Preoperative investigations in adult cardiac surgery patients

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Abstract

Preoperative investigations in cardiac surgery can be divided into diagnostic and assessment of fitness for surgery. Diagnostic investigations are used to detect and evaluate coronary, valvular, myocardial and thoracic aortic disease. Knowledge of an individual patient's co-morbidities is essential in determining the risk of postoperative morbidity and mortality, thus allowing for more accurate informed consent. Furthermore, the results of preoperative investigations may predict the likely postoperative hospital stay and support required in order to maximize the chances of uneventful recovery. Additionally, the changing operative demographic, with an increased age and burden of co-morbidities frequently makes open-heart surgery challenging prompting a reliance on minimally invasive procedures that may not require cardiopulmonary bypass such as transcatheter aortic valve implantation (TAVI) and mitral valve repair. This article highlights the tests for preoperative diagnosis and assessment of fitness for surgery in adult cardiac patients. They should be used to guide clinicians in making appropriate management decisions, particularly with regard to elderly, frail or complex cardiac cases discussed in the setting of joint cardiology and cardiothoracic meetings.

Keywords Cardiac; carotid; echocardiogram; investigations; preoperative; risk stratification

Diagnostic investigations of adult cardiac disease

Coronary heart disease

The exercise tolerance test is a useful screening investigation in which a patient undergoes a standardized protocol of increasing exercise with continuous recording of 12-lead ECG and blood pressure monitoring. It is used for the diagnosis of ischaemic heart disease (ST segment depression >1 mm, fall in blood pressure or angina), and the assessment of asymptomatic valvular disease and exercise related arrhythmias. Its usefulness is limited in patients on beta-blockers, those with limited exercise tolerance due to co-morbidities and those with resting ECG abnormalities.

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Radionuclide perfusion imaging with thallium or technetium can also be used as a screening investigation for significant coronary artery disease. For patients that are unable to exercise, vasodilators such as adenosine may be used to stress the heart. Images are obtained at peak stress and at rest. Reversible perfusion defects indicate viable ischaemic myocardium; irreversible defects indicate non-viable scar.

Cardiac catheterization: a recent (within the previous 12 months) **coronary angiogram** is required for patients undergoing coronary artery bypass surgery. It is used to demonstrate coronary artery anatomy and to identify the location and severity of disease; a stenosis >50% is considered significant. This guides selection of the target vessels to graft. A **left ventriculogram** shows left ventricular function and may detect mitral regurgitation.

Stress echocardiography: echocardiography provides information on ejection fraction, left ventricular size and regional wall motion abnormalities. Stress echocardiograms are performed using dobutamine infusion to pharmacologically stress the heart by increasing cardiac work. It can identify hibernating myocardium and predicts the likely improvement in cardiac performance following revascularization. (Hibernating myocardium is defined as reversible left ventricular dysfunction caused by chronically insufficient myocardial perfusion.)

Positron emission tomography (PET) scanning helps to differentiate stunned and hibernating myocardium from scarred myocardium in patients who do not complain of angina but present primarily with symptoms of heart failure or poor left ventricular function. FDG-PET additionally enables visualization of the metabolic activity in viable myocardial cells.

Cardiac MRI can be used to further assess left ventricular function, myocardial perfusion and viability. Gadolinium contrast MRI discriminates between partial thickness and full thickness infarcts, and therefore is useful when evaluating patients with poor left ventricular function who are doubtful candidates for coronary revascularization.

Coronary CT angiogram (CTA): advances in CT imaging technology, including the introduction of multidetector (multi-slice) row systems with electrocardiographic gating, have made imaging of the heart and the coronary arteries feasible. Cardiac CTA can provide information about coronary anatomy and left ventricular function that can be used in the evaluation of patients with suspected or known CAD. It is also useful to visualize previous coronary grafts in patients planned for redo cardiac surgery.

In most circumstances, a negative coronary CT angiogram rules out significant obstructive coronary disease with a very high degree of confidence, based on negative predictive value of 93% obtained in cohorts. Therefore it is useful for managing patients scheduled for non-coronary artery cardiac surgery particularly in the surgery of aortic root aneurysms where it may be difficult to engage the coronary ostia in angiography.

On the contrary, the positive predictive values probabilities following a positive coronary CT angiogram are more variable,

due in part to the tendency to overestimate disease severity, particularly in smaller and more distal coronary segments or in segments with artefacts caused by calcification in the arterial walls. It can therefore be used concomitantly with myocardial perfusion imaging (MPI).

The differences in the parameters measured by MPI ('function' or 'physiology') and CTA ('anatomy') must be considered when making patient management decisions with these studies. Of note, a normal MPI does not exclude the presence of coronary atherosclerosis although it does signify a very low risk of future major adverse events over the short to intermediate term. Conversely, coronary CTA allows detection of some coronary atherosclerotic plaques that are not haemodynamically significant. Neither test can presently identify with any reasonable clinical probability non obstructive coronary plaques that might rupture in the future and cause acute myocardial infarction.

Valvular heart disease

Echocardiography

Transthoracic echocardiogram (TTE) – is the primary investigation for valvular heart disease. It detects most valvular conditions and is widely available in UK hospitals, but the quality of images obtained is operator and machine dependent.

Transoesophageal echocardiography (TOE) – provides excellent images of the heart, allowing more detailed examination of the mitral valve and aortic root. It is vital in patients with mitral regurgitation who may be suitable for mitral valve repair. Limitations include the need for sedation or anaesthesia and the availability of a skilled operator to conduct the procedure and interpret the images.

Three-dimensional echocardiography – can be performed via a trans-thoracic and trans-oesophageal approach. It can provide a surgeon's view allowing morphologic evaluation of the valve leaflets especially of the prolapsing segment and measurement of the annulus, thus helping plan surgical strategy. It use as an accurate predictor of surgical closure has been well documented. It also allows a dynamic assessment of the valve following surgical repair, for example the ability to look at the mitral closure line in a loaded ventricle in systole.

Four-dimensional echocardiography – is used to provide real-time rendering of the heart based on 3-D reconstructed images.

Cardiac catheterization

Coronary angiography – is only performed in patients aged >40 years and in younger patients with significant risk factors for coronary artery disease.

Aortography – can help to identify the severity of aortic regurgitation and the presence of aortic root or ascending aortic dilatation.

Right-heart catheterization – is useful in patients with mitral or tricuspid valve disease, congenital heart disease, pulmonary hypertension and severe left ventricular dysfunction.

Structural disease of the heart

Non-valvular heart disease such as atrial or ventricular septal defects, more complex adult congenital heart disease, pericardial fluid or thickening can be identified and evaluated using techniques already described, particularly *echocardiography*, *cardiac MRI* and *cardiac catheterization*.

Disease of the thoracic aorta

Chest radiograph may show mediastinal widening suggesting an aortic aneurysm. It detects pleural effusions, and a large cardiac silhouette may indicate pericardial effusion.

CT aortogram is a valuable investigation for the diagnosis and assessment of thoracic aortic disease, demonstrating aortic atheroma, calcification, ulceration, intramural haematoma, dissection and aneurysm. It is widely available in UK hospitals and is therefore the first-line investigation in the acute setting. Multi-slice CT scanning with three-dimensional reconstruction is essential for preoperative planning for non-emergency thoracic aortic interventions (both surgical and endovascular) and for postoperative evaluation.

MRI is the investigation of choice for the screening of chronic thoracic aortic dissection or aneurysm. It avoids the radiation dose of CT and provides excellent images of the aortic tree as well as allowing dynamic assessment of valves and ventricles. It can illustrate subclinical disease using molecular imaging techniques. For example quantifying the proportion of elastin in the aortic wall, therefore identifying patients at risk of aortic dilatation that require follow up and intervention. Additionally, it can demonstrate areas of irregular endothelial permeability thus enabling focused preventative treatment. Moreover, four-dimensional phase contrast MRI scanning (4D PC-MR) provides imaging of the flow in both the true and the false lumens, enabling calculation of the rate of aortic expansion, hence guiding prospective endovascular treatment.

Positron emission tomography (PET) is increasingly used with CT. This has the benefit of significantly superior images when performed in combination. It can illustrate aortic wall inflammation, with preliminary studies showing strong correlation between increasing inflammation and worsening outcomes.

Echocardiography enables rapid assessment of the aortic valve, root and ascending aorta. It is useful to confirm the presence of a dissection flap and to examine the aortic valve in acute type A dissection. Although views of the arch are limited, echocardiography can also be used to screen for coarctation in patients with bicuspid aortic valve disease.

Preoperative assessment of fitness for surgery

Risk stratification models: objective assessment of surgical risk is undertaken to facilitate better informed consent. Surgical risk is influenced by co-morbidity:

- diabetes
- chronic pulmonary disease
- renal dysfunction
- neurological dysfunction
- peripheral vascular disease
- endocrine disease
- obesity or frailty.