# INVESTIGATION AND MANAGEMENT OF CHEST PAIN

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Chest pain is the most common presenting symptom of coronary heart disease (CHD). The effective assessment and management of patients with chest pain is central to any strategy to reduce the burden of coronary disease. Furthermore the investigation of patients with chest pain absorbs a substantial proportion of the resources of cardiologists and their departments.

The simple facts of taking a history to elicit features of ischaemic pain, examining and then investigating using established procedures such as exercise testing, functional imaging, and angiography are well described in any textbook of medicine or cardiology. Indeed these will be well known to medical students. The challenge to senior clinicians is to synthesise a service that brings these principles to the patient in a timely, accessible, consistent, and cost conscious format to provide an effective service that takes patients within the population to the correct diagnosis and then onwards along their journey to evidence based treatments.

This article will therefore focus on how to organise services so that the full spectrum of patients with chest pain are assessed in the right way, in the right environment, and in the right time frame. Overall the evidence base for the way we organise services is limited and mainly observational, but the use of randomised trials is gaining a foothold. This article will take the subject of chest pain through assessment and investigation with a particular focus on CHD.

## EPIDEMIOLOGY OF CHEST PAIN

Annually it is estimated that there are 634 000 primary care consultations for angina each year. The overall cost of caring for angina was calculated to be around 1% of the UK National Health Service (NHS) budget.[1] The burden of chest pain is far greater than the burden of angina. Nilsson and colleagues report from Sweden that 1.5% of primary care consultations are for chest pain, but only 17% of these are associated with definite or possible angina.[2]

A recent epidemiological study from South East London has provided contemporary data on the presentation of CHD (fig 1). The most common first presentation of CHD is exertional angina. Less than 14% present with sudden death, and 54% of men and 65% of women have preserved myocardium at presentation.[3] So opportunities to offer effective secondary preventive treatment exist for most cases of CHD; for the majority, left ventricular (LV) damage, which is one of the most powerful adverse prognostic features, is not present at first presentation.

Data from Gandhi and colleagues[4] show that if evidence based treatments are to be used effectively, they must be introduced promptly. In their study of cases of new exertional angina, 10% of patients suffer death or infarction in the first year (besides another 20% who undergo revascularisation), an event rate that falls dramatically thereafter.[4]

Within the UK overall CHD mortality is falling. There are also data on the falling prevalence of anginal symptoms. In the British regional heart study of 7735 men aged 40–59 years at entry, and monitored from 1978 to 1996, the prevalence of anginal symptoms has fallen by 1.8%, although the prevalence of a diagnosis of CHD is essentially unchanged.[5] The authors suggest that several factors may be at work here. Diagnostic thresholds may have fallen such that less severe disease is identified. The increasing numbers of patients being diagnosed with angina in rapid access chest pain clinics (RACPCs) supports this. Angina, as the presentation of CHD, may be declining (unlikely from recent data). A third option is that the clinical course of angina is becoming more benign through a mixture of population factors and the introduction of more effective treatments, therefore reducing the symptom burden of those with angina.

## ACCESS TO CARE

If patients do not access care—for example, by not presenting to health care services—or are not able to fully participate in care, then outcomes will be suboptimal both for the individuals concerned and for the population. Barriers to full and equitable access can be related to patients, physicians, and services. Patient factors may include language, culture, and socioeconomic status. Physician factors include inequitable referral patterns while complexities, biases, and queues in

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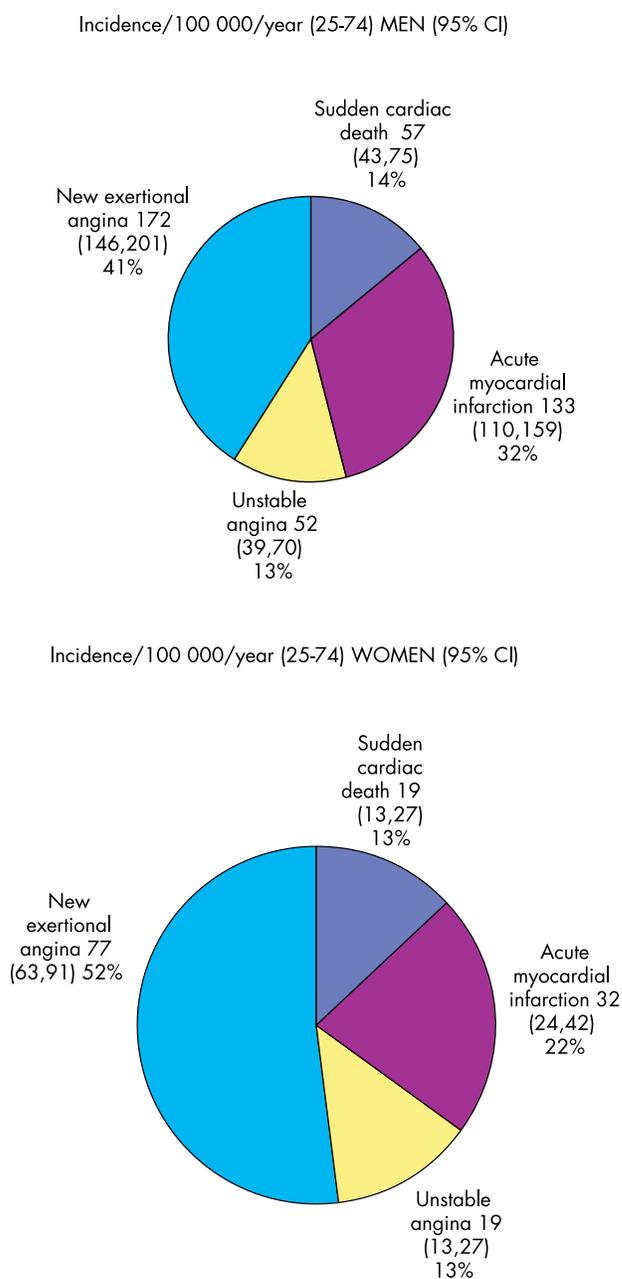
Incidence/100 000/year (25-74) MEN (95% CI)

Sudden cardiac death 57 (43,75) 14%

New exertional angina 172 (146,201) 41%

Acute myocardial infarction 133 (110,159) 32%

Unstable angina 52 (39,70) 13%

Incidence/100 000/year (25-74) WOMEN (95% CI)

Sudden cardiac death 19 (13,27) 13%

New exertional angina 77 (63,91) 52%

Acute myocardial infarction 32 (24,42) 22%

Unstable angina 19 (13,27) 13%

**Figure 1** The presentation of coronary heart disease in men and women.[3]

the service may mean that accessing care is more a test of skill in navigating the system than clinical need.

Richards and colleagues[6] showed that patients from a more deprived area of Glasgow reported greater perceived vulnerability to heart disease, but did not present because of fears they would be blamed by general practitioners for their risk behaviour and a sense that they already overused medical services. A further qualitative study by Gardner and colleagues[7] of stable angina patients in Liverpool showed that patients perceived themselves as old, had low expectations of treatment, knew little of recent advances, feared hospitals and tests, and saw doctors as busy.

Clinician and service based inequalities in access follow patients through their journey. Distance from the cardiac catheter lab influenced referral for coronary angiography,

based on data from a Danish study.[8] In a UK study older patients and women were shown to be less likely to be referred for exercise testing and subsequent angiography despite appropriate indications.[9] This study also showed underuse of angiography based on current accepted indications across all patient groups. Simple expansion of services is unlikely to resolve problems of access without specific measures to address inequalities and barriers.

## PRIMARY CARE SERVICES

There is increasing diversity in primary care services for the assessment of chest pain. Patients may choose between their own primary care practitioner, walk-in centres, NHS Direct (a telephone based advice service in the UK), a hospital emergency department, and dialling for an ambulance. These services provide the primary point of contact for patients and an important filter, so their effectiveness, and their integration with secondary care services, is key to a successful patient journey.

Grant and colleagues[10] compared quality of assessment of several sample patients, including one with chest pain, between walk-in centres, standard primary care, and NHS Direct. NHS Direct referred onwards the highest proportion (82% v 26% onward referral for walk-in centres). Based on an overall score derived by the authors, walk-in centres, whose key feature is to use a protocol based assessment process, performed most favourably.

## SECONDARY CARE SERVICES

A variety of models of secondary care services may exist for the assessment of suspected exertional angina referred from primary care, but the most significant development has been the establishment of focused clinics or RACPCs.[11]

Although first developed to support epidemiological research, their potential to improve service provision was soon recognised. Within the UK such clinics were given a substantial financial boost through their designation as the service model of choice in the National Service Framework for CHD. They provide prompt access to diagnosis, risk stratification, and treatment initiation for suspected angina. Compared to traditional outpatients they employ focused, standardised, consistent rather than complex assessment, and typically they are staffed by non-consultant grade physicians or nurses (fig 2).

Direct access exercise testing has fallen in popularity as a model of service, reflecting a general view of primary care that the preferred services to support primary care are specialist directed and contextualised investigation. In the related area of suspected heart failure Fuat and colleagues[12] described, in a qualitative study of primary care practitioners in north east England, concerns with a service based on open access investigation.

Observational data consistently support the effectiveness of RACPCs and overall suggest that risk stratification is effective, admissions are saved, and costs reduced. Dougan and colleagues[13] report no cardiac events among 395 patients diagnosed as having ''non-cardiac pain'' within three months of attendance at an RACPC in Belfast and a cost saving of £58 per patient compared to usual care. Newby and colleagues from Edinburgh presented data on GP management with and without an RACPC and reported a 46% reduction in admissions.[14] However, no trials have compared RACPCs with other models, and the main finding of a meta-analysis of studies on RACPCs was to highlight the sparsity of data.[15]
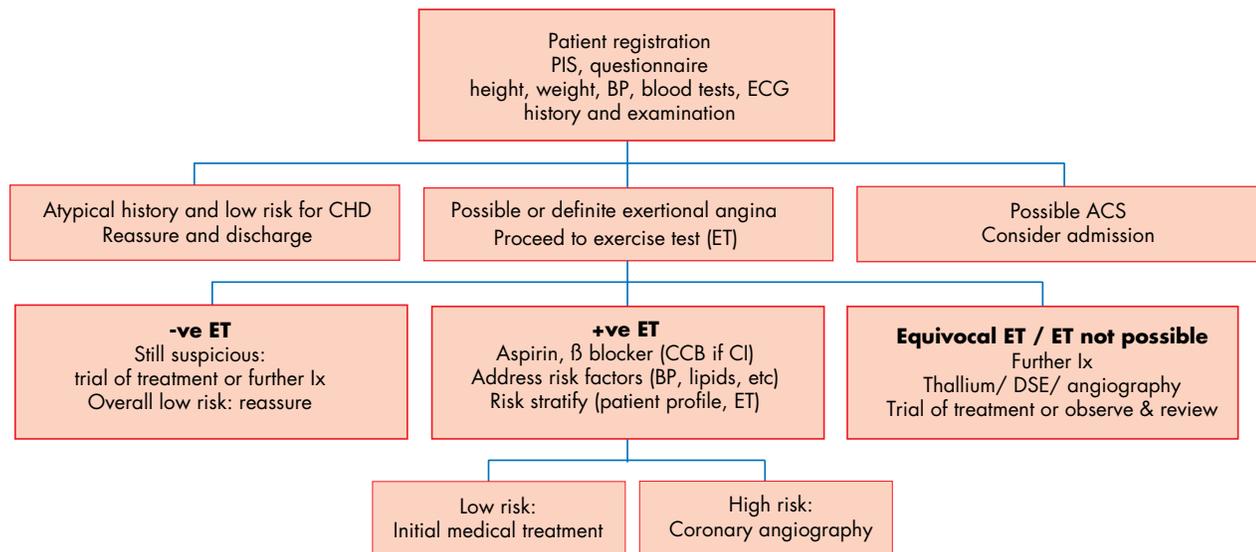
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**Figure 2** Core protocol for a rapid access chest pain clinic (RACPC). Adapted from Sutcliffe and colleagues.[11] ACS, acute coronary syndrome; BP, blood pressure; CCB, calcium channel bloker; CI, contraindicated; DSE, dobutamine stress echocardiogram; Ix, investigation; PIS, patient information sheet.

## NON-INVASIVE ASSESSMENT OF CHEST PAIN

Adequate history taking is essential to evaluate suspected cardiac chest pain. The priority is to identify ischaemic pain. The core features that diagnose exertional angina are readily accessible from a straightforward assessment of the patient and the pain (table 1).

Cooke and colleagues[16] examined the description of pain in 65 patients with normal angiograms compared to 65 with significant coronary stenosis. The presence of two out of three of (1) pain duration < 5 minutes, (2) rest pain < 2/10 episodes, (3) 10/10 episodes being reproduced by a similar level of exertion was noted in 85% with significant disease while in only 26% of those with normal angiograms.[16]

Resting physical examination and a 12 lead ECG are essential components of the assessment of chest pain, although in suspected exertional angina they are usually normal.

Exercise tolerance testing with continuous 12 lead ECG monitoring is the primary non-invasive test for the evaluation of suspected ischaemic chest pain. There are widely published reviews and guidelines for its conduct and interpretation[17] (www.bcs.com).

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**Table 1** Features of chest pain caused by coronary heart disease (CHD)

▶ Features in the patient
  – family history of CHD (male first degree relative <55 years old, female <60 years old)
  – hyperlipidaemia
  – hypertension
  – diabetes
▶ Features to seek in the pain characteristics (and typical answers)
  – location: central (radiating to left arm and throat)
  – character: tight, squeezing, constricting
  – duration: <5 minutes
  – worsened by exertion (physical but also emotional)
  – relieved by rest (or nitrates)

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Exercise testing encapsulates a fundamental principle of all investigations—the application of Baye's theorem. For exercise tests this manifests in the statement that the post-test likelihood of CHD depends both on the test result *and* the pre-test likelihood of CHD.

Exercise testing is simple, safe (mortality 1 in 10 000), and a widely applicable test, and has a valuable 78% sensitivity and 70% specificity for detecting CHD. But in practice the outcome can be even more helpful. A negative exercise test at adequate workload in patients with low to moderate pre-test probability of CHD effectively eliminates the likelihood of significant CHD. Such patients form a significant proportion of the workload of many RACPCs and their investigation should stop and reassurance begin following the exercise test. Exercise testing outcomes are not abnormal or normal but continuous variables in exercise duration, physiology, and ECG changes. Careful study of all the parameters measured is needed if the pre-test probability of CHD is to be appropriately adjusted.

Despite the usefulness of exercise testing, a substantial number of patients do not have their diagnosis and risk fully determined by an exercise test, or are unable to perform an adequate test. Additional non-invasive investigations (often loosely grouped as "functional tests") bridge the gap between exercise testing and invasive assessment. Excellent reviews of stress echocardiography and myocardial perfusion imaging have been published in this series.[18 19] Such reviews, combining multiple studies, report a sensitivity and specificity for dobutamine stress echocardiography of 81% and 80%, and for perfusion imaging > 90% and 70% (table 2). Physiological rather than pharmacological stress improves sensitivity. Importantly a negative study using either modality predicts a < 1% major event rate over the subsequent few years.

The recent National Institute for Clinical Excellence (NICE) guidelines on myocardial perfusion imaging did not consider other modalities, but in many ways are a template for provision of functional testing in general, rather than specific to nuclear cardiology (table 3) (www.nice.org.uk).

**Table 2** Stress echocardiography versus perfusion imaging. Adapted from Marwick[18]

| | |
|---|---|
| • Diagnosis of CHD | Similar accuracy in meta-analyses and head-to-head trials |
| | Stress echo less sensitive for mild disease |
| | Perfusion scanning less specific |
| • Prognostic evaluation | Similar (very good) prognostic implications of a negative test |
| • Detection of myocardial viability | Stress echo less sensitive but more specific for prediction of long term recovery |

**Table 3** The NICE guidance on myocardial perfusion scintigraphy (MPS)

1.1 MPS using single photon emission computed tomography (SPECT) is recommended for the diagnosis of suspected coronary artery disease (CAD) in the following circumstances:

▶ As the initial diagnostic tool for people with suspected CAD for whom stress electrocardiography poses particular problems of poor sensitivity or difficulties in interpretation, including women, patients with cardiac conduction defects (for example, left bundle branch block), and people with diabetes, and for people for whom treadmill exercise is difficult or impossible

▶ As part of an investigational strategy for the diagnosis of suspected CAD in people with lower likelihood of CAD and of future cardiac events. The likelihood of CAD will be based on the assessment of a number of risk factors including age, gender, ethnic group, family history, associated co-morbidities, clinical presentation, physical examination, and results from other investigations (for example, blood cholesterol values or resting ECG)

1.2 MPS using SPECT is recommended as part of the investigational strategy in the management of established CAD in people who remain symptomatic following myocardial infarction or reperfusion interventions
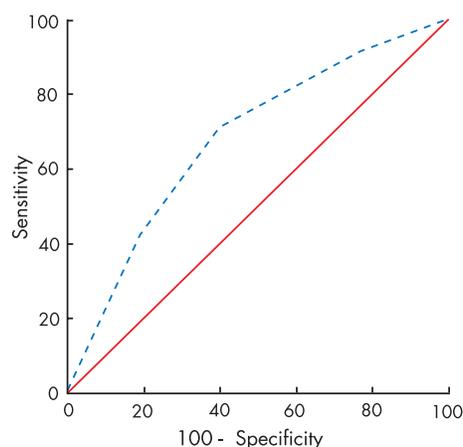
The optimal integration of functional testing into a chest pain assessment pathway relies on appreciating both the test and the characteristics of the patients likely to be referred. In many assessment algorithms patients referred for functional testing have a low to moderate pre-test probability of CHD, are often poorly mobile with raised body mass index, and not optimal for exercise testing or functional imaging. In contrast high pre-test probability patients are referred directly for angiography. So the sensitivity and specificity of these investigations may be lower than published data. Intense quality control is essential and particularly so if the investigation crosses boundaries between cardiology and radiology. Newer modalities of imaging (cardiac magnetic resonance (CMR) and computed tomography (CT)) show promise as adding to the options available in the future, but are not immune to the same principles and limitations that apply to all investigations.

## CORONARY ANGIOGRAPHY IN THE INVESTIGATION AND MANAGEMENT OF CHEST PAIN

With its currently unrivalled ability to demonstrate coronary anatomy and as a prelude to revascularisation, coronary angiography has a pivotal role in the assessment of a patient's CHD. While the gold standard for anatomy, it does not however provide functional information and carries a small but definite mortality (1 in 1400).

Generally there has been under-provision of angiography in the UK and this has skewed services for the assessment of chest pain by creating the need for rationing by referral or waiting times. There are many guidelines describing indications for angiography and increasingly UK, European, and US indications are coalescing.[20]

De Bono and colleagues[21] describe a prioritisation system based on severity of angina, exercise test outcome, age, and risk factors that produced a score which correlated with the finding of three vessel disease (including proximal left anterior descending artery) or left main stem disease (fig 3). More detailed inspection of the scoring system shows that in essence class 3 angina or a positive exercise test in stages 1 or 2 (Bruce protocol) give a reasonable likelihood of significant disease. These are American Heart Association/American College of Cardiology (AHA/ACC) class 1 and 2a indications for angiography, suggesting that simply following these guidelines suffices.

The ACRE study investigated the issue of appropriateness of angiography referrals.[22] An expert panel established a consensus on appropriateness across a range of indications. These were then prospectively applied to a cohort of 3631 patients undergoing angiography and matched to the



**Figure 3** Receiver operating characteristic (ROC) curve for the ability of a scoring system to identify patients with three vessel (including proximal left anterior descending artery) or left main stem disease. Reproduced with permission from De Bono and colleagues.[21]

angiographic findings. Sixty two per cent of referrals were rated appropriate, 5% inappropriate, and 33% uncertain appropriateness. Mortality and revascularisation rates correlated strongly with appropriateness although 11% of the "inappropriate" angiograms revealed three vessel or left main stem disease. Interestingly, when "urgency" was analysed, the median waiting time for appropriate patients was 91 days but just 58 days for inappropriate patients.

## REST PAIN AND ACUTE CORONARY SYNDROMES

There are several important differences in the assessment of suspected ischaemic rest pain compared to exertional angina that create diagnostic and logistical challenges.

One of the most valuable features of the history, namely the exertional nature of ischaemic chest pain, by definition cannot be invoked. The diagnostic process therefore relies on using a combination of the pre-test probability of CHD with other features of the history, the examination (still generally non-contributory), and the resting ECG. The resting ECG is of more value compared to when assessing suspected exertional angina because, particularly if the patient has symptoms

**Table 4** Comparison of chest pain assessment units (CPAUs) and rapid access chest pain clinics (RACPCs)

|  | CPAU | RACPC |
|---|---|---|
| Open times | Round the clock | Working hours |
| Monitoring equipment | Definitely | Resuscitation trolley only |
| Beds | Definitely | Examination couch only |
| Troponin assays | Definitely | Selectively useful |
| Length of stay | 12 hours | 1–2 hours |
| Location | Typically near emergency department | Typically near cardiology department |
| Staffing | Specialist nurse (thrombolysis) *and* clinician | Various, including nurse specialist/ technician |
| Patients | Rest pain—some at high risk of acute haemodynamic deterioration | Mainly low to moderate risk during assessment |

during the recording, it has some parallels with the usefulness of the ECG during ischaemia provoking exercise.

The essential role of risk stratification, together with the management of patients with suspected acute coronary syndromes (ACS), is evidence based and described in guidelines.[23]

Currently the majority of these patients are assessed within emergency departments. The introduction of readily available assays for troponin (I and T) has contributed significantly to the risk stratification of suspected ACS.[24] However, the sensitivity of the result is established for assay 12 hours after onset of symptoms, so not necessarily on arrival in the emergency department. The specificity depends on the pre-test probability of disease, and inappropriate measurement of troponin in very low risk patients leads to false positive results. Undetectable or low concentrations of troponin are a strong but not complete predictor of low short term event rates. They do not exclude CHD and local algorithms must show that they enable early ambulation and stress testing, not immediate discharge without follow up.

Business cases for introducing troponin assays rely on cost effectiveness data particularly focused on lengths of stay. False positives leading to unnecessary admissions, failure to provide results promptly, and failure to provide same day stress testing after the result is available, will eradicate cost savings.

As an alternative service model the introduction of chest pain assessment units (CPAUs) has been advocated.[25] These dedicated areas incorporate a monitoring area for observing patients with suspected ACS until an appropriately timed troponin assay can be performed, and stress testing facilities to determine diagnosis, short term risk, and initiate treatment. Potentially blurred but important differences exist between CPAUs and RACPCs (table 4). In establishing models for chest pain assessment within a hospital these must be appreciated when configuring services. Randomised trials, initially from North America but now in the UK, support the introduction of CPAUs.[26] The CHEER study from New York showed cost savings and equivalent safety comparing a CPAU with usual care. A recent randomised trial in Sheffield of 972 patients showed reduced admissions and cost savings without compromising safety for a CPAU compared to usual care.[27]

A hybrid approach, rather than segregating acute chest pain patients, is to invest in educating staff and emergency department teams and apply clear simple algorithms or integrated care pathways to their care. The ROMEO study in Bath showed the effectiveness of this approach.[28] In this study a rapid protocol for ruling out myocardial ischaemia, involving troponin assay followed by exercise testing, was used to achieve median admission times of 23 hours for patients presenting with suspected ACS without adverse events among discharged patients.

## NON-CARDIAC CHEST PAIN

The challenge of non-cardiac chest pain and its utilisation of cardiologist's time and resource are substantial. Over two thirds of patients assessed in RACPCs do not have a cardiac cause to their symptoms. While perhaps counter intuitive to a cardiologist, careful investment of time in arranging the assessment, diagnosis, and management of non-cardiac chest pain is worthwhile if the services for those with cardiac disease are not to be compromised.

Prompt rather than delayed reassurance seems more effective, particularly compared to a prolonged period of "suspected" CHD.[29] RACPCs may well have an important role here. RACPCs can quickly establish a diagnosis, not exercise low risk patients, provide leaflets and brief explanation, and, if using a database, make entering patients with non-cardiac disease easy and rapid through appropriate default settings.

At all times one should communicate fully with patients so they understand where there is uncertainty—for example, when treatment is a "trial"—and can therefore be safely stopped at a later stage if significant disease is excluded (table 5).

When is investigation appropriate to "reassure" the patient? As has been repeatedly discussed most of our tests

**Table 5** Priorities in addressing non-cardiac chest pain. Adapted from Bass and Mayou[29]

**General**
- ▶ Diagnose promptly and positively
- ▶ Consider oesophageal/musculoskeletal/hyperventilation/ psychological
- ▶ Avoid over investigation and referral
- ▶ Provide specific treatments as appropriate

**For others (no specific treatment available)**
- ▶ Explain diagnosis and reassure that this is a real and common problem
- ▶ Advise to not avoid exercise
- ▶ Discuss concerns
- ▶ Provide written information
- ▶ Involve relatives
- ▶ Consider follow up appointments, especially after prolonged investigation
- ▶ Consider cognitive behaviour therapy/antidepressant drugs/ psychological intervention

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## Investigation and management of chest pain: key points

► Most patients presenting in primary and secondary care with chest pain do not have coronary heart disease (CHD) as the cause

► The value of all tests and investigations depends on the quality of the test *and* the pre-test probability of disease

► A consistent and comprehensive, not complex, assessment using history and appropriately performed and interpreted non-invasive tests will achieve a correct diagnosis in most cases

► An effective pathway for the investigation of chest pain needs to lead to diagnosis, risk stratification, and prompt initiation of treatment

► Managing non-cardiac chest pain effectively releases time and resources for those with CHD

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establish a probability of disease. In reality non-invasive tests struggle to distinguish a low risk of the presence of CHD, from the presence of CHD but at very low risk of events, an uncertainty that can be uncomfortable for patients and their doctors. An example is a patient with exertional pain reproduced on a treadmill but not associated with ECG changes.

Keavney and colleagues[30] looked at the cost of caring for 69 consecutive patients in the 12 months before and after a normal coronary angiogram. They showed that the cost of the angiogram would be recouped in 18 months. So at least by this marker, a normal coronary angiogram was of use. De Fillipi and colleagues[31] randomised 248 patients with a low risk of cardiac events after CPAU assessment to exercise testing and angiography if abnormal, or angiography for all, before discharge. Angiography for all led to 12 extra revascularisations, but reduced re-attendances and admissions. However, no infarcts occurred in those with normal exercise tests during the one year follow up.[31]

## CONCLUSIONS

Braunwald's textbook comments that the diagnosis of cardiac amyloidosis is difficult and historically was often made post-mortem.[32] This should not be the case with CHD. The great majority of patients first present alive and can be diagnosed with a focused history and a stepwise programme of appropriately requested, performed, and interpreted investigation. The elements of this pathway can be performed in any district general hospital and much of it undertaken by appropriately trained nursing and non-consultant grade staff.

It is a central role of the cardiologist to coordinate teams to provide an assessment service for those presenting with suspected cardiac chest pain. Cardiologists ultimately will have substantial responsibility for telling patients whether they have CHD and its severity. Sufficient evidence exists to suggest that if we follow a consistent, carefully designed, integrated, audited, and coordinated pathway of assessment, the vast majority of the time we will get it right.

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