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Perioperative cardiac investigations - indications and interpretation

Key Points

- An accurate assessment of cardiovascular function is fundamental when assessing fitness for anaesthesia and surgery.
- Cardiac investigations enable anaesthetists and surgeons to risk stratify patients and plan for post operative care.

Introduction

"In the UK 25 000 to 30 000 patients per annum die within 28 days of surgery. The majority of these patients are over 65. Cardiovascular and respiratory disease are most commonly implicated in the cause of death." (ELFH 2014)

"Following major surgery, the inflammatory response increases the body's oxygen consumption by up to 40%. The higher oxygen demand postoperatively lasts for several days and is met mainly by increased cardiac output. Any disease which affects the function of the cardiac system may lead to major morbidity or mortality." (ELFH 2014)

Role of Cardiac Investigations

Cardiac investigations during the perioperative period have several roles:

They may be used to diagnose previously unknown underlying cardiac disease, to investigate the risk posed by pre-existing cardiac disease and predict complications during the perioperative period.

The nature of investigations needed for each patient should be individualised based upon the type of surgery, any pre-existing co-morbidities and the clinical urgency of surgery. Elective surgery may allow detailed cardiological preoperative investigation. In the

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emergent setting it is often prudent to plan perioperative care on the assumption that there is underlying cardiac pathology rather than delaying surgery to obtain investigations.

Non-invasive cardiac tests:

Provide information on 3 cardiac risk markers:

1) Left Ventricular (LV) and Right Ventricular (RV) function.
2) Sequelae of myocardial ischaemia.
3) Heart valve abnormalities.

(Kristensen et al. 2014)

12 lead ECG:

Provides information regarding heart rate, rhythm and axis deviation and assessment of pacemaker function.

Abnormalities may include:

1) Evidence of myocardial ischaemia: pathological Q waves, ST segment abnormalities.
2) Dysrhythmias: atrial fibrillation, atrial flutter, ventricular ectopic beats or unexplained sinus tachycardia.
3) Myocardial disease: evidence of ventricular hypertrophy and sequelae of hypertension.

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ECG is not required for all patients undergoing anaesthesia below is a summary table from the NICE 2016 guidelines outlining the indications for routine pre op ECG.

Type of surgery	ASA I*	ASA II*	ASA III*	ASA IV*
Minor**	Not indicated	Not indicated	Yes [if not performed in last 12 months]	
Intermediate**	Not indicated	Consider for patients with cardiovascular, renal or diabetes comorbidities.	Yes	
Major or complex**	Consider for patients aged over 65 if no ECG results available from past 12 months	Yes		

[*Appendix 1 ** Appendix 2]

Echocardiography:

Echocardiography is a readily available test, allowing evaluation of cardiac and ventricular function, identification of valvular defects plus assessment of endocardial, myocardial and pericardial disease.

Despite echocardiography being user dependant it has been shown to change the cardiac diagnosis in over two thirds of patients in emergency settings, where the ability to gain accurate, effective histories and information can be challenging. (Canty et al. 2012) The findings of echocardiography can have a huge bearing on patients planning and outcomes, but even focussed transthoracic echocardiography (TTE) has been shown to lower mortality in some patient groups when performed perioperatively. (Canty et al. 2012)

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History and examination may indicate the need for preoperative echocardiography. The following table summarises many of these indications. [British Society of Echocardiography]

Condition	Indications for pre-operative echo
Murmur	• Presence of cardiac or respiratory symptoms. • Murmur in an asymptomatic individual with clinical features suggestive of structural heart disease.
Known native valvular pathology: stenosis or regurgitation	• Repeat assessment if change in clinical status. or with severe stenosis
Prosthetic valves	• Assessment of prosthetic valve with change in clinical status.
Ischaemic heart disease	• New murmur following acute or recent myocardial infarction. • Assessment of infarct size, presence of complications and baseline LV function following MI. • Evaluation of patients with non-diagnostic ECG.
Cardiomyopathy	• Clinical cardiomegaly • Signs of heart failure • Unexplained dyspnoea in the absence of clinical signs of heart failure. • Suspected cardiomyopathy based on abnormal examination, ECG, or family history.
Pericardial disease	• Suspected pericarditis, pericardial effusion, tamponade or constriction
Pulmonary disease	• Lung disease with clinical suspicion of cardiac involvement • Suspected or established pulmonary hypertension • Right heart dysfunction
Hypertension	• Suspected LV dysfunction. • Clinically suspected aortic coarctation.
Syncope	• Clinical suspicion of structural heart disease causing arrhythmia
Major arterial/aortic disease.	• Assessment of aortic aneurysm or aortic dilatation.

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Pre-operative LV systolic dysfunction, moderate to severe mitral regurgitation and increased pressure gradients across the aortic valve are all associated with adverse cardiac events perioperatively and identification can help with anaesthetic and surgical planning, along with risk stratification.

As the use of transthoracic echo becomes more ubiquitous and readily available, bedside echocardiography is becoming more common place. Bedside echocardiography performed by members of the anaesthetic team can reduce cardiology department pressures and allow for faster and smoother care for patients. (Barber & Fletcher 2014) TTE has been shown to change management plans of patients up to the point of the anaesthetic room (Canty & Royse 2009) and its use can allow better utilization of resources, reduce burden on higher level care beds and improve inpatient logistics such as late cancellations of procedures. (Canty & Royse 2009)

As technology has developed, plug in echo probes that attach to smart devices are now reaching the market, and may replace the stethoscope in years to come (Michard 2017).

Biomarkers

Biochemical markers that can be detected with a simple blood test can give a non interventional method of assessing myocardial damage and LV function. Currently in anaesthesia biomarkers are used in two separate ways; the predication of risk from cardiac failure and the assessment of perioperative ischaemia.

In heart failure B-type natriuretic peptide (BNP) and N-terminal pro-BNP (NT-proBNP) are cardiac biomarkers produced by cardiac myocytes in response to an increase in myocardial stretch. Typically, increases are seen in heart failure and ischaemia, as the ventricular filling pressures increase, as the myocardium fails leading to increased wall stress and BNP/NT-proBNP production. (Kristensen et al. 2014; Minto & Biccard 2014; Ponikowski et al. 2016) Raised preoperative values for these markers provide an additional indicator of the risk of developing post operative cardiac failure. In those patients whose cause of breathlessness remains uncertain, elevated BNP/NT-proBNP levels may guide further preoperative testing such as CPEX. (Kristensen et al. 2014; Minto & Biccard 2014)

Heart failure causes chronic activation of the immune system via a number of mechanisms such as tissue bed ischemia and as such acute phase proteins such as CRP can be used in heart failure to guide certain anti-inflammatory therapies such as statin use. Raised CRP has been related to worse outcomes in patients with heart failure. (Minami et al. 2017; Anand 2005) However this is due to multifactorial reasons and therefore cannot be evaluated as an independent marker in heart failure.

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Recent studies have outlined the next generation of heart failure biomarkers, which include soluble source of tumorigenecity 2 (sST2)(Y.-C. Wang et al. 2013) , galectin-3 (Gal3) (Anand et al. 2014) growth differentiation factor-15 (GDF15) (Corre et al. 2013))and diverse microribonucleic acids (miRNAs)(Vegter et al. 2016) These newer biomarkers not only facilitate risk stratification in heart failure but can potentially identify different heart failure sub types and help assess cardiac remodeling (Magnussen & Blankenberg 2018). In the future the use of multiple markers may help deliver personalised medicine and risk stratification to an increasingly ageing surgical population, with high cardiac risk burden.

Perioperative cardiac considerations extend beyond heart failure in this period. Cardiac ischemia is not an uncommon event perioperatively and even in non cardiac surgery major cardiovascular complications can occur in up tot 3.5% of patients. (Priebe 2011) Troponin T and Troponin I are effective markers of myocardial damage and in recent years higher sensitivity troponin measurement has allowed for earlier diagnosis of acute coronary syndromes. Higher troponin levels post operatively have also been shown to be associated with an increased 30 day mortality (T. J. Wang et al. 2003). Thus pre and post operative measurement of cardiac troponins in high risk patients can be considered.

Invasive testing

Coronary angiography

An invasive procedure that provides dynamic imaging of the coronary circulation alongside ventricular function. There are specific indications for both elective and emergency coronary angiography but there is very little evidence for routine coronary angiography in the peri-operative period unless indicated by the results of other investigations.

Dynamic testing

The use of physical exercise such as treadmill or static bike may provide an estimate of functional capacity. During these tests changes in blood pressure and heart rate can be measured along with ECG monitoring to asses for ST changes indicating myocardial ischaemia. Pre-existing ECG changes such as bundle branch blocks or other ST segment abnormalities many prevent accurate ECG analysis. (Kristensen et al. 2014)

Patients with limited functional capacity may be unable to exercise to threshold for these tests and pharmacological options such as dipyridamole, dobutamine and adenosine may be used instead.

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Exercise echocardiography will provide additional information regarding left ventricular function. It will also demonstrate ischaemia by highlighting regional wall abnormalities which may be provoked by exercise secondary to underlying ischaemia. These changes may be detected earlier than changes on a 12 lead ECG.

There is good evidence that these dynamic tests are associated with improved 1-year survival and hospital stay after surgery, presumably because test results prompt closer attention to patients' haemodynamics in the perioperative period. (Minto & Biccard 2014)

Cardiopulmonary exercise testing

Exercise testing provides a more objective demonstration of a patient's functional capacity. It is a representation of the adaptive ability of the heart, lungs and muscles to respond to the increase in physiological stress. It is performed most commonly with patients using a static cycle and data is gathered using a metabolic cart. The cycle is loaded incrementally as the patient cycles. The metabolic cart gathers information on oxygen consumption, CO2 production and ECG and blood pressure readings alongside pulse oximetry.

This information can be used to calculate anaerobic threshold (the point at which muscles cells generate switch energy production to anaerobic respiration), demonstrated as a rapid rise in CO2 production. The VO2 max, oxygen pulse [VO2/HR], maximal heart rate, blood pressure and respiratory quotient [carbon dioxide produced/oxygen utilization].

CPET test results have a prognostic role in patients with cardiac failure and respiratory disease. They may also detect other conditions such as myocardial ischaemia and pulmonary hypertension. These results may enable clinicians to consider additional cardiological intervention in order to mitigate risk of elective non-cardiac surgery. A patient who is unable to achieve a peak oxygen consumption during CPET of 15 ml O_2 kg−1 min−1 (which corresponds to ~4 METs) is at risk of functional heart failure after surgery.(Minto & Biccard 2014)

Summary

Cardiac investigations during the perioperative period enable a more objective prediction of risk from cardiac complications during this period. Investigations should be tailored to each patient and their premorbid condition.

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Further Reading

My e-Learning Anaesthesia (e-LA) Core Training - Clinical e-LA Module 01 - Introduction to Clinical Anaesthesia 2014 04 Preoperative Assessment and Management 10 Higher risk patients 01_10_01 Higher Risk Groups: Cardiovascular and Respiratory Disease

My e-Learning Anaesthesia (e-LA) Core Training - Clinical e-LA Module 01 - Introduction to Clinical Anaesthesia 2014 04 Preoperative Assessment and Management 1_09_05 ASA Grading and Preoperative Investigations

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Appendix 1:

Surgery Grades	**Examples**
Minor	• excising skin lesion

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	• draining breast abscess
Intermediate	• primary repair of inguinal hernia • excising varicose veins in the leg • tonsillectomy or adenotonsillectomy • knee arthroscopy
Major or Complex	• total abdominal hysterectomy • endoscopic resection of prostate • lumbar discectomy • thyroidectomy • total joint replacement • lung operations • colonic resection • radical neck dissection

[NICE 2016]

Appendix 2:

ASA grades

The ASA (American Society of Anesthesiologists) Physical Status Classification System is a simple scale describing fitness to undergo an anaesthetic.

ASA I	A normal healthy patient
ASA II	A patient with mild systemic disease
ASA III	A patient with severe systemic disease
ASA IV	A patient with severe systemic disease that is a constant threat to life

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