalopathy	No encephalopathy	Grade 1–2 (or medically suppressed)	Grade 3–4 (or refractory)
INR	< 1.7	1.7–2.3	< 2.3
Serum albumin (g/l)	> 35	28–35	< 28
Total bilirubin (μmol/l)	< 34	34–50	> 50

5–6 points: Child-Pugh class A, 6–9 points: Child-Pugh class B, 10–15 points: Child-Pugh class C

INR, international normalized ratio

Besides CKD, HF is the strongest risk factor for postoperative AKI [36, 38, 39] . In patients with preoperative AKI, surgery should be postponed unless AKI is attributed to HF [40•]. A consensus statement on AKI in cardiac surgery patients recommends preoperative assessment of estimated glomerular filtration rate, cystatin C, and albuminuria [41••]. Angiotensin-converting-enzyme inhibitors (ACEI) and angiotensin II receptor blockers (ARB) should be discontinued [42, 43].

In patients undergoing elective surgery, creatinine should be at the lowest individual value within a year before cardiac surgery [35••] and surgery delayed 24–72 h after iodine contrast administration [44, 45].

Given weak evidence for dopamine and loop diuretics to prevent AKI, their use should be individualized [46, 47], with the primary goals to maintain euvolemia at the time of surgery and avoid preoperative volume overload.

Abnormal liver function tests (LFTs) may indicate hypervolemia and right-sided HF or primary liver dysfunction. Patients with elevated LFTs should undergo further diagnostics and optimization [48, 49, 50•].

Nutritional Status

Albumin levels should be assessed before cardiac surgery because malnutrition is a modifiable risk factor [51, 52]. Determining the prealbumin concentration is of prognostic value in patients at risk of malnutrition and those with HF [53, 54]. The goal is albumin concentration > 30 g/L, with prealbumin > 20 mg/dL [35••].

Functional Lung Assessments and Pulmonary Disease

Patients with a history of obstructive or restrictive lung disease, suspected reduced functional lung capacity, physical examination findings of lung disease, functional capacity < 4 metabolic equivalents (METs) assessed with a 6-min walk test or bike ergometer require preoperative optimization, evaluation of carbon dioxide retention via arterial blood gas analysis, and testing for response to bronchodilators as indicated [55]. Further optimization depends on results of the testing.

Postoperative pulmonary complications (PPC) including atelectasis, pneumonia, bronchospasm, pleural effusion, pulmonary edema, and respiratory failure are major causes of morbidity and mortality in adults undergoing cardiac surgery [56, 57]. The etiology of PPC can be multifactorial, but recognized patient-related risk factors include age > 60 years, pre-existing pulmonary disease, smoking, and alcohol consumption [57, 58]. While there is no consensus when to avoid or postpone cardiac surgery in patients with impaired pulmonary function, some evidence suggests that preoperative inspiratory muscle training (IMT) to increase overall exercise capacity might be beneficial and should be performed preoperatively [57–60].

Diabetes Mellitus and Glucose Control

Diabetes mellitus is associated with increased risk in patients undergoing cardiac surgery, is associated with endothelial and platelet dysfunction, adverse vascular events, and increased rates of infections, myocardial infarction (MI), and AKI [61, 62]. Standard management strategies are recommended [63••, 64••, 65]. In brief, oral diabetic medications and long-acting subcutaneous insulin are omitted on the day of surgery, and replaced with short-acting insulin to maintain blood glucose levels between 120 and 180 mg/dl, with recommended checks every 4 h [63••, 64••, 65]. Blood glucose levels should be determined at hospital admission in all cardiac surgery patients, and treatment initiated for blood glucose > 120 mg/dl.

Preoperative Anemia

Preoperative anemia occurs in approximately 25% of patients undergoing cardiac surgery, and appropriate management is indicated [66]. According to current consensus, patients with hemoglobin concentrations < 7.5 g/dL should receive red blood cell transfusion before cardiac surgery [67••]. Patients with coronary artery disease (CAD) should be transfused for a hemoglobin < 8.0 g/dL [67••, 68•]. Individualized thresholds for high-risk groups, such as HF patients and patients with severe CAD, might be beneficial [66, 69]. Iron supplementation is indicated for iron deficiency anemia before surgery [67••]. Iron supplementation may be given intravenously 3 to 4 weeks before surgery [70•].

Laboratory Tests

Recommended preoperative laboratory tests include complete blood count, platelet count, activated partial thromboplastin time, prothrombin time, international normalized ratio, fibrinogen, identification of blood group, serum electrolytes, blood urea nitrogen, creatinine, transaminases, glucose, thyroid-stimulating hormone (TSH), and C-reactive protein (CRP). Preoperative plasma proBNP concentration is a sensitive marker for cardiac decompensation, and some studies suggest that elevated concentrations are associated with an increased risk of MACCE [71, 72••]. In HF patients and those with suspected malnutrition, prealbumin concentrations should be investigated [35••].

Electrocardiography, Transthoracic Echocardiography (TTE), Coronary Angiography

Patients scheduled for cardiac surgery undergo extensive cardiac examinations including a 12-lead electrocardiogram and

TTE. Left-heart catheterization, including a coronary angiogram, should be performed to identify CAD in all cardiac surgery patients except in younger patients (men < 40 years, women < 50 years), with a low risk for atherosclerosis and no history of CAD. In such cases, multislice computer tomography (MSCT) may be used to rule out CAD. Additional tests may include right heart catheterization, cardiac magnetic resonance imaging (MRI), stress TTE, cardiac scintigraphy, and trans-esophageal echocardiography (TEE) [73••].

Chest Radiography (X-Ray) and Carotid Ultrasound and/or Angiography

Standard assessment includes imaging of the chest by X-ray or computed tomography (CT) in cases with suspected aortic pathology. A CT can be used to detect major calcifications of the aorta that require an alternative approach for cannulation or aortic clamping. A CT scan is also appropriate in patients undergoing cardiac reoperation [74].

The prevalence of carotid stenosis > 50% in patients undergoing coronary artery bypass graft (CABG) surgery is 9%, with a 1–2% incidence of stroke after CABG [75, 76••]. Therefore, routine screening for carotid stenosis in asymptomatic cardiac surgery patients with no prior history of neurological disease and aged < 70 years is not recommended [76••]. However, in CABG patients with prior history of transient ischemic attacks, stroke, and those with carotid occlusion, the rate of post-CABG stroke is significantly higher [76••]. In patients with significant cardiovascular risk profile and in those with CAD or peripheral artery disease, a preoperative carotid ultrasound may be justified at age < 70 years.

Management of Cardiac Implantable Electronic Devices

If a patient is pacemaker dependent, a magnet can be positioned over the skin to set the pacemaker to asynchronous mode before surgical incision if the surgical approach allows.

If the surgical approach does not allow the placement of a magnet, the device must be reprogrammed to an asynchronous mode (V00 or D00). Implantable cardioverter defibrillators (ICDs) must be inactivated. In both cases, percutaneous pacemaker/defibrillator pads must be placed before surgical incision, while intravenous pacemakers might be an alternative for pacing, they do not offer the option for defibrillation.

Medication Management

Beta blockers Current evidence shows that beta blockers (BB) provide an overall survival benefit and overall reduction of arrhythmic events in the early postoperative period in cardiac surgery patients [77]. BB are recommended for 2 years in patients after MI if hemodynamics allow [78]. The European Association for Cardio-Thoracic Surgery (EACTS) guidelines recommend continuation of prior BB therapy until the day of surgery. If de novo BB are initiated preoperatively, careful uptitration of short-acting agents is recommended [63••, 79].

Renin-Angiotensin-Aldosterone System Inhibitors Renin-angiotensin-aldosterone-system (RAAS) blockers (ACEI, ARB, aldosterone-receptor inhibitors, and direct renin inhibitors) are used to treat arterial hypertension and HF. Because RAAS blockers are reno-protective, they are especially beneficial in patients with HF [80•, 81•, 82, 83], but should be discontinued 12–24 h before surgery [63••]. Some studies showed increased risks if ACEI were continued during cardiac surgery [84]. In uncontrolled arterial hypertension, long-acting agents (e.g., enalapril and lisinopril) should be replaced with short-acting substances (e.g., captopril) the day before surgery to mitigate intraoperative hypotension [63••].

Diuretics Diuretics and fluid restriction are used to achieve euvolemia and to avoid preoperative fluid overload and cardiac decompensation. In HF patients, however, diuretics should be suspended 24–48 h before surgery to minimize the risk for perioperative hypotension [35••].

Statin Therapy A recent trial showed that rosuvastatin therapy established shortly before cardiac surgery does not prevent perioperative myocardial damage or reduce the risk of postoperative atrial fibrillation, but rather leads to an increase in AKI [85]. If statin therapy is ongoing before surgery, however, it may be continued [63••].

Proton Pump Inhibitors (PPIs) and Ulcer Prevention Upper gastrointestinal bleeding and ulceration occur in 1% of patients undergoing cardiac surgery [86]. PPIs were found to reduce postoperative gastrointestinal complications, with significantly lower rates of active ulcers compared to groups treated with histamine 2 antagonists and mucosal protectors [87, 88]. Therefore, prophylaxis with a PPI should be considered in all patients undergoing cardiac surgery [63••].

Steroids Steroids reduce the systemic inflammatory response often observed in cardiac surgery, but may also increase the risk for infections and MI. Multiple randomized controlled trials showed no difference in overall early postoperative mortality and morbidity in patients receiving steroids [89, 90]. Current consensus does not recommend routine prophylactic use of steroids in patients undergoing cardiac surgery [63••]. In patients receiving chronic steroid therapy, perioperative steroids are continued, but specific recommendations for perioperative stress doses are lacking [91].

Antibiotics Postoperative surgical site infections (SSI) and deep sternal wound infections are serious complications in

cardiac surgery [92, 93]. Diabetes mellitus requiring insulin, BMI > 30 kg/m^{-2}, female gender, and severe kidney dysfunction being the main non-modifiable risk factors [93, 94, 95•]. The majority of infections are attributed to gram-positive bacteria [96], and antibiotic prophylaxis within 1 h before surgical incision is recommended [63••]. First-line agents are cefazolin or cefuroxime (1.0 or 1.5 g) [63••] or, in documented β-lactam allergy, clindamycin (600 mg) or vancomycin (20 mg/kg body weight) [63••]. It remains unclear whether vancomycin dosing must be adjusted for creatinine clearance in renally impaired patients. Potential risk of overdosing might be minimal compared to potential risks of SSI [97]. Vancomycin may also be used as an adjuvant first-line therapy in patients undergoing valve or vascular implant surgery, in patients colonized with methicillin-resistant *Staphylococcus aureus*, or in selected patients at high risk for deep sternal infections [95•]. Vancomycin should be administered within 2 h of the surgical incision [63••].

Coagulation and Perioperative Bleeding Management

Many cardiac patients take anti-thrombotic or anti-coagulation medications. Perioperative bleeding has a negative impact on the early and late outcomes of patients undergoing cardiac surgery [98, 99], but data on discontinuing anti-thrombotics before cardiac surgery are limited. Guidelines recommend ticagrelor is stopped at least 3 days, clopidogrel at least 5 days, and prasugrel at least 7 days before surgery [100•]. The European CABG registry showed no increased risk of re-sternotomy because of bleeding if acetylsalicylic acid (ASA) was discontinued less than 7 days before CABG [101••]. The 2017 EACTS guidelines recommend continuation of ASA throughout the preoperative period in patients having CABG surgery, and ASA should be restarted within 24 h [63••]. The guidelines further recommend postoperative resumption of purinergic receptor P2Y12 inhibitors (e.g., clopidogrel, prasugrel, ticagrelor, cangrelor) as soon as possible in patients who have experienced an ACS in the past 12 months. In patients at high risk of cardiac ischemia, P2Y12 inhibitors should be restarted within 48 h after surgery, and in patients considered at low risk, inhibitors should be restarted within 3–4 days after cardiac surgery [63••]. In CABG patients with prior MI at high risk of bleeding, P2Y12 inhibitors are discontinued 6 months postoperatively [100•].

The addition of dual antiplatelet therapy to oral anticoagulants results in a two to threefold increase in bleeding complications [102]. Triple therapy is only used if a compelling indication exists, and should be terminated upon hospital discharge [100•].

The HAS-BLED (hypertension, abnormal renal/liver function, stroke, bleeding history or predisposition, labile international normalized ratio, elderly [> 65 years], drugs/alcohol concomitantly) score has been shown to outperform $CHADS_2$ (congestive heart failure, hypertension, age ≥ 75 years, diabetes, stroke [2 points], and CHA_2DS_2-VASc (congestive heart failure, hypertension, age ≥ 75 years [2 points], diabetes, stroke [2 points], vascular disease, age [65–74 years], sex category [female]) in predicting bleeding risk [100•, 103]. While there is no definitive evidence to guide perioperative management of patients taking direct oral anticoagulants (DOACs), an international consensus statement supports a pragmatic approach in such patients [104••]. DOACs should be discontinued 2 days before cardiac surgery and plasma levels of anti-factor-Xa (or alternatively DOAC plasma concentrations) monitored in patients at high risk of bleeding. Short-term bridging with low molecular weight heparin (LMWH) or unfractionated heparin (UFH) is not required in the preoperative period [104••], and is associated with significantly higher bleeding risk (OR 16.8; 95% CI 3.8–78.9, $p < 0.001$) [105].

For patients receiving DOACs until cardiac surgery, measures such as ultrafiltration during cardiopulmonary bypass, postoperative hemodialysis to remove dabigatran, administration of activated prothrombin complex concentrate, fibrinogen concentrate, tranexamic acid, or activated factor concentrates (factor VIIa or activated prothrombin complex concentrates) may be considered to reduce bleeding [104••, 106–108].

Current guidelines recommend stopping vitamin K antagonists (VKA) 5 days before cardiac surgery [63••]. Bridging with LMWH or UFH is recommended only in patients with mechanical prosthetic heart valves, valvular atrial fibrillation (AF), AF with a CHA_2DS_2-VASc score > 4 (European guidelines [63••]) or ≥ 8 (American guidelines [109]) respectively, or an acute thrombotic event within the previous 4 weeks (defined as ischemic stroke, ACS, or pulmonary embolism), the presence of a left ventricular apex thrombus, or antithrombin III, or protein C, and S deficiencies [63••]. LMWH should be discontinued 24 h before cardiac surgery, and UFH is stopped 6 h before procedures [63••].

Intraoperative autologous blood collection and retransfusion is recommended when expected blood loss is > 500 mL, as it reduces exposure to allogenic blood products, infections, and extended hospital stays [106, 110, 111••].

Shared Decision Making

All treatment options, scientific evidence, and the patient's healthcare goals should be discussed in a multi-disciplinary way before initiation of treatment. Ideally, these discussions occur early in the course of treatment, perhaps initiated by the patient's primary care physician or cardiologist, followed by the involvement of the cardiac surgeon and the anesthesiologist. Both medical and interventional treatment options and pros and cons of each need to be discussed. Healthcare providers need to understand the patient's current physical and

mental condition, overall prognosis, expectations about treatment, and short- and long-term goals. Shared decision making is a multidisciplinary approach where both clinicians and patients discuss the available evidence about clinical care, while patients are supported to make decisions about their care that are right for them, so that informed preferences can be achieved [112•]. Each intervention has its own risk and benefits, and may not necessarily be concordant with the patient's wishes and preferences. The emphasis is on a multidisciplinary approach, which should lead to high-quality, patient-centered care.

Conclusion

While specific guidelines for pre-anesthetic evaluation of patients undergoing cardiac surgery are sparse, some evidence pertaining to specific organ systems is available. Current risk scores form the basis for predicting the operative risk and adequately preparing patients for cardiac surgery. Clinicians should establish and adhere to standardized preoperative assessments of organ systems, management of medication, and coagulation status, and anticipate patient blood management. New approaches to optimize the preoperative physical status (physical training, nutrition status, hemoglobin concentration) and, thereby, reduce frailty are currently under investigation. We highly recommend a thorough preoperative workup in this vulnerable cohort. Assessing the cardiac surgery patient with a multidisciplinary team promotes high-quality shared decision-making consistent with the patient's goals and values.

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- • Of importance
- •• Of major importance

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