**An evaluation of the use of investigations in nurse led rapid access chest pain clinic and patient outcomes**

Short title: Investigations in nurse led chest pain clinic

Chun Shing Kwok,1,2 Debbie Jackson,1 Sadie Bennett,1 Jacopo Tafuro,1 Adrian Large,1 Christian D Mallen,2 Dot-Morgan Smith,1 Simon Duckett1

**Author affiliations**

1. Department of Cardiology, Royal Stoke University Hospital, Stoke-on-Trent, UK

2. School of Medicine, Keele University, Keele, UK

**Corresponding author**

Dr Chun Shing Kwok

School of Medicine, Keele University,

Stoke-on-Trent, UK

Newcastle-under-Lyme, UK

E-mail: shingkwok@doctors.org.uk

**Tel:** +44 1782 732911 **Fax:** +44 1782 734719

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**Abstract**

**Background:** Chest pain is a common symptom and diagnosis can be challenging because its cause is diverse and presentation variable. This study aims to describe our experience of a nurse led rapid access chest pain clinic (RACPC) and associated use of investigation and patient outcomes.

**Methods:** A retrospective service evaluation of patients referred to a nurse-led rapid access chest pain clinic was performed. Routinely recorded information on patient demographics, symptoms, comorbidities, medications, cardiology clinic attendances and investigations were collected. In addition, admissions to accident and emergency (A&E) or inpatient, death, acute myocardial infarction and percutaneous coronary intervention within 1 years were obtained.

**Results:** A total of 279 patients were included in the evaluation between January and February 2019. Chest pain was present as a symptom in 92.8% of patients while 37.6% of patients had shortness of breath. Only 16.8% had typical angina while 34.4% had atypical angina. The majority (93.9%) had two or fewer cardiology clinic appointments and the most common imaging investigation used was CT coronary angiogram (47.3%) and 8.2% had stress echocardiogram or invasive angiogram. Approximately 1 in 5 patients had an admission within 1 year. Mortality rate within 1 year was 1.4% which were all non-cardiac causes. There was only 1 case of acute myocardial infarction and 3.6% underwent PCI.

**Conclusions:** This service evaluation shows that nurse led RACPC are safe and efficient and closely adhere to NICE guidelines. Many patients do not require unnecessary and potentially harmful investigations and revascularisation rate are low.

**Keywords:** Chest pain; clinic; nurse; investigations; outcome

**Key points**

* Chest pain is a common reason for patients present to healthcare professionals.
* Nurse led rapid access chest pain clinics (RACPC) are safe with low event rates.
* 43% of patient receive no further investigation after RACPC review.
* The use of RACPC is efficient as 94% of patient have two or less clinic visits.
* Revascularization rates for patients who attend clinic are low at 3.6% at 1 year.

**Reflective questions**

* What type of clinic do patients with chest pain attend as outpatients?
* What proportion of patients with chest pain are reviewed and discharged without investigation?
* What proportion of patients attending chest pain clinics undergo revascularization at 1 year?

**Introduction**

Chest pain is a common reason for patients presenting to healthcare professionals. Diagnosis of the underlying cause of chest pain can be challenging as noncardiac causes are common and it is important not to overlook serious conditions (Cayley 2005). Most clinicians recognise that severe and persistent chest pain merits urgent evaluation but more common are cases of stable chest pain in the community. These patients with stable chest pain are often seen first by a general practitioner who then refer the patient to outpatient services led by cardiologists or acute medicine physician.

In the United Kingdom, the National Service Framework for coronary heart disease identified rapid access chest pain clinics (RACPC) as an immediate priority to deal with the large volume of chest pain referrals (Boyle, 2007). This approach has been shown to be successful in identifying patients with angina (Sekhri, 2007). These clinics can be run by consultant, junior doctor, nurses or cardiac physiologists who act as a gateway to the plethora of tests for the diagnosis of chest pain. These tests range from simple blood tests such as full blood count, urea & electrolytes and cardiac troponins, electrocardiograms and chest X-ray to more advanced investigations such as computed tomography coronary angiography (CTCA), stress testing, echocardiography and cardiac magnetic resonance imaging. As misdiagnosis of cardiac chest pain as non-cardiac may lead to serious adverse outcomes (Soltani, 2016), these chest pain evaluation pathways enable prompt review of patients from time of referral to specialist consultation and are designed to identify patients with stable angina. The clinics themselves combine clinical evaluation and rapid access to diagnostic test that enables diagnosis and evidence-based treatments to be started promptly. It is important to evaluate these services on a local level to determine that they are effective and safe.

University Hospital of North Midlands (UHNM) provides tertiary level cardiology care for the population of Stoke-on-Trent and neighbouring hospitals which includes a RACPC. The RACPC is delivered across two sites and there are six clinics offering up to 42 new appointments each week and one additional clinic dedicated for patients requiring follow up. Clinics are delivered in a mixture of face-to-face and telephone consultations. The clinics are run throughout the year excluding bank holidays. Patients are referred by general practitioners via a dedicated referral pathway and assessed within two weeks of referral. At the clinic appointments, ECGs are performed for all patients and blood tests can be taken if required after clinical assessment. Clinics are delivered by a team of advanced cardiac nurse practitioners, supported by three cardiology consultants. The team have all completed (or are currently undertaking) advanced training including Master of Science in Cardiology (practitioners with a special interest), health assessment and are independent prescribers. The nurses undergo formal training as described previously (Kwok, 2020). Patients are assessed in clinic and then either reassured and discharged, commenced on treatment if a clinical diagnosis is reached or sent for diagnostic tests. Diagnostics commonly requested include CT coronary angiogram (CTCA), echo, rhythm monitoring, sleep studies and chest X-ray. Less commonly patients are sent for invasive coronary angiogram, cardiac magnetic resonance imaging, stress echo or myocardial perfusion scan. Results of any diagnostics are returned to the practitioner for further actioning. This may include discharge from the service with advice on diagnosis and management, referral for further investigation, initiation of further treatment or further follow up either in the RACPC follow up clinic or cardiology consultant clinic or referral onto other services outside of cardiology (a common example of this is the lung nodule surveillance clinic – a significant number of lung nodules are picked up on CTCA). The follow up clinic provides the opportunity to review patient symptoms in view of any changes since the last appointment particularly if antianginal medications were started. This clinic is also an opportunity to review and discuss results of investigations and provide any explanation and reassurance. There is a weekly RACPC multidisciplinary team (MDT) available for any complex cases attended by the practitioners and the consultant leads for the service. Cases that are discussed in the MDT include patients where the decision about the choice of management or method of coronary revascularization is not straight forward or how incidental findings on imaging such as atrial septal defect or liver cyst should be managed.

This report describes the experience of a nurse led RACPC and the associated use of investigation and patient outcomes.

**Methods**

The reporting of this evaluation is in accordance to the standards set by the Strengthening the reporting of observational studies in epidemiology (STROBE) statement (von Elm, 2007). This evaluation was conducted as a clinical health service evaluation which is registered with our institutional audit department (Clinical Audit ID CA28621) and ethical approval was not required.

*Evaluation design*

A retrospective evaluation of patients who were reviewed in the nurse-led RACPC at UHNM was carried out for patients seen between January and February 2019. Only patients with chest pain or suspected angina referred as outpatients were included.

*Data collection*

Patients were initially identified by DJ and data was collected by DJ, SB and JT from the electronic medical records. Information on the age, sex, symptoms, comorbidities, medications, the number of clinics attended by the patients and investigations used was recorded. In addition, admissions, death, acute myocardial infarction and percutaneous coronary intervention (PCI) within 1 year were also collected. For patients with admissions to hospital and A&E visits, the reason for return to hospital was determined.

*Statistical analysis*

Statistical analysis was performed by CSK using Stata 13 (College Station, Tx). Data was presented was mean and standard deviation for continuous variables and number and percentage for categorical variables. Patients with missing data on chest pain, comorbidities and medications were excluded (n=9). Descriptive statistics were reported for the full cohort together with stratification based on symptoms and investigations. Patients were classified according to their symptoms as typical angina, atypical angina and non-anginal pain based on the NICE criteria (NICE, 2010). Angina was distinguished from non-anginal chest pain by the criteria as per the NICE guidelines which included three features of 1) constricting discomfort in the front of the chest, or in the neck, shoulders, jaw are arm 2) precipitated by physical exertion 3) relieved by rest or GTN within about 5 minutes (NICE, 2010). All three were considered typical angina while satisfying two of the three criteria is considered atypical angina. Patients with one or no features were classified as non-anginal chest pain. The cohort was also divided into those with CTCA, invasive angiogram without CTCA and neither CTCA or invasive angiogram. Statistical testing was performed with oneway analysis of variance for continuous variables and Chi2 test for categorical variables with a p-value of <0.05 indicating statistical significance.

*CT protocol*

The radiology department at Royal Stoke University Hospital is led by radiologists and has a protocol to perform calcium score routinely for patients with CTCA. The coronary artery calcium score was interpreted as an age and gender adjusted centile according to the study by Hoff et al.(Hoff, 2001)

**Results**

A total of 279 patients were included in the evaluation. The demographics of the patients included in the analysis are shown in Table 1. The average age of patients was 60 years and 48.4% were men. There were 259 patients with chest pain (92.8%) and 105 (37.6%) had shortness of breath. A total of 91 patients (32.6%) had both chest pain and shortness of breath. There were 6 patients with neither chest pain or shortness of breath who presented with palpitations (n=3), left arm pain (n=1), palpitations and left arm pain (n=1) and dyspepsia (n=1). Considering the NICE criteria for angina, only 16.8% had typical angina while 34.4% had atypical angina (Figure 1). The proportion of patients with hypertension, hypercholesterolaemia, a family history of coronary artery disease and smoking history was 47.3%, 44.4%, 44.8% and 41.6%, respectively. The most frequently prescribed medications in clinic included a statin (40.1%), nitrate (35.5%), aspirin (28.0%) and β-blocker (25.1%). The vast majority (93.9%) had two or fewer clinic appointments with the service and the most common imaging investigation used was CTCA (47.3%) and less than 1 in 10 patients (8.2%) had stress echocardiogram or invasive angiogram (Figure 2). In terms of outcomes, more than 1 in 5 patients had admission to A&E (21.9%) or inpatient (20.9%) within 1 year. Mortality rate was 1.4%. There was only 1 case of acute myocardial infarction and 3.6% underwent PCI.

135 patients under went CTCA and/or calcium score (Table 2). The average calcium score was 119. Moderate or severe disease of the left anterior descending artery was observed in 13.4% of patients and less than 5% had disease in the left circumflex (4.5%) or right coronary arteries (5.3%). From these patients, 11 were referred for computed tomography-fractional flow reserve (CT-FFR) and 8 were accepted. It is notable that poor image quality resulted in 3 CT scans being rejected from post-processing by HeartFlow who apply the FFRCT analysis algorithm.

From the 8 patients with CT-FFR, 50% had significant left anterior descending artery disease and 25% had significant left circumflex and right coronary artery disease (Table 2).

The results for the additional analysis consider whether patients had CTCA or invasive coronary angiogram without CT or no investigation is shown in Table 3. The proportion of patients who were male was much greater for patients who had invasive angiogram (85.7%) compared to patients who had CTCA (48.5%) and no investigation (43.8%) (p=0.012). Hypertensive patients (50.0% invasive angiogram vs 54.6% CTCA and 36.6% no investigation, p=0.019) and smokers (85.7% invasive angiogram vs 40.2% CTCA vs 36.6% no investigation, p=0.002) were more likely to be investigated. The proportion of patients on β-blockers was greater among patients who underwent investigations compared to no investigation (50.0% invasive angiogram vs 25.8% CTCA vs 17.9% no investigations). For nitrates, a similar greater proportion of patients were on treatment for the group with investigations compared to no investigations (64.3% invasive angiogram vs 37.9% CTCA and 26.8% no investigation, p=0.010). Patients who have invasive angiography have the highest proportion of patient admitted to hospital within 1 year (78.6% invasive angiogram vs 19.1% CTCA and 16.1% no investigation). Acute myocardial infarction rates within 1 year is low overall which occurred in 1 case in a patient who had invasive angiography. PCI rates within 1 year were 3.0% for patients with CTCA and 35.7% in patients with invasive angiography and 0% among patients with no investigation.

The characteristics of patients according to presentation is shown in Table 4. The use of CTCA was greatest in patients with atypical angina (56.3%) followed by typical angina (51.1%) and non-anginal pain (39.7%). Invasive angiogram was used to the greatest proportion among patients with typical angina (29.8%). Majority of patients with non-anginal pain, atypical angina and typical angina have 1 clinic visit only which occurred in 82.2%, 65.6% and 57.5%, respectively. Interestingly, inpatient admission within 1 year was greatest for patients with typical angina (40.4%) followed by non-anginal pain (20.0%) and atypical angina (12.5%). Death rates within 1 year were low affecting 2.2%, 0% and 2.1% of patients with non-anginal pain, atypical angina and typical angina, respectively. Acute myocardial infarction occurred in one patient who had non-anginal pain and PCI rates within 1 year were greatest among patients with typical angina (14.9%), atypical angina (1.0%) and non-anginal pain (1.4%).

The visits to A&E and hospital within 1 year according to receipt of investigation and type of angina are shown in Table 5 and 6. The most frequent cause of admission to A&E was for trauma or injury and the most common reason for hospitalization was for coronary angiogram.

There was a total of 6 deaths in the cohort which were due to alcoholism, general deterioration in health, metastatic lung cancer, urinary tract infection and hospital acquired pneumonia and two patients of unknown reasons.

Among the patients with non-anginal chest pain, 3 underwent coronary angiograms. One patient had a CTCA after the initial visit. Another had an outpatient exercise tolerance test that was positive and then had subsequent invasive coronary angiogram. The last patient with non-anginal chest pain on initial assessment was readmitted to hospital for chest pain without troponin rise but ST-depression on electrocardiogram and subsequent angiography showed left anterior descending artery disease that was stented.

One patient was admitted with acute myocardial infarction before CTCA took place as an outpatient investigation. This patient had an assessment that was felt not to be angina as it was right sided chest pain that was worse when he lied on that side. He also had exertional breathlessness. When he was admitted, he underwent invasive angiogram which showed severe proximal LAD disease that was stented.

**Discussion**

 This evaluation has several important findings. First, nurse led RACPC are safe with low event rates. Secondly, the approach of nurse led clinics are an effective way to follow clinical guidelines. Third, 43% of patients received no further cardiac investigations after RACPC review. Fourth, this approach appears to be an efficient pathway as 95% of patients have two or less clinic visits. Finally, the revascularization rates for patients who attend clinic are low at 3.6% at 1 year. These findings suggest that nurse led RACPC are an effective strategy to care for patients with chest pain with prompt review and delivery of guideline-based therapies and efficient use of diagnostic resources.

While it is recognized that primary care physicians do not have the same expertise in chest pain as specialist, a key finding is that many of the patients that are referred for specialist input do not require investigation and only 3.6% required revascularization. An important consideration is the willingness of general practitioners to manage chest pain without specialist input as well as those who would prefer not to refer patients with chest pain and investigate or treat themselves. General practitioners have variable training, experience and knowledge about chest pain and their current guidelines. It may be very different between a newly qualified practitioner compared to one that has been practicing for decades. In order for patients to be seen in the specialist clinic a general practitioner must complete a referral proforma which includes information about chest pain, symptoms and comorbidities. Using the NICE criteria for chest pain, it is possible that decision could be made about review just based on the referral alone. NICE defines chest pain as typical chest pain, atypical angina and non-angina chest pain. Using these entities based on referral information it is possible to determine which patients should have investigations and/or clinical review. Despite the clear criteria defined by NICE regarding angina, patients are regularly sent for tests. By following guidelines many patients may not have tests and this is supported by the data presented in the current evaluation where just under half of patients received no further cardiac investigations. Ultimately, to provide an effective and efficient care pathway for chest pain, there must be good understanding, communication and trust between the people making the referrals and the specialist team. Local exchange of information and a process where there is open feedback from both side and regular auditing of clinical practices and patient outcomes would improve the referral process and efficiency of the pathway.

The benefits of RACPC have been reported in several studies. A study from Australia of 1,479 patients seen were compared to 435 historical controls seen in general cardiology clinic and they found that the median time to review was shorter (12 days vs 45 days) and there were fewer major adverse cardiovascular events (0.2% vs 1.4%) (Black, 2019). The nurse led set up reported in the current evaluation is different from that used Black et al. In the study by Black et al. it states that patients were initially seen by a registered nurse who documented their cardiovascular risk factors, took an electrocardiogram (ECG), and calculated their 5-year Australian absolute cardiovascular disease risk score (www.cvdcheck.org.au). Clinical review was undertaken by a cardiologist, general physician, or advanced trainee. In the current study, the clinic was nurse led with the support of a consultant where nurses performed their assessment and made decisions about patient care with or without the advice from a consultant. Another Australian study between 2008 and 2017 found that there was increasing use of CTCA over time and 1.6% underwent revascularization (Yu, 2018). In the United Kingdom, 1382 patients seen in RACPC and 228 controls who attended out-patient cardiology clinic reported that all patients were seen within 24 hours while the mean wait time for the outpatient clinic was 97 days and patients seen in the RACPC had nearly fourfold increase in odds of referral for coronary angiogram (Sekhri, 2007). The findings from the current evaluation differ from that reported by Sekhri et al which found a significant increase in invasive angiography in patients referred to the chest pain clinic. The data presented in Sekhri et al was from 1996 to 2002 and clinical practice and guidelines have changed significantly. CTCA has grown over the years and is now recommended to exclude coronary disease in low and intermediate risk patients. This was less available during the time of this study and invasive angiography was the best option to exclude coronary disease. Because of the risk of invasive angiography there is a drive for low-risk patients to undergo CT or alternative functional imaging evaluation first so that patients who do go on to have invasive angiography are those who are more likely to have PCI during the same procedure. A further study from the United Kingdom of 7066 patients reported that 46.0% of patients seen in RACPC were discharged with non-angina chest pain and rates of acute coronary syndrome and deaths were 0.25% and 0.3%, respectively (Kite, 2020). Another United Kingdom evaluation of 454 patients reported that 24.9% of patients seen in nurse led RACPC underwent angiography and 66.4% of these patients had coronary heart disease of which 29.2%, 16.8% and 20.4% were managed with PCI, coronary artery bypass grafting and medical therapy, respectively (Pottle, 2005). This study adds to the literature regarding the effectiveness of the RACPC in the care pathway for patients with chest pain in an era where CTCA is readily available and the findings show that many patients can be safely discharged without further investigation using a nurse led service.

A review of the patients who had stress echo and MRI scanning for typical angina found that one patient who had the MRI had actually undergone a CT after the clinic review which showed moderate coronary disease. The nurses running the RACPC are able to order CTCA. The results of the CTCA were reviewed by the nurse and the doctor responsible for the patient arranged for the MRI after the abnormal CT result. The patient was then admitted for hospital for chest pain and troponin were negative. An outpatient stress MRI scan was booked following the admission. Particularly for patients with renal disease, a few stress echocardiograms were arranged because it avoids exposure to nephrotoxic contrast. Also, stress echocardiography was used in patients with coronary disease of unknown significance and CT-FFR assessment could not be performed due to poor quality images.

The decision about invasive angiography was typically based on failure of symptom relief despite optimal antianginal therapy. Some GPs had prescribed patients on antianginals before referring to the clinic but those who had significant coronary artery disease were frequently treated with medical therapy before invasive angiography. Nevertheless, clinical decision making is not as straight forward as a cut-off for stenotic lesions. Some patients are elderly or frail and may be managed medically despite significant coronary lesions.

The ideal person to run RACPC merits discussion. Appropriate cardiologist led training and education about chest pain guidelines enables most healthcare practitioners such as doctors or nurses to be able to take on this role. Furthermore, the huge volume of work is such that experience for the clinician evaluating the patients builds up quickly which improves the clinical evaluation of new assessors. Nurses have the advantage over junior doctors to take on this role because nurse led services are typically a permanent position while junior doctors frequently rotate to different specialities. A potential disadvantage of the nurse led approach is that protocols for excluding coronary artery disease may be effective but due to differences in training between nurses and doctors, non-cardiac causes for chest pain may less likely to be investigated and diagnosed with nurses. Nevertheless, it is important that nurses identify the cause of chest pain in a safe and effective manner and consider both cardiac and non-cardiac causes (George 2019).

The purpose of the RACPC is to identify patients with a cardiac cause for chest pain and the nurses who run the clinic must be familiar with the tests required to make a diagnosis of angina. However, this is not always apparent to patients and referrers and patients who have a cardiac cause excluded may find it frustrating that the underlying cause has not been determined. Nevertheless, the nurses running the clinic do have experience evaluating chest pain and can suggest possible diagnosis for primary care to investigate further.

It is notable that many of the patients who had non-anginal chest pain underwent CTCA. This test was performed because identification of normal coronary arteries on this test can help exclude coronary artery disease as a cause for the patient symptoms. This is particularly helpful in cases where patients have risk factors for coronary artery disease but their history is not suggestive of typical angina. Therefore, this test has value in patients with suspected non-anginal chest pain to provide some reassurance to patients so that alternative causes for chest pain can be found. In addition, there may be concerns from the clinical assessment that the patient will require the test to exclude coronary disease because they have struggled to cope with the symptoms and will likely repeatedly seek help from professionals if coronary artery disease could be a cause for their symptoms.

One of the questions in the developed this study was the impact of CT-fractional flow reserve on RACPC. CTCA has become the most commonly used investigation for assessment of chest pain as it is an effective test in ruling out low risk cases without coronary artery disease. However, the test alone does not determine the functional significance of lesions identified. CT-FFR was developed to address this issue. CTCA images are sent to the HeartFlow core lab for post-hoc analysis with software algorithms used to determine whether one or more lesions are functionally significant. The current study found that out of 279 patients of which 132 had CTCA only 8 had CT-FFR. This suggests that the frequency of use of CT-FFR in routine CTCA reporting is low and that the additional cost of CT-FFR is not significant.

The clinical impact of this study is that nurse-led RACPC should be supported where there is demand for this service. Patients managed through this pathway appear to be safe and with few untoward outcomes. However, there is scope for better understanding which patients need a CTCA. In addition, visit to the emergency department and admission to hospital are not uncommon in everyday practice and interventions should be developed to reduce them. Most RACPC are nurse-led and more research is needed to understand how they operate, the resources required to carry out these clinics and how effective they are in diagnosing patients with stable angina and underlying cause for the chest pain. There should also be further evaluations regarding how these clinics compare to those which are run by doctors with consideration of the cost of running the clinics, use of investigations as well as patient experience and outcomes.

*Limitations*

This service evaluation has several limitations. First, the data is retrospectively collected. Second, the data is observation so it may be affected by biases and confounding. Third, the sample size is not large. Fourth, while the population studied may be typical of the UK population, not all centres have the cardiac assessment nurses used in the current study. Fifth, the nurse-led RACPC has access to consultant advice for decision making but it is not known the extent to which advice from consultant was sought. Finally, patients were only followed up for cardiovascular events through review of the local records. If patients were readmitted to other hospitals, the patient’s data may not be available.

In conclusion, this service evaluation shows that nurse led RACPC are safe and efficient and closely adhere to NICE guidelines. It is important that specialist nurses that undertake these clinics have the appropriate training and support from cardiology consultants. With appropriate protocols and pathways in place, many patients do not require unnecessary and potentially harmful investigations. It is also interesting that following appropriate clinical assessment and referral for appropriate investigations that the revascularisation rate is incredibly low. These findings would support the development of nurse-led RACPC in hospitals which is particularly with the current challenges with COVID leading to staff redeployment and changes in service provision.

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**Figures and Tables**

**Figure 1: Presentation to chest pain clinic**

**Figure 2: Investigations in chest pain clinic**

**Table 1: Data for the entire cohort including extent of available data**

**Table 2: Findings on CT coronary angiogram for 137 patients (1 patient had only calcium score)**

**Table 3: Demographics according to tests received**

**Table 4: Demographics according to presentation**

**Table 5: Causes of visits to A&E and admissions according to investigation received**

**Table 6: Causes of visits to A&E and admissions according to presentation**

**Figure 1: Presentation to chest pain clinic**

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**Figure 2: Investigations in chest pain clinic**

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**Table 1: Data for the entire cohort (n=279)**

|  |  |
| --- | --- |
| **Variable** | **Value** |
| Mean age (SD) | 60.7±13.3 |
| Male | 135 (48.4%) |
| Chest painQuality as heaviness/tightnessExertionalRelief with nitrate | 259 (92.8%)202 (72.4%)145 (52.0%)80 (33.1%) |
| Typical anginaAtypical angina | 47 (16.8%)96 (34.4%) |
| Shortness of breath | 105 (37.6%) |
| ComorbiditiesHypertensionHypercholesterolaemiaDiabetes mellitusSmoking (ex or current)Ischaemic heart diseaseFamily history of CAD | 132 (47.3%)124 (44.4%)54 (19.4%)116 (41.6%)6 (2.2%)125 (44.8%) |
| MedicationsAspirinClopidogrelTicagrelorPrasugrelβ-blockerCalcium channel blockerNitratesRanolazineIvabradineStatin | 78 (28.0%)9 (3.2%)0 (0%)0 (0%)70 (25.1%)67 (24.0%)99 (35.5%)0 (0%)2 (0.7%)112 (40.1%) |
| Total clinics12345 | 201 (72.3%)61 (21.9%)12 (4.3%)3 (1.1%)1 (0.4%) |
| InvestigationsCTCAStress echoMIBIMRI Invasive angiogram | 132 (47.3%)23 (8.2%)1 (0.4%)3 (1.1%)23 (8.2%) |
| Admissions within 1 yearA&E visitInpatient | 61 (21.9%)58 (20.9%) |
| Death within 1 year | 64 (1.4%) |
| Acute myocardial infarction within 1 year | 1 (0.4%) |
| Percutaneous coronary intervention within 1 year | 10 (3.6%) |

SD=standard deviation; CAD=coronary artery disease; CTCA=computed tomography coronary angiography; MIBI=myocardial perfusion imaging; MRI=magnetic resonance imaging

**Table 2: Findings on CT coronary angiogram for 135 patients (1 patient had only calcium score)**

|  |  |
| --- | --- |
| **Variable** | **Value** |
| Calcium score | 119±288 |
| Moderate or severe diseaseLeft main arteryLeft anterior descending arteryLeft circumflex arteryRight coronary arteryAny vessel | 2 (1.5%)18 (13.4%)6 (4.5%)7 (5.3%)22 (16.3%) |
| Fractional flow reserve requestAcceptedRejected | 11 (8.2%)8 (6.0%)3 (2.2%) |

|  |  |
| --- | --- |
| **Variable** | **Value** |
| Left main artery>0.8Left anterior descending artery≤0.8>0.8Left circumflex artery≤0.8>0.8Right coronary artery≤0.8>0.8 | 8 (100.0%)4 (50.0%)4 (50.0%)2 (25.0%)6 (75.0%)2 (25.0%)6 (75.0%) |

\*A cutoff of ≤0.80 on FFR represents a coronary vessel that may be associated with ischaemia while vessels with FFR values >0.80 were not considered to be at significant risk of ischaemia.

**Table 3: Demographics according to tests received**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Variable** | **No investigation (n=112)** | **CTCA (n=132)** | **Invasive angiogram no CT (n=14)** | **p-value** |
| Mean age (SD) | 61.6±14.9 | 58.3±12.0 | 62.9±7.1 | 0.010 |
| Male | 49 (43.8%) | 64 (48.5%) | 12 (85.7%) | 0.012 |
| Chest painQuality as heaviness/tightnessExertionalRelief with nitrate | 101 (90.2%)71 (63.4%)47 (42.0%)26 (28.0%) | 126 (95.5%)104 (78.8%)76 (57.6%)40 (33.9%) | 13 (92.9%)11 (78.6%)11 (78.6%)8 (66.7%) | 0.270.0240.0060.027 |
| Shortness of breath | 37 (33.0%) | 54 (40.9%) | 6 (42.9%) | 0.41 |
| ComorbiditiesHypertensionHypercholesterolaemiaDiabetes mellitusSmoking (ex or current)Ischaemic heart diseaseFamily history of CAD | 41 (36.6%)48 (42.9%)18 (16.1%)41 (36.6%)4 (3.6%)45 (40.2%) | 72 (54.6%)56 (42.4%)25 (18.9%)53 (40.2%)1 (0.8%)70 (53.0%) | 7 (50.0%)7 (50.0%)3 (21.4%)12 (85.7%)0 (0%)3 (21.4%) | 0.0190.860.790.0020.250.023 |
| MedicationsAspirinClopidogrelTicagrelorPrasugrelβ-blockerCalcium channel blockerNitratesRanolazineIvabradineStatin | 26 (23.2%)0 (0%)0 (0%)0 (0%)20 (17.9%)22 (19.6%)30 (26.8%)0 (0%)0 (0%)37 (33.0%) | 32 (24.2%)8 (6.1%)0 (0%)0 (0%)34 (25.8%)34 (26.5%)50 (37.9%)0 (0%)2 (1.5%)52 (39.4%) | 9 (64.3%)1 (7.1%)0 (0%)0 (0%)7 (50.0%)4 (28.6%)9 (64.3%)0 (0%)0 (0%)8 (57.1%) | 0.0030.027--0.0200.410.010-0.380.18 |
| Total clinics12345 | 85 (76.6%)20 (18.0%)5 (4.5%)1 (0.9%)0 (0%) | 94 (71.2%)30 (22.7%)6 (4.6%)1 (0.8%)1 (0.8%) | 9 (64.3%)4 (28.6%)0 (0%)1 (7.1%)0 (0%) | 0.48 |
| Admissions within 1 yearA&E visitInpatient | 27 (24.1%)18 (16.1%) | 25 (18.9%)25 (19.1%) | 5 (35.7%)11 (78.6%) | <0.001 |
| Death within 1 year | 2 (1.8%) | 2 (1.5%) | 0 (0%) | 0.88 |
| Acute myocardial infarction within 1 year | 0 (0%) | 0 (0%) | 1 (7.1%) | <0.001 |
| Percutaneous coronary intervention within 1 year | 0 (0%) | 4 (3.0%) | 5 (35.7%) | <0.001 |

SD=standard deviation; CAD=coronary artery disease

**Table 4: Demographics according to presentation**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Variable** | **Non-anginal chest pain (n=136)** | **Atypical CP (n=96)** | **Typical CP (n=47)** | **p-value** |
| Mean age (SD) | 59.8±14.3 | 61.2±13.0 | 62.2±10.6 | 0.50 |
| Male | 59 (43.4%) | 44 (45.8%) | 32 (68.1%) | 0.012 |
| Shortness of breath | 49 (36.0%) | 36 (37.5%) | 20 (42.6%) | 0.73 |
| ComorbiditiesHypertensionHypercholesterolaemiaDiabetes mellitusSmoking (ex or current)Ischaemic heart diseaseFamily history of CAD | 61 (44.9%)55 (40.4%)27 (19.9%)56 (41.2%)2 (1.5%)56 (41.2%) | 46 (47.9%)49 (51.0%)18 (18.8%)37 (38.5%)3 (3.1%)45 (46.9%) | 25 (53.2%)20 (42.6%)9 (19.2%)23 (48.9%)1 (2.1%)24 (51.1%) | 0.610.270.980.490.690.44 |
| MedicationsAspirinClopidogrelTicagrelorPrasugrelβ-blockerCalcium channel blockerNitratesRanolazineIvabradineStatin | 31 (22.8%)4 (2.9%)0 (0%)0 (0%)29 (21.3%)31 (22.8%)24 (17.7%)0 (0%)1 (0.7%)45 (33.1%) | 18 (18.8%)2 (2.1%)0 (0%)0 (0%)22 (22.9%)23 (24.0%)34 (35.4%) 0 (0%)0 (0%)40 (41.7%) | 29 (61.7%)3 (6.4%)0 (0%)0 (0%)19 (40.4%)13 (27.7%)41 (87.2%)0 (0%)1 (2.1%)27 (57.5%) | <0.0010.38--0.0280.80<0.001-0.370.012 |
| InvestigationsCTCAStress echoMIBIMRI Invasive angiogram | 54 (39.7%)8 (5.9%)1 (0.7%)1 (0.7%)5 (3.7%) | 54 (56.3%)10 (10.4%)0 (0%)1 (1.0%)4 (4.2%) | 24 (51.1%)5 (10.6%)0 (0%)1 (2.1%)14 (29.8%) | 0.0390.380.590.73<0.001 |
| Total clinics12345 | 111 (82.2%)20 (14.8%)4 (3.0%)0 (0%)0 (0%) | 63 (65.6%)27 (28.1%)5 (5.2%)1 (1.0%)0 (0%) | 27 (57.5%)14 (29.8%)3 (6.4%)2 (4.3%)1 (2.1%) | 0.005 |
| Admissions within 1 yearA&E visitInpatient | 34 (25.0%)27 (20.0%) | 15 (15.6%)12 (12.5%) | 12 (25.5%)19 (40.4%) | 0.190.001 |
| Death within 1 year | 3 (2.2%) | 0 (0%) | 1 (2.1%) | 0.35 |
| Acute myocardial infarction within 1 year | 1 (0.7%) | 0 (0%) | 0 (0%) | 0.59 |
| Percutaneous coronary intervention within 1 year | 2 (1.5%) | 1 (1.0%) | 7 (14.9%) | <0.001 |

SD=standard deviation; CAD=coronary artery disease; CTCA=computed tomography coronary angiography; MIBI=myocardial perfusion imaging; MRI=magnetic resonance imaging

**Table 5: Causes of visits to A&E and admissions according to investigation received**

|  |  |  |  |
| --- | --- | --- | --- |
| **Variable** | **No investigation (n=112)** | **CTCA (n=132)** | **Invasive angiogram no CT (n=14)** |
| No visit to A&E | 84 (%) | 106 (%) | 9 (64.3%) |
| Reason for visit to A&E | Trauma or injury 7 (6.3%)Non-chest infection 5 (4.5%)Shortness of breath 3 (2.7%)Non-chest musculoskeletal pain 3 (2.7%)Atrial fibrillation/flutter 2 (1.8%)Pneumonia 1 (0.9%)Other 7 (6.3%) | Trauma or injury 9 (6.8%)Non-cardiac chest pain 8 (6.1%)Non-chest musculoskeletal chest pain 2 (1.5%)Non-chest infection 1 (0.8%)Other 6 (4.6%) | Trauma or injury 2 (14.3%)Non-cardiac chest pain 2 (14.3%)Angina 1 (7.1%) |
| No visit to hospital | 93 (83.0%) | 107 (81.1%) | 4 (28.6%) |
| Return for coronary angiogram | 2 (1.8%) | 9 (6.8%) | 6 (42.9%) |
| Reason for hospitalization | Elective surgery/procedure 5 (4.5%)Pneumonia 1 (0.9%)Chest pain 1 (0.9%)Further investigations 1 (0.9%)Shortness of breath 1 (0.9%)Trauma or injury 1 (0.9%)Urinary tract infection 1 (0.9%)Subarachnoid haemorrhage 1 (0.9%)Other 5 (4.5%) | Elective surgery/procedure 3 (2.3%)Non-cardiac chest pain 3 (2.2%)Non-chest musculoskeletal pain 2 (1.5%)Trauma or injury 1 (0.8%)Reveal 1 (0.8%)Other 6 (4.6%) | Elective surgery/procedure 1 (7.1%)Further investigation 1 (7.1%)Chest pain 2 (14.3%) |

**Table 6: Causes of visits to A&E and admissions according to presentation**

|  |  |  |  |
| --- | --- | --- | --- |
| **Variable** | **Non-anginal chest pain (n=136)** | **Atypical chest pain (n=96)** | **Typical chest pain (n=47)** |
| No visit to A&E | 101 (74.3%) | 80 (83.3%) | 35 (74.5%) |
| Reason for visit to A&E | Trauma or injury 9 (6.6%)Non-cardiac chest pain 7 (5.2%)Non-chest musculoskeletal pain 4 (2.9%)Non-chest infection 4 (2.9%)Shortness of breath 2 (1.5%)Angina 1 (0.7%)Atrial fibrillation/flutter 1 (0.7%)Pneumonia 1 (0.7%)Other 6 (4.4%) | Trauma or injury 7 (7.3%)Non-cardiac chest pain 2 (2.1%)Non-chest infection 2 (2.1%)Atrial fibrillation/flutter 1 (1.0%)Other 4 (4.2%) | Trauma or injury 4 (8.5%)Non-cardiac chest pain 2 (4.3%)Angina 1 (2.1%)Non-chest musculoskeletal pain 1 (2.1%)Shortness of breath 1 (2.1%)Other 3 (6.4%) |
| No visit to hospital | 112 (82.3%) | 84 (87.5%) | 28 (59.6%) |
| Return for coronary angiogram | 3 (2.2%) | 2 (2.1%) | 12 (25.5%) |
| Reason for hospitalization | Elective surgery/procedure 5 (3.7%)Chest pain 4 (2.9%)Pneumonia 1 (0.7%)Non-chest musculoskeletal pain 1 (0.7%)Reveal 1 (0.7%)Shortness of breath 1 (0.7%)Urinary tract infection 1 (0.7%)Subarachnoid haemorrhage 1 (0.7%)Other 6 (4.4%) | Elective surgery/procedure 4 (4.2%)Trauma or injury 2 (2.1%)Urinary tract infection 1 (1.0%)Other 3 (3.1%) | Further investigation 2 (4.3%)Chest pain 2 (4.3%)Elective surgery/procedure 1 (2.1%)Non-chest musculoskeletal pain 1 (2.1%)Other 1 (2.1%) |