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Title

Appropriate use of elective coronary angiography in patients with suspected stable coronary artery disease

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Abstract

Introduction

The American College of Cardiology Foundation (ACCF) with other professional societies developed Appropriate Use Criteria (AUC) for diagnostic coronary angiography. This study aims to examine the appropriate use of elective coronary angiography for patients with suspected stable coronary artery disease in an Irish tertiary referral centre.

Methods

A retrospective chart review of all elective outpatient diagnostic coronary angiograms performed in Cork University Hospital in 2014 was carried out. Data on demographics, risk factors, clinical presentation and prior non-invasive investigations was extracted. Each patient was evaluated according to the 2012 ACCF Appropriate Use Criteria and classified as appropriate, uncertain or inappropriate. Univariable and multivariable logistic regression was performed to investigate the factors that predict patients undergoing appropriate diagnostic coronary angiography.

Results

Of 417 elective outpatient diagnostic coronary angiograms 259 (62%) were included in the analysis. Of these 108 (42%) were classified as appropriate, 97 (37%) as uncertain and 54 (21%) as inappropriate. In multivariable analysis those with private health insurance were more likely to have an appropriate indication for coronary angiogram (OR 2.1, 95% CI 1.2 – 3.7) as were those with atrial fibrillation (OR 3.9, 95% CI 1.2 – 12.8). Ever smokers were less likely to have an appropriate indication for coronary angiogram than never smokers (OR 0.5, 95% CI 0.3 – 0.9).

Conclusion

This is the first Irish study to evaluate the appropriate use of elective coronary angiography. Rates were similar to those of studies in other jurisdictions however there remains significant potential for quality improvement.

Keywords:

Coronary Angiography; Cardiac catheterisation; Appropriate Use Criteria; Quality of Health Care

Introduction

Coronary angiography plays a vital role in the diagnosis and management of coronary artery disease (CAD). It is clearly the appropriate investigation in those who present with acute coronary syndromes. It is also appropriate for certain elective indications such as evaluation prior to valve or transplant surgery and to further evaluate those who have undergone non-invasive investigation with high risk findings potentially indicating disease of prognostic importance where revascularisation may have a role.

However the low diagnostic yield of elective coronary angiography has been highlighted with 39.2% of patients having no coronary artery disease in one USA registry based study. (1) Further evidence from the USA suggests that up to 1 in 4 cardiac catheterisations in the non-acute setting may be inappropriate. (2) Appropriate Use Criteria (AUC) have been developed by the American College of Cardiology Foundation (ACCF) in conjunction with other relevant professional societies. (3) These criteria evaluate the appropriateness of coronary angiography for selected clinical indications in order to reduce unnecessary procedures and improve quality of care. The aim of AUC is to improve patient care and outcomes in a cost-effective manner.

The rational use of investigations in clinical practice has long been discussed. (4) It is more relevant now than ever given limited fiscal resources. (5) At present there is no available evidence on the extent of inappropriate or appropriate elective coronary angiography or the profile of patients undergoing this procedure in Ireland.

The aim of this study is to examine the appropriate use of elective coronary angiography for patients with suspected stable CAD in a large tertiary university hospital in the south of

Ireland. We also examined the factors that predict patients undergoing appropriate coronary angiography.

Methods

Setting

Cork University Hospital (CUH) is a large university teaching hospital in Ireland serving a population of approximately 550.000. Yearly approximately 2000 diagnostic coronary angiograms are performed in the cardiac catheterization laboratory.

Design

We carried out a retrospective chart review of elective diagnostic coronary angiograms performed in the cardiac catheterization laboratory of CUH between January 1st 2014 and December 31st 2014.

Inclusion and Exclusion Criteria

Those considered for inclusion were CUH outpatients aged ≥ 18 years undergoing elective coronary angiogram for suspected stable coronary artery disease.

We excluded those with pre-existing coronary artery disease, those undergoing emergency or urgent coronary angiogram, those who were inpatients in CUH or another institution and those undergoing coronary angiogram as workup for other procedures such as valve surgery.

Data Collection

Data on demographics, risk factors, clinical presentation and prior non-invasive investigations i.e. exercise stress testing, echocardiogram or CT coronary angiography, were extracted from electronic demographic and clinical databases and in some cases from paper records by a single researcher (MH).

Medical care was defined as private if patients were covered by private health insurance. Medical care was defined as public if patients had a medical card which is a means-tested public health insurance scheme, or, had no health insurance.

Height and weight measurements were recorded by nursing staff and used to calculate body mass index (BMI). Obesity was defined as BMI ≥ 30.

Details of lipid profile results and smoking status were extracted from the clinical database.

Blood pressure was recorded and entered into the clinical database by nursing staff.

Symptoms were defined as chest pain/discomfort/tightness/dyspnoea/reduced exercise tolerance/shoulder pain/left arm pain/jaw pain and other symptoms potentially related to coronary artery disease.

Cardiovascular Risk

The 10 year risk of fatal cardiovascular disease was calculated using sex, age, blood pressure, total cholesterol and smoking status and the low risk SCORE risk chart as recommended for Ireland. If blood lipid values were missing the study population median for males and females was substituted. Individuals with SCORE <1% were defined as low risk. Those with SCORE ≥1% and <5% were defined as moderate risk. Individuals with SCORE ≥5% and <10% were defined as high risk and those with SCORE ≥10% were defined as very high risk. (6)

Appropriateness Scoring

Each patient was evaluated according to the scoring system outlined in the 2012 ACCF Appropriate Use Criteria. (3) Appropriateness was scored on a scale of 1 – 9 and categorized as: inappropriate (1-3), uncertain (4-6) or appropriate (7-9).

For those with non-invasive investigations scores were assigned based on investigation outcome and the presence or absence of symptoms as recommended by Patel et al. (3)

All exercise stress tests were performed according to the Bruce protocol. (7) Duke treadmill scores were calculated for all exercise stress tests [Duke treadmill score = duration of exercise in minutes — (5 × the maximal net ST-segment deviation during or after exercise, in millimeters) — (4 × the treadmill angina index)] (8). Exercise stress test results were categorised as low risk (Duke treadmill score >5), intermediate (Duke treadmill score -10 to 5) and high risk (Duke treadmill score < -10 and/or other high risk findings such as ST elevation, hypotension with exercise, ventricular tachycardia or prolonged ST depression). (3)

If subjects underwent 2 or more non-invasive investigations the higher AUC score was assigned.

For asymptomatic patients with no prior non-invasive investigations the SCORE risk was used to assign an appropriateness score; in the case of symptomatic patients with no prior non-invasive investigations pre-test probability was used to assign the score. (3)

Coronary Anatomy

Angiographic findings were extracted from the cardiologist's electronic report. Obstructive CAD was defined as ≥50% stenosis in any of the left main coronary artery (LMCA), the left anterior descending (LAD), the left circumflex artery (LCx) or the right coronary artery (RCA). Patients were categorised as having single vessel, two vessel or three vessel disease depending on the number of vessels involved. Those with <50% coronary stenosis in all vessels were defined as having non-obstructive coronary disease. Those with no luminal

irregularities were defined as having angiographically normal coronary arteries. Diagnostic yield was the rate of obstructive coronary disease in the sample.

Statistical Analysis

Analysis was performed using Stata version 13. Continuous variables were summarised as mean and standard deviation (mean ± SD). Categorical variables were summarised as counts and percentages.

Univariable and multivariable logistic regression was performed to investigate the factors that predict whether patients undergo appropriate coronary angiography. Risk scores were not included in the multivariable regression model due to multi-collinearity with other study variables.

Ethics

This study was approved by the Clinical Research Ethics Committee of the Cork Teaching Hospitals (CREC) and by the Quality and Risk Management Department of CUH.

Results

There were 417 elective, outpatient coronary angiograms performed between January 1st 2014 and December 31st 2014. Of these 259 fulfilled inclusion criteria. Figure 1.

The mean age of patients undergoing elective coronary angiography was 63 (+/-10) years. The majority, 253 (98%), were of caucasian ethnicity and 152 (59%) were male. Table 1 outlines the baseline characteristics of the study sample.

Most patients underwent non-invasive testing prior to coronary angiography, 221 (85%) underwent exercise stress testing and 98 (38%) had an echocardiogram. Just 1 (0.4%) patient underwent CT coronary angiogram prior to invasive coronary angiogram. These investigations were used to determine appropriateness score in 215 (83%) of the patients. In the remaining 44 (17%) patients appropriateness score was calculated based on their symptom status and either their pre-test probability of CAD (38(15%)) or their SCORE risk (6 (2%)). Table 2.

Of the 259 patients included in this study, 108 (42%) were classified as appropriate, 97 (37%) as uncertain and 54 (21%) as inappropriate.

Table 3 shows the results of the univariable and multivariable logistic regression models of the association between selected variables and appropriateness.

In univariable analysis those more likely to have an appropriate indication for coronary angiography were over 65 years of age (OR 1.8, 95% CI 1.1 – 2.9), those with private health insurance (OR 2.5, 95% CI 1.5 – 4.2), those with atrial fibrillation (OR 5.9, 95% CI 1.9 – 18.4) and those with symptoms (OR 1.7, 95% CI 1.0 – 2.8). Subjects less likely to have an

appropriate indication were those with obesity (OR 0.5, 95% CI 0.3 – 0.9) and current or ex-smokers (OR 0.5, 95% CI 0.3 – 0.8).

In adjusted models the findings for health insurance, atrial fibrillation and current or ex-smokers persisted. Those with private health insurance were more likely to have an appropriate indication for coronary angiogram (OR 2.1, 95% CI 1.2 – 3.7) as were those with atrial fibrillation (OR 3.9, 95% CI 1.2 – 12.8). Ever smokers were less likely to have an appropriate indication for coronary angiogram than never smokers (OR 0.5, 95% CI 0.3 – 0.9). The final model was adjusted for age, gender, medical care, BMI, smoking status, hypertension, hyperlipidemia, diabetes mellitus, atrial fibrillation and symptoms.

The overall diagnostic yield in this sample undergoing elective coronary angiography for suspected stable CAD was 26%. The diagnostic yield by appropriateness category is presented in table 4. Those classified as appropriate indication for coronary angiogram had higher diagnostic yield at 34%, compared to 22% in those of uncertain indication and 19% of those classified as inappropriate.

Discussion

This study reports on the appropriate use of elective, outpatient coronary angiography in patients who underwent the procedure for investigation of suspected stable CAD in a single large tertiary referral centre between January 1st 2014 and December 31st 2014. This is the first detailed report on the appropriate use of invasive coronary angiography in non-urgent practice in the Irish state. In total, 42% of procedures were classified as appropriate, 37% were classified as uncertain and 21% were classified as inappropriate. The diagnostic yield of coronary angiography in this sample was 26%. Coronary angiograms that were classified as appropriate had better diagnostic yield (34%).

The proportions of coronary angiograms classified as appropriate, uncertain and inappropriate are similar to those of other studies. Hannan et al looked at 8986 patients undergoing diagnostic catheterisation for suspected CAD in New York state in the USA and found 35.3% were rated as appropriate, 39.8% as uncertain, and 24.9% as inappropriate.(2) Mohareb et al examined 48 336 patients in a registry of patients having elective angiography in Ontario, Canada and classified 58.2% as appropriate, 31% as uncertain and 10.8% as inappropriate. (9) They also reported that even in those with considered inappropriate indications, 30.9% had obstructive CAD and 18.9% underwent revascularization. Accepting that selection for coronary angiography should comply with agreed appropriateness criteria, there can be justifiable exceptions that such guidelines fail to characterise. This point was highlighted in the accompanying editorial by Doll and Patel who highlight that some variables such as extremes of age, comorbidities and patient preference are not represented in appropriate use criteria. (10) Indeed the authors of the AUC also acknowledge this point in their preface stating that AUC should not be substitutes

for clinical judgement and experience. (3) In our study smokers were less likely to undergo coronary angiogram deemed appropriate by AUC. This may reflect clinicians making decisions based on the excess risk that smoking confers irrespective of AUC.

Variation in the diagnostic yield of elective diagnostic coronary angiography in the CathPCI Registry in the USA has been reported with a range from 23% to 100% (median 45%). (11) The Swedish Coronary Angiography and Angioplasty Register (SCAAR) found significant CAD in 56% of 12,200 undergoing diagnostic coronary angiography. (12) Both of these studies used a stenosis of ≥50% to define obstructive CAD. The diagnostic yield of the present study is therefore low at 26%. In our study just a single patient underwent a CT coronary angiogram while a large majority underwent exercise stress testing prior to invasive coronary angiography. This reflects the limited availability of non-invasive techniques to assess coronary anatomy and stress imaging in the Irish healthcare system. The National Institute for Health and Care Excellence in the UK recommend invasive coronary angiography as a third-line investigation for patients with stable chest pain when the results of non-invasive functional imaging are inconclusive. (13) The European Society of Cardiology state that invasive coronary angiography is rarely needed in stable patients with suspected coronary artery disease to establish or exclude the diagnosis as non-invasive testing can do this. (14) Previous work by Jennings et al has demonstrated a higher proportion of percutaneous interventions are carried out for stable coronary artery disease in Ireland relative to the USA and UK. (15) This may be a consequence of the limited access to non-invasive investigations. Policy makers and healthcare managers need to take action on the infrastructure and resources in the Irish healthcare system to bring it into line with international best practice.

The Irish healthcare system has a complex funding system with public and private sources. The OECD describes Ireland as a duplicate system whereby private health insurance covers services already covered by government funding while also offering access to private providers. (16) Perhaps surprisingly those with private health insurance were more likely to have an appropriate indication for coronary angiogram in this study. This may just be a chance finding. It may reflect earlier access to a senior decision maker as these patients are more likely to have seen a consultant in the outpatient setting. Another possibility is that those with a medical card and free access to healthcare may have increased interaction with the healthcare system which may result in more referrals and investigations. Indeed in 2004 Layte et al looked at the utilisation of healthcare in Ireland and found that those in the lowest quintile of disposable income had greater utilisation of GP visits, hospital inpatient and outpatient visits and filled more prescriptions than those in any of the other quintiles. (17) This may of course be justified as these patients are likely those at highest risk of adverse health outcomes.

Limitations

This is a single centre retrospective observational study. Therefore the limited generalisability of the study and indeed the potential for information bias must be considered when interpreting the results.

Much of the data was extracted from demographic and clinical databases. In addition some of the clinical data was recorded by clinical staff at the time of coronary angiography. The accuracy and reliability of such data may be an issue. One study looked at 607 randomly selected patients in 219 US hospitals found significant deficiencies in recording of clinical details in those presenting with acute coronary syndromes. (18)

Therefore we cannot exclude the possibility of misclassification of AUC scores. Misclassification may have occurred due to inconsistent reporting of variables required to assign AUC scores. This is relevant regarding symptoms in particular. Symptoms were recorded for just 106 (41%) of patients. The primary source of chest pain data was exercise stress test reports. Medical records were also checked for descriptions of the patients' symptoms. Information bias is possible where chest pain was reported inconsistently or without using standardised definitions such as the Canadian Cardiovascular Society grading of angina pectoris.

It is possible that patients with private health insurance may have had non-invasive investigations with private providers which would not have been available for review for the study. Furthermore it wasn't possible to differentiate between those who had a medical card and those who had no health insurance. These patients were both classified in the public medical care category. Those with a medical card are entitled to free access to primary care services while those without a medical card have to pay for GP and other primary care services therefore there is likely to be significant differences between these groups.

Total cholesterol levels were missing for 28 (11%) of patients. Again this may reflect patients having had their blood sample analysed at another institution which would not be available for review and inclusion in the study. This may have affected the estimation of cardiac risk.

Those included in this study underwent elective coronary angiography for the investigation of suspected stable CAD with no previous angiographic findings of obstructive CAD, MI, PCI, CABG or valve disease. Our final sample size was 259 patients. This relatively small sample

size may have provided inadequate statistical power to detect associations in the statistical models.

Conclusion

This is the first study to evaluate the appropriate use of elective coronary angiography in patients with suspected stable CAD in Ireland using the 2012 ACCF Criteria. Overall rates were similar to that of studies in other jurisdictions. However the study highlights a number of issues within the Irish healthcare system. Firstly it demonstrates how the duplicate funding system in place may contribute to differences in how patients are investigated. It highlights the limited availability and use of non-invasive cardiac imaging. Finally it underlines the need for high quality data in order to monitor and plan services. This is turn will improve quality of care and patient outcomes which should be the goal of every healthcare system.

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Compliance with Ethical Standards

Conflicts of Interest

Dr. O'Flynn reports conference attendance and subsistence support from Pfizer pharmaceutical company and speaking honoraria from Menarini and Daiichi Sankyo pharmaceutical companies.

No other conflicts of interest are reported.

Research Involving Human Participants

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent

This was a retrospective audit and for this type of study formal consent is not required.

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