HHS Public Access
Author manuscript
Curr Anesthesiol Rep. Author manuscript; available in PMC 2021 June 01.

Published in final edited form as:
Curr Anesthesiol Rep. 2020 June ; 10(2): 185–195. doi:10.1007/s40140-020-00377-7.

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

Maks Mihalj, MD,
Department of Cardiovascular Surgery, Inselspital, Bern University Hospital, University of Bern, Bern, Switzerland

Thierry Carrel, MD,
Department of Cardiovascular Surgery, Inselspital, Bern University Hospital, University of Bern, Bern, Switzerland

Richard D. Urman, MD, MBA,
Department of Anesthesiology, Perioperative and Pain Medicine, Brigham and Women's Hospital, Boston, MA

Frank Stueber, MD,
Department of Anaesthesiology and Pain Medicine, Inselspital, Bern University Hospital, University of Bern, Bern, Switzerland

Markus M. Luedi, MD, MBA
Department of Anaesthesiology and Pain Medicine, Inselspital, Bern University Hospital, University of Bern, Bern, Switzerland

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 currently is 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.

Correspondence: Markus M. Luedi, MD, MBA, Department of Anaesthesiology and Pain Medicine, Inselspital, Bern University Hospital, University of Bern, Freiburgstrasse, 3010 Bern, Switzerland, Phone: +41 31 632 24 83, markus.luedi2@insel.ch.
Contributions: Maks Mihalj, Thierry Carrel, Richard D. Urman, Frank Stueber, and Markus M. Luedi helped to write the article

Human and Animal Rights and Informed Consent
This article does not contain any studies with human or animal subjects performed by any of the authors.

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, 2, 3, 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 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, 15, 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, 20, 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). 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 24-72h after iodine contrast administration [45, 46].

Given weak evidence for dopamine and loop diuretics to prevent AKI, their use should be individualized [47, 48], 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 dys-function. Patients with elevated LFTs should undergo further diagnostics and optimization [49, 50, 51].

Nutritional Status

Albumin levels should be assessed before cardiac surgery because malnutrition is a modifiable risk factor [52, 53]. Determining the prealbumin concentration is of prognostic value in patients at risk of malnutrition and those with HF [54, 55]. 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 minute 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 [56]. 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 [57, 58]. 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 [59, 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 [59, 60, 61, 58].

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 [62, 63]. Standard management strategies are recommended [64, 65, 66]. 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 120-180 mg/dl, with recommended checks every 4 hours [64, 65, 66]. Blood glucose levels should be determined at hospital admission in all cardiac surgery patients, and treatment initiated for blood glucose >120 mg/6dl.

Preoperative Anemia

Preoperative anemia occurs in approximately 25% of patients undergoing cardiac surgery, and appropriate management is indicated [67]. According to current consensus, patients with hemoglobin concentrations <7.5 g/dL should receive red blood cell transfusion before cardiac surgery [68]. Patients with coronary artery disease (CAD) should be transfused for a hemoglobin <8.0 g/dL [68, 70]. Individualized thresholds for high-risk groups, such as HF patients and patients with severe CAD, might be beneficial [67, 71]. Iron supplementation is indicated for iron deficiency anemia before surgery [68]. Iron supplementation may be given intravenously three to four weeks before surgery [69].

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 [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) [74].

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 [75].

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 [76, 77]. 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 [77]. 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 [77]. 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 [78]. BB are recommended for 2 years in patients after MI if hemodynamics allow [79]. 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 up-titration of short-acting agents is recommended [80, 64].

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 [81, 82, 83, 84], but should be discontinued 12-24 hours before surgery [64]. Some studies showed increased risks if ACEI were continued during cardiac surgery [85]. 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 [64].

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:

Arecent 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 [86]. If statin therapy is ongoing before surgery, however, it may be continued [64].

Proton pump inhibitors (PPIs) and ulcer prevention:

Upper gastrointestinal bleeding and ulceration occur in 1% of patients undergoing cardiac surgery [87]. 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 [88, 89]. Therefore, prophylaxis with a PPI should be considered in all patients undergoing cardiac surgery [64].

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 [90, 91]. Current consensus does not recommend routine prophylactic use of steroids in patients undergoing cardiac surgery [64]. In patients receiving chronic steroid therapy, perioperative steroids are continued, but specific recommendations for perioperative stress doses are lacking [92].

Antibiotics:

Postoperative surgical site infections (SSI) and deep sternal wound infections are serious complications in cardiac surgery [93, 94]. Diabetes mellitus requiring insulin, BMI >30 kg/m^{-2}, female gender and severe kidney dysfunction being the main non-modifiable risk factors [94, 95, 96]. The majority of infections are attributed to gram-positive bacteria [97], and antibiotic prophylaxis within 1 hour before surgical incision is recommended [64]. First-line agents are cefazolin or cefuroxime (1.0 or 1.5 g) [64] or, in documented β-lactam allergy, clindamycin (600 mg) or vancomycin (20 mg/kg body weight) [64]. 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 [98]. 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 [96]. Vancomycin should be administered within 2 hours of the surgical incision [64].

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 [99, 100], 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 [101]. The European CABG registry showed no increased risk of re-stemotomy because of bleeding if acetylsalicylic acid (ASA) was discontinued less than 7 days before CABG [102]. The 2017 EACTS guidelines recommend continuation of ASA throughout the preoperative period in patients having CABG surgery, and ASA should be restarted within 24 hours [64]. 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 hours after surgery, and in patients considered at low risk, inhibitors should be restarted within 3-4 days after cardiac surgery

[64]. In CABG patients with prior MI at high risk of bleeding, P2Y12 inhibitors are discontinued 6 months postoperatively [101].

The addition of dual antiplatelet therapy to oral anticoagulants results in a two to threefold increase in bleeding complications [103]. Triple therapy is only used if a compelling indication exists, and should be terminated upon hospital discharge [101].

The HAS-BLED (*h*ypertension, *a*bnormal renal/liver function, *s*troke, *b*leeding history or predisposition, *l*abile international normalized ratio, *e*lderly [>65 years], *d*rugs/alcohol concomitantly) score has been shown to outperform $CHADS_2$ (*c*ongestive heart failure, *h*ypertension, age ≥75 years, *d*iabetes. *s*troke [2 points], and CHA_2DS_2-VASc (*c*ongestive heart failure, *h*ypertension, *a*ge ≥75 years [2 points], *d*iabetes. *s*troke [2 points], *v*ascular disease, *a*ge [65-74 years], *s*ex *c*ategory [female) in predicting bleeding risk [101, 104]. 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 [105]. DOACs should be discontinued two 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 [105], and is associated with significantly higher bleeding risk (OR 16.8; 95% CI 3.8–78.9, $p < 0.001$) [106].

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 [105, 107, 108, 109].

Current guidelines recommend stopping vitamin K antagonists (VKA) five days before cardiac surgery [64]. Bridging with FMWH 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 [64]) or ≥8 (American guidelines [110]) 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 [64]. FMWH should be discontinued 24 hrs before cardiac surgery, and UFH is stopped 6 hours before procedures [64].

Intraoperative autologous blood collection and re-transfusion is recommended when expected blood loss is > 500 mL, as it reduces exposure to allogenic blood products, infections and extended hospital stays [111, 107, 112].

Shared Decision Making

All treatment options, scientific evidence, and the patient's healthcare goals should be discussed in a multidisciplinary 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 [113]. 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.

Acknowledgements:

The authors acknowledge the Agency for Healthcare Research and Quality (AHRQ) for its support of Dr. Richard D. Urman's research on shared decision-making 5R01HS025718-02. The authors also acknowledge Jeannie Wurz, Medical Editor, for careful reading and editing of the manuscript, as well as Dr. Tatjana Dill from the Bern University Hospital, for her inputs for preparing this manuscript.

Funding: Richard D. Urman is funded by the U.S. federal AHRQ grant # 5R01HS025718-02

Conflict of Interest

Maks Mihalj declares that he has no conflict of interest.

Thierry Carrel declares that he has no conflict of interest.

Richard D. Urman has received research funding from Merck, Medtronic, Takeda, Mallinckrodt, and NSF International.

Frank Stueber declares that he has no conflict of interest.

Markus M. Luedi declares that he has no conflict of interest.

References:

Articles of particular interest, published recently, have been highlighted as:

*Of importance,

**Of major importance

1. Lombardi C, Sbolli M, Cani D, Masini G, Metra M, Faggiano P. Preoperative cardiac risks in noncardiac surgery: The role of coronary angiography. Monaldi Archives for Chest Disease. 2017;87(2).
2. Cornelissen H, Arrowsmith JE. Preoperative assessment for cardiac surgery. Continuing Education in Anaesthesia, Critical Care & Pain. 2006;6(3):109–13.
3. Kristensen SD, Knuuti J, Saraste A, Anker S, Botker HE, De Hert S et al. 2014 ESC/ESA Guidelines on non-cardiac surgery: cardiovascular assessment and management: The Joint Task Force on non-cardiac surgery: cardiovascular assessment and management of the European Society of Cardiology (ESC) and the European Society of Anaesthesiology (ESA). European journal of anaesthesiology. 2014;31(10):517–73. doi:10.1097/eja.0000000000000150. [PubMed: 25127426]
4. Morales D, Williams E, John R. Is resternotomy in cardiac surgery still a problem? Interactive cardiovascular and thoracic surgery. 2010;11(3):277–86. doi: 10.1510/icvts.2009.232090. [PubMed: 20525761]
5. JI Ejiofor, Ramirez-Del Val F, Nohria A, Norman A, McGurk S, Aranki SF et al. The risk of reoperative cardiac surgery in radiation-induced valvular disease. The Journal of thoracic and cardiovascular surgery. 2017; 154(6): 1883–95. doi: 10.1016/j.jtcvs.2017.07.033. [PubMed: 28870399]
6. Gujral DM, Lloyd G, Bhattacharyya S. Radiation-induced valvular heart disease. Heart (British Cardiac Society). 2016;102(4):269–76. doi: 10.1136/heartjnl-2015-308765. [PubMed: 26661320]
7 ••. Quinn TD, Wolczynski P, Sroka R, Urman RD. Creating a Pathway for Multidisciplinary Shared Decision-Making to Improve Communication During Preoperative Assessment. Anesthesiology clinics. 2018;36(4):653–62. doi:10.1016/j.anclin.2018.07.011. [PubMed: 30390785] Recent overview of the importance of shared decision making process through improved communication emphasizing the role of anesthesia in the process.
8. James LA, Levin MA, Lin HM, Deiner SG. Association of Preoperative Frailty With Intraoperative Hemodynamic Instability and Postoperative Mortality. Anesthesia and analgesia. 2019; 128(6): 1279–85. doi: 10.1213/ane.0000000000004085. [PubMed: 31094800]
9. Esses GJ, Liu X, Lin HM, Khelemsky Y, Deiner S. Preoperative frailty and its association with postsurgical pain in an older patient cohort. Regional anesthesia and pain medicine. 2019. doi: 10.1136/rapm-2018-100247.
10. Rengel KF, Hayhurst CJ, Pandharipande PP, Hughes CG. Long-term Cognitive and Functional Impairments After Critical Illness. Anesthesia and analgesia. 2019;128(4):772–80. doi: 10.1213/ane.0000000000004066. [PubMed: 30883422]
11. Graham A, Brown CHt. Frailty, Aging, and Cardiovascular Surgery. Anesth Analg. 2017; 124(4): 1053–60. doi: 10.1213/ane.0000000000001560. [PubMed: 27622718]
12 ••. McCann M, Stamp N, Ngui A, Litton E Cardiac Prehabilitation. Journal of cardiothoracic and vascular anesthesia. 2019;33(8):2255–65. doi:10.1053/j.jvca.2019.01.023. [PubMed: 30765210] Recent review focusing on the role of preconditioning the patient before cardiac surgery, and discussing the ways to minimize peri- and postoperative mortality through modifiable risk factors.
13 ••. Alvarez-Nebreda ML, Bentov N, Urman RD, Setia S, Huang JC, Pfeifer K et al. Recommendations for Preoperative Management of Frailty from the Society for Perioperative Assessment and Quality Improvement (SPAQI). Journal of clinical anesthesia. 2018;47:33–42. doi:10.1016/j.jclinane.2018.02.011. [PubMed: 29550619] 2018 international recommendations on preoperative diagnostics and management of frail patients.
14. Nilsson J, Algotsson L, Hoglund P, Luhrs C, Brandt J. Early mortality in coronary bypass surgery: the EuroSCORE versus The Society of Thoracic Surgeons risk algorithm. The Annals of thoracic surgery. 2004;77(4): 1235–9; discussion 9–40. doi:10.1016/j.athoracsur.2003.08.034. [PubMed: 15063242]
15. Gogbashian A, Sedrakyan A, Treasure T. EuroSCORE: a systematic review of international performance. European journal of cardio-thoracic surgery : official journal of the European Association for Cardio-thoracic Surgery. 2004;25(5):695–700. doi:10.1016/j.ejcts.2004.02.022. [PubMed: 15082269]
16. Noyez L, Kievit PC, van Swieten HA, de Boer MJ. Cardiac operative risk evaluation: The EuroSCORE II, does it make a real difference? Netherlands heart journal: monthly journal of the

Netherlands Society of Cardiology and the Netherlands Heart Foundation. 2012;20(12):494–8. doi: 10.1007/s12471-012-0327-1.

17. Ad N, Holmes SD, Patel J, Pritchard G, Shuman DJ, Halpin L. Comparison of EuroSCORE II, Original EuroSCORE, and The Society of Thoracic Surgeons Risk Score in Cardiac Surgery Patients. The Annals of thoracic surgery. 2016;102(2):573–9. doi: 10.1016/j.athoracsur.2016.01.105. [PubMed: 27112651]
18. Qadir I, Alamzaib SM, Ahmad M, Perveen S, Sharif H. EuroSCORE vs. EuroSCORE II vs. Society of Thoracic Surgeons risk algorithm. Asian cardiovascular & thoracic annals. 2014;22(2):165–71. doi: 10.1177/0218492313479355. [PubMed: 24585787]
19. Afilalo J, Alexander KP, Mack MJ, Maurer MS, Green P, Allen LA et al. Frailty assessment in the cardiovascular care of older adults. Journal of the American College of Cardiology. 2014;63(8):747–62. doi:10.1016/j.jacc.2013.09.070. [PubMed: 24291279]
20. Lee DH, Buth KJ, Martin BJ, Yip AM, Hirsch GM. Frail patients are at increased risk for mortality and prolonged institutional care after cardiac surgery. Circulation. 2010;121(8):973–8. doi: 10.1161/circulationaha.108.841437. [PubMed: 20159833]
21. Arnold SV, Afilalo J, Spertus JA, Tang Y, Baron SJ, Jones PG et al. Prediction of Poor Outcome After Transcatheter Aortic Valve Replacement. Journal of the American College of Cardiology. 2016;68(17):1868–77. doi:10.1016/j.jacc.2016.07.762. [PubMed: 27765189]

22 ••. Acosta A, Garzon MP, Urman RD. Screening and Diagnosing Frailty in the Cardiac and Noncardiac Surgical Patient to Improve Safety and Outcomes. International anesthesiology clinics. 2019;57(3):111–22. doi: 10.1097/aia.0000000000000239. [PubMed: 31577242] Comprehensive review of currently available evidence about frailty assessment in surgical patients and the importance of pre- and postoperative strategies to improve outcomes in such patients.

23 •. Joseph SM, Manghelli JL, Vader JM, Keeney T, Novak EL, Felius J et al. Prospective Assessment of Frailty Using the Fried Criteria in Patients Undergoing Left Ventricular Assist Device Therapy. The American journal of cardiology. 2017;120(8):1349–54. doi:10.1016/j.amjcard.2017.07.074. [PubMed: 28843393] Recent prospective study focusing on the diagnosis and role of frailty in patients with advanced heart failure undergoing LVAD implantation using the modified Fried criteria.

24. Fried LP, Tangen CM, Walston J, Newman AB, Hirsch C, Gottdiener J et al. Frailty in older adults: evidence for a phenotype. The journals of gerontology Series A, Biological sciences and medical sciences. 2001;56(3):M146–56. doi:10.1093/gerona/56.3.m146.
25. Bentov I, Kaplan SJ, Pham TN, Reed MJ. Frailty assessment: from clinical to radiological tools. British journal of anaesthesia. 2019;123(1):37–50. doi:10.1016/j.bja.2019.03.034. [PubMed: 31056240]
26. Pugh RN, Murray-Lyon IM, Dawson JL, Pietroni MC, Williams R. Transection of the oesophagus for bleeding oesophageal varices. Br J Surg. 1973;60(8):646–9. doi: 10.1002/bjs.1800600817. [PubMed: 4541913]
27. Hsieh WC, Chen PC, Corciova FC, Tinica G. Liver dysfunction as an important predicting risk factor in patients undergoing cardiac surgery: a systematic review and meta-analysis. International journal of clinical and experimental medicine. 2015;8(11):20712–21. [PubMed: 26884994]
28. Yang JA, Kato TS, Shulman BP, Takayama H, Farr M, Jorde UP et al. Liver dysfunction as a predictor of outcomes in patients with advanced heart failure requiring ventricular assist device support: Use of the Model of End-stage Liver Disease (MELD) and MELD excluding INR (MELD-XI) scoring system. The Journal of heart and lung transplantation : the official publication of the International Society for Heart Transplantation. 2012;31(6):601–10. doi:10.1016/j.healun.2012.02.027.
29. Gustin AN Jr. Shared Decision-Making. Anesthesiology clinics. 2019;37(3):573–80. doi:10.1016/j.anclin.2019.05.001. [PubMed: 31337486] Comprehensive overview of the importance of shared decision making in surgical patients.

30 ••. Gainer RA, Curran J, Buth KJ, David JG, Legare JF, Hirsch GM. Toward Optimal Decision Making among Vulnerable Patients Referred for Cardiac Surgery: A Qualitative Analysis of Patient and Provider Perspectives. Medical decision making : an international journal of the Society for Medical Decision Making. 2017;37(5):600–10. doi:10.1177/0272989x16675338.

[PubMed: 27803362] Recent study analysing the efficacy of shared decision making process in cardiac surgery patients, providing suggestions how to improve the patients' understanding.

31 ••. Urman RD, Southerland WA, Shapiro FE, Joshi GP. Concepts for the Development of Anesthesia-Related Patient Decision Aids. Anesthesia and analgesia. 2019;128(5):1030–5. doi: 10.1213/ane.0000000000003804. [PubMed: 30320645] Recent comprehensive overview of the literature in shared decision making, focusing on methods and aids from the anesthesiological perspective.

32 ••. Sroka R, Gabriel EM, Al-Hadidi D, Nurkin SJ, Urman RD, Quinn TD. A novel anesthesiologist-led multidisciplinary model for evaluating high-risk surgical patients at a comprehensive cancer center. Journal of healthcare risk management: the journal of the American Society for Healthcare Risk Management. 2019;38(3):12–23. doi:10.1002/jhrm.21326. [PubMed: 30033650] Recent study analyzing the effectiveness when identifying high-risk patients for surgery in cancer populations, and suggestions fora novel anesthesiology-led model for identifying respective patients prior to surgery.

33. Chaudhry W, Cohen MC. Cardiac Screening in the Noncardiac Surgery Patient. The Surgical clinics of North America. 2017;97(4):717–32. doi:10.1016/j.suc.2017.03.010. [PubMed: 28728711]

34. Garg PK. Preoperative cardiovascular evaluation in patients undergoing vascular surgery. Cardiology clinics. 2015;33(1):139–50. doi:10.1016/j.ccl.2014.09.004. [PubMed: 25439336]

35 ••. Pichette M, Liszkowski M, Ducharme A. Preoperative Optimization of the Heart Failure Patient Undergoing Cardiac Surgery. The Canadian journal of cardiology. 2017;33(1):72–9. doi:10.1016/j.cjca.2016.08.004. [PubMed: 27876563] Recent comprehensive overview of the existing literature on preoperative optimization in heart failure patients undergoing cardiac surgery.

36. Englberger L, Suri RM, Li Z, Casey ET, Daly RC, Dearani JA et al. Clinical accuracy of RIFLE and Acute Kidney Injury Network (AKIN) criteria for acute kidney injury in patients undergoing cardiac surgery. Critical care (London, England). 2011;15(1):R16. doi: 10.1186/cc9960.

37. Bastin AJ, Ostermann M, Slack AJ, Diller GP, Finney SJ, Evans TW. Acute kidney injury after cardiac surgery according to Risk/Injury/Failure/Loss/End-stage, Acute Kidney Injury Network, and Kidney Disease: Improving Global Outcomes classifications. Journal of critical care. 2013;28(4):389–96. doi:10.1016/j.jcrc.2012.12.008. [PubMed: 23743540]

38. Pannu N, Graham M, Klarenbach S, Meyer S, Kieser T, Hemmelgarn B et al. A new model to predict acute kidney injury requiring renal replacement therapy after cardiac surgery. CMAJ : Canadian Medical Association journal = journal de I'Association medicale canadienne. 2016; 188(15): 1076–83. doi: 10.1503/cmaj.151447.

39. Ranucci M, Castelvecchio S, Menicanti L, Frigiola A, Pelissero G. Risk of assessing mortality risk in elective cardiac operations: age, creatinine, ejection fraction, and the law of parsimony. Circulation. 2009; 119(24):3053–61. doi: 10.1161/circulationaha.108.842393. [PubMed: 19506110]

40 •. Kim K, Joung KW, Ji SM, Kim JY, Lee EH, Chung CH et al. The effect of coronary angiography timing and use of cardiopulmonary bypass on acute kidney injury after coronary artery bypass graft surgery. The Journal of thoracic and cardiovascular surgery. 2016;152(1):254–61.e3. doi:10.1016/j.jtcvs.2016.02.063. [PubMed: 27060028] Large study focusing on the importance of timing/delaying cardiac surgery after coronary angiography and iodine contrast administration.

41 ••. Nadim MK, Forni LG, Bihorac A, Hobson C, Koyner JL, Shaw A et al. Cardiac and Vascular Surgery-Associated Acute Kidney Injury: The 20th International Consensus Conference of the ADQI (Acute Disease Quality Initiative) Group. Journal of the American Heart Association. 2018;7(11). doi: 10.1161/jaha.118.008834.2018 international consensus statement of the ADQI task force on acute kidney failure in cardiac surgery patients.

42. Coca SG, Garg AX, Swaminathan M, Garwood S, Hong K, Thiessen-Philbrook H et al. Preoperative angiotensin-converting enzyme inhibitors and angiotensin receptor blocker use and acute kidney injury in patients undergoing cardiac surgery. Nephrology, dialysis, transplantation : official publication of the European Dialysis and Transplant Association - European Renal Association. 2013;28(11):2787–99. doi: 10.1093/ndt/gft405.

43. Yacoub R, Patel N, Lohr JW, Rajagopalan S, Nader N, Arora P. Acute kidney injury and death associated with renin angiotensin system blockade in cardiothoracic surgery: a meta-analysis of

observational studies. American journal of kidney diseases : the official journal of the National Kidney Foundation. 2013;62(6): 1077–86. doi:10.1053/j.ajkd.2013.04.018. [PubMed: 23791246]

44. Lee EH, Kim WJ, Kim JY, Chin JH, Choi DK, Sim JY et al. Effect of Exogenous Albumin on the Incidence of Postoperative Acute Kidney Injury in Patients Undergoing Off-pump Coronary Artery Bypass Surgery with a Preoperative Albumin Level of Less Than 4.0 g/dl. Anesthesiology. 2016; 124(5): 1001 −11. doi: 10.1097/aln.0000000000001051. [PubMed: 26891150]

45. Hu Y, Li Z, Chen J, Shen C, Song Y, Zhong Q. The effect of the time interval between coronary angiography and on-pump cardiac surgery on risk of postoperative acute kidney injury: a meta analysis. Journal of cardiothoracic surgery. 2013;8:178. doi:10.1186/1749-8090-8-178. [PubMed: 23915489]

46. Zhang Y, Ye N, Chen YP, Cheng H. Relation between the interval from coronary angiography to selective off-pump coronary artery bypass grafting and postoperative acute kidney injury. The American journal of cardiology. 2013;112(10):1571–5. doi:10.1016/j.amjcard.2013.07.011. [PubMed: 23993118]

47. Kellum JA, J MD. Use of dopamine in acute renal failure: a meta-analysis. Critical care medicine. 2001 ;29(8): 1526–31. doi: 10.1097/00003246-200108000-00005. [PubMed: 11505120]

48. Lassnigg A, Donner E, Grubhofer G, Presterl E, Druml W, Hiesmayr M. Lack of renoprotective effects of dopamine and furosemide during cardiac surgery. Journal of the American Society of Nephrology : JASN. 2000;11(1):97–104. [PubMed: 10616845]

49. Lopez-Delgado JC, Esteve F, Javierre C, Ventura JL, Manez R, Farrero E et al. Influence of cirrhosis in cardiac surgery outcomes. World journal of hepatology. 2015;7(5):753–60. doi: 10.4254/wjh.v7.i5.753. [PubMed: 25914775]

50. Modi A, Vohra HA, Barlow CW. Do patients with liver cirrhosis undergoing cardiac surgery have acceptable outcomes? Interactive cardiovascular and thoracic surgery. 2010;11(5):630–4. doi: 10.1510/icvts.2010.241190. [PubMed: 20739405]

51 •. Deppe AC, Weber C, Zimmermann J, Kuhn EW, Slottosch I, Liakopoulos OJ et al. Point-of-care thromboelastography/thromboelastometry-based coagulation management in cardiac surgery: a meta-analysis of 8332 patients. The Journal of surgical research. 2016;203(2):424–33. doi:10.1016/j.jss.2016.03.008. [PubMed: 27363652] Large meta-analysis emphasizing the importance of perioperative point-of-care diagnostics as decision-making aid for coagulation management in cardiac surgery patients.

52. Bhamidipati CM, LaPar DJ, Mehta GS, Kern JA, Upchurch GR Jr., Kron IL et al. Albumin is a better predictor of outcomes than body mass index following coronary artery bypass grafting. Surgery. 2011;150(4):626–34. doi: 10.1016/j.surg.2011.07.056. [PubMed: 22000173]

53. Thourani VH, Keeling WB, Kilgo PD, Puskas JD, Lattouf OM, Chen EP et al. The impact of body mass index on morbidity and short- and long-term mortality in cardiac valvular surgery. The Journal of thoracic and cardiovascular surgery. 2011; 142(5): 1052–61. doi: 10.1016/j.jtcvs.2011.02.009. [PubMed: 21450310]

54. Go PH, Hodari A, Nemeh HW, Borgi J, Lanfear DE, Williams CT et al. Effect of Preoperative Albumin Levels on Outcomes in Patients Undergoing Left Ventricular Device Implantation. ASAIO journal (American Society for Artificial Internal Organs : 1992). 2015;61(6):734–7. doi: 10.1097/mat.0000000000000272. [PubMed: 26262585]

55. Yu PJ, Cassiere HA, Dellis SL, Manetta F, Kohn N, Hartman AR. Impact of Preoperative Prealbumin on Outcomes After Cardiac Surgery. JPEN Journal of parenteral and enteral nutrition. 2015;39(7):870–4. doi:10.1177/0148607114536735. [PubMed: 24898210]

56. Zambouri A Preoperative evaluation and preparation for anesthesia and surgery. Hippokratia. 2007; 11 (1): 13–21. [PubMed: 19582171]

57. Brooks-Brunn JA. Postoperative atelectasis and pneumonia: risk factors. American journal of critical care : an official publication, American Association of Critical-Care Nurses. 1995;4(5):340–9; quiz 50–1.

58. Mendez-Tellez P, Dorman T, Cameron J. Current Surgical Therapy. 9th edition ed. Philadelphia: Mosby; 2008.

59. Katsura M, Kuriyama A, Takeshima T, Fukuhara S, Furukawa TA. Preoperative inspiratory muscle training for postoperative pulmonary complications in adults undergoing cardiac and major

abdominal surgery. The Cochrane database of systematic reviews. 2015(10):Cd010356. doi: 10.1002/14651858.CD010356.pub2. [PubMed: 26436600]

60. Cordeiro AL, de Melo TA, Neves D, Luna J, Esquivel MS, Guimaraes AR et al. Inspiratory Muscle Training and Functional Capacity in Patients Undergoing Cardiac Surgery. Brazilian journal of cardiovascular surgery. 2016;31(2):140–4. doi:10.5935/1678-9741.20160035. [PubMed: 27556313]

61. Nomori H, Kobayashi R, Fuyuno G, Morinaga S, Yashima H. Preoperative respiratory muscle training. Assessment in thoracic surgery patients with special reference to postoperative pulmonary complications. Chest. 1994; 105(6): 1782–8. doi: 10.1378/chest.105.6.1782. [PubMed: 8205877]

62. Ascione R, Rogers CA, Rajakaruna C, Angelini GD. Inadequate blood glucose control is associated with in-hospital mortality and morbidity in diabetic and nondiabetic patients undergoing cardiac surgery. Circulation. 2008; 118(2): 113–23. doi: 10.1161/circulationaha.107.706416. [PubMed: 18591441]

63. Gandhi GY, Nuttall GA, Abel MD, Mullany CJ, Schaff HV, O'Brien PC et al. Intensive intraoperative insulin therapy versus conventional glucose management during cardiac surgery: a randomized trial. Annals of internal medicine. 2007;146(4):233–43. doi: 10.7326/0003-4819-146-4-200702200-00002. [PubMed: 17310047]

64 ••. Sousa-Uva M, Head SJ, Milojevic M, Collet JP, Landoni G, Castella M et al. 2017 EACTS Guidelines on perioperative medication in adult cardiac surgery. European journal of cardio-thoracic surgery : official journal of the European Association for Cardio-thoracic Surgery. 2018;53(1):5–33. doi:10.1093/ejcts/ezx314. [PubMed: 29029110] Most recent guidelines on pre-, peri- and postopertive medication management in cardiac surgery patients.

65 ••. Neumann FJ, Sousa-Uva M, Ahlsson A, Alfonso F, Banning AP, Benedetto U et al. 2018 ESC/EACTS Guidelines on myocardial revascularization. European heart journal. 2019;40(2):87–165. doi:10.1093/eurheartj/ehy394. [PubMed: 30165437] 2018 ESC/EACTS guidelines on myocardial revascularization.

66. Goergen SK, Rumbold G, Compton G, Harris C. Systematic review of current guidelines, and their evidence base, on risk of lactic acidosis after administration of contrast medium for patients receiving metformin. Radiology. 2010;254(1):261–9. doi: 10.1148/radiol.09090690. [PubMed: 20032157]

67. Kulier A, Levin J, Moser R, Rumpold-Seitlinger G, Tudor IC, Snyder-Ramos SA et al. Impact of preoperative anemia on outcome in patients undergoing coronary artery bypass graft surgery. Circulation. 2007; 116(5):471–9. doi: 10.1161/circulationaha.106.653501. [PubMed: 17620512]

68 ••. Mueller MM, Van Remoortel H, Meybohm P, Aranko K, Aubron C, Burger R et al. Patient Blood Management: Recommendations From the 2018 Frankfurt Consensus Conference. Jama. 2019;321(10):983–97. doi:10.1001/jama.2019.0554. [PubMed: 30860564] 2019 international consensus statements on patient blood management in pre-, peri- and postoperative setting including cardiac surgery patients.

69 •. Munoz M, Gomez-Ramirez S, Kozek-Langeneker S. Pre-operative haematological assessment in patients scheduled for major surgery. Anaesthesia. 2016;71 Suppl 1:19–28. doi: 10.1111/anae.13304.Comprehensive review of the role and ways of achieving patient blood managements that are beneficial for postoperative outcome after major surgery.

70 •. Carson JL, Stanworth SJ, Alexander JH, Roubinian N, Fergusson DA, Triulzi DJ et al. Clinical trials evaluating red blood cell transfusion thresholds: An updated systematic review and with additional focus on patients with cardiovascular disease. American heart journal. 2018;200:96–101. doi:10.1016/j.ahj.2018.04.007. [PubMed: 29898855] Recent large systematic review of randomized trials aiming at evaluating the thresholds in cardiac surgery patients.

71. Boening A, Boedeker RH, Scheibelhut C, Rietzschel J, Roth P, Schonburg M. Anemia before coronary artery bypass surgery as additional risk factor increases the perioperative risk. The Annals of thoracic surgery. 2011;92(3):805–10. doi:10.1016/j.athoracsur.2011.02.076. [PubMed: 21592459]

72. Michtalik HJ, Yeh HC, Campbell CY, Haq N, Park H, Clarkek W et al. Acute changes in N-terminal pro-B-type natriuretic peptide during hospitalization and risk of readmission and mortality in patients with heart failure. The American journal of cardiology. 2011; 107(8): 1191–5. doi:10.1016/j.amjcard.2010.12.018. [PubMed: 21296322]

73 ••. Lobo SA, Fischer S. Cardiac Risk Assessment StatPearls. Treasure Island (FL): StatPearls Publishing. StatPearls Publishing LLC; 2019.Comprehensive overview of existing literature about cardiac risk assessment tools and factors contributing to increased cardiovascular risk profiles.

74 ••. Baumgartner H, Falk V, Bax JJ, De Bonis M, Hamm C, Holm PJ et al. 2017 ESC/EACTS Guidelines for the management of valvular heart disease. European heart journal. 2017;38(36):2739–91. doi:10.1093/eurheartj/ehx391. [PubMed: 28886619] 2017 ESC/EACTS guidelines for the management of patients with valvular heart disease.

75. Taylor AJ, Cerqueira M, Hodgson JM, Mark D, Min J, O'Gara P et al. ACCF/SCCT/ACR/AHA/ASE/ASNC/NASCI/SCAI/SCMR 2010 appropriate use criteria for cardiac computed tomography. A report of the American College of Cardiology Foundation Appropriate Use Criteria Task Force, the Society of Cardiovascular Computed Tomography, the American College of Radiology, the American Heart Association, the American Society of Echocardiography, the American Society of Nuclear Cardiology, the North American Society for Cardiovascular Imaging, the Society for Cardiovascular Angiography and Interventions, and the Society for Cardiovascular Magnetic Resonance. Journal of the American College of Cardiology. 2010;56(22):1864–94. doi: 10.1016/j.jacc.2010.07.005. [PubMed: 21087721]

76. Naylor AR, Mehta Z, Rothwell PM, Bell PR. Carotid artery disease and stroke during coronary artery bypass: a critical review of the literature. European journal of vascular and endovascular surgery : the official journal of the European Society for Vascular Surgery. 2002;23(4):283–94. doi: 10.1053/ejvs.2002.1609.

77 ••. Naylor AR, Ricco JB, de Borst GJ, Debus S, de Haro J, Halliday A et al. Editor's Choice - Management of Atherosclerotic Carotid and Vertebral Artery Disease: 2017 Clinical Practice Guidelines of the European Society for Vascular Surgery (ESVS). European journal of vascular and endovascular surgery : the official journal of the European Society for Vascular Surgery. 2018;55(1):3–81. doi:10.1016/j.ejvs.2017.06.021.2017 ESVS guidelines for managing carotid artery disease.

78. Blessberger H, Kammler J, Steinwender C. Perioperative use of beta-blockers in cardiac and noncardiac surgery. Jama. 2015;313(20):2070–1. doi:10.1001/jama.2015.1883. [PubMed: 26010637]

79. Fleisher LA, Beckman JA, Brown KA, Calkins H, Chaikof E, Fleischmann KE et al. ACC/AHA 2006 guideline update on perioperative cardiovascular evaluation for noncardiac surgery: focused update on perioperative beta-blocker therapy: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Writing Committee to Update the 2002 Guidelines on Perioperative Cardiovascular Evaluation for Noncardiac Surgery): developed in collaboration with the American Society of Echocardiography, American Society of Nuclear Cardiology, Heart Rhythm Society, Society of Cardiovascular Anesthesiologists, Society for Cardiovascular Angiography and Interventions, and Society for Vascular Medicine and Biology. Circulation. 2006;113(22):2662–74. doi:10.1161/circulationaha.106.176009. [PubMed: 16754815]

80. Steinberg BA, Zhao Y, He X, Hernandez AF, Fullerton DA, Thomas KL et al. Management of postoperative atrial fibrillation and subsequent outcomes in contemporary patients undergoing cardiac surgery: insights from the Society of Thoracic Surgeons CAPS-Care Atrial Fibrillation Registry. Clinical cardiology. 2014;37(1):7–13. doi:10.1002/clc.22230. [PubMed: 24353215]

81 •. Chandra A, Lewis EF, Claggett BL, Desai AS, Packer M, Zile MR et al. Effects of Sacubitril/Valsartan on Physical and Social Activity Limitations in Patients With Heart Failure: A Secondary Analysis of the PARADIGM-HF Trial. JAMA cardiology. 2018;3(6):498–505. doi: 10.1001/jamacardio.2018.0398. [PubMed: 29617523] Recent results from the large multicenter prospective double-blind control PARADIGM-Trial showing beneficial effect of angiotensin-neprilysin inhibition in heart failure patients.

82 •. Khariton Y, Fonarow GC, Arnold SV, Hellkamp A, Nassif ME, Sharma PP et al. Association Between Sacubitril/Valsartan Initiation and Health Status Outcomes in Heart Failure With Reduced Ejection Fraction. JACC Heart failure. 2019. doi: 10.1016/j.jchf.2019.05.016.Results from the large multicenter CHAMP-HF-registry showing beneficial effect in subjective overall health status in patients with heart failure under sacubitril/valsartan therapy.

83. Mangieri A Renin-angiotensin system blockers in cardiac surgery. Journal of critical care. 2015;30(3):613–8. doi: 10.1016/j.jcrc.2015.02.017. [PubMed: 25813547]

84. Savarese G, Costanzo P, Cleland JG, Vassallo E, Ruggiero D, Rosano G et al. A meta analysis reporting effects of angiotensin-converting enzyme inhibitors and angiotensin receptor blockers in patients without heart failure. Journal of the American College of Cardiology. 2013;61 (2): 131–42. doi: 10.1016/j.jacc.2012.10.011. [PubMed: 23219304]
85. Rouleau JL, Warnica WJ, Baillot R, Block PJ, Chocron S, Johnstone D et al. Effects of angiotensin-converting enzyme inhibition in low-risk patients early after coronary artery bypass surgery. Circulation. 2008;117(1):24–31. doi:10.1161/circulationaha.106.685073. [PubMed: 18071079]
86. Zheng Z, Jayaram R, Jiang L, Emberson J, Zhao Y, Li Q et al. Perioperative Rosuvastatin in Cardiac Surgery. The New England journal of medicine. 2016;374(18):1744–53. doi: 10.1056/NEJMoal507750. [PubMed: 27144849]
87. Filsoufi F, Rahmanian PB, Castillo JG, Scurlock C, Legnani PE, Adams DH. Predictors and outcome of gastrointestinal complications in patients undergoing cardiac surgery. Annals of surgery. 2007;246(2):323–9. doi:10.1097/SLA.0b013e3180603010. [PubMed: 17667513]
88. Shin JS, Abah U. Is routine stress ulcer prophylaxis of benefit for patients undergoing cardiac surgery? Interactive cardiovascular and thoracic surgery. 2012;14(5):622–8. doi: 10.1093/icvts/ivs019. [PubMed: 22345061]
89. Hata M, Shiono M, Sekino H, Furukawa H, Sezai A, lida M et al. Prospective randomized trial for optimal prophylactic treatment of the upper gastrointestinal complications after open heart surgery. Circulation journal: official journal of the Japanese Circulation Society. 2005;69(3):331–4. doi:10.1253/circj.69.331. [PubMed: 15731540]
90. Whitlock RP, Devereaux PJ, Teoh KH, Lamy A, Vincent J, Pogue J et al. Methylprednisolone in patients undergoing cardiopulmonary bypass (SIRS): a randomised, double-blind, placebo-controlled trial. Lancet (London, England). 2015;386(10000):1243–53. doi:10.1016/s0140-6736(15)00273-1.
91. Dieleman JM, Nierich AP, Rosseel PM, van der Maaten JM, Hofland J, Diephuis JC et al. Intraoperative high-dose dexamethasone for cardiac surgery: a randomized controlled trial. Jama. 2012;308(17):1761–7. doi:10.1001/jama.2012.14144. [PubMed: 23117776]
92. Liu MM, Reidy AB, Saatee S, Collard CD. Perioperative Steroid Management: Approaches Based on Current Evidence. Anesthesiology. 2017;127(1):166–72. doi: 10.1097/aln.0000000000001659. [PubMed: 28452806]
93. Gelijns AC, Moskowitz AJ, Acker MA, Argenziano M, Geller NL, Puskas JD et al. Management practices and major infections after cardiac surgery. Journal of the American College of Cardiology. 2014;64(4):372–81. doi:10.1016/j.jacc.2014.04.052. [PubMed: 25060372]
94. Fowler VG Jr., O'Brien SM, Muhlbaier LH, Corey GR, Ferguson TB, Peterson ED. Clinical predictors of major infections after cardiac surgery. Circulation. 2005; 112(9 Suppl):l358–65. doi: 10.1161/circulationaha.104.525790.
95. Lepelletier D, Bourigault C, Roussel JC, Lasserre C, Leclere B, Corvee S et al. Epidemiology and prevention of surgical site infections after cardiac surgery. Medecine et maladies infectieuses. 2013;43(10):403–9. doi:10.1016/j.medmal.2013.07.003. [PubMed: 23988675]
96 •. Vos RJ, Van Putte BP, Kloppenburg GTL. Prevention of deep sternal wound infection in cardiac surgery: a literature review. The Journal of hospital infection. 2018;100(4):411–20. doi: 10.1016/j.jhin.2018.05.026. [PubMed: 29885873] Comprehensive overview of managing patients with deep sternal wound infections and suggestions on implementing current guidelines updates for preventive measures.
97. Gudbjartsson T, Jeppsson A, Sjogren J, Steingrimsson S, Geirsson A, Friberg O et al. Sternal wound infections following open heart surgery - a review. Scandinavian cardiovascular journal: SCJ. 2016;50(5–6):341–8. doi:10.1080/14017431.2016.1180427. [PubMed: 27102109]
98. Lanckohr C, Horn D, Voeller S, Hempel G, Fobker M, Welp H et al. Pharmacokinetic characteristics and microbiologic appropriateness of cefazolin for perioperative antibiotic prophylaxis in elective cardiac surgery. The Journal of thoracic and cardiovascular surgery. 2016;152(2):603–10. doi: 10.1016/j.jtcvs.2016.04.024. [PubMed: 27209020]
99. Eikelboom JW, Mehta SR, Anand SS, Xie C, Fox KA, Yusuf S. Adverse impact of bleeding on prognosis in patients with acute coronary syndromes. Circulation. 2006;114(8):774–82. doi: 10.1161/circulationaha.106.612812. [PubMed: 16908769]

100. Rao SV, O'Grady K, Pieper KS, Granger CB, Newby LK, Van de Werf F et al. Impact of bleeding severity on clinical outcomes among patients with acute coronary syndromes. The American journal of cardiology. 2005;96(9): 1200–6. doi:10.1016/j.amjcard.2005.06.056. [PubMed: 16253582]

101 ••. Valgimigli M, Bueno H, Byrne RA, Collet JP, Costa F, Jeppsson A et al. 2017 ESC focused update on dual antiplatelet therapy in coronary artery disease developed in collaboration with EACTS: The Task Force for dual antiplatelet therapy in coronary artery disease of the European Society of Cardiology (ESC) and of the European Association for Cardio-Thoracic Surgery (EACTS). Eur Heart J. 2018;39(3):213–60. doi:10.1093/eurheartj/ehx419. [PubMed: 28886622] Recent consensus statements by the ESC and EACTS collaborative task force on dual antiplatelet therapy in CAD.

102 ••. Biancari F, Mariscalco G, Gherli R, Reichart D, Onorati F, Faggian G et al. Variation in preoperative antithrombotic strategy, severe bleeding, and use of blood products in coronary artery bypass grafting: results from the multicentre E-CABG registry. European heart journal Quality of care & clinical outcomes. 2018;4(4):246–57. doi:10.1093/ehjqcco/qcy027. [PubMed: 29939246] Recent analysis of the large prospective multicenter E-CABG registry focusing on the anticoagulative treatment and its effects on outcomes.

103. Sorensen R, Hansen ML, Abildstrom SZ, Hvelplund A, Andersson C, Jorgensen C et al. Risk of bleeding in patients with acute myocardial infarction treated with different combinations of aspirin, clopidogrel, and vitamin K antagonists in Denmark: a retrospective analysis of nationwide registry data. Lancet (London, England). 2009;374(9706): 1967–74. doi:10.1016/s0140-6736(09)61751-7.

104. Lane DA, Lip GY. Use of the CHA2DS2-VASc and HAS-BLED scores to aid decision making for thromboprophylaxis in nonvalvular atrial fibrillation. Circulation. 2012;126(7):860–5. [PubMed: 22891166]

105 ••. Erdoes G, De Arroyabe B Martinez Lopez, Bolliger D, Ahmed AB, Koster A, Agarwal S et al. International consensus statement on the peri-operative management of direct oral anticoagulants in cardiac surgery. Anaesthesia. 2018;73(12):1535–45. doi:10.1111/anae.14425. [PubMed: 30259961] Recent international consensus statement on pre- and perioperative management of direct oral anticoagulants in cardiac surgery patients.

106. Beyer-Westendorf J, Gelbricht V, Forster K, Ebertz F, Kohler C, Werth S et al. Peri-interventional management of novel oral anticoagulants in daily care: results from the prospective Dresden NOAC registry. European heart journal. 2014;35(28):1888–96. doi: 10.1093/eurheartj/eht557. [PubMed: 24394381]

107. Meybohm P, Zacharowski K, Weber CF. Point-of-care coagulation management in intensive care medicine. Critical care (London, England). 2013;17(2):218. doi: 10.1186/cc12527.

108. Perel P, Ker K, Morales Uribe CH, Roberts I. Tranexamic acid for reducing mortality in emergency and urgent surgery. The Cochrane database of systematic reviews. 2013(1):Cd010245. doi: 10.1002/14651858.CD010245.pub2. [PubMed: 23440847]

109. Ker K, Prieto-Merino D, Roberts I. Systematic review, meta-analysis and meta-regression of the effect of tranexamic acid on surgical blood loss. The British journal of surgery. 2013; 100(10): 1271–9. doi:10.1002/bjs.9193. [PubMed: 23839785]

110. January CT, Wann LS, Alpert JS, Calkins H, Cigarroa JE, Cleveland JC Jr. et al. 2014 AHA/ACC/HRS guideline for the management of patients with atrial fibrillation: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines and the Heart Rhythm Society. J Am Coll Cardiol. 2014;64(21):e1–76. doi: 10.1016/j.jacc.2014.03.022. [PubMed: 24685669]

111. Carless PA, Henry DA, Moxey AJ, O'Connell D, Brown T, Fergusson DA. Cell salvage for minimising perioperative allogeneic blood transfusion. The Cochrane database of systematic reviews. 2010(4):Cd001888. doi:10.1002/14651858.CD001888.pub4.

112 •. Meybohm P, Herrmann E, Steinbicker AU, Wittmann M, Gruenewald M, Fischer D et al. Patient Blood Management is Associated With a Substantial Reduction of Red Blood Cell Utilization and Safe for Patient's Outcome: A Prospective, Multicenter Cohort Study With a Noninferiority Design. Annals of surgery. 2016;264(2):203–11. doi:10.1097/sla.0000000000001747. [PubMed:

27163948] Recent prospective multicenter trial focusing on the role of patient blood management in surgical patients.

113 •. Robertson AC, Fowler LC, Niconchuk J, Kreger M, Rickerson E, Sadovnikoff N et al. Application of Kern's 6-Step Approach in the Development of a Novel Anesthesiology Curriculum for Perioperative Code Status and Goals of Care Discussions. The journal of education in perioperative medicine : JEPM. 2019;21(1):E634.Recent publication on shared decision making process with a suggestion of a novel curriculum design for anesthesiology residents' approach for efficient SDM and patient-centered-care.

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 feet in 6-7 seconds
Weakness	BMI and gender-stratified cutoffs
Weight loss	Unintentional loss of >10 lbs over the past year

Abbreviations: kcal: kilocalories, BMI: Body Mass Index

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 pints: Child-Pugh class B, 10-15 points: Child-Pugh class C

INR, International normalized ratio