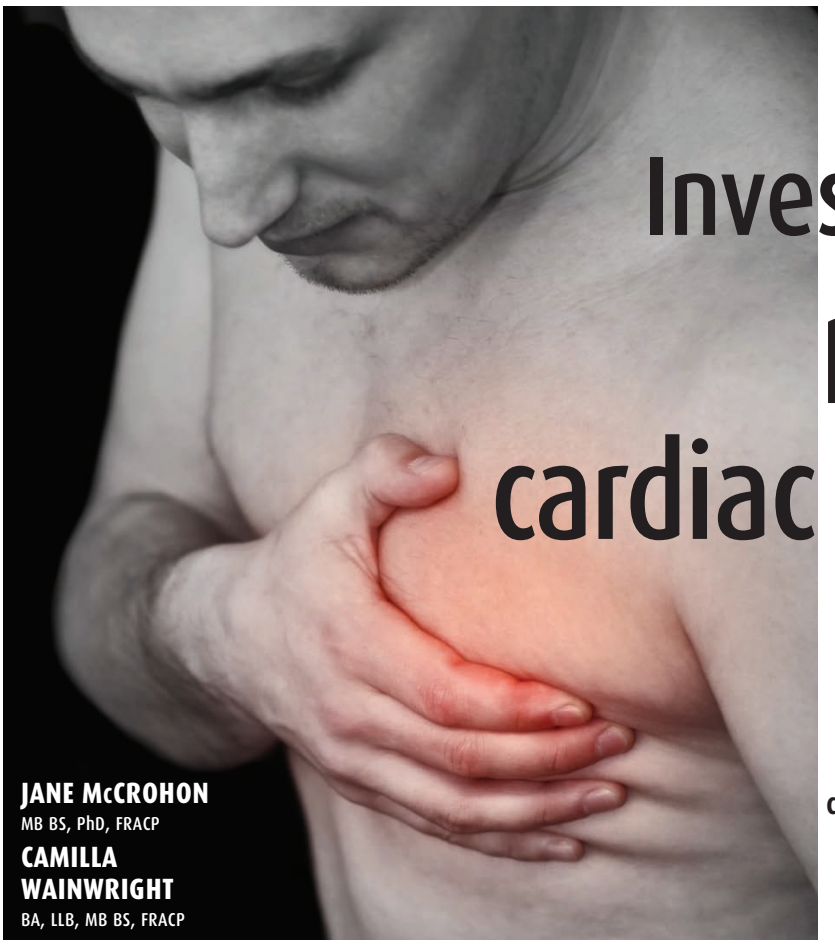

Investigating the patient with cardiac chest pain

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In this series, we present authoritative advice on the investigation of a common clinical problem, especially commissioned for family doctors and written by members of the Royal Australasian College of Physicians.

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Chest pain is one of the most common reasons for presentations to emergency departments. Chest pain due to coronary artery disease is the leading cause of death in Australia, with more than 23,000 deaths attributed to this in 2005 alone.[1] With an estimated 55,000 myocardial infarctions occurring in Australia in 2009,[2] and at an approximate average cost of $281,000 per event,[2] the cost of coronary artery disease is substantial. In addition to this, there are a further 32,452 estimated cases of chest pain not attributed to a myocardial infarct and each chest pain event itself costs $74,000.[2] In addition to enormous financial costs, there is also a high cost of morbidity and mortality.

Defining the nature and possible aetiology of chest pain can pose a diagnostic dilemma for all clinicians, despite there being multiple algorithms to assist in managing these patients. Most investigations are initially performed to explore the possibility of ischaemic heart disease or other high-risk presentations, such as pulmonary embolism. This article predominantly explores the investigation of patients with chest pain in whom the diagnosis of ischaemic heart disease

IN SUMMARY

- **The diagnosis and investigation of the patient with chest pain can be challenging.**
- **The early identification of a patient with acute coronary syndrome or other sinister causes for chest pain, such as aortic dissection or pulmonary embolism, is important to allow early intervention and treatment.**
- **Risk stratification of any patient with chest pain aids in the decision for investigations.**
- **Patients without cardiac causes for chest pain but with adverse risk factor profiles can be recommended for risk factor modification.**

Table 1. Differential diagnoses for cardiac causes of chest pain

- Acute coronary syndrome
  - ST-segment elevation acute coronary syndrome
  - non-ST-segment elevation acute coronary syndrome
  - unstable angina
- Chronic stable angina
- Acute aortic dissection
- Myocarditis/pericarditis
- Aortic stenosis
- Hypertrophic obstructive cardiomyopathy
- Other cardiomyopathies
- Stress-related conditions (e.g. takotsubo cardiomyopathy, coronary artery spasm)

as a cause requires exclusion. It is important, however, to mention that ischaemic symptoms may not present with chest pain, but rather chest pain equivalents, such as dyspnoea on exertion, sweating or arm, back or jaw discomfort. Up to a third of patients presenting with an acute myocardial infarction may not experience pain at all.[3] Furthermore, 'pain' is a subjective experience, with many patients with myocardial ischaemia describing the experience, as 'discomfort' or 'pressure' rather than pain.

In defining the basis of chest pain, there are a number of investigations from which to choose. These range from the least invasive, such as an electrocardiogram (ECG) or assessment of serum markers for myocardial injury, to more involved tests, such as an exercise stress test, to the more invasive modalities, such as an invasive coronary angiogram. Each has its place and its limitations and the test of choice for a particular patient is dependent on a number of different considerations.

What remains consistent in any management paradigm is the need for a thorough history and assessment of whether the patient is at low, intermediate or high risk for acute coronary syndromes (ACS). This will in turn determine the most appropriate pathway of investigation and management.

Assessment

Chest pain can be due to cardiac, respiratory, gastrointestinal or musculoskeletal causes. Noncardiac causes of chest pain include pulmonary embolus, pneumonia, gastritis/peptic ulcer disease and costochondritis. Cardiac causes of chest pain are listed in Table 1. This article focuses on chest pain of a cardiac origin.

Aims of assessment of patients with chest pain are to:

- identify ACS and refer for urgent treatment
- diagnose other sinister causes for chest pain (e.g. aortic dissection, pulmonary embolism)
- identify benign causes of chest pain and manage symptoms according to the diagnosis
- recommend risk factor modification in those without a cardiac cause for chest pain but with an adverse risk factor profile.

History

The history of all patients presenting with chest pain should include a description of the nature of the pain, the site/location and any precipitating, exacerbating or relieving triggers. It is also important to elicit the duration and timing of the pain, whether the pain radiates to another location, such as the arm or the jaw, and whether there are other associated symptoms, such as sweating, nausea or breathlessness, which might point towards ischaemia as the cause. In addition, patients should be asked whether they have experienced the type of pain before and, if so how frequently, and whether they have had prior investigations. A thorough past medical history is important because this can help risk stratify the patient.

Characteristics in the pain description that might suggest ACS are:

- central location
- radiating to the left arm and throat
- tight, squeezing, constricting or pressure-like in nature
- more than five minutes in duration
- precipitated/exacerbated with exertion (physical or emotional)
- relieved with rest or by nitrate supplements.

The risk factors for ischaemic heart disease include:

- type 2 diabetes
- a history of hypertension
- dyslipidaemia
- increased BMI
- a significant smoking history
- a family history of premature coronary artery disease.

Physical examination

In the acute setting of patients presenting with chest pain, examination should focus initially on an assessment of their haemodynamic stability, looking at their blood pressure and heart rate, as well as respiratory rate. Cardiovascular assessment might yield information about whether a patient has a murmur, additional heart sounds, a rub, heave or prominent apex beat. Respiratory examination should focus on whether there is symmetry of the chest on inspiration, whether the breath sounds are vesicular in nature and whether the lung fields sound clear with no additional wheeze, crepitations or dullness to percussion. Abdominal examination may reveal organomegaly, a pulsatile mass in the situation of an abdominal aortic aneurysm or the presence of ascites in patients with right heart failure. If a patient appears sweaty/ clammy with hypotension/ hypertension and/or tachycardia, urgent referral to an emergency department is necessary.

It is important to recognise that although an accurate history and thorough examination are very important in the assessment of a patient with chest pain, these alone are not reliable in excluding ACS. Therefore, investigations such as an ECG and blood tests are essential.

Investigations

Routine investigations for any patient who presents with chest pain include a basic ECG. If the ECG is markedly abnormal and there is a high index of suspicion of a cardiac cause of pain (Table 2), urgent referral of the patient to the emergency department should be made. Other basic tests such as a chest radiograph, as well as blood tests, are usually performed in the emergency department but can be done in the outpatient setting if the presentation is not acute and if the patient is not at an intermediate or high risk of ACS.

The box on page 56 provides a brief summary of additional investigations that may be of value in the evaluation and risk stratification of patients with chest pain of a cardiac cause.

ECG

An ECG can diagnose the following:

- ST-segment elevation myocardial infarction (or new left bundle branch block [LBBB]). Patients with this diagnosis require an urgent transfer to hospital for emergency reperfusion (fibrinolysis or primary percutaneous coronary intervention). There are, however, other important causes of ST elevation on an ECG to be aware of (Table 3).
- Acute ischaemic changes (ST-segment depression, T-wave changes). Patients with this diagnosis require an urgent referral to hospital for further investigations.
- Evidence of prior myocardial infarction (pathological Q-waves, a LBBB or if there are persisting T-wave abnormalities). Patients with this diagnosis

Table 2. Features associated with high, intermediate and low risk non-ST-segment elevation acute coronary syndrome (ACS)*

High-risk features (>10% risk)

Presentation with clinical features consistent with ACS and any of the following high-risk features:

- Repetitive or prolonged (>10 minutes) ongoing chest pain or discomfort
- Elevated level of at least one cardiac biomarker (troponin or creatine kinase-MB isoenzyme)
- Persistent or dynamic electrocardiographic changes of ST-segment depression ⩾ 0.5 mm or new T-wave inversion ⩾ 2 mm
- Transient ST-segment elevation (⩾0.5 mm) in more than two contiguous leads
- Haemodynamic compromise: systolic blood pressure <90 mmHg, cool peripheries, diaphoresis, Killip class > I and/or new-onset mitral regurgitation
- Sustained ventricular tachycardia
- Syncope
- Left ventricular systolic dysfunction (left ventricular ejection fraction <0.40)
- Prior percutaneous coronary intervention within six months or prior coronary artery bypass surgery
- Presence of known diabetes (with typical symptoms of ACS)
- Chronic kidney disease (estimated glomerular filtration rate <60 mL/ minute; with typical symptoms of ACS)

Intermediate-risk features (2 to 10% risk)

Presentation with clinical features consistent with ACS and any of the following intermediate-risk features and who are not meeting the criteria for high-risk ACS

- Chest pain or discomfort within the past 48 hours that occurred at rest or was repetitive or prolonged (but currently resolved)
- Age >65 years
- Known coronary heart disease: prior myocardial infarction with left ventricular ejection fraction ⩾ 0.40 or known coronary lesion more than 50% stenosed
- No high-risk changes on electrocardiography (see above)
- Two or more of the following risk factors: known hypertension, family history, active smoking or hyperlipidaemia
- Presence of known diabetes (with atypical symptoms of ACS)
- Chronic kidney disease (estimated glomerular filtration rate <60 mL/minute; with atypical symptoms of ACS)
- Prior aspirin use

Low-risk features (<2% risk)

Presentation with clinical features consistent with cardiac cause of chest pain without intermediate-risk or high-risk features.

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Table 3. Differential diagnoses for ST elevation on ECG

- Acute ST-segment elevation acute coronary syndrome
- Pericarditis
- Early repolarisation
- Left ventricle aneurysm post infarction

require a high index of suspicion for urgent referral.
- Arrhythmia with a rapid ventricular response and associated rate-related ischaemia.
- Conduction abnormalities. This may not cause chest pain, but may manifest with other cardiac symptoms of concern, such as syncope or dyspnoea.

It is important to remember that an ECG may be normal in 90% of patients with coronary artery disease.[4]

Chest x-ray

A chest x-ray can diagnose the following:
- Cardiomegaly. This suggests longstanding cardiac pathology – for example, a cardiomyopathy.
- Widened mediastinum. This may be diagnostic of an acute aortic dissection.

Additional investigations that may be of value in evaluating patients with cardiac chest pain

Transthoracic echocardiogram
- Able to diagnose significant valvular pathology (e.g. aortic stenosis).
- Can identify regional wall motion abnormalities indicating an underlying coronary artery territory, which may have jeopardised blood supply.
- Can exclude pericardial thickening or a pericardial effusion, which may occur in patients with pericarditis.
- Can diagnose type A aortic dissection.

Exercise stress test
- Provides a good noninvasive assessment of a patient's exercise tolerance as well as giving a good guide about exercise-induced cardiac ischaemia and exercise-induced arrhythmias.

Myocardial perfusion scan
- Has a sensitivity of 80% with a negative predictive value of 72% and a positive predictive value of 85%.[5]
- Dipyridamole myocardial perfusion scan is available for those who cannot exercise.

Stress echocardiogram
- Can be performed with an exercise test or using a pharmacological agent, such as dobutamine, in situations where the patient cannot exercise.
- Provides additional information on chamber size and valvular and ventricular function similar to a standard transthoracic echocardiogram.
- Good noninvasive test that has a similar sensitivity and specificity to a nuclear medicine study (positive predictive value of 92% and a negative predictive value of 69% for dobutamine stress echocardiogram).[5]

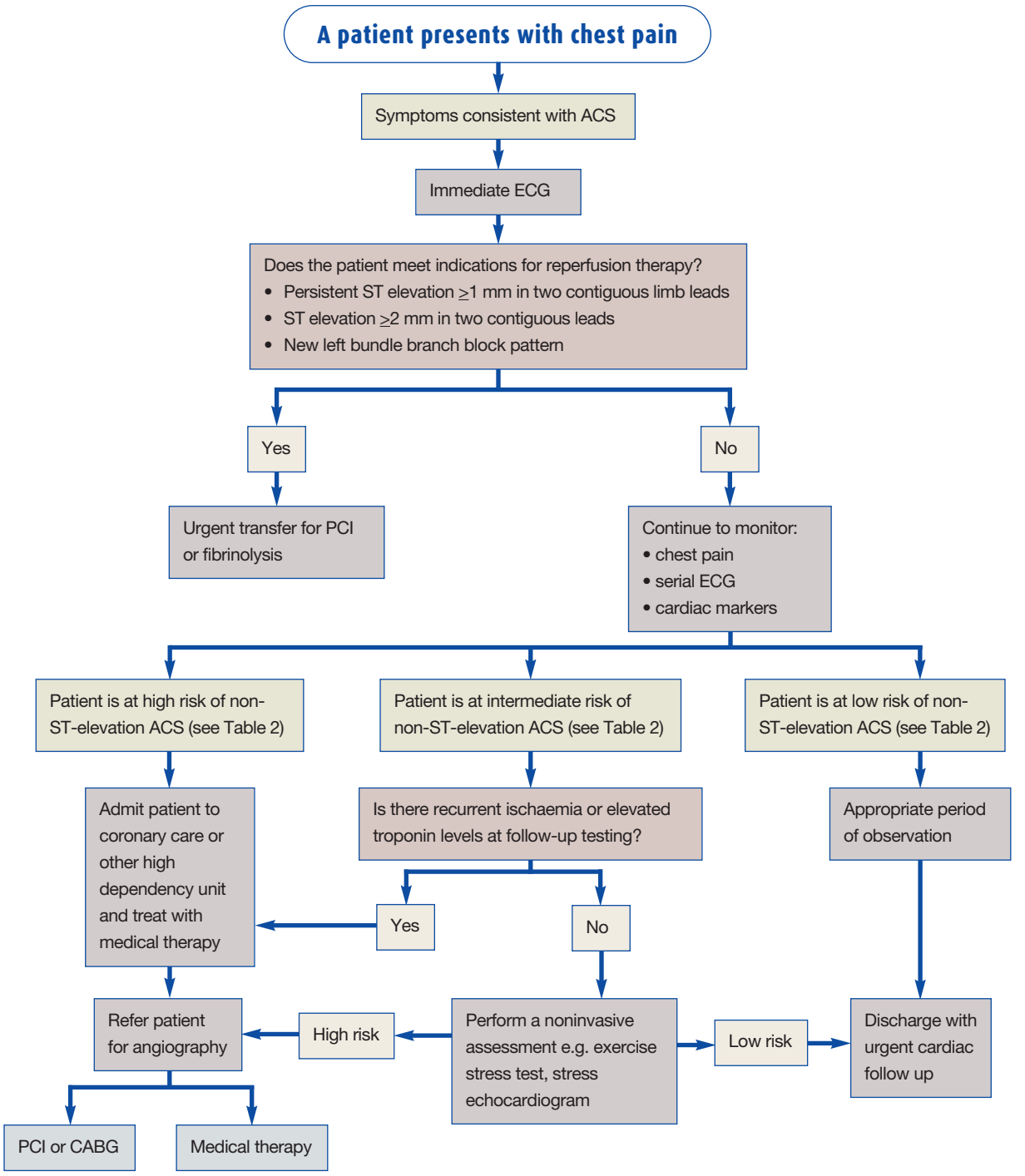
Computed tomography coronary angiography
- Is an emerging modality to investigate a patient presenting with chest pain.
- Has a high negative predictive value, therefore a result showing no evidence of coronary artery disease is very reassuring.
- Can also identify noncoronary cardiac pathologies as well as incidental noncardiac abnormalities that may be the underlying reason for the patient's presentation.

Coronary angiogram
- Is the current gold-standard investigation to identify coronary artery disease in patients who present with acute coronary syndrome.
- Allows visualisation of the lumen of the coronary arteries to identify possible narrowed segments responsible for ischaemia or even complete acute occlusion in the case of an acute infarct or a chronic occlusion.
- An assessment can be made at the time of angiography whether revascularisation is necessary and whether it can be done percutaneously or whether referral of the patient for coronary artery bypass grafting is appropriate.

Cardiac magnetic resonance imaging
- Is not available in all centres but is a very useful tool that has the advantage of not using ionising radiation but providing excellent temporal and spatial resolution.
- Has the ability to assess the pericardium.
- Evaluates ventricular function.
- Allows excellent tissue characterisation.
- The diagnostic test of choice if myopericarditis is suspected.
- Can localise the region of acute coronary syndrome or identify underlying coronary ischaemia with a perfusion modality.
- Recommended in patients with congenital heart disease or aortic disease, especially for serial evaluation.

continued

Investigating a patient presenting to the emergency department with chest pain of possible cardiac origin*



* Based on the National Heart Foundation of Australia/Cardiac Society of Australia and New Zealand 'Guidelines for the management of acute coronary syndromes 2006'.[6]
ABBREVIATIONS: ACS = acute coronary syndrome; CABG = coronary artery bypass grafting; ECG = electrocardiogram; PCI = percutaneous coronary intervention.

Case study. A man with persisting symptoms of chest pain

A 51-year-old man with a six-month history of intermittent chest pain presented to his local doctor for review. He had a history of hypertension but had achieved good blood pressure control on antihypertensive medication. He had no other significant risk factors for coronary artery disease. His episodes of chest pain had been short-lived and had predominantly occurred postprandially with no associated symptoms of dyspnoea or sweating. The chest pain usually subsided spontaneously within 10 to 15 minutes. An ECG showed normal sinus rhythm and some routine blood tests did not reveal any abnormality except that his fasting lipid profile was mildly abnormal.

The patient's symptoms of chest pain persisted over the following week and as they were somewhat atypical, a gastroenterologist's opinion was sought. An endoscopy demonstrated gastritis and Barrett's oesophagus and he was commenced on therapy for this. However, he continued to get intermittent epigastric/chest pain and started to experience some mild exertional dyspnoea, which was a new feature. He was referred for an exercise stress test and an appointment was made for cardiology review thereafter.

Unfortunately, during the stress test, the patient was only able to exercise for four minutes of the Bruce protocol because he was limited by knee pain due to a recent injury. Therefore, the stress test was submaximal. After reviewing the patient and given that there had been no progression of his symptoms and that he had an intermediate probability of coronary artery disease, his cardiologist referred him for a CT coronary angiogram.

The CT coronary angiogram demonstrated a critical stenosis in his proximal left anterior descending coronary artery and two tandem stenoses in his first diagonal branch, with disease in his left circumflex artery as well (Figures 1 and 2). He then proceeded to an invasive coronary angiography and a successful percutaneous coronary intervention with stents deployed to his left anterior descending coronary artery and diagonal arteries (Figures 3 and 4).

The patient was reviewed several months later and he reported feeling well with no residual symptoms. He had also resumed regular exercise.

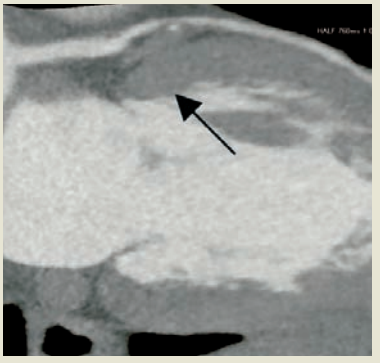


Figure 1. CT coronary angiogram demonstrating significant soft plaque (>80% stenosis) in the proximal left anterior descending coronary artery (arrow).

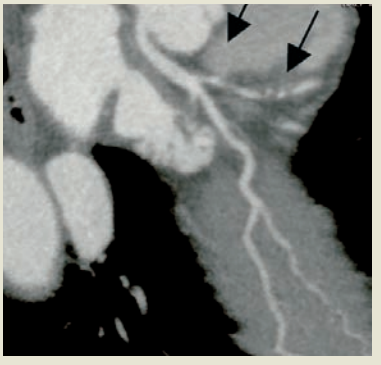


Figure 2. CT coronary angiogram multiplanar reconstruction demonstrating the left anterior descending coronary artery and diagonal branch (arrows) with significant soft plaque causing severe obstructive stenoses.

Figure 3. 3D coronary tree reconstruction showing the severe obstructive stenoses.

Figure 4. 3D reconstruction showing the anterior aspect of the heart with the left anterior descending artery and diagonal branches.

- A globular heart. This may occur with a significant pericardial effusion.
- Upper lobe redistribution of blood vessels/pleural effusion/alveolar oedema. These suggest left ventricular failure.

Blood tests

Results of blood tests may suggest the following:

- Raised creatine kinase-MB isoenzyme and cardiac troponin I levels. This is diagnostic of acute myocardial damage.
- Severe anaemia detected by a full blood count. This may provoke angina. A raised white blood cell count may indicate infection.
- Raised inflammatory markers, erythrocyte sedimentation rate and C-reactive protein levels. This may lend evidence for an inflammatory state such as myopericarditis or an underlying infection.
- Elevated liver function tests. This may identify a diagnosis of acute cholecystits/cholelithiasis.

Referral for cardiac diagnostic testing

The method and time line for continued assessment of a patient with chest pain of potential ischaemic origin may occur in the inpatient or outpatient setting. Any patient with acute ECG changes, continuing potentially ischaemic pain or symptoms suggesting possible ACS will more than likely require admission and urgent review in hospital. (The case study on page 59 outlines the assessment of a man with persisting symptoms of chest pain.) A percentage of these patients will have troponin elevation excluded and may undergo a basic risk stratification process, allowing their discharge or subsequent hospitalisation.

A general flowchart outlining investigations for patients referred to the emergency department with chest pain of possible cardiac origin is shown on page 58.[6] Once a patient has been diagnosed with ACS, the timing of referral for angiography is dependent on whether the patient is at high, intermediate or low risk.

The future

The management of the patient with chest pain is a complex issue. Importantly, our health system and clinical practice is likely to be shaped in the years ahead by economic and efficiency concerns, along with technological advances and information emerging from randomised controlled trials, which are designed to evaluate the best algorithm for patients presenting with cardiac chest pain.

Conclusion

It is important to identify early those patients with typical sounding chest pain or significant risk factors for ischaemic heart disease. Any patient with ST-segment elevation ACS should be referred for urgent cardiac catheterisation, or fibrinolytic therapy if there is likely to be a delay in catheterisation or there is no facility available for percutaneous coronary intervention.

Once a patient has been diagnosed with a non-ST-segment elevation ACS, he or she should be risk stratified as high, intermediate or low risk and referred for investigations appropriately. MT

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