A practical approach to perioperative risk optimisation for non-cardiac surgery

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Introduction

The combination of careful perioperative considerations, less invasive surgeries and the liberal use of neuro-axial techniques has decreased perioperative major adverse cardiac events (MACE) and overall mortality in vascular surgical patients.

Despite this, the recently published ASOS-2 study still demonstrated a 1% mortality even with intensive postoperative monitoring for a range of patients and procedures in lower-middle income countries (LMICs).[1] As surgeons, our outcome measures are sometimes different to other perioperative physicians (primarily anaesthesiologists and cardiologists). Our outcomes are not limited to the myocardial function or the safe awakening after anaesthesia, but also incorporates medium term outcomes such as postoperative infections, wound healing, returns to the operating theatre and restoration of pre-morbid functional capacity.

Several scoring systems and guidelines exist for perioperative risk assessment, and most are variations of each other with a bias towards the society or organisation that publishes them. We use a combination of the Lee Revised Cardiac Index (LRCI),[2] the American Heart Association (AHA) guideline,[3] the Canadian guideline[4] and the most contemporary and relevant to us in South Africa, the South African Perioperative guideline[5] to formulate our own checklist. These guidelines have shaped the current treatment algorithms for non-cardiac surgery and have made a complex decision-making process much simpler. However, they are cardiac-centric and tend to overlook multiple other systems that can be optimised during the perioperative period. Other factors such as chronic obstructive pulmonary disease (COPD), obstructive sleep apnoea (OSA), anaemia and renal insufficiency cumulatively add to the risk perioperatively, and influence modes of anaesthesia administered as well as postoperative monitoring and care. Interestingly, the LRCI has been demonstrated to provide only a modest predictive value in patients undergoing vascular surgery.[6]

There are, however, still deficiencies in these algorithms. For example, the LRCI estimates a risk of a cardiac event for a specified number of pre-existing conditions. This is helpful in making us understand the risk, but very difficult to translate on an individual patient level. How does one meaningfully explain an 11% risk of a cardiac event to a patient, when even phrasing it as an 89% chance of a non-event skews the decision. Biomarker incorporation into the algorithm has further simplified and revolutionised it, but again, how does one interpret a ProBNP of 500 ng/ml and explain the risks to patients of a future postoperative MACE. An understanding of probabilistic thinking is difficult enough for physicians, let alone for patients. Additionally, the guidelines (LRCI) highlight the percentage risk of complications but are opaque on the management strategies when abnormalities are detected.

Furthermore, the decision-making for the indications, appropriateness and type of surgery are intertwined with perioperative 'fitness', and no guideline has been able to incorporate these pivotal decision-making steps. Very often diseases have a best-case operative solution which is more invasive but has a durable result; however, there is sometimes a compromise procedure which is less invasive but has less durable outcomes and may be more appropriate for higher risk patients with higher procedural risk. This circular decision-making strategy is harder to incorporate into linear algorithms. Examples of these are open vs endovascular surgery for complex lower limb occlusions, where an endovascular solution can potentially be performed under local anaesthetic, however the long-term durability is inferior to an open bypass. Or, in breast cancer where low-risk tumours sensitive to oestrogen and progesterone receptors may be treated with tamoxifen alone, and not a mastectomy followed by chemotherapy. This decision may be more appropriate when the cancer-related mortality is less than the systemic disease-related mortality (e.g. severe COPD). In cancer surgery, the same perioperative assessment is incorporated into the ability to withstand chemotherapies (e.g. doxorubicin and cardiac toxicity), and influences both the tolerance for chemotherapy and the type of chemotherapy.

Over the past few years (2012–current), we have refined our own algorithm for perioperative assessment, incorporating the common guidelines and contemporary recommendations but also placing emphasis on optimisation of organ function as a goal. Below, I will present our 'systems approach' to perioperative

assessment, as well as our algorithm, then discuss some of the potential pitfalls and developing directions in the field.

Systems approach

The concept of 'fitness for surgery' is a misnomer, as procedures can be performed on even the highest-risk patients if the risks are accepted. More aptly, it should be considered as 'appropriateness of surgery'. For example, an elective incisional hernia repair in a high-risk elderly patient with cardiac failure would be deemed inappropriate, however in the same patient with an 8 cm aortic aneurysm, we would reconsider the risks, optimise the cardiac failure, share the decision-making with the patient and plan an anaesthetic accordingly. Thus, the focus on modifying risks throughout the perioperative period is key.

In general, it is simple to identify the low-risk and high-risk patients; it is the intermediate-risk patients that pose a challenge. They often leave us feeling uneasy as we require balancing over-investigation with its own potential harm and time delays versus continuing without any consideration to the tail risks of an unwanted event. A simple traffic light decision-making algorithm to begin with (Figure 1), screens out low-risk and high-risk patients, prompting a nudge in the direction of appropriateness of the surgery in high-risk individuals.

One of the limitations of the multiple perioperative guidelines that exist is that they are organ-specific, and to the best of my knowledge, there is none that incorporates a comprehensive
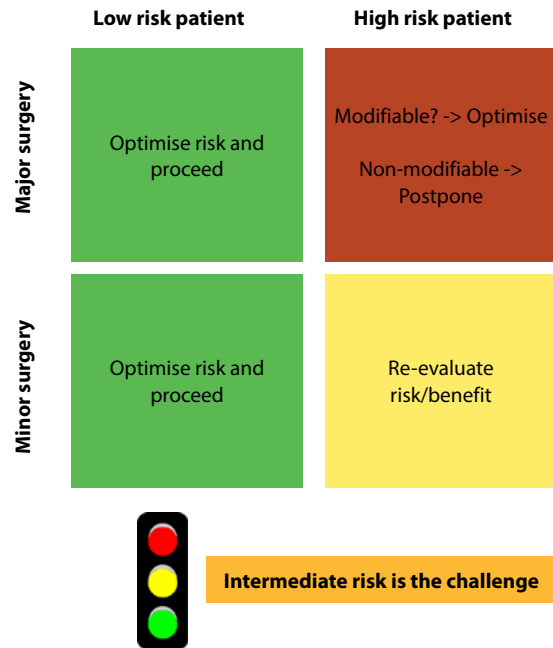
	Low risk patient	High risk patient
Major surgery	Optimise risk and proceed	Modifiable? -> Optimise Non-modifiable -> Postpone
Minor surgery	Optimise risk and proceed	Re-evaluate risk/benefit

Intermediate risk is the challenge

Figure 1: A traffic light approach to decision-making for low- and high-risk patients

multi-organ assessment. Individually we are aware of the significance and dangers of diseases such as OSA, chronic renal failure (CRF) or hyperthyroidism, thus a unifying framework made intuitive sense to us (Figure 2). Furthermore, even subtilties such as preoperative haemoglobin (Hb) optimisation, nutritional
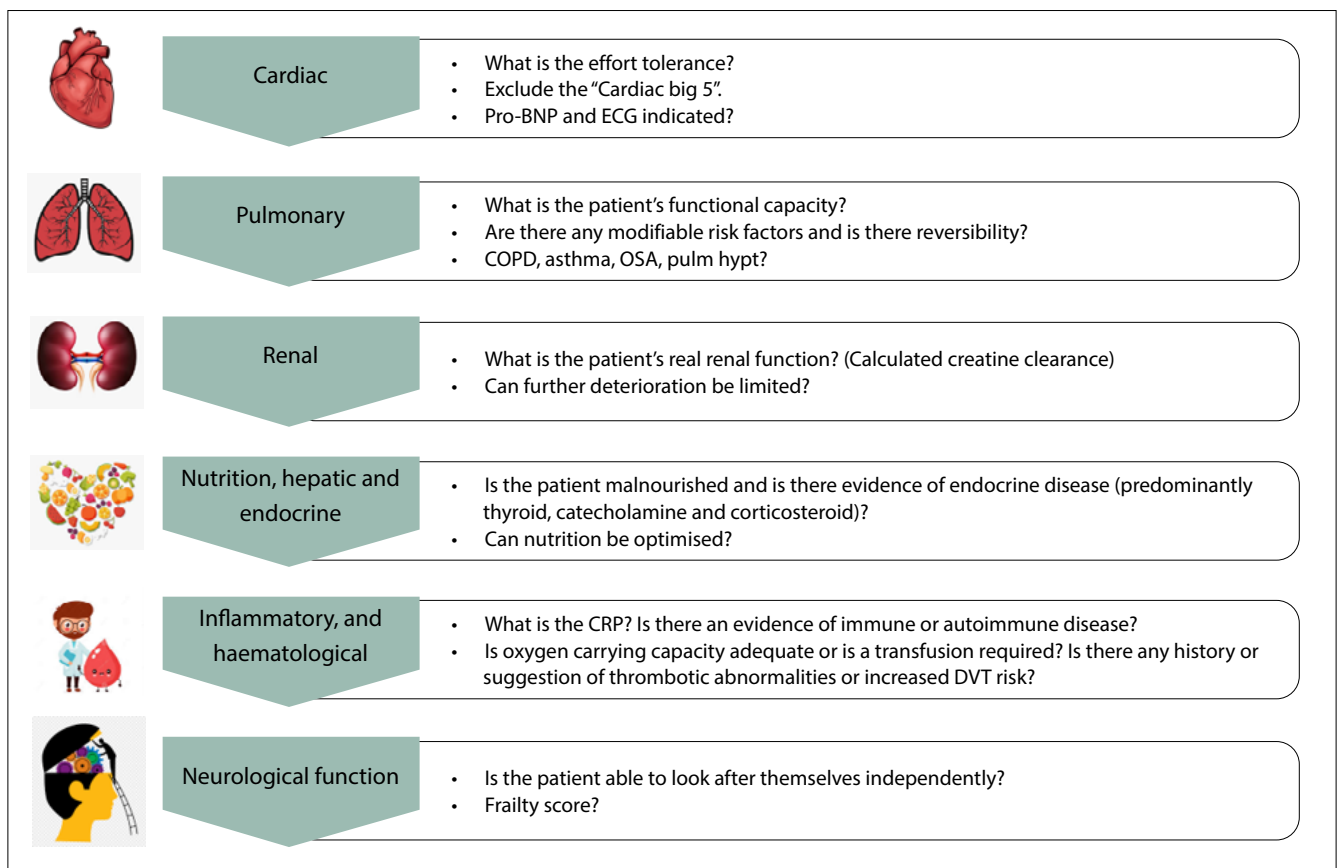
Cardiac	• What is the effort tolerance? • Exclude the "Cardiac big 5". • Pro-BNP and ECG indicated?
Pulmonary	• What is the patient's functional capacity? • Are there any modifiable risk factors and is there reversibility? • COPD, asthma, OSA, pulm hypt?
Renal	• What is the patient's real renal function? (Calculated creatine clearance) • Can further deterioration be limited?
Nutrition, hepatic and endocrine	• Is the patient malnourished and is there evidence of endocrine disease (predominantly thyroid, catecholamine and corticosteroid)? • Can nutrition be optimised?
Inflammatory, and haematological	• What is the CRP? Is there an evidence of immune or autoimmune disease? • Is oxygen carrying capacity adequate or is a transfusion required? Is there any history or suggestion of thrombotic abnormalities or increased DVT risk?
Neurological function	• Is the patient able to look after themselves independently? • Frailty score?

Figure 2: Systems approach to perioperative screening. (WITS vascular surgery algorithm)
Cardiac big 5 – acute coronary syndromes, decompensated heart failure, severe valvular lesions, arrythmias, pericarditis, COPD – chronic obstructive pulmonary disease, OSA – obstructive sleep apnoea, CRP – C-reactive protein, DVT – deep venous thrombosis

depletion or even the presence of an active autoimmune condition purport additional risks and poorer surgical outcomes. We have been using this framework in our unit now for several years and continue to update it with evolving evidence.

Cardiac screening: Our approach

1. What is the effort tolerance?

2. Exclude the 'Cardiac big 5'

3. What is the Pro-BNP and ECG?

4. Optimise chronic conditions (blood pressure control, glycaemic control, etc.)

Within a South African context, basing our assessment on the criteria of the LRCI alone would be inadequate to screen HIV-positive patients with vascular disease. In one of the few perioperative studies of vascular surgical patients in South Africa, the 30-day MACE event rate was 19.4%, whereas the LRCI would have predicted only 4.9% in that cohort.[7]

Effort tolerance

A cornerstone of perioperative screening has been effort tolerance, where a metabolic equivalent of > 4 (MET > 4) has traditionally been thought of as the minimum requirement to withstand anaesthesia safely. The specifics of how one comes to the decision of METS > 4 is not as yet standardised. A provocative and important publication questioned the validity of self-reported effort tolerance.[8] This forces us to question our reliance on self-reported effort tolerance which forms an anchor of most perioperative algorithms.

In this publication, Wijeysundera et al. recruited 1 401 patients with more than one cardiac risk factor and combined the subjective assessment of self-reported functional capacity with objective measures: cardio-pulmonary exercise testing (CPET), the Duke activity score index (DASI) as well as an NT-ProBNP. Only 2% of their patients had a complication (28 of 1 401), and this was not limited to cardiac events only. One of the most important findings was that self-reported exercise tolerance does not correlate with CPET outputs (peak oxygen consumption and anaerobic threshold), and self-reported METS < 4 had a sensitivity of only 19.4%. Out of the three measures, only the DASI scores were predictive of the primary outcome. DASI and NT-ProBNP correlated reasonably well (AUC 0.7), and our interpretation is that these should be used in combination not as competitors. Since the publication of this study, we have reflected on our practice and included the DASI in our daily algorithm.

The DASI combines 12 questions and provides a score,[9] which is then calculated as a metabolic equivalent (Figure 3). It was first published in 1989, but online calculators make its use and interpretation very simple. Experienced perioperative clinicians perform this sort of multi-faceted evaluation without having formalised it into a questionnaire and score. The take-home should be that a single self-reported question on functional capacity is not adequate. Although DASI has been validated

Questionnaire Item	Points
1. Can you take care of yourself, that is, eat dress, bathe or use the toilet?	2.75
2. Can you walk indoors, such as around your house?	1.75
3. Can you walk 200 yards on level ground?	2.75
4. Can you climb a flight of stairs or walk up a hill?	5.50
5. Can you run a short distance?	8.00
6. Can you do light work around the house like dusting or washing dishes?	2.70
7. Can you do moderate work around the house like vacuuming, sweeping floors, or carrying groceries?	3.50
8. Can you do heavy work around the house like scrubbing floors or lifting or moving heavy furniture?	8.00
9. Can you do yard work like raking leaves, weeding or pushing a power mower?	4.50
10. Can you have sexual relations?	5.25
11. Can you participate in moderate recreational activities like golf, bowling, dancing, doubles tennis, or throwing a ball?	6.00
12. Can you participate in strenuous sports like swimming, singles tennis, football, basketball, or skiing?	7.50

Figure 3: The Duke activity score index[9]

in the developed world, there are some questions that require adaptation to a South African context. For example, playing golf, dancing or skiing may not be appropriate, nor a direct question on sexual relations be culturally sensitive. Shortening the DASI to just five questions correlated well with CPET outputs and omitting the sensitive sexual relation question also had no impact on the predictive outcomes.[10]

Cardiac big 5

Borrowing from the Goldman index and LRCI, we identified five high-risk cardiac conditions that require immediate referral to cardiology for assessment of severity and possible intervention prior to elective non-cardiac surgery. These are acute coronary syndromes (ACS), decompensated heart failure (NYHCA grades 3 and 4), severe valvular lesions (especially severe aortic stenosis), arrhythmias (especially the tachyarrhythmias or a bradycardia requiring pacing) and pericarditis. These conditions would necessitate an immediate referral to cardiology for either a definitive repair or optimisation prior to elective non-cardiac surgery.

NT-ProBNP

We have been using NT-ProBNP in our unit since 2012 and have found it to be the most useful biomarker available. It has both prognosticating value and acts as a screening tool for underlying cardiac disease. The South African Perioperative guideline recommends its use in all patients over the age of 65 and in patients with at least one risk factor for cardiovascular disease who are over the age of 45. However, the guideline is not clear on how to proceed once an abnormal value is detected. Values of NT-ProBNP vary widely, with a normal value of less than 300 pg/ml in most laboratories, thus incorporating its use into a perioperative algorithm does not produce binary management options.

Rodseth et al., in 2011, reported a patient level meta-analysis of six studies, providing insights into Pro-BNP use and benefits.[11] Measuring NT-ProBNP altered the risk prediction in 58% of

patients undergoing vascular surgery when compared to using the LRCI alone. The Canadian guideline reports that NT-ProBNP levels > 300 mg/L have a 21.8% MACE at 30 days.[4] This is somewhat misleading though, because the range is so wide above this level, and seen in the context of vascular surgical patients, the majority have a Pro-BNP > 300 ng/L. This makes practical implementation not as clearly-defined or evidence-based. Extrapolating from the Rodseth et al. meta-analysis of 2014 which examined the additive value of a postoperative NT-ProBNP measurement, they reported on the predictive value of a preoperative NT-ProBNP from their pooled data. This provided some guidance on cut-offs with which to base decisions on. They found that a preoperative NT-ProBNP value for mortality or non-fatal myocardial infarction of 0–300 ng/L, 300–900 ng/L, 900–3 000 ng/L and > 3 000 ng/L had a 5.2%, 16.1%, 26% and 39.5% rate respectively[12] (Figure 4).

0–300 ng/L	300–900 ng/L	900–3 000 ng/L	> 3 000 ng/L
5.2%	16.1%	26%	39.5%

Figure 4: NT-ProBNP thresholds for 30-day postoperative mortality and non-fatal MI

Extrapolating from this information, we incorporated these cut-offs into our algorithm for cardiac risk assessment (Figure 5). Comparing our algorithm to the South African perioperative guideline or the Canadian perioperative guideline, the major difference is the referral for a cardiology consult and presumably non-invasive echocardiography. We find that although the findings may not directly influence the decision to operatively intervene on a patient, it provides information that helps direct therapy perioperatively. For example, valve lesions may prompt reconsideration for spinal anaesthesia, or subclinical heart failure will allow for evidence-guided remodelling therapy to be instituted timeously, thereby influencing long-term outcomes.

The risk of this strategy is unnecessarily intervening on ischaemic changes found perioperatively and thus causing harm. Coronary revascularisation prior to non-cardiac surgery has been found to be not beneficial and perhaps even harmful.[13] However, these trials are not without controversy. The DECRASE trails were discredited due to the primary investigator being found to have broken research protocols and subsequently retracted. These were principally around perioperative B-blockade, which influenced the B-blocker strategy in the main CARP trial but also included the DECREASE V study which showed no benefit for coronary revascularisation prior to vascular surgery.[14] One of the difficulties in interpreting this data is that the CARP trial excluded left main coronary lesions of > 50%. In practical terms, how would one exclude a 50% lesion in the left coronary artery in a patient found to have hypokinesia in the distribution of the left coronary segment myocardium without an angiogram. Furthermore, are patients presenting with ischaemic cardiomyopathy truly asymptomatic (i.e. no chest pain), especially if they have reversibility? Our approach is that if hypokinesia is detected on echocardiography in the face of a patient with ischaemic

cardiomyopathy and reduced ejection fraction, we ask our cardiologists to determine the reversibility of the segment. If the segment is reversible, our cardiologists perform an angiogram. For significant left main lesions, we generally defer to coronary revascularisation first. For other significant lesions, we have a multidisciplinary team (MDT) meeting. If the vascular surgery requires an open operation (aortic or lower-limb) and can be deferred by six weeks to three months, we generally proceed with coronary revascularisation. As vascular surgeons, we have become accustomed to operating on patients with dual antiplatelets, and this is no longer a deterrent to lower limb bypass or aortic surgery, and we would not interrupt clopidogrel for these. This is a space that requires contemporary investigation. Endovascular procedures are lower risk, but open aortic surgery is still necessary in one-third of patients with aneurysms. Very often in MDT discussions around open aortic surgery, patients are excluded on this basis, as revascularisation prior to surgery is assumed not to be beneficial. It must be noted however, this is not a common scenario, but testing this strategy of pre-screening with a Pro-BNP within the confines of a clinical trial would be beneficial.

The remainder of our systems-based approach attempts to standardise investigations and cover most organ systems that may benefit from optimisation. A detailed presentation of this is beyond the scope of this article. However, the system that is most difficult to assess from a clinical decision-making standpoint is the neurological system.

In the clinical spectrum of patients with vascular disease, dementia, strokes and frailty are common. From an ethical standpoint, we are often faced with a patient with a large
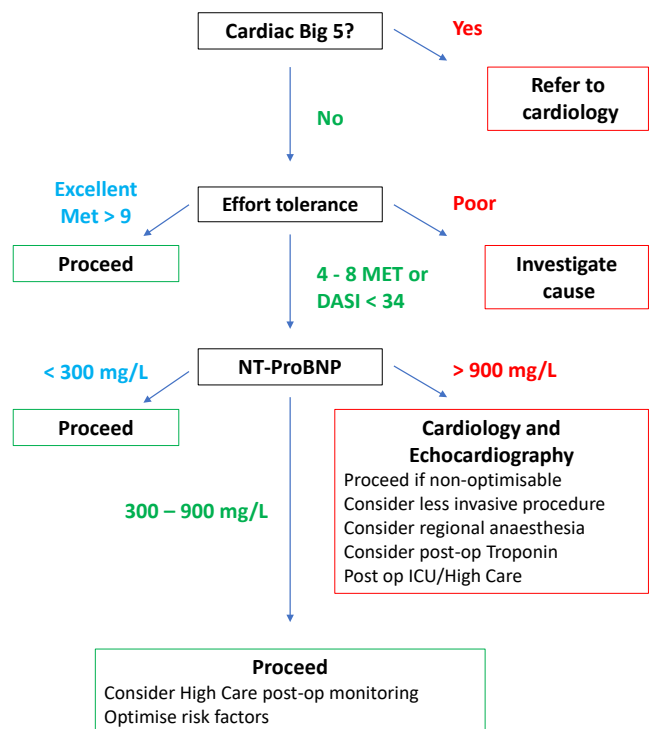

Figure 5: Preoperative cardiac algorithm incorporating NT-ProBNP
DASI – Duke activity score index, MET – Metabolic equivalents

aneurysm who is cognitively incapable of the awareness of their condition. Although physiologically they may be fit, it is not appropriate to subject patients to major procedures without changing their quality of life. These decisions require involvement of the primary caregivers and should be a shared decision process.

Frailty and frailty scores are gaining popularity in the perioperative space. Within vascular surgery, markers such as psoas muscle sarcopenia are markers of poorer outcomes.[15] We have found the DASI useful in grading frailty as well.[16] In the future we might use remote monitoring devices to gain a more accurate measure of frailty and activity.

Several other current perioperative strategies have the potential to influence the framework in the future. In particular, postoperatively the evolving role of myocardial injury after non-cardiac surgery (MINS), and preoperatively the incorporation of supervised exercise therapy before surgery. MINS is an evolving concept, though its existence is well established, its relevance and therapeutic options are still to be clearly outlined. MINS data also merges postoperative therapeutic options on the background of emerging concepts of long-term postoperative low-dose anticoagulation (rivaroxaban) in patients undergoing vascular surgery to decrease composite vascular events.[17]

Conclusion

Perioperative optimisation prior to non-cardiac surgery has iteratively evolved over the last two decades. In South Africa, we are fortunate to have world-leading perioperative researchers who continue to actively influence this field. The implementation of widely available guidelines requires consolidation of the evidence and a practical implementation strategy. Presented above is one such strategy, incorporating several societal guidelines into a single useable framework.

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