Preoperative assessment of patients for major vascular surgery

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Abstract

Effective preoperative evaluation of patients prior to major vascular surgery remains a significant multidisciplinary challenge. Focussed preoperative evaluation targeted to organ systems can mitigate the combined effects of inherently high-risk surgical procedures undertaken in a patient population with well-recognized comorbidity. Careful history and examination, supported by appropriate investigations and specialist input, remains the cornerstone of this process, with risk increasingly quantified by dedicated scoring systems. In addition, the objective assessment of functional capacity is now common in UK units with cardiopulmonary exercise testing widely employed and considered a 'gold standard' by many. When employed in a timely manner, complete preoperative assessment allows more informed perioperative decision-making, frank discussion of risk with the patient and effective utilization of critical care resources if required.

Keywords Cardiopulmonary exercise testing; cardiovascular system; functional assessment; preoperative assessment; risk scoring; vascular surgery

Royal College of Anaesthetists CPD Matrix: 2A03, 3A05

Learning objectives

After reading this article, you should:

- be aware of the comorbidities commonly encountered in the preoperative assessment of vascular surgical patients
- understand the importance of targeted assessment of organ systems
- understand the relevance of functional patient assessments, both subjective and objective

Background

Major vascular surgery is associated with a higher risk of adverse outcome when compared to other forms of non-cardiac surgery. Published evidence from the recently established National Vascular Registry reports mortality rates of 4.1% for open aortic surgery in the UK with overall mortality for all major vascular procedures of 2.2%. This is coupled with frequent cardiorespiratory morbidity postoperatively.[1] A step-change in UK vascular care has been the introduction of the National Abdominal Aortic Aneurysm Screening Programme (NAAASP), with evidence building that otherwise asymptomatic patients identified through this route have more favourable postoperative outcomes.[2] In all cases, accurate preoperative risk assessment is of paramount importance to inform clinical decision making, reduce risk and improve individual patient outcome following surgery.

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The preoperative assessment process is crucial in achieving this goal, with anaesthetists increasingly acting in the 'perioperative physician' role and coordinating this process. The major objectives of preoperative assessment of any surgical patient include: accurate risk assessment, optimization of comorbidities, targeted speciality referral, determining postoperative care facility, full patient counselling and consideration of non-operative management where appropriate. This can be achieved through:

- history, including clinical risk predictors
- physical examination with particular emphasis on the cardiorespiratory system
- objective assessment of functional capacity and aerobic fitness
- targeted investigations
- a validated scoring system to bring the above points together and accurately predict personalized risk.

Recognizing the high-stakes nature of vascular surgery and to facilitate this process, a preoperative assessment clinic with senior anaesthetic involvement was recommended by the National Confidential Enquiry into Patient Outcome and Death (NCEPOD) 10 years ago.[3] These increasingly sophisticated services now frequently feed into dedicated vascular multidisciplinary team meetings incorporating a full range of medical and non-medial personnel to plan care. Patients should be assessed at an appropriate time interval prior to elective surgery. It is vital that appropriate infrastructure, education and resources are made available locally to facilitate effective preoperative assessment. This article is not intended to cover preoperative optimization or modification of risk as this is covered in *Risk Modification and Preoperative Optimization of Vascular Patients* on pages 262–265 of this issue.

Cardiovascular system[4]

The prevalence of cardiac disease in vascular surgical patients is high (25–60%). Cardiac morbidity, specifically myocardial infarction, remains the most common cause of death following vascular surgery, with the American Heart Association (AHA) classifying major vascular procedures as 'high cardiac risk'. The perioperative period puts significant stress on the cardiovascular system through markedly increased systemic and myocardial oxygen demand. Commonly this occurs in the context of established coronary artery disease. While careful history and examination remain vital to identifying cardiac comorbidity, functional assessment is now the established adjunct to this process (see below).

History and examination

Patients should be assessed for the following conditions.

Coronary artery disease (CAD): is present in up to 60% of patients undergoing vascular surgery and a particular association exists with abdominal aortic aneurysm. Of major concern are individuals who suffer from unstable coronary syndromes (myocardial infarction within 6 weeks or Canadian Cardiovascular Society (CCS) class 3 and 4 angina, Table 1), who generally warrant preoperative cardiological assessment. Chronic stable angina (CCS class 1 and 2) carries a minimally increased risk of perioperative events as long as the condition is medically optimized. Individuals with covert disease are often diagnosed in the preoperative setting, with rapid medical optimization critical in this group. In those patients suffering an established acute coronary syndrome a multidisciplinary decision is key; however, there are clear benefits in terms of postoperative outcome to delaying surgery beyond 60 days when no coronary intervention was performed, 14 days following primary angioplasty, 30 days following bare metal stent insertion and 365 days when a drug-eluting stent was utilized.[4]

Cardiac failure: has long been recognized as a major cause of morbidity and mortality following surgery with a steadily increasing prevalence in the perioperative setting as general cardiovascular care improves.[4] Optimized or non-decompensated ventricular dysfunction rarely requires cardiological referral. Individuals considered to have decompensated cardiac failure evidenced by positive findings on history, examination or chest X-ray must be referred for cardiological assessment and optimization prior to surgery. Echocardiographic evidence of an ejection fraction of less than 30% is an independent risk predictor, however there remains no established role for routine echocardiography in search of otherwise asymptomatic left ventricular dysfunction.

Valvular lesions: aortic stenosis is the most common valve lesion in the UK. Severity of stenosis should be assessed, and if severe (gradient >60 mmHg, area <1 cm^2) or symptomatic, consideration should be given to surgical correction prior to major surgery. Mitral stenosis carries an increased risk of heart failure and, if severe, consideration should be given to correction prior to major surgery.

Canadian Cardiovascular Society (CCS) angina classification

CCS class	Symptoms
1	Angina with strenuous exercise (e.g. rapid stair climbing)
2	Angina with moderate exertion (e.g. long-distance walking, walking on an incline)
3	Angina with mild exertion (e.g. climbing one flight of stairs at normal pace)
4	Angina at rest or on minimal exertion

Table 1

Hypertension: uncontrolled hypertension is a risk factor for both CAD and stroke. Current National Institute for Health and Care Excellence (NICE) guidelines suggest a target blood pressure of less than 140/90 mmHg for secondary risk prevention. Diagnosis of hypertension is best undertaken utilizing serial readings in primary care (or 24-hour recording). Uncontrolled hypertension preoperatively is now considered a more minor risk factor than previously with debate continuing surrounding the perceived benefit of postponing surgery in order to confirm diagnosis or achieve control.[5] Grade 3 hypertension (systolic >180, diastolic >110) or higher, necessitates consideration of surgical delay until optimization is achieved. Current evidence recommends continuing antihypertensive medication perioperatively in the majority of situations. Lability of blood pressure intraoperatively is common in hypertensive patients requiring knowledge of preoperative measurements to inform intraoperative management.

Arrhythmias: high-grade arrhythmias include complete heart block, Mobitz type II atrioventricular block and symptomatic ventricular arrhythmias. Patients with these conduction defects will require referral to cardiology for treatment prior to major surgery. Supraventricular arrhythmias (including atrial fibrillation) should be rate controlled to less than 100 beats per minute preoperatively to minimize the risk of perioperative cardiac ischaemia. In particular, presence of an isolated arrhythmia should raise the question of another underlying causative pathology such as ischaemic heart disease. Increasing numbers of patients are presenting with implantable cardiac devices (ICDs), key initial questions in these patients should include the type of device and programming as well as the underlying indication for its insertion.

Investigations

All patients should have a resting 12-lead electrocardiograph (ECG) to identify arrhythmias, conduction defects, or pre-existing cardiac pathology. Further cardiac investigations should be selective and done on the basis of clinical findings and functional assessment together with advice from cardiologists (Table 2).

Interest continues in the utility and significance of cardiac biomarkers in preoperative risk assessment and their supporting evidence is disputed. At the time of writing, several studies and two meta-analyses have highlighted the incremental predictive value of markers such as brain natriuretic peptide (BNP), pro-BNP and C-reactive protein, although how these might be practically incorporated into vascular pre-assessment, as an adjunct to the established risk scores, remains unclear.

Functional assessment

Assessment of functional capacity is now recommended prior to major vascular surgery. The American Heart Association (AHA)/American College of Cardiology (ACC) continues to recommend assessment of metabolic equivalents (METs)[4] (Table 3). A score of less than 4 METs has been identified as the level below which cardiac risk is increased. Assessment of METs based on 'subjective' patient reporting of exercise capacity carries an inherent risk of inaccuracy and there is evidence that high-risk individuals may not be identified relying on such a system alone.

Many authorities recommend objective assessment of functional capacity prior to major vascular surgery. Observing

Preoperative cardiac investigations

Investigation	Reason	Technique and risk	Diagnosis
Resting echocardiogram	• Undiagnosed murmur • Assess established valve lesion • Assess resting ventricular function	• Low risk, non-invasive and ultrasound based	• Presence and severity of valve lesions • Resting ventricular function and hypertrophy
Dobutamine stress echocardiogram (DSE)	• Dynamically assess coronary perfusion	• Incremental increase in heart rate through dobutamine while assessing for new wall motion abnormality using echocardiography • 1% risk of precipitating unstable acute coronary syndrome	• Identify territory and severity of cardiac ischaemia • Dynamic assessment of cardiac reserve
Dipyridamole thallium scan (DTS)	• Dynamically assess coronary perfusion	• Heart rate increased by dipyridamole with uptake of thallium by myocardium in proportion to blood supply. Thallium scanning identifies areas of poor uptake and therefore perfusion with increasing cardiac work • 1% risk of precipitating unstable acute coronary syndrome	• Identify territory and severity of cardiac ischaemia
Coronary angiography	• Assess resting coronary circulation and cardiac reserve	• Coronary circulation imaged using radio-opaque dye • 1% risk of precipitating unstable acute coronary syndrome or stroke	• Mapping of stenotic lesions in coronary circulation • Assess resting left ventricular function • Facilitate preoperative percutaneous coronary intervention (PCI)

Table 2

Metabolic equivalents (METs) scoring system

METs	Equivalent activity ability
2	Dress oneself or do washing up
3	Vacuum or do light housework
4	Climb a flight of stairs without stopping
5	Dig the garden
6	Run a short distance
7	Jog, swim or play tennis
10	Play a game of football or squash

1 MET = 3.5 ml/kg/minute of oxygen consumed (equivalent to resting state).

Table 3

exercise capacity directly, for example stair climbing, has some evidence base but gives limited information. Cardiopulmonary exercise testing (CPET) is now commonplace throughout UK units. CPET has a recognized and developing evidence base for predicting adverse outcome in vascular surgery[6] and non-cardiac surgery more generally. The dynamic integrated and non-invasive nature of this test make it particularly attractive to use in risk prediction in the perioperative period, particularly prior to aortic surgery.[7]

Much useful integrated information can be gained from a well-conducted CPET examination, as follows.

- A dynamic overview of cardiorespiratory fitness/reserve as compared to predictive values for sex and age.
- An assessment of degree of limitation (compared to predicted values) and identification of system causing limitation, notably cardiac or respiratory.
- Dynamic 12-lead ECG analysis for ischaemia or arrhythmia during exercise.
- Anaerobic threshold (AT) and peak oxygen consumption (VO_2 Peak) identify high-risk individuals and increased morbidity/mortality risk:
  - AT $<$ 10 ml/kg/minute (specifically for vascular surgery).
  - VO_2 Peak $<$ 15 ml/kg/minute (non-cardiac surgery).

A full overview of CPET is beyond the scope of this article (see Further Reading).

Respiratory system

The high prevalence of smoking (35–85%) and coexistent respiratory disease (10–50%) in patients presenting for vascular surgery is reflected in the high incidence of postoperative respiratory complications. Severity, type (obstructive or restrictive) and reversibility of respiratory disease can be assessed using

static lung function tests. A forced expiratory volume in 1 second (FEV_1) of less than 70% predicted or FEV_1/FVC (forced vital capacity) ratio of less than 65% indicates high risk of perioperative complications. Arterial blood gas analysis may be useful in patients with poor lung function and may reveal underlying respiratory failure. CPET can further be used to assess lung function under dynamic conditions as outlined above.

Renal system

Renal dysfunction is prevalent in vascular surgical patients (4−13%) and postoperative renal dysfunction correlates with increased mortality. A creatinine level of greater than 177 mmol/litre has been identified as a risk factor for cardiac morbidity warranting its inclusion as a criterion of the revised cardiac risk index. Many laboratories now report estimated glomerular filtration rate, however this is probably of limited use at the individual patient level in prediction of adverse outcome.

Diabetes mellitus (DM)

Diabetes is common in vascular patients and is associated with renal dysfunction, cardiac disease and autonomic neuropathy. Diabetic control should be stabilized prior to surgery and HbA_{1C} can be used as an indicator of long-term glucose control. Autonomic neuropathy predisposes to perioperative hypotension and may be predicted prior to anaesthesia by the presence of a resting tachycardia, orthostatic hypotension and peripheral neuropathy. Diabetics are at risk of silent myocardial ischaemia, which should prompt a thorough assessment in the preoperative period.

Risk scoring systems for vascular surgery

Scoring systems are used in non-cardiac surgery to bring together all elements of assessment and estimate risk. The 'ideal' scoring system should:

- be validated against outcome in the desired surgical population
- be simple to use, utilizing preoperative variables alone
- provide an accurate assessment of risk at the individual patient level
- be inclusive of overall risk rather than risk specific to individual organ systems
- incorporate clinical risk factors, functional assessment, investigations and type of surgery in a multi-faceted model.

The array of different scoring systems makes no individual system ideal for all operations. The below provide a brief overview of those available for vascular surgery in particular.

- ***Revised cardiac risk index (RCRI)*** is a targeted assessment of cardiac risk in non-cardiac surgery and widely accepted as the best available system for patient factors affecting cardiac risk in non-cardiac surgery. The index combines the presence of up to six evenly weighted risk factors into a total score out of 6. A total of 3 or higher predicts a minimum 11% risk of a major postoperative cardiac event. The RCRI is well validated in large non-cardiac surgical populations generally, but cannot be modified based on simultaneous functional assessment.
- ***Customized probability score (CPS)*** − an evolution of the RCRI, the CPS incorporates type of surgery and coexistent medication usage alongside the original RCRI risk factors to generate an individualized prediction of all-cause mortality. Unlike the RCRI, individual risk factors are variably weighted. The CPS is internally validated for vascular surgery specifically and emergency surgery generally. It is, however, yet to undergo external validation and is similarly unable to incorporate objectively established functional capacity.
- ***AHA/ACC consensus guidelines*** − though not a dedicated risk scoring system, the 2014 update of the AHA/ACC consensus guidelines provides a comprehensive, evidence-based approach to cardiac risk in non-cardiac surgery. The guidelines direct a clear, algorithm-based, global assessment across three domains: patient risks, surgical risks and uniquely, functional capacity. While practically useful, the guidelines only allow unquantified stratification of cardiac risk in isolation. Assessment of functional capacity by subjective patient reporting and use of METs or an activity scale is recommended. However, formal exercise testing such as CPET is highlighted for consideration only when cardiac risk is otherwise elevated and objective functional status is unknown.

Informed patient discussion

The preoperative assessment clinic provides the ideal environment for informed patient discussion of risk prior to major surgery. This can be achieved in a timely manner prior to the planned surgical date to allow appropriate multidisciplinary decision making. Recent work has produced a tool aimed at accurate prediction of longer-term survival following proposed abdominal aortic aneurysm repair to allow individualized comparison with risk of death associated with a non-operative.[8] Conservative management should always be considered as an appropriate outcome, depending on patient preference and risk assessment.

Discussion

Preoperative patient evaluation and risk assessment in vascular surgery are central components of good-quality patient care. Risk assessment, surgical and postoperative care facility planning, patient counselling and options for conservative treatment can all be discussed and planned in a timely manner. Objective functional assessment and risk scoring systems are now increasingly being utilized as part of this multimodal decision-making process. Preoperative assessment and the perioperative role of the anaesthetist are now firmly established in delivering improved outcome through this process. ◆

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