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Risk stratification for non-cardiac surgery

T N Ngobeni

Department of Anaesthesia, Chris Hani Baragwanath Academic Hospital, University of the Witwatersrand
Correspondence to: Dineo1979@gmail.com

Introduction

Over 234 million major non-cardiac surgeries are performed annually worldwide with an estimated mortality rate of 0.5–1.5%. Perioperative major adverse cardiac events (MACE) contribute up to one third of these complications leading to prolonged hospital stay, increased medical cost and perioperative deaths annually.[1] The definition of perioperative cardiac complications is not standardised, however in the revised cardiac risk index (RCRI), which has been used for over 20 years, it is defined as cardiac death, non-fatal cardiac arrest, myocardial infarction, pulmonary oedema and complete heart block.[2] Research has shown that perioperative outcomes depend on the patient's premorbid state, the type of surgery and the circumstances under which the surgery took place. The mortality rate increases 1.5 times in patients diagnosed with coronary artery disease, heart failure, stroke and peripheral artery disease and by 2–5 times in emergency surgery.

A 2011 UK NCEPOD report on perioperative care of surgical patients evaluated over 19 000 major surgeries done in a period of a week and found that 20% of patients had significant cardiac risk factors and 55% of those patients had major surgery with a 30-day mortality rate of 6% for elective surgery and 30% for urgent or emergency surgery.[3]

Smilowitz et al. did a retrospective data analysis from hospital admissions for major non-cardiac surgery in the United States from 2004–2013 to evaluate the trend of perioperative major adverse cardiovascular and cerebrovasular events (MACCE) and the associated surgical subtypes. Data from over 10 million cases analysed found a 3% incidence which translated into 150 000 events annually with higher rates in vascular, thoracic and transplant surgery. The incidence has shown a declining trend over the past decade due to improvements in perioperative risk stratification, surgical and anaesthetic techniques. However, with the increasing number of high-risk patients presenting for major non-cardiac surgery, the concern is that the improvements that have been made will be attenuated.[1]

Importance of risk stratification

The aim is to reduce perioperative mortality and morbidity by:

- Identifying the patient's medical risk factors, their severity and stability
- Establishing a clinical risk profile
- Recommending needed specialty consultation, further testing or optimisation
- Evaluating the timing of surgery and its mortality risk
- Guidance on the appropriate level of perioperative care for the patient[4,5,6,7]

This facilitates informed decision-making by the healthcare provider and patient when weighing the risks and benefits of surgery.

Approach to risk stratification

All patients scheduled for elective non-cardiac surgery should be assessed for risk of MACE. There are several risk scores, risk

Table I. Findlay GP et al: Data from UK NCEPOD Prospective Audit of 19 097 patients having inpatient surgery 1–7 March 2010[3]

Comorbidity	30-day mortality %	Number of patients with comorbidity
Respiratory disease	3.7	1 810
Ischaemic heart disease	3.8	1 457
Cancer	3.8	1 417
Arrhythmias	5.7	1 029
Diabetes non-insulin	2.9	1 005
Cerebrovascular accident	4.4	591
Diabetes insulin	4.1	386
Congestive cardiac failure	8.2	243
Documented cirrhosis	8.9	123

prediction calculators and guidelines available to risk-stratify patients. Risk prediction scores assign importance to identified independent risk predictors of outcome and scores the patient on a scale derived from research done on similar patients e.g. RCRI score.

Risk prediction calculators estimate probability of risk by entering the patient's information into a multivariable risk-prediction model e.g. ACS NSQIP calculator. Listed below are different tools available:

- 1999 – RCRI score by Lee and Goldman
- 2011 – Gupta risk calculator
- 2013 – ACS NSQIP risk calculator
- 2014 – ACC/AHA and ESC Guidelines
- 2017 – Canadian Cardiovascular Society Guidelines

Revised cardiac risk index (RCRI) score

The first cardiac risk index for non-cardiac surgery which consisted of nine variables associated with increased risk of MACE, was developed by Goldman, et al. in 1977.

Table II. Goldman, et al.: Independent risk variables of cardiac complications[8]

Risk factors	Points
S3, distended JVP indicating HF	11
MI past six months	10
≥ 5 PVC/min prior surgery	7
Rhythm other than sinus	7
Age > 70 years	5
Emergency surgery	4
Significant aortic stenosis	3
High-risk surgery	3
Markers of poor general condition	3

The RCRI developed in 1999 by Lee et al. is a modification and simplification of the Goldman index. It is derived from a single-centre prospective cohort study of 2 893 patients of ≥ 50 years of age undergoing elective major non-cardiac surgery who were monitored for major cardiac complications. Six independent predictors that increased the risk of cardiac complications were identified. The index was validated in a cohort of 1 422 similar patients and, because of its simplicity, it has been the gold standard for a number of years in assessing the risk of MACE.

Limitations of the RCRI

A 2009 systemic review by Ford MK et al. on prediction of perioperative cardiac complications and mortality using the RCRI in various populations and settings after major non- cardiac surgery, found that RCRI:

- Performed well in predicting outcome in low-risk patients vs. high-risk patients
- It poorly predicted outcome in vascular surgical patients
- Was validated in predicting risk for elective major non-cardiac surgery and was found to be less accurate in emergency or urgent surgery, and
- Did not predict all causes of mortality as it does not include other non-cardiac risk predictors of perioperative mortality[7]

The following studies investigated other important independent predictors of perioperative cardiac outcomes:

Intraoperative predictors

RCRI risk factors
1. High-risk surgery
2. Ischaemic heart disease
3. Heart failure
4. Stroke or TIA
5. Diabetes requiring insulin
6. Creatinine > 176 µmol

Risk for cardiac death, nonfatal MI and nonfatal cardiac arrest
Predictors
0 = 0.4%
1 = 0.9%
2 = 6.6%
≥ 3 = 11%

- A 2013 systemic review by Biccard, Rodseth, et al. on intraoperative predictors of perioperative cardiac outcome identified 10 predictors that impact outcome as: intraoperative blood transfusion, vascular surgery, urgent/emergency surgery, decreased MAP > 20 mmHg for > 60 mins, a > 30% increase in SBP from baseline, increase in HR > 30 b/min in recovery room > 5 mins, new onset of atrial fibrillation, hypothermia and remote ischaemic preconditioning which are risk factors that can be modified preoperatively.[9]

Biomarkers,

- The Vision Study by Devereaux PJ, Bruce M, Biccard et al. showed that a high sensitivity troponin level post non-cardiac surgery was an independent predictor of 30-day mortality with peak levels 0.03 ng/ml judged to be diagnostic of myocardial injury after non-cardiac surgery (MINS). Eighty percent of patients with a troponin leak had no symptoms of myocardial ischaemia.[10]
- A 2014 systemic review by Rodseth, Biccard, et al. on the prognostic value of preoperative and postoperative NT-ProBNP in patients undergoing non-cardiac surgery showed that postoperative levels were the strongest independent predictor of outcome at 30 and ≥ 180 days postsurgery and it enhances risk stratification for MACE compared to preoperative levels.[11]
- A 2011 study by Van Diepen, et al.[12] compared postoperative 30-day mortality in patients with coronary artery disease, heart failure and atrial fibrillation undergoing major and minor non-cardiac surgery and showed a higher mortality rate was in heart failure 9%; AF 6% vs. CAD 2.9%.

Age

Age is an independent predictor of cardiovascular events. In the PeriOperative Ischemic Evaluation II trial, a population of 75 years and older was identified as being at risk for post-operative myocardial infarction. At ages 50–80 years in the National Surgical Quality Improvement Program (NSQIP) model it was found that the risk of myocardial infarction and cardiac arrest increased by 1.8 times.[13,14]

Vascular surgical patients[15]

The South African Vascular Surgical Cardiac Risk Index study by Moodley Y, et al. identified six independent predictors of MACE that were superior in risk stratifying vascular South African patients vs. RCRI. The predictors were identified as age ≥ 65 years, history of ischaemic heart disease, diabetes, chronic beta blocker blockade, prior coronary revascularisation and type of vascular

surgery. However this risk index is yet to be independently validated.

Valvular heart lesions

- Valvular stenotic lesions are associated with an increased risk of MACE and the severity of the lesion and the type of surgery greatly influences the outcome. Aortic stenotic lesions are becoming more common in the elderly population with increasing life expectancy. In the western population 25% of patients presenting for major non-cardiac surgery are 65 years and older.[16,14]

Functional capacity

Functional status has been shown to be an independent predictor of perioperative cardiac risk with METS < 4 increasing short- and long-term risk.[13,14]

Recommendations on enhancing the performance of RCRI

The RCRI is a score that is validated and commonly used; a lot of research has been done with the aim to improve its ability to discriminate risk. Some of the recommendations made by research done are:

- Addition of biomarkers in high-risk patients[11]
- Using glomerular infiltration rates to define renal function instead of creatinine clearance[13]
- Functional capacity[13]
- History of peripheral disease[13]
- Age[13]
- Type of surgery[13]
- Including intraoperative predictors of MACE, and[9]
- Diabetes requiring insulin does not add any predictive value and should be removed as a risk factor[17,18]

ACS NSQIP universal surgical risk calculator

The surgical risk calculator was developed from data of 1.4 million cases from 393 hospitals that took part in the ACS NSQIP programme in the United States. A web-based tool consisting of 21 patient-related factors and eight surgical procedures is used to calculate the risk of MACE and eight other outcomes individualised to the patient with excellent performance in predicting outcome.[19]

Gupta myocardial infarction/cardiac arrest NSQIP risk model

The NSQIP database was used to identify intraoperative and postoperative risk factors for myocardial infarction or cardiac arrest. Five independent predictors were identified as:

- Type of surgery
- Dependent functional status
- Abnormal creatinine
- ASA classification, and
- Increased age

The model was validated on a 2008 data set of over 250 000 patients with a relatively high predictive accuracy which outperformed RCRI. However, the model is limited to predicting only two cardiac complications as these were the only cardiac complications captured in the NSQIP database.[20,21,22]

Limitations of NSQIP calculator[6,23,19,24,22,21]

- It is more comprehensive compared to other calculators but cumbersome to use
- It has not been validated outside the NSQIP population
- Only preoperative variables are used to estimate postoperative complications
- Indication for surgery is not included
- Myocardial infarction defined only as troponin leak that is three times the normal value and abnormal ST-segments, and
- Using ASA score which is known to have poor discrimination ability and is unfamiliar to surgeons

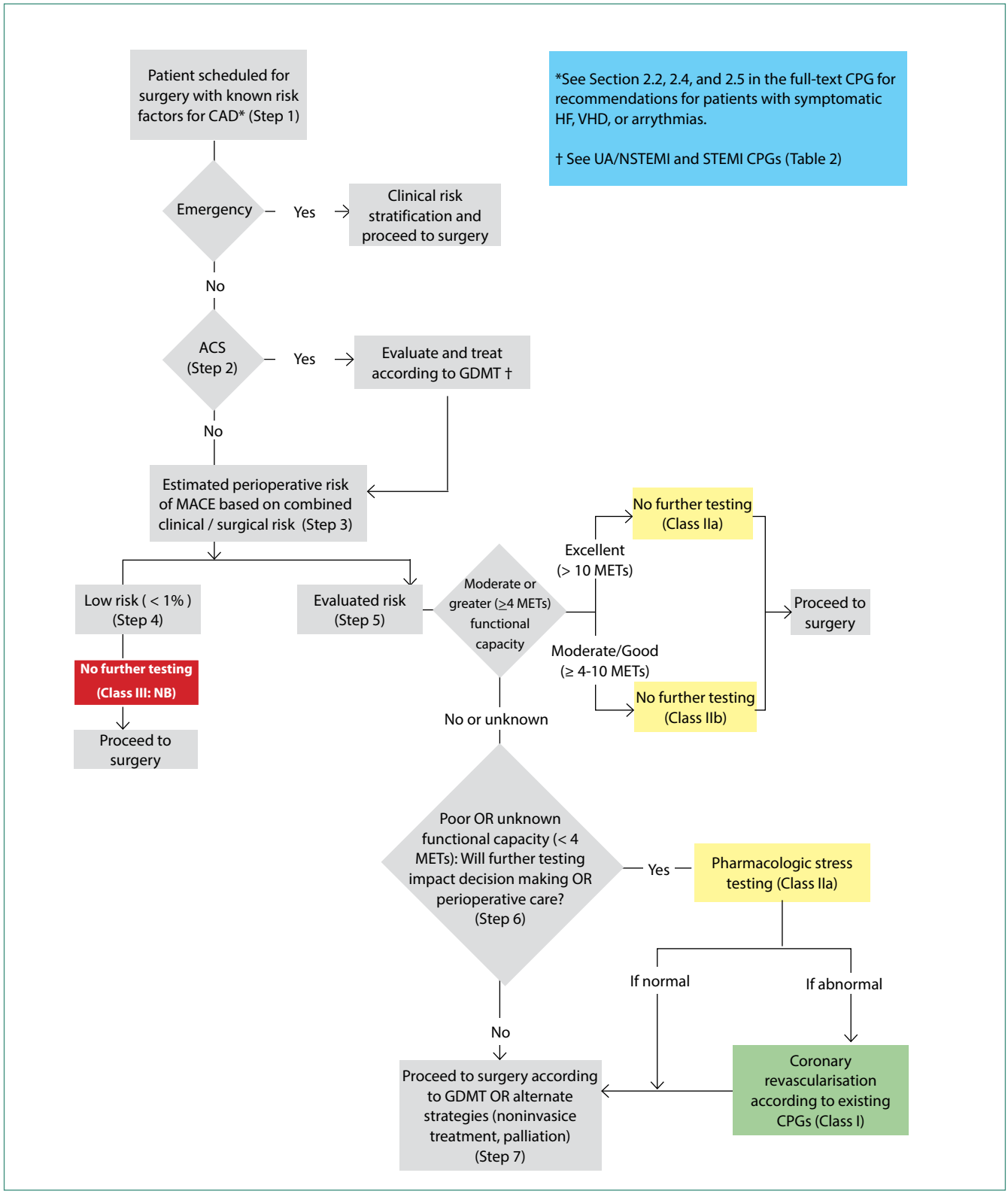
2014 ACC/AHA Guidelines for perioperative cardiovascular evaluation for non-cardiac surgery

Stepwise approach to perioperative assessment of CAD, J AM Coll Cardiol. 2014;64(22): e77-e137[23]

- *STEP 1:* Aimed at acute coronary artery disease and syndromes excluding other significant cardiac conditions associated with MACE.
- *STEP 3:* To predict the risk of MACE and surgery the RCRI score, Gupta MICA and ACS NSQIP calculators are used.
- *STEP 5:* Elevated risk > 1% with moderate to good functional capacity – proceed with surgery.
- *Step 6*: Elevated risk > 1% with METS unknown or < 4 a multidisciplinary decision should be taken on whether further testing will change management.
- If further testing will change management then pharmacological testing is recommended.

Recommendation on medical therapy[23]

- Beta blockers: Chronic therapy should be continued (class 1); high-risk patient with RCRI ≥ 3 not on treatment it is recommended to start treatment 2–7 days prior to surgery (class 2b).
- Statins: Chronic therapy should be continued (class 1a) in vascular surgical patients not on treatment; it should be started at least two weeks prior to surgery (class 2b).
- Aspirin: Initiation or discontinuation prior to surgery in patients without coronary stents is not beneficial (class 3).
- ACE inhibitors and ARBs: Discontinuation is reasonable in the perioperative period but should be restarted as soon as



2014 ESC/ESA Guidelines on non-cardiac surgery: Cardiovascular assessment and management[25]

ESC/ESA Guidelines European Heart Journal (2014)35,2383-2431

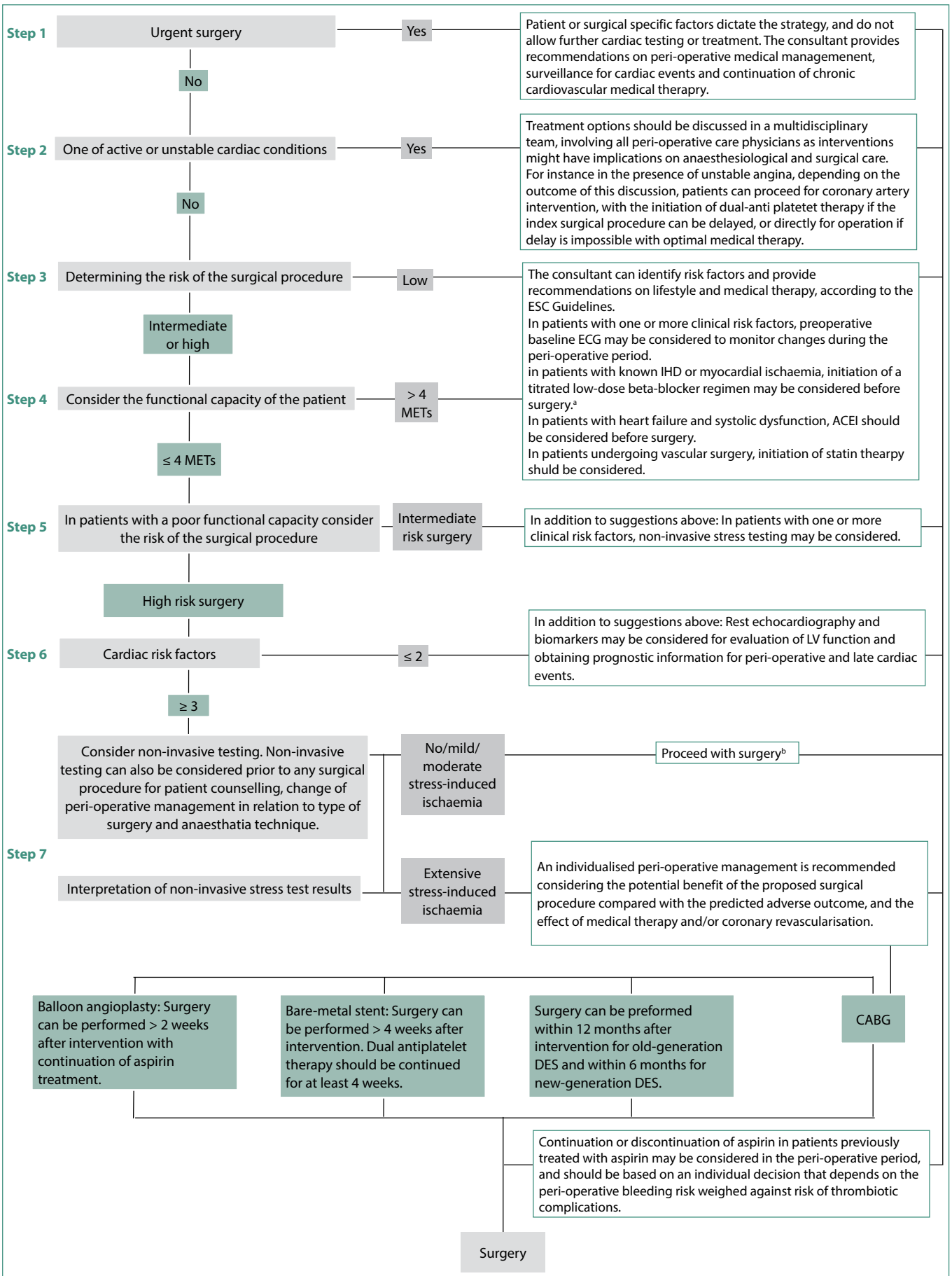
STEP 1: Urgency of surgery? Proceed if it is an emergency.

STEP 2: Unstable cardiac conditions defined by unstable coronary syndromes, severe arrhythmias, decompensated heart failure and symptomatic valvular disease; management of patients with these conditions should be discussed by a multidisciplinary team weighing the risks and benefits of delaying surgery to optimise the patient.

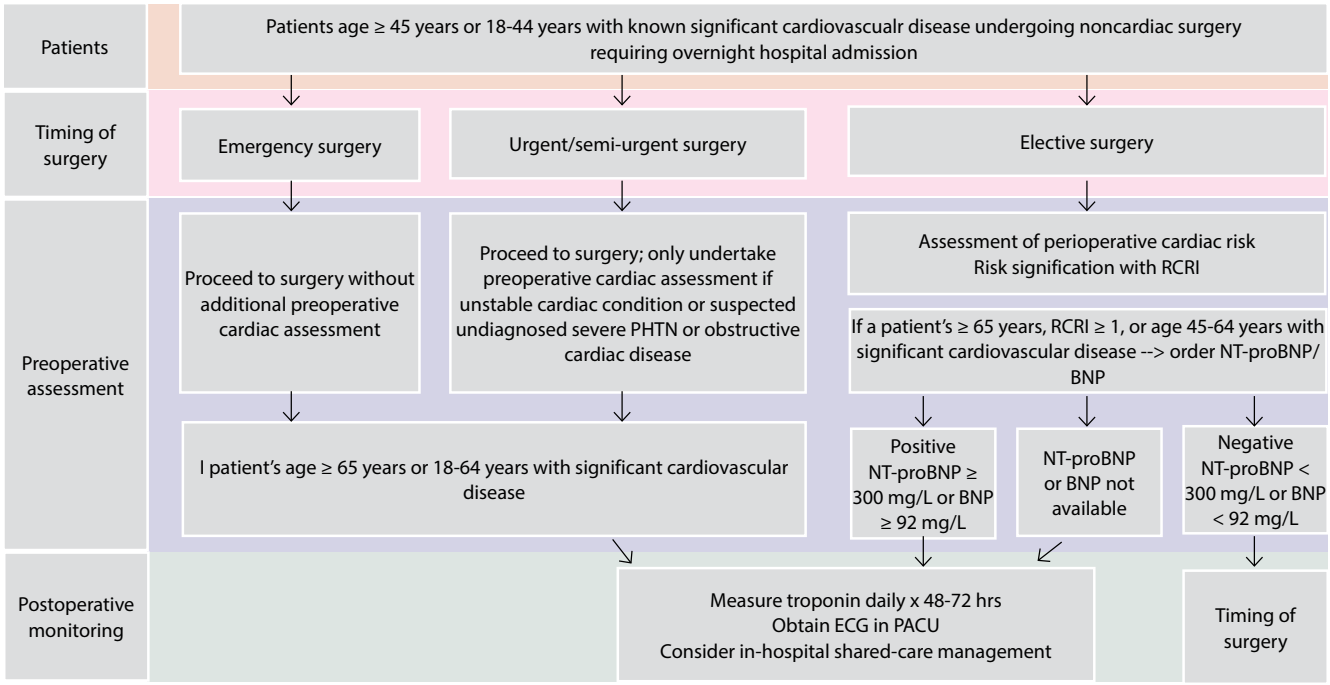
STEP 3: The risk of surgery low risk < 1%, moderate risk 1–5%, high risk > 5%.

STEP 4: Functional capacity METS > 4 – Proceed.

STEP 5: METS ≤ 4 consider surgical risk if it is low or moderate – Proceed.



[a]Treatment should be initiated optimally between 30 days and at least 2 days before surgery and should be continued postoperatiely aimint at target resting heart rate of 60-70 beats per minute and systolic blood pressure . 100 mmHg.
[b]For strategy of anaesthesia and perioperative monitoring see appropriate sections.
ACEI = angiotension converting enzyme inhibitor; CABG = coronary artery bypass; DES = drug-eluting stent; ECG = elecgtrocardiogram; IHD = ischaemic heart disease; MET = Metabolic equivalent.



STEP 6: High-risk surgery with METS ≤ 4 used RCRI to evaluate risk of MACE. Risk factors ≤ 2 consider biomarkers.

STEP 7: RCRI score ≥ 3 noninvasive stress testing recommended. Results with evidence of severe ischaemia, coronary revascularisation should be considered.

Recommendation on medical therapy[25]

- Beta blockers: Continue treatment if on chronic treatment (class 1). High-risk patients with RCRI ≥ 2 and ASA ≥ 3 treatment should be initiated at least 2–30 days prior to surgery (class 2b).
- Statins: Chronic therapy should be continued (class 1a). In vascular surgical patients not on treatment it should be started at least two weeks prior to surgery (class 2b).
- Aspirin: Initiation or discontinuation prior to surgery in patients without coronary stents is not beneficial (class 3).
- ACE inhibitors/ARBs: Chronic therapy should be continued in stable left ventricular systolic heart failure and discontinued in hypertensive patients (class 2a).

Canadian Cardiovascular Society Guidelines on perioperative cardiac risk assessment and management for patients who undergo non-cardiac surgery.

Duceppe et al. Perioperative Cardiac Risk Assessment and Management. Canadian Journal of Cardiology 33(2017)17-32[26]

Canadian guidelines recommend risk stratifying cardiac risk for non-cardiac surgery by using RCRI and preoperative NT-pro BNP levels. They further recommend against testing resting Echo, exercise testing, coronary CT angiography, pharmacological stress Echo as research has shown that their quality of evidence was low–moderate and that NT-proBNT was a more superior independent predictor of outcome and more cost effective. Measurement of troponin levels for 48–72 hrs is recommended for patients with a risk of MACE > 5%.

Recommendations on medical therapy[26]

- Beta blockers: Continue if patient on chronic therapy; recommend against starting patients on treatment 24 hrs prior to surgery.
- ACEI/ARBs: Recommend stopping treatment 24 hrs prior to surgery to reduce risk of intraoperative hypotension which is an independent intraoperative predictor for MACE.
- Statins: Continue treatment if on chronic statin therapy.

Conclusion

Risk stratification provides guidance on appropriate perioperative management which has been shown to decrease mortality. Even though the risk prediction tools available are not ideal, their use has improved patient outcomes and should continue to be used in assessing risk in patients undergoing elective major non-cardiac interventions until a more ideal risk prediction model is available. It follows then that there is a need for an improved standardised cardiovascular risk prediction model to succeed the RCRI.

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