# Cardiac Imaging

## A Report from the National Imaging Board

March 2010.

Gateway reference number: 13859

## Foreword

We hope this report will prove to be a very useful resource to stimulate development of effective cardiac imaging services. The report represents the current status of a rapidly evolving field of imaging and is evidenced where such information exists. It has been produced in response to numerous requests for information on cardiac imaging services. The report acknowledges that the Cardiac Networks are at different levels of development and are configured differently across England.

2010-11 will see tougher economic circumstances. The report outlines many opportunities which can be used to transform cardiac services and support the QIPP (quality, innovation, productivity and prevention) agenda. It illustrates how the NHS can improve quality, safety and productivity while working across disciplines to deliver better care for cardiac patients.

No attempt has been made to replicate the detail to be found in a textbook of cardiac imaging, but an overview of cardiac imaging services is provided with a focus on the information that would be beneficial for commissioners of these services.

The document has been produced by a complex group of stakeholders from many different disciplines and we are indebted to them for giving up their time and their extensive knowledge and expertise to make this report possible

This document is produced at a time when the evidence base for functional imaging is sufficiently robust that proceeding to elective cardiac intervention without prior testing is increasingly seen to be inappropriate.

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## Summary of key points

- Cardiac imaging services should ideally be specifically and separately commissioned.
- The key principle behind commissioning cardiac imaging should be that the service is of demonstrably high quality wherever and by whoever it is delivered.
- A poorly performed imaging procedure may lead to patient harm less directly but just as easily as a poorly performed invasive procedure.
- Where standards for accrediting individuals and departments exist these could be used as a basis for supporting commissioning.
- There are a variety of different imaging tests which will provide answers to cardiac imaging clinical questions. These pathways will vary according to local expertise, experience and equipment availability.

## Background

1. This report has been prepared by a specially convened sub-group of the National Imaging Board to provide advice on Cardiac Imaging Services. The report discusses where the use of particular imaging modalities, for specific groups of patients, may contribute to improvements in Quality, Innovation, Productivity and Prevention (QIPP). Evidence is cited where it exists, whilst recognising that some emerging technologies do not have an established evidence base.

2. This report contains information for those professionals working in, commissioning or interfacing with, cardiac imaging services. This will include those who are:
   - responsible for commissioning cardiac imaging services
   - managing cardiac imaging services
   - involved in the education and training of staff who will be working with patients who require imaging
   - involved in the care of patients who require imaging
   - involved in supporting the development of cross organisational patient pathways e.g. Cardiac Networks

3. The key principle behind the commissioning of cardiac imaging should be that the service delivery is of demonstrably high quality irrespective of where or by whom it is delivered. A poorly performed functional imaging procedure may lead to patient harm less directly but just as easily as a poorly performed invasive procedure. Where standards for accrediting individuals and departments exist these could be used as a basis for setting commissioning standards.

4. While diagnosis and prognosis in heart disease are important, the main practical goal of investigation is identifying which patients will benefit from specific therapies, for example coronary angioplasty, bypass surgery, valve replacement, cardiac resynchronization therapy or defibrillators. It is with this in mind that implementing a streamlined process for the management of patients with known or suspected coronary artery disease using appropriate tests remains at the forefront of this report.

5. This report describes the role that each imaging modality has in investigating and managing a patient with known, or suspected, Coronary Heart Disease (CHD) *.

6. It acknowledges recent improvements in technology that allow improved anatomical and functional assessment of CHD. In doing so it does not define a definitive imaging pathway, but, recognises the need for local solutions according to the expertise and experience of an existing workforce and currently available facilities.

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Coronary Heart Disease (CHD) – narrowing or blockage of the coronary arteries by the fatty material termed atheroma, which may lead to angina, coronary thrombosis or heart attack, heart failure and/ or sudden death.

*( NIAP – National Infarct Angioplasty Project)*

7. Delivery of cardiac imaging services across England varies considerably and the various successful approaches and models of investigation of these patients adopted currently within the NHS are described.

8. The report also explores alternatives for imaging and considers the likely presenting symptoms for this patient group. Descriptions of the specialised equipment needed to provide these services and the necessary workforce are included.

9. At a time of economic constraint funding new or expanding existing services is more challenging. This is recognised with a discussion of the current funding issues and tariff for this diagnostic area.

10. Appendix C provides current examples of service delivery from different cardiac networks. These explore the challenges and solutions found at a local level to delivery of effective cardiac imaging services.

## What do we mean by Cardiac Imaging?

11. Coronary angiography (CA) was introduced in the 1960's and has for many years been the gold standard for confirming the presence of atheromatous coronary obstruction and played a central role in the management of patients with coronary artery disease. For a more detailed explanation of this technique please see page 13. However, recent developments in non-invasive testing with established functional studies such as stress echocardiography (SE), myocardial perfusion scintigraphy (MPS) and cardiac magnetic resonance imaging (CMR) are now considered more than screening tests, since they also provide valuable information on disease severity and patient prognosis.

12. Functional imaging[1] remains underused in the UK, despite echocardiography machines, gamma cameras and MR equipment that could be configured for cardiac work being available in most hospitals. These modalities have the potential for directing coronary angiography more effectively towards those patients most likely to require invasive intervention. Studies have shown that MPS, SE and CMR can predict the likely symptomatic and prognostic outcome after subsequent revascularisation. Patients with normal MPS can be reassured that further invasive investigation is unlikely to lead to either symptomatic or prognostic benefit, even if they do have narrowing of coronary vessels.

13. There have been recent developments in anatomical imaging, particularly in computerised tomography (CT) which have increased the potential shift away from coronary angiography. The extent to which this impacts on the need for CA will depend on many factors and these are discussed later.

## The Technology and Equipment

14. All cardiac imaging departments should develop robust well documented programmes for equipment quality assurance, timely equipment replacement, appropriate IT systems, image archiving facilities and, for many, telecardiology. Advances in cardiac imaging equipment are rapid and likely to continue swiftly, particularly for the newer imaging modalities. Benefits of newer equipment can include:
    - better, more detailed and more useful diagnostic information to target therapy more effectively
    - more efficient rapid image acquisition, workflow, analysis and reporting
    - rapid and widespread availability of results to clinicians
    - replacing invasive procedures with non-invasive tests

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[1]Functional Imaging (FI) reveals physiological activity within a tissue or organ by detecting or measuring changes in metabolism, perfusion, chemical composition or mechanical function.

15. FI has the ability to:
    - substitute tests using ionising radiation for tests using non-ionising imaging where appropriate i.e. provided diagnostic accuracy is maintained or improved. For example use SE or CMR instead of CA, MPS or CT.
    - permit development of image guided techniques to replace and enhance existing medical and surgical treatments.

16. All imaging equipment wears out over time, but its expected life may be shortened as a result of improvements in technology, particularly for newer imaging modalities. The expected useful life of imaging equipment depends upon:
    - Age, intensity of use and care taken (particularly for echo/ultrasound probes and MRI coils)
    - Availability of spare parts
    - New imaging protocols (e.g. CMR perfusion or myocardial viability assessment) may require more modern equipment
    - Regular equipment maintenance
    - Equipment upgrades (particularly software, computers)
    - Radiation dose because higher dose techniques decrease the life of an x-ray tube, especially in CT

17. For service planning purposes reasonable replacement ages for cardiac imaging equipment are currently approximately:
    Echocardiography machines, 5 years
    SPECT imaging equipment, 7 years
    Computed tomography (CT) equipment, 7 years
    CMR equipment, 7 years.
    Coronary Angiography, 7 years

18. As equipment ages and newer, often faster, equipment is available, business cases for earlier replacement than these recommendations may be the most appropriate strategy as the existing equipment may be inefficient or manufacturers may no longer carry spare parts to support ongoing maintenance.

19. Maintenance and quality assurance protocols for imaging equipment, including calibration of equipment by appropriate personnel, up-to-date safety inspection certificates where needed, and inspection by qualified medical physics personnel for quality control must be in place.

20. More detail on equipment specifications can be found at Appendix A

## The Workforce

21. All cardiac imaging requires a dedicated, multidisciplinary, appropriately trained workforce.

22. It is likely there will be an increase in cardiac imaging services to meet future population demand and this will require an expansion of staff numbers across all disciplines. It is anticipated that medical consultant post holders in cardiac imaging will come from a background of cardiology, radiology or nuclear medicine. This will require careful consideration and co-operation between the professions, particularly, where equipment is shared. Shared training is also best practice to produce a new breed of skilled cardiac imaging clinicians. Appointment panels should aim to have appropriate professional representation to ensure that multi disciplinary involvement is maintained in the delivery of cardiac imaging services. There should be a designated team leader, who will take responsibility for ensuring that the team provides care which is safe, effective, and efficient.

23. In 2003 Hackett and a working group of the British Cardiac Society published a report on Cardiac Workforce Requirements. The recommendation at that time was for 35 cardiologists per million head of population. They also described an increased need for cardiac physiologists. Further work is being undertaken to update this report but the issues identified in 2003 broadly remain the same but with an increasing need for cardiac imaging expertise in line with evolving technology and less invasive diagnostic investigation.

### Training Standards

24. Radiologists and cardiologists receive core training in cardiovascular physiology and imaging. However, as cardiac CT and MRI emerge it is unlikely that sufficient experience will have been obtained during basic training in either specialty, and specific training should therefore be obtained prior to independently performing complex cardiac imaging.

### Cardiac CT Angiography (CCTA)

25. This is technically demanding. To effectively provide a clinical service, provision should be made for at least two Level 2 or equivalent trained clinicians (see The British Society of Cardiovascular Imaging guidelines) in any one institution. Whilst networking between hospitals with remote reporting can provide a reporting service there is a current need for direct supervision at the time of image acquisition for CCTA. Ideally both a cardiologist and radiologist should be involved in providing such a service as such a partnership is synergistic. If the service is to be provided by cardiologists alone, provision should be made for a second review by a radiologist trained in thoracic imaging, as up to 20% of CCTA's have significant non cardiac pathology

### Radiographers and Clinical Technologists

26. There are, at present, no formal training requirements in cardiac imaging for radiographic staff, CCTA and CMR place similar technical demands on these staff and ideally at least 2 radiographers or technologists in any organisation undertaking these techniques should obtain expertise in CCTA or CMR by a secondment to a centre proficient in these imaging modalities.

27. Elements of cardiac imaging are undertaken by cardiac technologists, radiographers and other health care staff who are not registered medical practitioners. The process of acceptance of a referral for a clinical imaging study and the performance of the procedure can be delegated to appropriately educated and trained healthcare practitioners under local protocols and clinical governance arrangements.

28. There is a shortage of technical staff skilled in cardiac imaging. Efforts are being made to increase the number of staff in training which may allow existing staff to specialise and undergo further training in cardiac imaging. Additionally, role extension initiatives to train members of the non-medical cardiac imaging team in skills previously only undertaken by doctors are being explored.

29. Increasing numbers of trainee cardiologists specialise in cardiac imaging, including echocardiography and, provided there is a corresponding increase in skilled technical staff, this should allow for expansion of stress echocardiography and other areas of CI. However, the current plans for Modernising Scientific Careers may exacerbate the shortage of highly skilled technologists including echocardiographers in the short term due to proposed changes to the training model and a perceived lack of clarity around career progression.

Cardiac Physiologists

30. Cardiac physiologists carry out an extensive range of diagnostic and interventional procedures for patients with known or suspected heart disease. They work independently with patients largely without direct clinical supervision. Cardiologists and other specialists use the information gathered by cardiac physiologists when making a diagnosis and prescribing appropriate treatment.

31. Workforce Review Team (WRT) analysis (2009) suggests demand for cardiac physiology services and therefore an appropriate workforce is increasing. This is a result of increasing workload in diagnostic studies for cardiac pathways.

32. Although there is limited accurate data on the number of cardiac physiologists, WRT evidence gathering suggests that there is a significant national shortage. “Skill mix” initiatives including the use of assistant/associate practitioner grades in non specialist support roles may increase the workforce.

Clinical Scientists and Technologists.

33. All cardiac imaging modalities are supported by Clinical Scientists and Technologists. These staff groups provide advice on equipment specification and procurement, image quality, radiation dose, staff safety and quality assurance. They

also carry out a range of services including equipment commissioning, quality control testing, image acquisition and image processing. Formal roles include : The Radiation Protection Adviser (RPA) – radiation safety and quality assurance, the Medical Physics Expert(MPE) – to advise on image quality and optimisation for modalities using ionising radiation and an MR Safety adviser in accordance with MHRA DB2007(03)

### Access and Choice

34. Following the NHS Next Stage Review, the WRT expect that transfer of technologies and competencies from one sector to another (e.g. secondary to primary care) is likely to take place over the next decade. This has implications for future training of, and increased roles particularly for, cardiac physiologists in the community. The development of assistant and associate practitioners to support specialist imaging roles and the emergence of consultant posts for cardiac physiology services is a natural progression to enhance career opportunities as well as increase capacity in the department. Additional roles, such as dedicated clerical support, are necessary to increase the clinical time spent by clinically trained staff in direct patient care.

### Accreditation, Certification and Re-validation

35. Following publication of the report “Trust, Assurance and Safety”, the General Medical Council (GMC), the Health Professions Council (HPC) and the Nursing & Midwifery Council (NMC) are in the process of reviewing the regulation of health care professionals. Fundamental to the principle of professional self regulation is the active participation of the registered individual in Continuing Professional Development.

36. For medical practitioners undertaking Continuing Medical Education (CME), training needs are detailed in the cardiology and radiology sub-specialty curricula. Although completion of UK training results in entry onto the specialist registry, additional national and international subspecialty standards are available.

37. Clinicians responsible for cardiac imaging need to keep knowledge, clinical and teaching skills up-to-date. For cardiac imaging, requirements depend on the specific imaging modality and level of pre-existing training.

38. All staff within a cardiac imaging department should have been trained to an appropriate level for their job according to national and/or international guidelines. Evidence of CPD is a core requirement of re-validation (GMC) and renewal of registration (HPC) thus dedicated time for CPD is necessary. CPD support is particularly important for new graduate staff to allow them to develop the level of skills relevant to their role. Competence must be maintained and this should include up-to-date training in resuscitation and the management of adverse reactions.

## The Cardiac Imaging Modalities

### Coronary Angiography

Introduction

39. Coronary angiography is an invasive technique to image the coronary arteries. Catheters are inserted under local anaesthetic via the femoral, radial or brachial arteries and directed using x-ray guidance so that their tips lie in the mouth of either the left or the right coronary arteries which arise from the ascending aorta. Radiographic contrast is then injected into the coronary arteries to visualise blood flow and identify any narrowing or blockage that could be causing symptoms. In expert hands the risk of a serious complication in coronary angiography is around 1 in 1000. Risks may be higher in elderly patients who are ill with other ongoing disease processes.

Indications

40. Coronary angiography is indicated in the assessment of chest pain in those with a high pre-test likelihood of coronary disease, in those with a diagnosis of angina and ongoing symptoms or a high risk evaluation on functional imaging (showing evidence of irreversible ischaemia) and in those presenting with an acute coronary syndrome or myocardial infarction. A proportion of these patients can go directly to a therapeutic procedure. Diagnostic Angiography is not usually used as a 'first test' for stable patients. It should (usually) be offered in the setting of an abnormal functional test or an abnormal imaging investigation such as cardiac CT. Currently it is the only investigation that can be used to plan Percutaneous Coronary Interventions or Coronary Artery Bypass Graft surgery (CABG.) Coronary angiography visualises the lumen of the coronary arteries. Combined with intracoronary ultrasound it can also be used to assess the walls of the coronary arteries and combined with intracoronary pressure wire studies to assess the functional significance of a narrowing.

Equipment

41. Coronary angiography requires a fully equipped and staffed catheterisation laboratory. This is usually a dedicated cardiac laboratory but may be shared with vascular radiology. Full resuscitation facilities are required.

Workforce

42. Coronary angiography requires a fully trained operator, usually a cardiologist or sometimes a cardiac radiologist. Trained support staff are also necessary. Traditionally these have been radiographers, cardiac technicians and nurses but some units are now developing highly skilled generic catheter laboratory workers with a combination of expertise.

## Cardiac CT

Introduction

43. Cardiac CT is a non-invasive x-ray based technique using conventional multi-detector CT scanners. The need to "freeze" cardiac motion necessitates the use of ECG gating requiring additional hardware and software when compared to traditional diagnostic CT.

44. The time taken to perform a cardiac CT is approximately 10 minutes although the actual data is acquired over only a few seconds. Intravenous iodinated contrast is given (CT coronary angiogram) although for a coronary calcium assessment (coronary calcium score) this is not required. Patients are often pre-medicated with oral or intravenous beta blockers immediately prior to the scan but there is no other patient preparation. Given the speed of image acquisition cardiac CT is well tolerated and routinely performed on out patients as well as more acutely unwell in-patients.

45. The strength of cardiac CT is its ability to provide high resolution images of the coronary arteries and cardiac morphology non-invasively. Unlike invasive angiography CT provides information about the vessel wall as well as the lumen and can detect early atheroma before vessel narrowing. It has a very high negative predictive value (approaching 100%) effectively excluding coronary disease in patients with a normal scan. Coronary calcium scoring identifies calcified coronary atheroma. Additional information on ventricular function and valve function as well as myocardial perfusion and scarring may be obtained. CT has limitations. For some patients the anatomy makes it difficult to image the coronary arteries in their entirety and for patients in atrial fibrillation ECG gating can be difficult however the anatomy can be more easily discerned than at coronary angiography in some patients.

46. Radiation doses for cardiac CT have fallen substantially with recent technical advances. Well-trained staff using appropriate techniques and equipment will routinely deliver doses below those of invasive coronary angiography.

Indications

47. Primary indications are:
    - The evaluation of coronary artery disease in patients with chest pain and a low to intermediate risk of coronary disease and particularly the ability to rule out CAD and therefore prevent unnecessary admissions of patients with undiagnosed chest pain and unnecessary invasive coronary angiography in patients with low to intermediate risk of CAD (NICE 2009).
    - Investigation of anomalous coronary arteries.
    - Evaluation of coronary artery bypass grafts.
    - Evaluation of cardiac anatomy (including prior to pulmonary vein isolation procedures).

48. Secondary indications include:

- Left and right ventricular function and volume analysis.
- Valve morphology and function assessment.
- Evaluation of congenital heart disease (particularly in patients with contra-indications to cardiac MRI).

Equipment

49. Cardiac CT is generally undertaken using CT scanners also designed for a full range of non-cardiac investigations. Technology is changing rapidly with consequent benefits of reduced radiation exposure and increased diagnostic accuracy. The minimum recommended requirement for cardiac CT angiography is 64-slice multi-slice scanner with associated cardiac hardware and software. Both prospective and retrospective cardiac gating techniques are needed.

Workforce

50. Workforce requirements are identical to those of a general CT department. Scanning is performed by one radiographer usually with the assistance of a radiographic assistant or second radiographer. Additional staff are of benefit to increase workflow. Scans are supervised indirectly or directly by an appropriately trained clinician. It is essential that a report is obtained covering both the cardiac and thoracic anatomy. Reporting of scans is optimally performed by a collaboration of appropriately trained Cardiologist and Radiologist, and this practice is encouraged. Sole reporting of cardiac CT is appropriate if they are suitably trained in both areas and that suitable clinical governance standards are adhered to such as audit of results and external review of cases.

## Echocardiography

Introduction

51. Echocardiography uses ultrasound to examine the structure and function of the heart. No ionising radiation is involved and the risks of diagnostic ultrasound are extremely low. Images can be obtained through two routes: transthoracic and transoesophageal using a specialised endoscopic probe. A standard transthoracic examination takes around 30-40 minutes including reporting time. Stress echocardiography (where a transthoracic examination is carried out while the circulation is stressed) and transoesophageal echo take around 45-60 minutes. Echocardiography produces 2 dimensional images of the heart (3-D is also widely available) with a fast frame rate allowing accurate estimation of both structure and function. The addition of Doppler imaging provides information about blood flow and indirect pressure measurement. 2-D echocardiography with Doppler is an essential tool for any cardiology department.

Indications

52. Indications for echocardiography are very broad and include suspected abnormalities of cardiac structure, e.g. atrial septal defect and suspected abnormalities of cardiac function, e.g. heart failure, valve disease. Echo is valuable for assessment of left ventricular systolic and diastolic function and can be used to track changes over time. Valve abnormalities are well demonstrated, providing information about morphology and degree of haemodynamic disturbance.

53. Stress echocardiography (see below) is indicated in chest pain with an intermediate probability of coronary disease, in the assessment of myocardial viability and for the assessment of recurrent chest pain after revascularisation.

Equipment

54. Echocardiography requires a dedicated ultrasound machine with specific cardiac software. General ultrasound machines are not suitable. Machines are portable and examinations can be performed at the bedside or in an outpatient setting. For transoesophageal echocardiography a dedicated probe and software are required. Images should be stored in a digital archiving system with their verified reports.

Workforce

55. Most transthoracic echocardiography is performed and reported by highly skilled physiologists. Transoesophageal and stress echocardiography require medical supervision. There is a national shortage of suitably skilled technical staff.

Standards

56. Standards for individual and departmental accreditation in echocardiography have been developed by the British Society of Echocardiography (www.bsecho.org).

Stress Echocardiography

57. Stress echocardiography uses ultrasound to image the heart while it is being stressed. Areas of the heart that become short of oxygen on stress can be detected as they fail to contract normally. Stress may be pharmacological (usually dobutamine) or exercise induced. For pharmacological stress an infusion pump is required to deliver dobutamine and many units also use a transpulmonary contrast agent to improve visualisation of the left ventricle. Full resuscitation facilities are required. Different myocardial responses to stress echo enable infarction, ischaemia and hibernation to be distinguished.

Transoesophageal Echocardiography

58. Transoesophageal echo is similar to upper gastrointestinal endoscopy and is usually performed under light conscious sedation as a day case procedure but may also be performed in ventilated patients on ITU or in theatre. Resuscitation facilities, piped oxygen, suction and a saturation probe are required as well as a suitable recovery area.

Strengths and weaknesses of Echocardiography:

59. Echo is relatively cheap and transthoracic examinations can be carried out by cardiac physiologists. The equipment is mobile and can be taken to the patient. Echo does not rely on ionising radiation so is particularly suitable for patients who require repeated imaging over time.

60. Some patients give poor transthoracic images ("poor echo windows") and the information derived can therefore be limited. The use of echo contrast material improves image quality in these patients but requires an intravenous injection. Echo reliability depends on the experience of the person reporting the images and this is more significantly the case for stress echo.

## Cardiac MRI

<u>Introduction</u>

61. Cardiac (or cardiovascular) MRI, known as CMR, uses a suitable MRI scanner to image the heart. It is a safe (being radiation-free), non-invasive technique. There are multiple different CMR techniques that can be done within one scan for different indications. Less than half of all CMR scans are for coronary artery disease, for example. Most (90%) of patients will be outpatients, but it is also valuable for inpatients, especially when planning complex interventions. There are some contra-indications to CMR, most commonly pacemakers, implantable defibrillators or intraocular metallic objects. Problems such as arrhythmias have largely been overcome by technical advances allowing more rapid image acquisition. All stents and surgically replaced cardiac valves are safe at 1.5 and 3T field strengths.

62. Severe renal failure (GFR<30mls/min) is, however, a relative contraindication to the use of MR contrast agents.

<u>Indications</u>

63. CMR is an alternative to other tests in many circumstances when initial tests do not give all the answers, and it is the gold standard in other circumstances. These include congenital heart disease from infancy to adulthood (although there remains a place for angiography, particularly for pressures and vascular resistance assessment), and other conditions such as cardiomyopathy, iron overload, myocarditis, and heart scarring. It provides added value that no other test can easily achieve. CMR can have a significant impact upon clinical decision making, patient management and prognostication. Within one scan any of the following can be performed:
    - Structure and Function: CMR is an excellent test for cardiac function and structure, particularly where echo leaves questions unanswered. It is probably the most accurate test for documenting ventricular function. CMR is especially good at the right ventricle and great vessels. Echo is better for diastolic dysfunction and valve morphology, so the two tests are complementary.
    - Blood flow: Blood flow and velocity can be measured in heart and large arteries (limited in the coronary arteries). This is particularly important in investigating congenital heart disease.
    - Infarction and Hibernation: Using MR contrast agent the extent of heart scarring can be detected and it can be shown how heart muscle will improve with revascularisation (viability versus hibernation).
    - Perfusion: CMR is a growing test for perfusion and ischaemia testing. It has similar accuracy to nuclear cardiology and carries prognostic information but has advantages for some groups such as the young (no ionising radiation), and patients with known coronary artery disease (added value). Dobutamine (stress) CMR can also be performed, which is particularly useful when echo windows are poor, an advantage that is reduced if echocardiographic contrast is used.

- **Other:** Coronary anomalies are well demonstrated by CMR techniques but all other anatomical coronary indications are better done by CT or invasive angiography.

Equipment

64. Most centres will use general MR equipment, but there will be some dedicated scanners doing just CMR. Almost any modern, closed bore MRI scanner can be upgraded for cardiac MRI. The British Society of Cardiac MR (BSCMR) has a specified minimum equipment level, including scanner specification, sequences and analysis equipment.

Workforce

65. A CMR service should have a nominated clinical lead, a nominated technical lead and appropriately trained medical and technical staff to deliver the service who are typically radiographers but may have echocardiography or cardiac physiologist backgrounds. CMR may be provided by cardiology, radiology or, ideally, as a joint service.

Standards for service delivery

66. CMR is complex and a quality service typically requires a minimum of 300 scans per year to maintain competency. Large centres may do 2000 scans a year. There are likely to be an estimated 50 centres in the UK, including all cardiac surgery centres. Standard scanning and reporting protocols are available from Society for Cardiac MR, (SCMR) and UK service standards are available from BSCMR.

## Nuclear Cardiology

### Introduction

67. Nuclear Cardiology uses an injection of a small dose of a radioactive tracer, or radiopharmaceutical, to image the heart. Conventional nuclear medicine uses single photon emitting radionuclides but positron emitting radionuclides provide higher resolution and potentially quantifiable information in centres with suitable Positron Emission Tomography (PET) technology. Depending upon the type of tracer used, different information is obtained, but nuclear imaging provides mainly functional information such as myocardial viability and perfusion and ventricular function. Full resuscitation equipment is required.

68. Myocardial Perfusion Scintigraphy (MPS) is the most commonly performed stress functional imaging technique. The tracers used are taken up by viable (healthy) myocardium in proportion to perfusion. The injections are given during some form of cardiovascular stress, which might be treadmill or bicycle exercise or pharmacological stress. Pharmacological stress is particularly valuable in patients who are unable to exercise maximally.

69. The images are acquired using a gamma camera, which rotates around the patient to acquire tomographic images using single photon emission computed tomography (SPECT). Two sets of images are normally acquired after stress and rest injections of tracer, since the resting image provides information of myocardial viability and changes between stress and rest images reflect changes in perfusion and uptake of tracer dependant on the degree of ischaemia. The stress and rest images can be acquired either on the same or separate days.

70. Radionuclide ventriculography (RNV) is another well established and validated technique in which the blood is labelled with technetium 99m. It is sometimes referred to as "multigated acquisition" or MUGA but the term RNV is preferred. ECG-gated images of the ventricular blood pools provide quantitative information of left and right ventricular function such as ejection fraction and regional function, and it is particularly suited to assessing the regional timing of contraction. The imaging is conventionally planar but, increasingly, SPECT is used to provide three dimensional information.

71. Cardiac Positron Emission Tomography (PET) is mainly confined to research centres because of the high cost of PET cameras and the need for an on-site cyclotron to generate the very short-life radiopharmaceuticals for some types of PET imaging. The increasing availability of fluorine-18 2-fluoro-deoxy-glucose (FDG) PET imaging in oncology may lead to greater use of cardiac PET because of the advantages of higher resolution and potentially quantifiable information. FDG is available without a cyclotron and it can be used to assess myocardial viability and ventricular function. Rubidium-82 is becoming available from a generator without a cyclotron and it is an

alternative to MPS for perfusion and viability. Nitrogen-13 ammonia and oxygen-15 water for perfusion imaging are only available with an on-site cyclotron.

Indications

72. MPS is primarily used to detect, localize and size areas of inducible ischaemia and myocardial viability in patients with known or suspected coronary disease. Abnormal perfusion (inducible ischaemia) usually indicates obstructive coronary disease and the extent and depth of the ischaemia correlates with the likelihood of future coronary events. It can therefore be used to diagnose and localise disease, to triage patients between medical therapy and revascularisation, and to assess risk before non-cardiac surgery. Abnormal viability images diagnose and size myocardial infarction and, with ECG-gating, left ventricular function can also be assessed. Patterns of viability, perfusion and function can be used to detect hibernating myocardium, which may benefit from revascularisation in patients with heart failure.

73. MPS is an integral part of diagnostic and management algorithms. NICE has appraised MPS for patients with angina and myocardial infarction and found it to be effective and cost-effective in this sub-set of patients. http://www.nice.nhs.uk/ta073.

74. A significant strength of RNV is its simplicity, accuracy and reproducibility for the assessment of left ventricular function. It is therefore most commonly used to monitor function in patients receiving cardiotoxic chemotherapy although echocardiography is an alternative. Assessment of synchronicity of contraction by RNV may become useful in patients being considered for resynchronisation pacing (CRT). The detection and measurement of shunting in patients with congenital heart disease is well validated but it is being replaced by MRI because of the additional anatomical information gained from CMR.

Advantages and Disadvantages

75. Nuclear medicine expertise is widely available in the UK and the techniques are well validated with extensive evidence to support their use in a range of clinical settings. The equipment required is relatively inexpensive and there is the potential to reduce costs with high patient throughput.

76. However nuclear medicine images have relatively low spatial and temporal resolution and the procedures involve exposing patients to low amounts of ionizing radiation, albeit decreasing as a result of hardware and software developments. Perhaps the most important limitation has been the concentration of nuclear imaging expertise outside the cardiology department with historically less multidisciplinary collaboration than ideal to provide clinically relevant interpretation. The practical and political limitations probably account in part for the under-provision of nuclear cardiology services in the UK compared with invasive cardiac investigation.

Equipment

77. A single camera nuclear cardiology department occupies approximately 65m² and a general purpose gamma camera can acquire good quality cardiac images. However a dedicated cardiac gamma camera (approximately £200,000) can be particularly effective when demand is sufficient. ECG-gating is essential and attenuation correction is desirable. Radiopharmaceuticals can either be prepared on-site or purchased from a commercial radiopharmacy. Stress facilities should accommodate both dynamic exercise and pharmacological stress. Dedicated nuclear medicine workstations and image storage are usual since current PACS systems cannot display nuclear cardiology images adequately.

Workforce

78. Cardiovascular stress must be led by an appropriately trained healthcare professional and clinical nurse specialists are increasingly taking on this role. Image acquisition is by a nuclear medicine trained radiographer or technologist. Quality control and other technical aspects require the input of a medical physics expert (MPE). Radiation protection requires a specialist advisor (RPA) who might be the same individual as the MPE. Reporting is usually led by a cardiologist with radionuclide imaging expertise, a nuclear medicine physician or a radionuclide radiologist, with collaborative reporting in some centres.

Existing Standards for service delivery

79. Standards for all aspects of a nuclear cardiology service are published and links are available on the BNCS website www.bncs.org.uk.

## Service Delivery in Cardiac Imaging

### Basic levels of service for Cardiac Imaging

80. Cardiac imaging departments have a responsibility to ensure that their practice achieves the highest possible standards. These standards include clinical care, choice of imaging modality, quality of images and their interpretation, measured against standards such as waiting times, facilities and speed of issue of the report. Standards of diagnostic accuracy are evolving and data for clear standards are incomplete. Departments should be aware of developments and contribute via research, audit data and national data returns to societies as appropriate.

81. **Commissioning a World Class Imaging Service** is a web-based tool developed to support commissioners of all imaging services. It aims to bring together a number of valuable resources about diagnostic imaging in one easy and convenient reference tool which will be useful to those who commission, work in or use any imaging facility. To read more and access the tool follow the link.
http://www.18weeks.nhs.uk/Content.aspx?path=/achieve-and sustain/Diagnostics/Imaging/commissioning-guidance

82. **Imaging Service Accreditation Scheme (ISAS)** The Royal College of Radiologists, in collaboration with the Society and College of Radiographers have developed an accreditation scheme for imaging services. This will help improve quality and patient experience as we continue to focus on sustaining the 18 weeks target. This scheme (ISAS) was formally launched in June 2009 and at the time of writing 8 services are working with UKAS as early adopters of the scheme. The scheme opened to all services across the UK on October 1st 2009. All imaging departments including cardiac imaging will be encouraged to seek accreditation of their services via ISAS see http://www.isas-uk.org/default.shtml

83. Relevant national and international standards for cardiac imaging are also available from The British Cardiovascular Society, Royal College of Radiology, the European Society of Cardiology, the American Society of Cardiology and other international, modality specific societies. For example the British Society for Echocardiography has developed an accreditation scheme for echocardiography departments including stress echocardiography. The scheme focuses on the quality of the service and is open to all echocardiography departments in the UK. See www.bsecho.org

84. The Royal College of Radiologists have published a Good Practice Guide for Clinical Radiologists which should be followed by all medical imaging specialists.

85. Any department performing cardiac imaging must ensure that equipment is up-to-date and safe as described previously. When appropriate, as stated in national and international guidance, equipment should be inspected by qualified medical physics personnel for quality control and these processes must be formally documented.

86. Technical staff acquiring images must be appropriately trained, professionally registered, if appropriate and be able to show evidence of training with formal CPD programmes. Technical and medical staff reporting images should

    - Have appropriate training and evidence should be available for this. Examples might include: BSE accreditation for echocardiography, Certification Board of Nuclear Cardiology accreditation for nuclear cardiology etc.
    - Complete the required CPD programmes annually.

87. Regular audits of image quality and reporting should be performed with comparison to an agreed “Gold Standard”, either local or national. A record of all adverse events should be kept in the department. Such adverse events should be within the internationally accepted rates.

88. A department should acquire sufficient studies to maintain practice. Reporters and technicians should perform sufficient scans to maintain skills and this will vary from technique to technique. Guidance is available from national societies. This may mean that it is appropriate for local service provision not to offer all imaging modalities and to focus local expertise into specific imaging services. Trainees should work under supervision and to a level appropriate to their level of training and expertise.

89. Every imaging department must ensure that there are systems in place to justify each imaging examination particularly where ionising radiation is involved. The Ionising Radiation (Medical Exposure) Regulations 2000 are based on local, national or international guidelines and ensure that the appropriate available imaging modality is used. Departments should also ensure the appropriate application of health and safety guidance including the application of the "as low as reasonably practical" (ALARP) principle for ionizing radiation.

90. All cardiac imaging departments should develop clearly defined quality assurance systems with established delegated responsibility and clear lines of communication. Cardiac imaging departments should strive for the highest possible levels of diagnostic accuracy. Although such standards are limited and often based on literature studies under optimum conditions of equipment, staffing and technical ability, imaging physicians should remain informed of the available literature and strive to achieve standards of accuracy similar to the best that is reported in the literature unless agreed minimum standards become available.

### Safety and Clinical Audit

91. Selecting the appropriate test, achieving an appropriate outcome and interpreting and taking appropriate action on the result of the test is essential.

92. Cardiac imaging departments should participate in appropriate audit processes. A local audit lead should be appointed and audit should link in with trust wide, national and international audit, as relevant, with regular meetings through the year. Cardiac imaging teams should work to monitor and maintain quality of the care they provide,

recording data honestly and, where necessary, responding to audit results to improve practice, for example by undertaking further training. These audits should be performed, normally with comparison to a “Gold Standard”. The national societies may recommend specific audit topics to be addressed for example The Royal College of Radiologists (RCR) published Clinical Audit in Radiology: 100+ Recipes. (1996). This described how to undertake audit in a systematic and logical way, repeating the cycle and above all choosing audits which are relevant. This publication has been superseded by an online audit tool - ‘Audit Live’.

http://www.rcr.ac.uk/audittemplate.aspx?PageID=1016

93. Non-invasive cardiac imaging carries risks and it is everyone in the multidisciplinary team’s responsibility to manage risk within the department. The following recommendations are made:

- A record of all adverse events should be kept in the department. Such adverse events need to be within the internationally accepted rates
- Ionising radiation use should adhere to the principle of "as low as reasonably practical" (ALARP). Radionucletides should be handled according to all appropriate national guidelines. This is particularly important where additional ionising radiation is used beyond the minimum for the core test requirements, (e.g. gated SPECT, CT delayed enhancement or function). In these circumstances the risks and benefits of additional information should be explicitly justified at department policy level and for individual patients.

## Reporting of Cardiac Imaging

94. In line with all imaging modalities it is essential that turnaround times from image acquisition to issue of report is as prompt as possible, in order for the report to contribute effectively to the diagnosis and management of the patient. To achieve this cardiology and imaging departments should ensure that reporting, typing, verification, and report issue processes are streamlined. There are recommendations to suggest minimum standards for the issue of reports, dependent on clinical urgency.

Urgent cases - Immediate (within 30 minutes)
Inpatients and A&E - Same working day
All other cases - By next working day.

*Radiology Reporting Times Best Practice Guidance*,
National Imaging Board Sept 2008.

http://www.18weeks.nhs.uk/Asset.ashx?path=/Imaging/RadiologyReportingTimes_September2008_160908.pdf

95. For some cardiac imaging investigations joint reporting is beneficial. This utilises the imaging and technical expertise of both radiologists and the clinical subspecialty knowledge of cardiologists, ensuring optimum clinical decision making. All medical staff undertaking reporting of cardiac imaging should be registered on the GMC specialist register for their appropriate specialty and be able to demonstrate that they had undertaken the appropriate training within the cardiac imaging modality,

96. Consultants in charge of a service may delegate reporting of some cardiac imaging investigations, to other UK registered healthcare professionals, undertaking image acquisition and reporting within their professional scope of practice. They must have successfully completed an appropriately accredited course and have maintained their continuing professional development in accordance with professional guidelines. Some cardiac imaging investigations are dependent on the skills of the operator in terms of the images acquired. For these investigations the report should be generated by the professional responsible for acquisition of the images. It may be appropriate for these images to be reviewed and authorised by a supervising clinician registered on the appropriate GMC specialist register or other suitably registered healthcare professional, who can demonstrate an appropriate level of competence to do so.

## Financing the Service

97. The NHS has a responsibility to provide appropriate cardiac imaging. The benefits to the patient of a good cardiac service in terms of the three main components of quality as stated in 'The Next Stage Review - High Quality Care for All' [1], patient safety, experience and outcomes, are clear and it is also appropriate to consider the various cardiac imaging modalities in terms of the QIPP (Quality, Innovation, Productivity and Prevention) agenda.

98. The Payment by Results 2010-11 road test tariffs and guidance notes which include the diagnostic imaging tariffs are on the Department of Health website. These non-mandatory tariffs are for direct access diagnostic imaging for 2010/11 but are useful for costing patient care pathways more broadly. http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_110106

99. Accurate cardiac specific tariffs which relate to the true cost of providing the procedure for all cardiac imaging modalities would support the development of effective cardiac imaging services.

100. A combination of accurate data handling and costing will facilitate full funding of cardiac imaging services and allow services to be improved. Trusts should ensure that IT structures within all cardiac imaging departments are sufficient to allow for accurate recording of the volume and mix of activity and to allow for audit of outcomes.

101. There is a PbR development site looking specifically at tariffs for cardiac CT and cardiac MRI. Work by the specialist societies is also underway to support accurate tariff development. NHS Connecting for Health have been asked for some new OPCS (procedure & intervention) codes specifically for cardiac imaging to ensure all cardiac work can be accurately coded.

102. There is ongoing development work by the PbR team at DH in conjunction with the British Society of Cardiovascular Magnetic Resonance (BSCMR) on coding and classification of this activity. Until this work is completed this is excluded from PbR tariffs.

103. 2010-11 may see a change of direction brought about by tougher economic circumstances. New features in PbR include the introduction of tariffs set, not on average costs, but on the cost of delivering best practice and also business rules which include the use of marginal rates for increases (but not decreases) in emergency activity.

104. The Draft Payment by Results Guidance for 2010-11 usefully for cardiac imaging also states that

- Where a specialist provider can demonstrate that it carries out more complex and costly diagnostic tests than the average (for example cardiac MRI or CT), commissioners should consider if there is a case for paying more than the mandatory tariffs for outpatient attendances.
- Single Photon Emission Computed Tomography (SPECT) scans are excluded from PbR in 2010-11 as they have only had dedicated codes created for them in the OPCS coding classification in 2009-10 and as a result the underlying reference costs do not reflect this type of scan.
- A new, unbundled Healthcare Resource Group (HRG) for simple echocardiograms replaces the core HRG of EA45Z used in 2009-10. As with other imaging, we have rebundled the costs of this activity, except for direct access. There is also a mandatory HRG for complex echocardiograms (EA45Z).

105. Options for the Future of Payment by Results: 2008/09 to 2010/11 is a consultation document which states that where secondary care clinicians are making the decisions on interventions, the proposal is to expand the use of casemix-based funding and to unbundle only high-cost, low-volume items.

## Choice of Test

106. The choice of cardiac investigation is not always a clear choice between imaging modalities. The important determinants of which test is chosen are:

- deciding on the question(s) to be answered
- considering which of the available tests could answer the question(s)
- knowing the strengths and weakness of the available tests (which may include knowing who will do the test in some operator-dependent tests)
- availability, cost and convenience
- the ionising radiation burden and any other risk to the patient.

107. A well thought-out evidenced imaging strategy may reduce the need for inappropriate imaging and revascularisation procedures leading to more targeted use of resources for patients and better outcomes.

108. The table below gives comparisons between the different modalities. This table is very simple and includes each modality as a broad category. It is not intended to be definitive information but has been designed particularly to help commissioners, service managers and others less familiar with the clinical service understand the different cardiac diagnostic modalities.

109. The Medical Exposures Directive [IR(ME)R 2000] requires that all medical exposures to ionising radiation must be justified prior to the exposure being made. Justification should be based on knowledge of the risks and potential benefits associated with the exposure. Useful Information about radiation dose from cardiac imaging investigations and sources of further information can be found at Appendix B.

<u>Imaging for coronary artery disease:</u>

110. The choice of imaging in coronary artery disease is difficult and many of the currently available imaging modalities are evolving rapidly. These tests can be roughly divided into 'structural' such as invasive coronary angiography or CTA (showing the shape of the arteries and the chambers of the heart, but not necessarily allowing the impact of any narrowing in the arteries to be assessed) and 'functional' where the objective is to demonstrate how perfusion or contraction of the myocardium is altered by stress (see 'demonstration of ischaemia' below)

111. The decision as to which to use will depend on local availability and expertise but also on the pre-test probability of finding that the patient has significant coronary artery disease. Pre-test probability is decided by clinical history, examination and evaluation of risk factors.

Table Comparing Imaging Parameters For Each Cardiac Imaging Modality

| | Echocardiography | Nuclear | CMR | Angiography | CTAngiography |
|---|---|---|---|---|---|
| Ventricular function | +++ | ++ | +++ | ++ | ++ |
| Valve function | +++ | + | ++ | ++ | + |
| Valve morphology | +++ | - | ++ | + | + |
| Coronary anatomy | - | - | - | +++ | +++ |
| Ischaemia | +++ | +++ | +++ | + | - |
| Blood flow in the cardiac chambers | +++ | + | ++ | ++ | - |
| Cost of basic test<br>Cheapest = +<br>Most expensive = +++ | + | ++ | +++ | +++ | ++ |
| Time for basic test | + | +++ | ++ | +++ | + |
| Reporting time<br>Shortest = +<br>Longest = ++ | + | + | ++ | + | ++ |
| Dedicated equipment Y/N | Y | N | N | Y | N |
| Ancillary equipment needed Y/N | N | N | Y | Y | Y |

Key - = test not useful
+ to ++++++ = increasing level of use diagnostically
Y = Yes
N = No

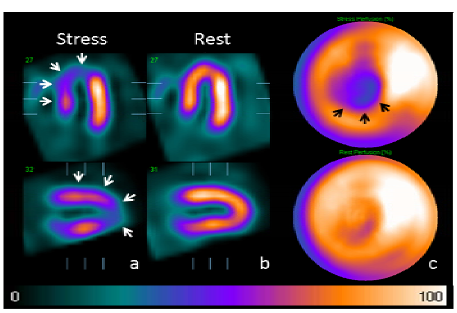
112. The following cases demonstrate the use of cardiac imaging in a selection of common clinical scenarios. Cases 1-6 describe functional tests and case 7 a non invasive anatomical test.

## Detection of ischaemia (functional tests)

113.Detection of ischaemia in patients with coronary artery disease presents a challenge because ischaemia is not present in stable patients at rest. Instead, the ischaemia has to be induced or provoked by stressing the heart. Stress images are then compared with resting images to detect, quantify and localise ischaemic changes. Induced ischaemia can be detected with myocardial perfusion scintigraphy, with stress echocardiography and with stress CMR. Documentation of ischaemia is an important part of the assessment of the patient with coronary disease as the potential benefit of revascularisation is closely linked to the volume of ischaemic myocardium. The following clinical cases describe how stress imaging can be used to decide when invasive investigation (i.e. coronary angiography) and interventional treatment (including Percutaneous Coronary Intervention and Coronary Artery Bypass Graft) may, or may not, be required.

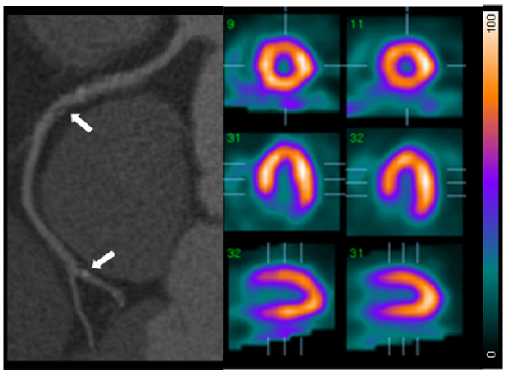
## Case 1

114.A 63 year old man presented with stable angina occurring when walking about 100m on the flat. His symptoms were not adequately relieved by medical therapy. Myocardial Perfusion Scintigraphy (MPS) showed an exercise inducible perfusion abnormality in the LAD territory (arrowed) but normal perfusion elsewhere. Invasive coronary angiography showed disease in both the left anterior descending (LAD) artery and the circumflex artery. Insertion of a stent across a narrowing in the LAD alone (leaving the circumflex lesion because it was not causing ischaemia) abolished his symptoms of angina.



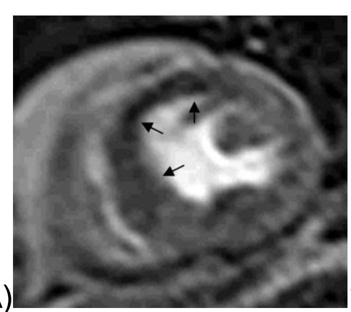
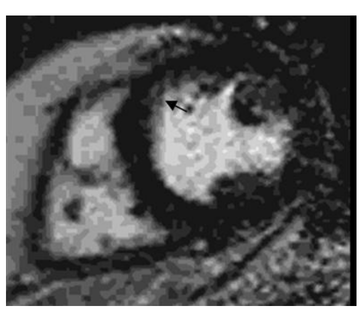

## Case 2

115.A 58 year old woman presented with atypical chest discomfort. Exercise ECG was inconclusive. CT coronary angiography showed some coronary atheroma (left, arrowed) but MPS was normal (the images shown are stress centre, rest right, all areas of myocardium with tracer uptake >70% in orange). The coronary disease was therefore not haemodynamically significant and the symptoms were not angina. No invasive coronary angiography or revascularisation treatment was indicated. Secondary prevention therapy was initiated because of risk factors and the demonstration of early coronary disease.



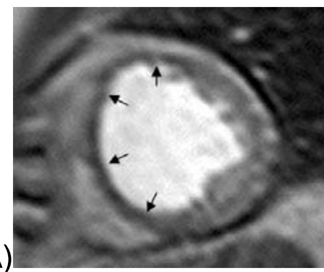
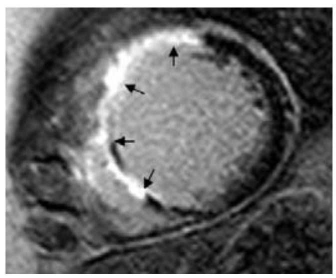
## Case 3

116.A 66yr old male presented with breathlessness and stable angina on exercise. He had recently suffered a myocardial infarction whilst abroad. Invasive angiography had shown that the left anterior descending coronary artery (LAD) was occluded and that the anterior wall of the heart (supplied by the LAD) was not contracting normally. A CMR study was requested to determine if there was any evidence of residual ischaemia in the LAD territory and to see also if there was viable myocardium. During adenosine stress CMR there was clear evidence of a large area of inducible ischaemia in the anterior wall and septum (Figure 1A, arrows) and with only a very small area of irreversible subendocardial infarction (Figure 1B, arrow), i.e. the heart muscle was almost all viable but most of the muscle supplied by the LAD was hibernating (not contracting because of chronic severe ischaemia). The patient had PCI and stenting to the LAD occlusion and his symptoms resolved completely. Note that in this case revascularisation had the potential to improve not only his symptom of angina but also his left ventricular function which is related to his long term prognosis.

1A)  1B) 

Case 4

117.A 62yr old male presented with stable angina on exercise. There was a history of MI one year previously. Invasive angiography had shown that the LAD was occluded. A CMR study was requested to look for evidence of ischaemia or viability in the LAD territory. During adenosine stress CMR there was extensive hypoperfusion in the anterior wall and septum (Figure 2A) which corresponded almost identically to the area of transmural infarction (white area, Figure 2B). The CMR demonstrated that revascularisation of the LAD territory, either by PCI or CABG, was unlikely to improve the patient's symptoms because the heart muscle in that area was non-viable following his infarct.

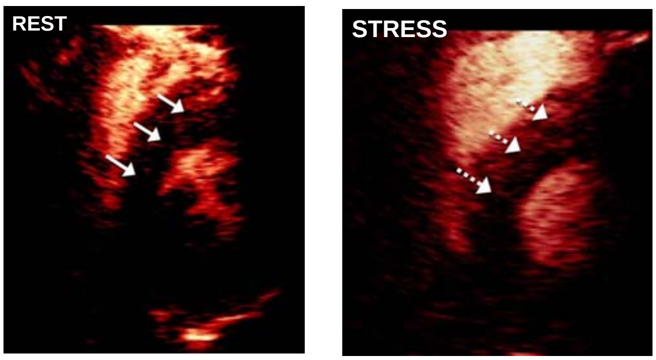
2A)  2B) 

Case 5

118.A 72 year old woman presented 3 weeks after an episode of prolonged cardiac type chest pain. ECG showed evidence of a completed anterior myocardial infarction. An invasive coronary angiogram showed a near total occlusion of the LAD. The clinical question was asked if opening of the LAD and insertion of a stent was indicated. Dobutamine Stress Echocardiogram with contrast showed an apical infarct at rest (white arrows) that did not change with stress (dashed white arrows) suggesting that the muscle tissue subtended by the LAD was not viable. Consequently no revascularisation was performed and medical treatment was recommended.


Case 6

119.A 72 year old man presented with worsening angina despite adequate anti-anginal treatment. A Dobutamine Stress Echo with contrast demonstrated ischaemia in the LAD territory with normal thickening of the antero-septum at rest (white arrows) and reduced thickening at stress (dashed arrows). Invasive coronary angiogram showed a tight narrowing in a diagonal vessel. Stent insertion across the narrowing abolished his symptoms of angina.




120.These clinical examples demonstrate how functional stress imaging can be used to identify those patients with stable coronary artery disease who are most likely to benefit from invasive coronary angiography and subsequent revascularisation. Just as importantly, they can identify patients who are unlikely to benefit from angiography and revascularisation.

121.At present, there is little evidence about which functional test is most cost-effective. The concept of a one-stop-shop with a single imaging technique that can handle all problems is currently not realistic. Local services need to develop skills and an equipment base to provide the breadth of cardiac imaging required to provide a high quality service for cardiac patients.

## Non invasive anatomical tests

122.Anatomical imaging demonstrates the distribution and severity of coronary artery disease to plan for treatment. It is also important in the exclusion of coronary artery disease and can detect vessel narrowing at an earlier stage than functional imaging. CT angiography can also detect disease in the vessel wall

## Case 7

123.A 47 year old female presents with symptoms suggestive of angina and an equivocal exercise test. Cardiac CT angiography was performed using prospective gating and low kV techniques. This generated a total dose for the examination of only 0.4 mSv (DLP of 28, using chest conversion factor of 0.014). The scan took 25 seconds and showed no evidence of coronary disease (either atheroma or narrowing). She was discharged from hospital follow-up direct from the scanner with no need to take any further medication.

The images demonstrate normal coronary arteries.

## Cardiac Imaging in Specific Clinical Pathways

### Cardiac Imaging in patients with recent onset chest pain.

124. One of cornerstones of the National Service Framework for Cardiology, published in 2000, was the establishment of “Rapid Access Chest Pain Clinics” designed to see patients with recent onset chest pain. At the Rapid Access clinic, the patient is assessed clinically, has a resting ECG and, if appropriate, an exercise ECG.

125. The publication of NICE Guidance on “Chest pain of recent onset: assessment and diagnosis of recent onset chest pain and discomfort of suspected cardiac origin” will change how these patients are managed and will shift the standard investigation from exercise ECG testing to cardiac imaging. The exercise ECG will no longer be recommended to diagnose or exclude stable angina in patients without known coronary artery disease. Instead, the likelihood of coronary artery disease will be estimated from a table taking into account the clinical assessment and the 12-lead ECG. Further diagnostic testing will then be recommended as follows:

- If the estimated likelihood of CAD is 61-90%, offer invasive coronary angiography as the first-line investigation if appropriate
- If the estimated likelihood of CAD is 30-60%, offer functional imaging as the first-line diagnostic investigation
- If the estimated likelihood of CAD is 10-29%, offer CT calcium scoring as the first-line diagnostic investigation

126. Most hospitals and cardiac networks in the UK have sufficient capacity for coronary angiography for those at higher risk. However, implementation of this NICE guideline will result in a significantly increased requirement for functional imaging (in place of exercise ECG testing) and, for many centres, the need for of a new cardiac CT service.

### Cardiac Imaging in patients with chronic stable angina

127. Coronary angiography has been regarded as the gold standard investigation for the diagnosis of coronary artery disease for more than forty years. In patients presenting acutely with ST segment elevation myocardial infarction, or in patients presenting with non-ST elevation MI with dynamic ECG changes and raised biochemical cardiac markers the evidence for significant myocardial ischaemia is often already available, so functional imaging is unnecessary. Hence revascularisation procedures are usually carried out based on the angiographic findings without functional imaging.

128. In patients with more stable symptoms (i.e. not covered by the NICE guidance described above), a number of recent developments have cast doubt on the premise

that patients with suspected coronary disease should have coronary angiography as a first line test to confirm or refute the diagnosis of coronary disease.

129.It is likely, therefore, that more widespread use of functional cardiac imaging prior to angiography could help to detect those patients most likely to benefit from revascularisation. Those patients with abnormal functional imaging would still require coronary angiography but it may be possible to reduce the requirement for coronary angiography in those patients who have normal coronary vessels or mild / moderate coronary disease with no evidence of reversible ischaemia because they can safely be managed medically in the first instance, with coronary angiography being used if their symptoms cannot be controlled.

### How many patients might this affect?

130.According to the 2008-9 Hospital Episode Statistics data for England, the figures for diagnostic coronary angiography and revascularisation on stable patients admitted from a waiting list were as follows:

| | | |
|---|---|---|
| Coronary angiography | Codes K63.1 – K63.9 | 119,954 |
| PCI | Codes K49.1 – K50.9 and codes K75.1 – K75.9 | 30,727 |
| CABG | Codes K40.1-K45.9 | 18,232 |

131.These data suggest approximately 71,000 stable patients underwent diagnostic coronary angiography but did not proceed to revascularisation via PCI or CABG in England.

132.What is not clear is the proportion of these patients who had some form of functional imaging prior to angiography. However, it is likely that a high proportion were referred for diagnostic coronary angiography without prior functional imaging. In some cardiac networks, it has been acknowledged that patients with suspected stable angina are referred for coronary angiography rather than functional imaging simply because of ease of access (i.e. shorter waiting times for angiography than for non-invasive functional imaging).

133.A pilot study in the Greater Manchester and Cheshire Cardiovascular and Stroke Network is currently examining this issue (See Appendix C, page 47). Estimates are given of the likely benefits to patients of such an imaging strategy together with the possible benefits to commissioners in terms of a reduced requirement for diagnostic angiography and appropriate selection of patients for revascularisation.

### <u>Imaging for valvular disease:</u>

134. The important questions in valve disease are:

- Which valve(s) is malfunctioning?
- How badly is it malfunctioning?
- What is the effect on the rest of the heart?
- Why is the valve malfunctioning and what is the structure of the valve and surrounding areas?
- Is the valve infected?

135. **Echocardiography** has revolutionised the assessment and management of valve disease. It provides good structural information (particularly with TOE and 3-D) about the valve and its supporting structures, and, with Doppler, good information about the severity of the lesion and whether the valve is repairable. It can also assess the impact of the valve lesion(s) on the heart as a whole. Echo is the mainstay of valve follow-up, being easily repeatable and safe. Patients can be managed for many years with regular echo assessments.

136. **CMR** is developing as a tool for valve assessment. It can provide good information about changes in ventricular size and shape and some information about valve structure.

137. **Cardiac Catheterisation** is used for patients with valve disease in whom non-invasive tests suggest that valve surgery may be necessary. Direct measurement of intracardiac and intrapulmonary pressures can verify non-invasive haemodynamic assessments. Imaging of the cardiac chambers and aorta gives information about leaking valves and left ventricular function. The coronary_anatomy can also be visualised to ensure that any important coronary disease is discovered before valve surgery.

## Conclusions

138. Modern cardiology services need access to the techniques described in this report.

139. There are few comparative data to allow selection of technique when capabilities overlap, for example the established techniques of myocardial perfusion scintigraphy and stress echo must not be cast aside because of the emergence of new technologies. Until we have comparative evidence, local facilities and interest will be the major factor in determining the shape of local provision.

140. In centres without access to functional imaging of any sort, the decision whether to establish myocardial perfusion scintigraphy, stress echo, or cardiac MR should be determined by local factors such as the availability of support from a local centre of excellence, and the training potential and enthusiasm of local medical and technical staff. Equipment and running costs are clearly important issues complicated by the fact that some equipment can only be used for one sort of test, whereas others have used outside cardiology.

141. When planning cardiac imaging services, commissioners and the team delivering these services should be aware of the complex issues described in this report. In particular the technology involved in all modalities for cardiac imaging is evolving at a rapid pace and up to date knowledge is essential for service management.

Appendix A

# Equipment Specification

<u>Coronary Angiography</u>

Coronary angiography requires a specialised laboratory with appropriate radiation protection. Most catheterisation laboratories are dedicated to cardiac procedures but some are joint with other interventional radiology services. Catheterisation laboratories should have the capability for digital acquisition and storage of images connected to a digital archive. Full resuscitation equipment must be immediately available.

Minimum Equipment Specification

- High frequency x-ray generator with power rating of at least 50kW per tube.
- User-selectable kV/mA curves for fluoroscopy and digital acquisition
- Automatic skin sparing filter selection
- Selection of fluoroscopy and digital acquisition pulse rates between 7.5 and 30 frames per second.
- Last Image Hold
- Fluoro Store and Grab
- Source to Image Distance (SID) Tracking
- Temporary stored auto positioning
- Virtual Collimation and virtual contour filter positioning.
- Ease of access to patient when in use and in emergencies
- Table to support CPR when at full extension
- Sufficient table travel to image heart to upper femoral arteries
- Flat panel digital detector with limiting resolution >2.5lp/mm
- At least two magnified fields of view
- PACS/RIS integration
- Dose Area Product (DAP) and skin dose displayed in room
- Display of physiological data alongside imaging data
- Rotational angiography is desirable

<u>Cardiac CT.</u>

Apart from at very specialist cardiac centres a CT scanner is likely to be used for a full range of examinations of the body. The following specification is for the cardiac element only. Technology in this area is changing rapidly and many new features are proving valuable in producing reliable high quality images at reduced doses. This specification should therefore be regarded as the minimum standard for new CT purchases at the time of publication only.

The minimum requirement for cardiac computed tomography angiography (CCTA) is a 64 slice multi-slice scanner with the associated cardiac hardware & software. The non-diagnostic rate of scanners with less than this has been shown to be up to 10% greater than those with 64 slices. Whilst there are dedicated cardiac scanners with either higher temporal or spatial resolution, or coverage, the incremental benefit of such equipment (with its added costs) has yet to be proven in comparative trials. The additional costs of such technology are therefore at the discretion of the purchasers. The provision of prospective gating, should however, be mandatory, as this has been shown to reduce the radiation dose in selected patients by up to 75%. Whilst the position of the CT scanner will be dictated by local circumstance ideally access from the trauma department and the coronary care unit should be considered because of CCTA's emerging role in acute cardiac conditions

Contrast injectors to be utilised in CCTA should be able to deliver up to 7.5 ml/sec and be dual headed as the use of a saline "chaser" reduces contrast requirements and facilitates the detection of intra & extra cardiac shunts.

As the supervising consultant will need to review the case for technical success there is a requirement for an appropriate workstation (with cardiac software) within the control room of the scanner. The need for further workstations will be decided by local working practices, but generally at least one other is required because of the need for case review with clinicians.

Minimum equipment specification:

- 64 simultaneous slices per rotation
- 20mm Z-axis coverage per rotation at the isocentre
- Prospective ECG gating and prospectively ECG triggered scan (axial scan)
- Retrospective ECG gating
- ECG controlled current modulation (helical mode)
- Minimum pitch of 0.2 for cardiac scanning
- Temporal resolution of at least 200mS for a single sector
- Scan plane resolution of at least 12.5lp/cm @10% MTF resolution
- Z-axis resolution of at least 8lp/cm@10%MTF
- ECG editing
- Contrast media bolus tracking
- Dual headed contrast media injector (may be supplied separately)
- ECG monitor

Software packages to include:

- CT Angiography
- Coronary Vessel Analysis
- Cardiac function & analysis
- Cardiac calcium scoring

<u>Cardiac Ultrasound and Stress Echocardiography</u>

There is a range of equipment with which to perform cardiac scanning. Units that are specially optimised for cardiology and general purpose systems which are suitable for cardiology with the use of specialised probes (such as phased array sector and trans-oesophageal transducers). The working lifetime of an ultrasound machine is usually taken to be ten years however it is likely to need a major upgrade at least every five years. The lifetime of an ultrasound probe is usually shorter, and typically a probe will last for about five years with careful use.

- Ability to display B-mode images and doppler spectrums simultaneously in real time known as ‘duplex’ operation.
- Second harmonic imaging
- Colour mapping
- Pulsed doppler, steerable and stand-alone continuous wave doppler.
- 30 frames per second at a depth of 12cm without lateral resolution loss.
- Ideally tissue doppler should also be available.

Equipment for stress echocardiography requires an echocardiography machine capable of digital image acquisition and storage. Most current machines are available with specific software including harmonic imaging for transpulmonary contrast. Most departments performing high volume stress echocardiography use transpulmonary contrast in a high proportion of their studies. The development of harmonic imaging and the use of transpulmonary contrast agents to opacify the left ventricle means that few patients are excluded due to inadequate image quality. This software enables the digital capture and simultaneous display of images recorded at different stages of the stress protocol.

Minimum equipment standards

- Echocardiography machine with stress specific software, including harmonic imaging.
- Digital image capture and simultaneous display of multiple cine loops.
- Digital archiving for future review.
- Variable rate electronic pump for pharmacological stress agents.
- Dedicated pump for infusion of transpulmonary contrast.

<u>Cardiac MR (CMR)</u>

Defining minimum equipment standards in CMR is difficult: the attainment of certain hardware high-end specifications facilities (e.g. a high number of RF Receiver channels) may not be advantageous if other components of the CMR limit the ability of the system to usefully exploit these.

Any new installation of a closed bore 1.5 or 3T CMR scanner can be cardiac enabled. With existing equipment, the preferred alternative approach would be to ensure that a standard includes reasonable specifications for the acquisition pulse sequences, e.g. number of slices in a perfusion sequence/heartbeat rather than physical hardware limits per se.

The following suggestions for minimum standards for Cardiac MR are subject to the above caveats:

- A fully maintained, shared or dedicated MRI scanner with cardiac capability
- Sufficient magnet access to achieve minimum annual unit numbers

- Procedures in place to ensure a safe environment and quality.-
- ECG gating, patient monitoring (including blood pressure and oxygen saturation)

For a new CMR installation, BSCMR recommendations are:

- RF subsystem: 16 RF channels
- Gradient specifications: 30mT/m, 150mT/m/msec
- Artefact resistant ECG hardware/software (e.g. vectorcardiogram)
- Torso/Body/Cardiac rf receiver array with > 5 channels

### Specific cardiac sequences

The minimum is:

- SSFP cine imaging (bFFE, FIESTA or TrueFISP)
- Black blood T1/T2W TSE sequences with/without fat sat
- Flow/velocity sequences
- Large vessel angiography
- Late gadolinium enhancement imaging

Recommended is

- Realtime cine sequence
- Perfusion sequences
- Alternative late enhancement sequences (3D, PSIR, IR_SSFP)
- 3D whole heart
- Other sequences (STIR, tagging, coronary sequence, cardiac iron)

### Specialist software for analysis

The minimum is:

- Volumetric quantification of LV/RV volumes and mass
- Quantification of velocity and flow
- 3D angiographic reconstruction with respiratory compensation

Additional software may include:

- complex 3D angiographic reconstruction,
- perfusion quantification, late enhancement quantification,
- LV analysis with long axis function, tagging analysis.

### Other equipment

- Resuscitation facilities (including defibrillation/Oxygen/suction),
- An emergency trolley with specific drugs to deal with potential reactions to IV contrast media and stressors.
- MR safe wheelchair & trolley.
- Monitoring equipment

Gamma Camera for Nuclear Cardiology

Apart from at very specialist cardiac centres a gamma camera is likely to be used for a range of examinations within the body. The following specification is for the cardiac element only.

- General purpose SPECT gamma camera
- Large field of view
- Ability to select energy window and collimation appropriate to the radionuclide and tracer.
- At least two detectors operable in a suitable configuration see (1) below.
- Low energy general purpose (LEGP) collimator is required for use with 201-Thallium tracers (2)
- Low energy high resolution (LEHR) collimator for 99m-Technetium
- Facility to review image data electronically using a continuous colour scale
- Facility to review ECG-gated data to verify suitable gating

Dual detector systems should use the detectors in a 90º configuration and a 180º orbit from 45º right anterior oblique to 45º left posterior oblique.

Triple-detector systems should use a 360º orbit.

Optimal choice is dependent upon the relative design specifications of the specific camera manufacturer’s LEGP and LEHR collimators

Appendix B

# Cardiac Imaging: Approximate Doses

## No radiation dose

Ultrasound (Echo & Stress Echo) uses sound waves and not ionizing radiation
MRI is magnetic resonance and does not apply ionizing radiation,

## Radiation Dose

### Nuclear Medicine:

Source: Hart and Wall 2003/04 Nuclear Medicine

| Procedure | Radioisotope | Effective dose (mSv) |
|---|---|---|
| Cardiac blood pool | $^{99}Tc^{m}$ | 4.7 |
| Myocardium | $^{201}Tl$ | 12.9 |
| | $^{99}Tc^{m}$ | 3.1 - 3.7 |

### Angiography

Source: Hart et al. 2005 and Hart and Wall NRPB-W4 for effective dose
Medical Examinations on Adults

| Procedure | Mean dose area product (Gy cm$^2$) | Third Quartile dose area product (Gy cm$^2$) | Effective dose (mSv) |
|---|---|---|---|
| Coronary Angiography | 25.7 | 29.0 | 6.6 |
| Angiography of coronary bypass graft | 42.3 | Too low statistics | Too low statistics |

### CT Angiography

Source: International Atomic Energy Agency
http://rpop.iaea.org/RPOP/RPoP/Content/Documents/TrainingCardiology/Lectures/CARD_L11_CardiacCT_WEB.ppt#267,13,Typical Effective Dose Values for CT

Cardiac CT – radiation doses, dose management and practical issues
Lecture 11

Page 11: Typical Effective Dose Values for CT:
Ca-Scoring:1.5 – 5.0 mSv
Cardiac CTA:10 - 25 mSv

Page 25: Effective doses for Cardiac Imaging

| Procedures | Modality | Effective Dose (mSv) |
|---|---|---|
| Ca Scoring | EBCT | 1.0 – 1.3 |
| | MDCT | 1.5 – 6.2* |
| CTA | EBCT | 1.5 – 2.0* |
| | MDCT | 6.7* - 25.0 |
| Cardiac SPECT w Tc-99m or Tl-201 | | 6.0 – 15.0 |
| CA (diagnostic only w fluoroscopy) | | 2.1* – 6.0 |
| Chest X-ray | | 0.1 |
| Hunold P. et al., Radiology 2003 | | |

It should however be noted that CT doses are changing rapidly and newer technology facilitates dose reduction

Cardiac Nuclear Medicine

Some 'nuclear' cardiac examinations that are commonly used to give different clinical information are summarised in the table below, with average dose ranges for each test.

| Examination | Isotope | Pharmaceutical | Activity (MBq) | ED (mSv) | Time |
|---|---|---|---|---|---|
| MUGA (ventricular function, EF) | 99Tcm | Pertechnetate | 800 | 6 | 1 hour |
| MPI (Ischaemia, EF) | 99Tcm | Sestamibi | 400 - 800 | 4 – 8 (Stress+Rest = 8 -16) | 2 day protocol |
| MPI (Ischaemia, EF) | 99Tcm | Tetrofosmin | 400 - 800 | 3 - 6 (Stress+Rest = 6 -12) | 2 day protocol |
| MPI (Ischaemia, EF) | 201Tl | Tl+ | 80 | 14 | 1 day protocol |
| Tissue viability | 18F | FDG | 400 | 8 (+CT dose for AC) | 2 hours |

Dose could range from 3mSv to 16mSv depending upon the investigation chosen based on 70kg patients with normal uptake.

Appendix C

# Innovative Practice Examples from the Cardiac Networks

1. Non-Invasive Imaging Pathway

2. Improved Quality Standards for Echocardiography

3. Improved Data Collection and Planning

4. Improved Cardiac Data Transfer

5. PACS/IT Case study

## Innovative Practice Examples

## 1.Non-Invasive Imaging Pathway

**Greater Manchester & Cheshire Cardiac and Stroke Network pilot a non-invasive cardiac imaging pathway for patients presenting through the rapid access chest pain clinic with stable angina.**

### The Issue

Capital expansions in catheter laboratory facilities across Greater Manchester have increased the availability of invasive angiography which has culminated in shorter waiting times over the last few years. This has resulted in patients who are more suitable for non invasive imaging, which has longer waiting times being offered angiography. All cardiologists across the network have agreed that there are many patients presenting with stable angina that are appropriate for non invasive imaging being referred for angiography due to ease of access. This lack of availability of non invasive imaging is due to the limited specialist imaging workforce and lack of commissioned capacity to provide the most appropriate and cost effective imaging. A strategy to support the implementation of the stable angina pathway which has been clinically endorsed and fully supported by public health will ensure that patients remain on the most appropriate agreed clinical pathway. (See Fig.1 - Pathway)

### The proposed approach

The agreed pathway also encompasses implementation of the Angina Plan, which is a mandatory aspect of the agreed service specification. The Angina Plan is a brief cognitive behavioural intervention for patients with stable angina. The aim is to educate patients to correct cardiac misconceptions and encourage a healthier lifestyle, thus improving symptoms and quality of life. It is a programme that can be undertaken by trained lay workers. It has been shown to reduce episodes of angina, GTN use, anxiety, depression and physical limitation and increase activity in patients with stable angina. An alternative to the Angina Plan could be used but must increase healthier lifestyles and medical adherence.

### Benefits to patients

Angina is a major cause of poor quality of life but many patients are not treated appropriately due to about a third of patients having their angina missed on exercise electrocardiogram (ECG) and a third of those without angina being wrongly diagnosed as having angina. This proposal for a major expansion of cardiac imaging would improve this situation markedly.

Patient's referral to rapid access chest pain clinic will, if they are assessed as medium or high risk, have immediate access (which may be the following day if they need further preparation before the test) to the modalities of imaging identified in the pathway. For up to 10% of patients Dobutamine Stress Echo (DSE) is not appropriate and they will require an alternative modality or test.

### The wider benefits (Quality and Productivity)

Functional imaging will give a higher sensitivity and specificity than continuing reliance on exercise ECG. The cardiologists and cardiac investigators have agreed a pathway (Fig.1). If the amount of angiography and revascularisation remains unchanged, then the cost-effectiveness depends on how long a misdiagnosis is accepted for false negatives and false positives as a result of exercise ECG. However, it is expected that there will be a consequential reduction in angiograms and revascularisation.

The break even point is when 100 functional imaging investigations results in a reduction of 10 angiographies, 2 angioplasties and 2 Coronary Artery Bypass procedures. Although this may not be fully achieved, some of this reduction will almost certainly occur. This confidence is partly based on an enthusiasm amongst clinicians, with a financial incentive for compliance with the pathway having been incorporated into the costings.

### Impact of roll-out across the Cardiac Network

The redesigned pathway across Greater Manchester will allow for an extra 10,000 patients per year having functional imaging, instead of stress ECG, to investigate angina. As 16% of patients, who were previously false negatives (1), will be diagnosed as having angina this has the potential to lead to a 4% annual absolute reduction of death and 20% absolute reduction in angina (2). The QALY of saved lives is about 0.75 per full year saved and the QALY of becoming angina free is 0.09 years (3). As patients who are false negatives may well be appropriately diagnosed at a later date, the cost per QALY will depend on the length of time this takes.

£500,000 has been identified in the 09/10 investment plans to support a pilot to confirm the cost effectiveness of the proposed pathway. This will assist in the implementation of non invasive cardiac imaging in a phased approach starting with two pilot sites to be identified via a network options appraisal process. This will also support existing imaging sites to support the existing work and allow for identified expansion.

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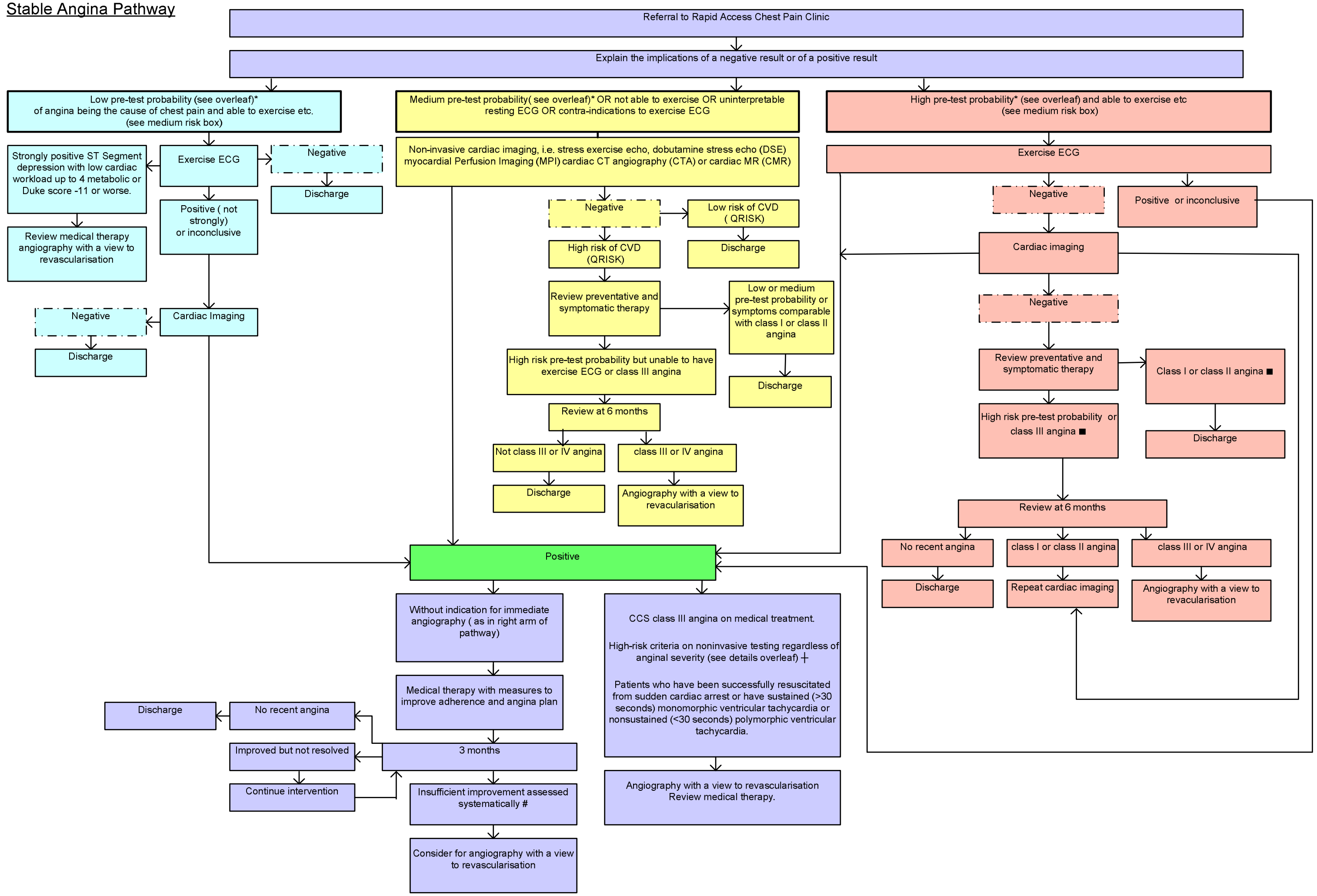
## Stable Angina Pathway



* Pre test probability is based on typicality of angina symptoms and CVD risk score.
The classification of chest pain is based on:

"(i) substernal chest discomfort with a characteristic quality and duration that is (ii) produced by exertion or emotional stress and (iii) relieved on rest by nitroglycerin.

Low pre test probability of angina being the cause of the chest pain is when no more than one of the above characteristics exist and the CVD risk, calculated by QRISK2, is less than 20% over the next ten years .

High pre test probability is when all three of the above characteristics exist and the CVD risk, calculated by QRISK2, is more than 30% over the next ten years. (excluding class IV angina)

Medium pre test probability are all others

┼ High risk criteria on non-invasive testing regardless of anginal severity

- Severe resting left ventricular dysfunction (LVEF<35%) - High-risk treadmill score (score-11)

- Extensive stress-induced myocardial perfusion defect (>25% of myocardium or >25% anterior myocardium)

- Regional wall motion abnormality (>2 segments)

# Factors that are more likely to lead to angiography are no or little symptomatic improvement or the previous cardiac imaging showing between 12.5 – 25% stress induced myocardial perfusion defect.
For others, there is more likely to be a review after three months but the threshold for angiography will become lower at each review.

■Patients in this box still have classical symptoms of angina but there is no evidence on investigation that they have ischaemic heart disease

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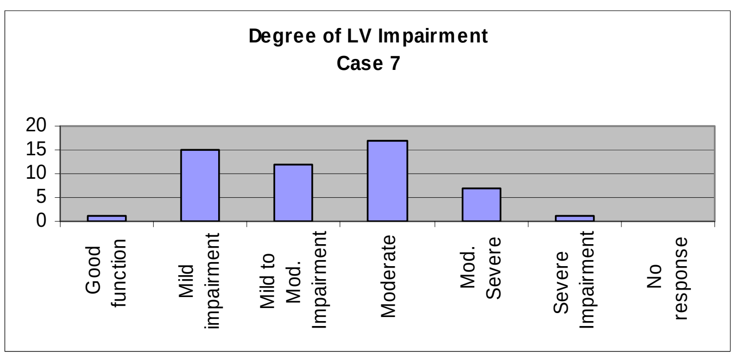
(3) Standards and Quality Analytical Team Department of Health September 2005 Measurement of Healthcare Output and Productivity: Management of Angina Technical Paper 4 Gateway No. 5886 December 2005

## 2.Improved Quality Standards for Echocardiography

**North of England Cardiovascular Network's audit of standards for echocardiography reporting across the network showed variation in the consistency of assessing left ventricular function, despite the existence of BSE guidance and standards. They have developed and are implementing network wide quality standards for echocardiography to improve quality across the region.**

### The Issue

An audit of the evaluation of left ventricular function using echocardiography was undertaken across the North of England Cardiovascular Network. There was evidence from this audit performed in 2008 that the standard of echocardiography reporting varied hugely across the region. A survey of the evaluation of left ventricular function, the commonest and most important reason for requesting an echocardiogram, demonstrated unacceptable variation both within and between echo departments. The 13 sites ranged from small units, with single practitioners, to large tertiary referral units with many operators. Sites were asked to assess the left ventricular function of ten recorded echocardiograms. The results showed huge variation in terms of the diagnoses (See below). Since left ventricular function is often used to guide therapeutic decision-making, e.g. whether to refer for an implantable defibrillator or cardiac resynchronisation therapy, it is important that it be done accurately.




### The proposed approach

The intention is to produce a greater uniformity of echo quality with a levelling up of standards ensuring that patients are entitled to the same high standard of echo wherever, whenever and whoever performs the test. Acknowledging the existing BSE standards, the approach was to adapt them to take account of local circumstances and service provision. The intention was to agree a set of network wide standards, approved with the CHD Clinical Advisory Group, which would enable departments to assess their own services to identify and then address areas of weakness. The standards will help the hospitals to continually improve their echo services through self assessment and audit, but may also support commissioners in developing service specifications for local services.

A network imaging sub-group was set up to develop and agree the standards. Consultation with key stakeholders (e.g. cardiologists, commissioners etc) has shown widespread support for the idea of network echo standards.

### Benefits to Patients

Standards and consistency of echo reporting will be improved for patients, ensuring accurate diagnoses and thus more appropriate management of their condition. The quality of reporting will be audited ensuring that standards are improved and maintained. Reports should be issued in a consistent timely manner, thus avoiding delays in patients being discharged. Patient information about the test will be provided for all patients. Patient information will be stored securely with transferability being improved, to enhance diagnoses of complex cases, teaching and a more seamless transfer for those patients requiring multisite input.

### The wider benefits (Quality and Productivity)

The adoption and implementation of the echocardiography standards will lead to an improved quality of echocardiography generally, with a more robust clinical governance and support framework in place. This reduction in variability of diagnoses will lead to a more consistent management of patient conditions and utilise expertise across the region in terms of supporting teaching, diagnoses of complex cases and audit. Data storage and retrieval / transfer will be improved resulting in a reduction in the number of tests that are repeated and improvements in information governance. This region- wide approach of self audit will provide an ongoing picture of echocardiography services across the region, to support planning (both capital and workforce), investment and future development.

### Impact of roll-out across the Cardiac Network

As some of the BSE standards would be impossible to achieve for some of the departments, due to local circumstances, it has allowed them to be modified to use regional resources to achieve improvements in the quality of services offered to patients. Self assessment allows an action plan to be developed by individual sites, with regional support, and continual improvement rather than simply being either successful in achieving BSE accreditation or not. Departments with single handed practitioners will be supported to gain BSE accreditation, by utilising skills and support from across the region and increasing multi-site and regional audit. This should all lead to targeted improvements of echo standards on a regional basis.

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## 3.Improved Data Collection and Planning

**Lancashire and Cumbria cardiac and stroke network undertook a network wide approach to data collection, in order to understand their baseline capacity and demand for non-invasive cardiac imaging across the network. This information was used to inform their future strategy, undertake a gap analysis and identify potential patient and cost benefits.**

### The Issue

The Cardiac and Stroke Networks in Lancashire and Cumbria as part of their 5 year strategy for cardiac services development identified understanding their current and future capacity for non-invasive cardiac imaging as a key priority. The strategy had four key principles:

- Demographic need
- Achieving national best practice standards and targets
- Closing identified gaps in service
- The development of cost effective, equitable, accessible high quality services

National Drivers for non-Invasive Cardiac Imaging:

- A reduction in the numbers of patients waiting due the 18 week Referral to Treatment Target of 2008 (RTT) an increase in demand for more timely diagnostic services is predicted.
- Advances in technology allow for more advanced and complex imaging techniques, as well as the possibility of delivery of services in a community setting.
- Finally, the impact of established NICE Guidance, as well as guidance in development, was used to support and influence the development of the Strategy.

### The proposed approach

CSNLC used broad stakeholder involvement throughout the development of their Cardiac and Stroke Strategy. 'Imaging and Diagnostics' was identified by the Strategy Group as a key area. As such a Task Advisory Group (TAG) was established for Non-invasive Cardiac Imaging. This group had multi-disciplinary representation from Cardiology and Radiology specialities, including clinical, managerial, commissioners and service improvement staff.

Initial baseline data was collected to include activity, workforce and facilities data for all imaging modalities. This was used to undertake a gap analysis for both future activity and workforce requirements.

The benefits of two of the newer modalities were assessed and Cardiac CT (CCT) and Cardiac MR (CMR) were included in the strategy, as well as echocardiography, cardiac angiography, and Myocardial Perfusion Imaging (MPI). Facility, capability and capacity and workforce implications were considered as part of the development of the strategy.

## Baseline data collection

Collaboration and engagement with IT and Divisional managers was essential to allow robust and consistent data collection, including clarity regarding exact data requirements (i.e. defining session length). Trusts offer a variety of sessions and different working days to accommodate a varying case mix where slots and patient procedures can take from 15 minutes up to 45 minutes. Demand for different modalities varies, across trusts within the Network, thus suggesting a variation in uptake.

## Gap analysis

Current activity data collected formed the basis of the gap analysis and was matched against current and future targets outlined below. (See table 1).

As there are no national targets set for each imaging modality, agreement of current and future targets was attained through consensus agreement from the Task Advisory Group and was based on those angiography and MPS targets available. (NSF revascularisation targets, NICE (TA73)). The group agreed that MPI, CMR and Stress Echo (SE) future targets of 4,000 MPI per million population could be divided between all three modalities due to the interchangeable nature of the imaging diagnostics. The group also agreed that it was likely that there would be a 15% reduction in cardiac angiography due to increased accessibility of cardiac CT.

## Benefits for Patients

The Task Advisory Group (TAG) developed referral pathways which outline the imaging diagnostics available for different disease groups. Where possible, these have been aligned to the Map of Medicine pathways to ensure a consistent approach to patient management. These pathways are to be implemented along with the referral criteria using the best evidence to ensure optimum patient management.

## The wider benefits (Quality and Productivity)

As an integral element of all good service development workforce planning should be undertaken. A similar workforce gap analysis was integral to this work.

Our recommendations support consultant appointments and job planning which supports the development of cardiac imaging as a speciality, both Cardiologists and Radiologists, and allows time for MDT meetings to underpin current and future services, education and training. Clinical leadership and clear governance arrangements for all cardiac imaging is seen as essential, to ensure high quality services. This would provide continuing clinical support for stress echocardiography services and allow jointly developed cardiology and radiology CT Angiography services.

## Cost Analysis/Benefit

The lack of availability of Stress Echo and Cardiac MRI has historically driven clinical choice towards MPI and this may not be able to continue if radioisotope shortages persist. Clinical choice is currently restricted and availability of a wider range of diagnostic modalities across the Network should be available. The cost analysis has therefore followed the gap analysis undertaken and has calculated the cost of MPI, CMR and SE provision as an equal split (as in Table 3). However this is rudimentary and may not reflect future activity depending on which services are developed locally.

The Task advisory group recommend development of Stress Echocardiography and Cardiac CT services at every acute trust. This will alleviate the demands placed upon MPS, reduce the need for invasive diagnostic angiography and will increase clinical choice available locally whilst retaining the educational and speciality support available within the network, underpinned and supported by the development of cross trust MDT meetings. As can be seen below, this also leads to a saving and is therefore a cost effective solution.

### Future Modelling Cost Assessment

By assessing the potential shift of 15% diagnostic angiography to Cardiac CT angiography, the potential savings for one year for the Network is highlighted. (See Table 2).

As established in Table 1, the activity target for MPI can be divided between the three imaging modalities, MPI, CMR and SE. Potential savings over one year were assessed if activity was split between these three modalities (See Table 3).

### Benefits to Patients, Clinicians and PCTs

- Extended clinical choice of diagnostics to support individual patient clinical requirement
- Local developments will enhance local services and support development of MDT environments
- Local developments will enhance access to services, reduce the potential for patient travel and deliver more equitable provision of imaging across the Network.
- Access to non-invasive imaging modalities, in particular Cardiac CT, will reduce the need for current and future invasive diagnostic angiography by an estimated 15%.

Table 1 - Activity Gap Analysis
Based on Lancashire and Cumbria (population 1.96million)

| Imaging Diagnostic | Total for network - Actual activity | Total for network (pmp) | Current target (pmp) | Future target (pmp) | Gap in current provision (pmp) | Gap in current provision in network | Gap in future provision (pmp) | Gap in future provision in network |
|---|---|---|---|---|---|---|---|---|
| **Angiography** | 5450 | 2781 | 2550 | 3230 by 2011<br>3825 by 2015 | None<br>excess of 231 | None<br>excess of 453 | 449 by 2011<br>1044 by 2015 | 880 by 2011<br>2046 by 2015 |
| **Cardiac CT** | 1035 | 528 | 450<br>(CT Angio only) | 570 by 2011<br>675 by 2015<br>(CT Angio only) | 450<br>(CT Angio only) | 882<br>(CT Angio only) | 570 by 2011<br>675 by 2015<br>(CT Angio only) | 1117 by 2011<br>1323 by 2015<br>(CT Angio only) |
| **MPI** | 2677 | 1366 | 400 | 1333 | None<br>excess of 966 | None<br>excess of 1893 | None<br>excess of 33 | None<br>excess of 65 |
| **CMR** | 95 | 48 | 400 | 1333 | 352 | 690 | 1285 | 2519 |
| **SE** | 253 | 129 | 400 | 1333 | 271 | 531 | 1204 | 2360 |
| **Joint MPI, CMR, SE** | 3025 | 1543 | 1200 | 4000 | None<br>excess of 343 | None<br>excess of 672 | 2457 | 4816 |

Table 2 - Future Modelling Cost Assessment

| Imaging Diagnostic | Current Activity (£) | Future Model (£) | Saving (£) |
|---|---|---|---|
| Diagnostic Angiography | £7,313,900.00 | £6,216,815.00 | £1,097,085.00 |
| Cardiac CT Angiography (15% of current Angio) | £152,145.00 | £174,966.75 | -£22,821.75 |
| Total | £7,466,045.00 | £6,391,781.75 | £1,074,263.25 |

Table 3 - Future Modelling Potential Cost Savings

| Imaging Diagnostic | Current Activity (£) | Future Model (£) | Saving (£) |
|---|---|---|---|
| MPI | £1,906,024.00 | £717,933.33 | £1,188,090.67 |
| CMR | £33,535.00 | £355,941.67 | -£322,406.67 |
| SE | £104,489.00 | £416,441.67 | -£311,952.67 |
| Total | £2,044,048.00 | £1,490,316.67 | £553,731.33 |

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# 4.Improved Cardiac Data Transfer

**The North of England Cardiovascular Network has developed a network wide approach to the electronic transfer of cardiac data for imaging and ECG between hospital sites (Echo, ECG, angiography and associated cardiac data). This will ensure secure transfer of patient data with the required clinical functionality.**

### The Issue

Image data management and storage is traditionally the domain of radiology in acute trusts as a result of the National Programme for IT (NPfIT). Stringent cancer waiting times and programmes of independent sector imaging have driven the need for electronic transmission of radiology diagnostic imaging across picture archive and communications system (PACS) pathways. Within the North of England Cardiovascular Network (NECVN) region there are disparate cardiology systems and PACS systems that pose difficulties in providing a solution to effective electronic patient data sharing. As cardiology is outside the NPfIT, there are often poor facilities in comparison to radiology for appropriate management and storage of cardiology diagnostic data. This poses a multitude of clinical and information governance risks, and complicates cardiology patient pathways leading to delays and waste of resources.

### The Approach

A project linking nine Acute Trusts (patient population 3.2 million) with the objective of improving patient pathways in the North East and North Cumbria has been undertaken by NECVN to enable electronic sharing of angiogram, ECG, echocardiograph and all related cardiology patient data. Initial scoping of the project demonstrated that around 90% of angiograms were being transferred on a CD by post, courier or taxi. Other cardiac studies were being repeated, or shared electronically by non-secure method. The project team developed and agreed the specification appropriate to the needs of cardiac imaging and cardiac data transfer across the region.

Specifications

- Bi-directional electronic transfer of cardiac data i.e. data follows the patient between service providers.
- Data encryption across the N3 connections in compliance with DH directives.
- User-friendly web-based system with appropriate provider support.
- Ability to convert non - DICOM data (ECG, legacy echo studies, reports).
- Temporary storage and viewer supporting functional imaging. All cardiac data can be viewed (functional diagnostic standard), edited and added into any local data store as required. Unwanted data not stored.
- Compliance with the workflow patterns in place across the nine acute Trusts involved.
- Compliance with NECVN standards for data management and storage.
- Full integration with existing systems

### Evaluation & Stakeholder engagement

Work was undertaken to evaluate three commercial solutions. This was done in collaboration with the North East SHA PACS programme board who are undertaking a concurrent PACS data sharing project. One product could satisfy the requirements of the cardiology project specification and requirements. This package was demonstrated to representatives of nine acute trusts and evaluated very well, particularly in regard to sharing and storage of cardiac data.

Full details of the project including the results of the selection and evaluation process were shared with cardiology and PACS stakeholders over a period of months and the project recommendations were approved through the NECVN Joint Clinical Advisory Group (CAG). It was agreed to progress using the recommended commercial solution as it has been successfully tried and tested across the UK and Europe, is available now, provides good value for money, and fulfils the remit of the NECVN data sharing project. The CAG also recommended that region-wide standards for electronic storage and management of cardiac data be agreed. These outcomes were agreed with the North East SHA Chief Information Officer who concurred that in terms of risk governance, a region-wide cardiology data management and storage solution should be implemented as quickly as possible.

Cost negotiations were entered into and a regional fixed price and terms and conditions were agreed by NECVN with the supplier on behalf of regional stakeholders. The recommendations and proposals were presented to the NECVN Executive Board who agreed to endorse the recommended commercial solution and also approved partial funding. Sign up to implementation was immediate from seven of nine trusts, while two trusts required further information regarding the options and recommendations process. Implementation phase meetings are underway with all trusts to discuss workflow and installation requirements to meet their local needs.

### Benefits for Patients

Electronic sharing of cardiac data has the potential to provide extensive benefits for patients, providing access to the same expert knowledge and facilities irrespective of the hospital that patients present in. Instantaneous data transfer facilitates immediate treatment decision-making and can reduce stay in hospital by up to four days or more. It will ensure effective repatriation and transfer of data and records for patients who undergo treatment at specialist centres and have follow-up care at their local hospital. Diagnostic tests will not be repeated unless there is a clinical indication to do so.

### The wider benefits (Quality and Productivity)

Implementation of a regional solution provides the following benefits:

- Increased clinical effectiveness. Timely decisions can be made on patient care if diagnostics are available across Trusts within minutes rather than days. MDT meetings are run more effectively when diagnostics can be shared electronically.
- Reduced wait for inter-hospital transfer. In six months, one tertiary centre officially received 440 CDs - many more were sent unofficially. Discs are often delayed in transit or missing. Electronic data sharing takes minutes – no discs required.

- Reduction in repeat diagnostics. Echo study - tariff @ £90, taking 30 minutes.
- Reduction in unnecessary administrative procedures. Equates to approx. £10,000 p.a. for one tertiary centre.
- Equity of service provision. Different Trusts use different methods of sharing data leading to inequity in referral and transfer times.
- Enables appropriate clinical follow-up. DGH clinicians need access to diagnostics carried out at referral centres.
- Information governance. Appropriate and secure methods of storing and sharing data are required. There are a diversity of processes in place, some of which are not secure. Some Trusts lack appropriate electronic storage for cardiology studies.
- Training benefits, particularly for echocardiography, by instantaneous transfer of diagnostics for discussion.

Key Learning Points
The project has not been without its difficulties. The approach that has been used to overcome these has been to:

- Keep all stakeholders informed of project progress. Achieve buy-in through effective communication.
- Use open and transparent processes that are robust and well documented.
- Take advice on NHS procurement rules.
- Seek help and support from high level stakeholders to gain regional buy-in.
- Expect some resistance: IT departments are under-resourced, accountability and financial constraints on all Trusts
- Prepare clear, concise information and documentation for use during implementation.

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## 5.PACS/IT Case study

**The Kent Cardiovascular Network along with the Kent and Medway HISS undertook a project to develop discrete local networks to enable data sharing between Kent and Medway hospitals and receiving hospitals in London. This originally focused on angiogram and echocardiogram images. This was undertaken in the form of a case study**

### The issue

The potential to enable transformation in the NHS through technology was acknowledged with the inception of the National Programme for IT (NPFIT). NHS Connecting for Health (NHS CFH) is now in a position to demonstrate the tangible benefits of the investment.

NHS CFH assembled a team of benefits specialists to work with various NHS organisations across the country and conduct local benefit and cost case studies of NPFIT products / care pathway developments / supporting technologies at sites where they have been deployed.

The Kent Cardiovascular Network, based in Aylesford, Kent, works across organisational and professional boundaries to provide coronary heart disease services for the residents of Kent and Medway (1.6 million residents across three PCTs)

As the reduction of wait times for cardiac diagnostics and treatments is a national priority in England it was agreed that the network would be involved in a project relating to cardiac image transfer..

Kent and Medway has six catheter labs in Kent:

- William Harvey Hospital (site of East Kent University Hospitals NHS Foundation Trust)
- Medway Maritime Hospital (Medway NHS Foundation Trust)
- Darent Valley Hospital (Dartford & Gravesham NHS Trust)
- Queen Elizabeth The Queen Mother Hospital (East Kent University Hospitals NHS Foundation Trust)
- Kent & Sussex Hospital (Maidstone and Tunbridge Wells NHS Trust)
- Maidstone Hospital (Maidstone and Tunbridge Wells NHS Trust)

All hospitals in Kent and Medway refer patients for further tests and procedures to two centres in London. Images were burned onto CDs in order to facilitate transfer of patients and the CD sent with the patient on transfer.

The case study review was conducted between November 2008 and March 2009.

### The approach

This case study focused on the implementation of clinical data sharing from Kent to London (the Kent-London cardiology link) using the Kent Community of Interest Network (COIN) running on the N3 network. The Kent-London cardiology link was fully implemented in March 2008 and enables Kent & Medway clinicians to send angiogram images and echocardiograms electronically to cardiac specialists in London. The case study aimed to answer the following:

- What are the benefits that should have been delivered from system deployment?
- What benefits have been achieved?
- What benefits have not been achieved?
- What disbenefits have arisen?
- What are the local costs associated with system deployment?
- What lessons can be learned about benefits and local costs capture?

### Patient benefits

An on-line staff survey was distributed to staff working in all six cardiac catheter labs in Kent & Medway as well as to the two specialist cardiac centres in London that receive patients' cardiac images – 11 responses were received from Kent & Medway and 1 response from London. These survey results, along with the evidence available from other data sources, allowed for the identification of the following benefits of the Kent-London cardiology link enabled by the Kent N3/COIN implementation:

<u>Safe care</u>

- Access to patient information increased
- Quality of patient care pathway increased
- Positive clinical patient outcomes increased
- Reliability of data transmission increased

<u>Effective care</u>

- Efficiency of patient transfer from Kent to London increased

### The wider benefits

The reliability of image sharing, the clinical time savings in CD processing, and the ability to conduct consultations remotely were cited as the top benefits of the Kent-London cardiology link by survey respondents. An unanticipated benefit that was suggested by the London hospital respondent was that repeat testing had decreased.

While the system experienced technical difficulties earlier in the deployment, these seem to have been resolved, and survey respondents did not identify significant disbenefits with the link.

<u>Efficient care</u>

- Use of CDs in Kent catheter labs decreased
- Time taken by clinical staff to process CDs decreased
- Short- and medium-term network costs decreased (by enabling future deployments)

### Further work across the Network

The most pressing area for further work is to reverse the Kent-London cardiology link to allow for data transfer back from London to Kent. Multiple respondents commented on the value they would place on this development, and this two-way link is already being explored by the Kent and Medway Health Informatics Service (HIS). In addition, there is an indication that users would value the ability to send increased referral information along with the angiogram and echocardiogram image.

The main local costs associated with implementing the Kent-London cardiology link were deployment and project staff, and the Philips Licence, and totalled £24,435. Although approximately £3,000 was originally budgeted for BT firewall configuration costs, these costs were waived by BT due to delays in configuration.

The Kent-London cardiology link enabled by the N3/COIN demonstrates the level of clinical and efficiency benefits which can be realised through the deployment of relatively simple technology. The N3/COIN network itself is expected to enable ongoing service improvements within Kent & Medway in order to increase the continuity and quality of all patient pathways.

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## Acknowledgements

We are indebted to all those who gave freely of their time and energy in writing this document most particularly to the members of the cardiac imaging sub group, but also to those in the cardiac networks who contributed to the best practice examples included in the report.

**Mohammed Adrish**, Diagnostic Imaging Lead, Department of Health

**Dr Roger Bury**, representing British Society of Cardiovascular Imaging

**Dr Mark Dancy**, Consultant Cardiologist

**Matthew Dunn**, representing Institute of Physics & Engineering in Medicine

**Steve Ebdon-Jackson,** representing Health Protection Agency

**Professor Mary Evans**, Patient Representative

**Dr John Greenwood,** Senior Lecturer in Cardiology

**Kathryn Leng**, representing Royal College of Nursing

**Dr Jim McLenachan**, National Clinical Lead for Reperfusion & Consultant Cardiologist

**Dr James Moon**, representing British Society of Cardiovascular MR

**Dr Stephan Neubauer**, representing British Society of Cardiovascular MR

**Dr Charles Peebles**, representing Royal College of Radiologists

**Dr Simon Ray**, representing British Society of Echocardiography

**Professor Carl Roobottom,** representing, Royal College of Radiologists

**Dr Dominik Schlosshan**. SpR Cardiology

**Anne Shaw,** representing Society College of Radiographers

**Fiona Thow**, representing NHS Improvement

**Helen Tomkys**, Heart Services Lead, Department of Health

**Dr Richard Underwood**, representing Royal College of Physicians

**Dr Gill Vivian**, representing British Nuclear Medicine Society

**Glynis Wivell**, Project Lead

**Dr Simon Woldman**, representing British Nuclear Cardiovascular Society