Emergency Medicine: Open Access
ISSN: 2165-7548
Sandler et al., Emerg Med (Los Angel) 2015, 5:6
DOI: 10.4172/2165-7548.1000283
Research Article
Open Access

Incidence and Management of Mild Coronary Atherosclerotic Disease Diagnosed with Coronary CTA in the Emergency Department

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Received date: August 24, 2015; **Accepted date:** October 05, 2015; **Published date:** October 12, 2015

Abstract

Introduction: Coronary computed tomography angiography (CTA) is an excellent tool for the evaluation of chest pain in patients with a low likelihood of having acute coronary syndrome. Patients with mild coronary disease are easily identified with coronary CTA in contrast to imaging studies that detect only hemodynamically significant stenosis. This study was designed to evaluate 1) the incidence mild coronary artery disease diagnosed by CTA and 2) the challenge of managing these patients in the emergency department setting.

Methods: A retrospective review was performed of coronary CTA examinations requested by ED physicians over three years. Imaging results were stratified as being negative, representing mild disease, and representing moderate to severe disease. Patients with mild disease were further evaluated to determine if the patient 1) had known CAD prior to the CTA, 2) was on or was prescribed a statin, 3) had a positive family history, 4) had a smoking history, 5) was diabetic, and 6) was scheduled for follow-up with Cardiology following discharge from the ED.

Results: A total of 140 coronary CTA examinations were performed on patients in the Emergency Department over a three-year period, with 137 meeting inclusion criteria. Of these, 109 studies were negative for coronary artery disease, 8 had significant CAD with greater than 50% luminal narrowing, and 20 demonstrated mild CAD without significant stenosis (age range 41-65 years with mean age of 50.2).

Conclusion: Coronary CT angiography is highly accurate for the detection of coronary artery disease and has proven to be an excellent tool for the evaluation of patients with chest pain and a low pre-test probability of having acute coronary syndrome. Patients diagnosed with mild disease present a challenge to emergency department physicians as they do not require immediate intervention, but can benefit greatly from therapies designed to prevent future coronary events.

Keywords: Coronary CTA; Atherosclerotic disease; Acute coronary syndrome; Statin therapy; Emergency medicine

Introduction

Chest pain is the second most common presenting complaint to Emergency Departments (EDs) in the US, accounting for over 7 million visits annually [1]. Coronary computed tomography angiography (CTA) is an excellent tool for the evaluation of patients with acute chest pain, providing both decreased cost and length of stay when compared to standard evaluation strategies [2,3]. Specifically, coronary CTA allows for accurate identification of significant coronary artery stenosis and atherosclerotic plaque. Among patients with no evidence of atherosclerotic plaque, normal imaging provides a negative predictive value of 99% for coronary artery disease [4]. This imaging modality also allows for the diagnosis of mild to moderate coronary disease that may not account for a patient's presenting symptoms but that may represent significant morbidity and mortality in future [5]. Identification of these intermediate risk patients presents a new challenge to ED physicians. Evidence of coronary atherosclerotic disease without significant stenosis may be a potential opportunity for initiating risk reduction in this population, among whom immediate cardiac catheterization and/or stenting is not clearly indicated.

Patients who present to the ED with chest pain and possible acute coronary syndrome are routinely assessed with EKG and biochemical markers, such as troponin. If troponins are within normal limits and the EKG is not consistent with ischemia, patients may be placed in observation units to continue cardiac evaluation, including functional testing [6]. Recent studies have proven that in targeted patient populations, rapid assessment with coronary CTA in patients with normal EKG and laboratory studies allows for significant cost savings and faster discharge from the ED without sacrificing diagnostic accuracy [7,8].

The ability of CTA to detect significant coronary artery disease (CAD) has been proven in multi-center trials. As early as 2005, an article published in JAMA demonstrated sensitivity, specificity, positive and negative predictive values of multi-slice CT of 95%, 98%, 87% and 99% respectively [9]. Patients with normal coronary arteries by CTA have been found to have extremely low risk of adverse coronary events in the near future [7,10]. The rate of such events in patients with low- to intermediate-probability of CAD based on clinical history with a normal coronary CTA remains low for the next five years [11], therefore allowing for more expeditious evaluation of patients in future if they return with similar complaints. What has not been evaluated, however, is how to manage patients with coronary

atherosclerotic disease without significant stenosis that does not clearly warrant immediate evaluation with catheterization.

Of those with CAD diagnosed by CTA, patients with evidence of coronary atherosclerotic disease without significant stenosis (defined as less than 50% luminal narrowing on CTA) have a significantly lower overall mortality than those with moderate-to-severe disease, defined as greater than 50% luminal narrowing [12]. Additionally, the progression of coronary atherosclerosis can be reduced substantially with intensive statin therapy [13-15]. This study was conducted to more fully understand 1) the proportion of patients identified by CTA as having evidence of coronary atherosclerotic disease without significant stenosis at our institution over a 3-year time frame, and 2) describe the clinical management of these patients, with a focus on whether there was evidence that statin therapy was initiated.

Methods

Patients and diagnostic algorithm

This study was performed in accordance with the Health Insurance Portability and Accountability Act and was approved by our Institutional Review Board. The informed consent requirement was waived for this retrospective review of consecutive patients who underwent coronary CTA after presenting to our ED with chest pain and possible acute coronary syndrome.

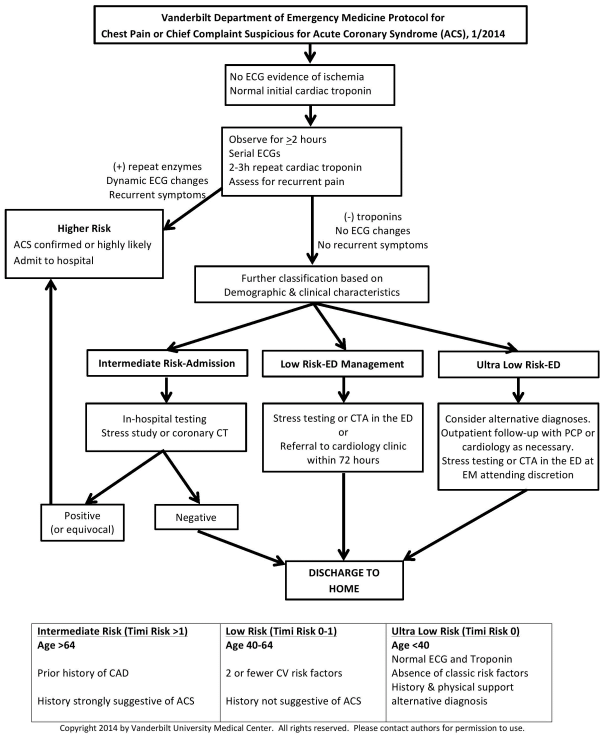

Figure 1: Patient selection and workup algorithm for patients presenting to the Emergency Department with chest pain.

A retrospective review was performed of coronary CTA examinations requested by ED physicians at Vanderbilt University Medical Center Adult ED (Nashville, TN, USA) from September of 2011 to September of 2014. All patients included in the study presented with chest pain and had troponin results within normal limits and no evidence of myocardial ischemia on EKG. For a portion of this study, an attending Cardiologist was available from 8 am to 5 pm, five days a week to guide chest pain evaluation; patients who presented outside these hours were kept overnight in the ED's Chest Pain Unit, to be evaluated in the morning by the attending Cardiologist. The ED selection algorithm for performance of CTA in patients with chest pain is provided in Figure 1.

CTA examinations were performed on one of four 64-slice CT scanners. The reports of the CTA examinations were analyzed and patients were divided into the following three categories: 1) no evidence of CAD, 2) evidence of coronary atherosclerotic disease by CTA without significant stenosis (defined as superficial plaque and/or less than 50% luminal narrowing), and 3) moderate-to-severe CAD resulting in greater than 50% luminal narrowing. The medical records of patients with evidence of coronary atherosclerotic disease with superficial plaque and/or less than 50% luminal narrowing were further reviewed to determine whether there was evidence in the electronic record that the patient 1) had known CAD prior to the CTA, 2) was on a statin prior to and/or after undergoing the CTA, 3) had family history of CAD, 4) had evidence of tobacco use, 5) was diagnosed with diabetes, and 6) was recommended to follow-up with Cardiology on an outpatient basis at time of discharge from the ED.

CT technique

Coronary CT angiograms were performed at our institution on one of four 64-slice CT scanners (Phillips BRILLANCE 2005, Philips BRILLANCE 2008, and Philips BRILLIANCE iCT 2008 (The Netherlands), and General Electric hybrid Ventri-VCT SPECT/CT (General Electric Medical Systems, Milwaukee, WI, USA). Patients were scanned following a single contrast injection of 90 milliliters Omnipaque 350 (iohexol, GE Healthcare, Ireland) delivered as a contrast bolus in an upper extremity (typically antecubital) vein. All studies were performed with cardiac gating. When possible, studies were performed with prospective gating, which reduces radiation by greater than 80% compared to retrospective gating [16].

Optimal conditions for the performance of cardiac CTA include a steady heart rate at or below 60 beats per minute and a weight of less than 100 kg [17]. Diagnostic studies can be obtained without significant motion artifact with heart rates of up to 80 beats per minute, though a higher heart rate often limits the ability to employ dose-reduction techniques [18]. If a patient's heart rate was poorly controlled and/or exceeded 70 beats per minute, or if a patient's body mass index (BMI) exceeded 30 kg/m^2, studies were exclusively performed with retrospective gating to ensure optimal imaging acquisition.

Patients were routinely administered oral beta blockers (typically 50 mg of metoprolol) before arriving at the CT scanner, and then received intravenous beta blockade as determined by the radiologist to further control heart rate (administered as a 5 mg IV metoprolol bolus every 5-10 minutes as tolerated). Medication administration was determined on an individual basis and done so only when the blood pressure allowed for such intervention. Heart rate was considered to be optimized if regular and less than 65 beats per minute. Patients whose

heart rate could not be controlled (e.g. those in atrial fibrillation) or exceeded weight limitations for the scanners did not undergo CTA.

Chart review

Two physicians reviewed the medical records for all patients with coronary atherosclerotic disease without significant stenosis. Where there was disagreement on coding, the chart was reviewed by a third physician. Agreement was achieved in all cases; therefore a kappa statistic was not computed.

Charts were reviewed to determine whether there was evidence in the electronic health record that patients had known prior CAD, diabetes, or tobacco use, an existing prescription for a statin, or family history of CAD. Disposition from the ED (admitted to the hospital, seen in the chest pain unit by a cardiology attending, or discharged from the ED without cardiology consultation), follow up recommendations (with primary care provider vs. with a cardiologist), and evidence of discussion of risk reduction was also recorded.

Results

A total of 140 coronary CTA examinations were performed on patients in the Adult ED over the three-year period. Three patients were excluded either because the Cardiology service (rather than the ED) requested the examination, or the patient had undergone an additional diagnostic study prior to undergoing CTA. Of the remaining 137 patients, 109 examinations found no evidence for CAD, 8 had significant CAD defined as greater than 50% luminal narrowing, and 20 demonstrated evidence of coronary atherosclerotic disease without significant stenosis by CTA, defined as superficial plaque and/or less than 50% luminal narrowing. The electronic health records of these 20 patients were reviewed in detail. Patient characteristics, including coronary vessels involved and the percent stenosis of the 20 patients with mild to moderate CAD are outlined in Table 1. Average age for these 20 patients ranged from 41-65 years, with mean of 50.0, (standard deviation 6.2 years). Fourteen of the 20 patients demonstrated disease in only one coronary vessel, and 18 had only superficial atherosclerotic calcification without quantifiable stenosis. Of these 20 patients, 16 presented while the EDs Chest Pain Unit was available and 4 presented after the Chest Pain Unit was no longer operational.

Patient	Age (years)	Sex	Vessels Involved	Superficial plaque and/or greatest degree of stenosis
1	51	Male	LAD	superficial plaque in LAD with <20% stenosis
2	52	Female	Left main	superficial plaque with luminal narrowing of 35-40%
3	43	Male	LAD	superficial plaque without significant stenosis
4	41	Male	LAD and Circ	superficial plaque without significant stenosis
5	45	Male	Left main and LAD	superficial plaque without significant stenosis
6	58	Female	LAD	superficial plaque without significant stenosis
7	48	Male	LAD	superficial plaque without significant stenosis
8	65	Male	RCA and LAD	superficial plaque without significant stenosis
9	60	Female	RCA, Circ, LAD	superficial plaque without significant stenosis
10	44	Male	LAD	superficial plaque without significant stenosis
11	46	Male	LAD	superficial plaque without significant stenosis
12	48	Male	LAD	superficial plaque without significant stenosis
13	47	Male	LAD	superficial plaque without significant stenosis
14	48	Male	LAD and Circ	superficial plaque without significant stenosis
15	41	Female	LAD	superficial plaque without significant stenosis
16	55	Male	LAD and RCA	superficial plaque without significant stenosis
17	45	Male	LAD	superficial plaque without significant stenosis
18	61	Male	RCA	superficial plaque without significant stenosis
19	49	Female	LAD	superficial plaque without significant stenosis
20	53	Male	LAD	superficial plaque without significant stenosis

RCA – right coronary artery

LAD- left anterior descending artery

Circ- circumflex artery

Table 1: Classification of mild to moderate coronary disease in ED patients with CTA.

Known Coronary Artery Disease Prior to CTA	0% (0)
Family History of Coronary Artery Disease	50% (10)
History of Tobacco Use	55% (11)
History of Diabetes	0% (0)
Previously on Statin	10% (2)
Started on Statin After Coronary CTA	40% (8)
Follow-up with Cardiology Recommended as an Outpatient*	30% (6)

*All patients who received recommendation for follow-up with Cardiology following CTA were also started on a statin.

Table 2: Risk Factors and Management of Patients with Mild Coronary Artery Disease Diagnosed by Coronary CTA while in the Emergency Department.

Of the 20 patients, two were admitted to the Cardiology service, 12 were evaluated by an attending Cardiologist in the ED's Chest Pain Unit and then discharged, and the remaining 6 were managed solely by

ED physicians. Risk factors and management of patients with superficial plaque and/or less than 50% luminal narrowing on CTA are provided in Table 2. Most notably, none had a prior known diagnosis of CAD. There was evidence in the electronic health record of a prescription for a statin prior to the CTA in two patients, and 8 patients were prescribed a statin, all after evaluation by an attending Cardiologist. Among a minority (30%) of patients, there was documentation of recommendation for follow-up with Cardiology on an outpatient basis. Follow up with a primary care provider was recommended for all patients.

Discussion

Chest pain is a common presenting complaint in ED's nationwide. The need to exclude acute coronary syndrome results in a large number of low risk patients undergoing extensive evaluation requiring prolonged evaluations, often with false-positive results that incur increasing cost and unnecessary invasive procedures [19]. Coronary CTA allows for rapid evaluation of patients with low to intermediate risk of having coronary disease and, when without evidence of any atherosclerosis, is associated with a low rate of major adverse coronary event in the subsequent five years, with a negative predictive value of 99% (Figure 2) [4,11].

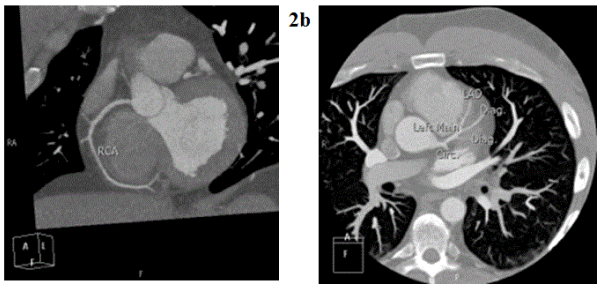

Figure 2: Coronary CTA demonstrating normal, widely patent coronary vessels in the right (A) and left (B) system.

Coronary CTA is highly accurate for the detection of CAD [9,20] and has proven to be an excellent tool for the evaluation of patients with chest pain who have a low pre-test probability of having acute coronary syndrome [21]. The limitations of coronary CTA have routinely included an inability to scan patients with rapid or irregular heart rates and increased exposure to radiation compared to other imaging modalities. Improvements in CT scanner technology are soon to make these much less problematic. Earlier studies have routinely excluded patients with heart rates exceeding 60 beats per minute, while newer machines allow for low dose (high pitch) imaging in patients with heart rates up to 70 beats per minute [22]. Some centers have reported routine radiation exposure at or below 1 mSv with optimal patient selection, which represents approximately 10% of the effective dose of a rest-stress cardiac imaging study [17,23].

While patients with normal CTA examinations can be confidently discharged from the ED and those with a clinically significant stenosis are treated either with coronary catheterization or surgery (Figure 3), there is not yet a clear consensus on management of patients for whom there is evidence of coronary atherosclerotic disease without significant stenosis by CTA. This 3-year observational study conducted using electronic health records was designed to evaluate how many patients evaluated with coronary CTA had evidence of coronary atherosclerotic disease without significant stenosis, defined as superficial plaque and/or less than 50% luminal narrowing. Furthermore, we explored how patients were managed. As expected, the vast majority of patients had normal CTA examinations (109 of 137 studies). Still, 14.6% of patients had evidence of coronary atherosclerotic disease without significant stenosis and therefore may benefit from cardiovascular risk reduction (Figure 4).

Appropriate utilization of coronary CTA in the ED begins with patient selection. This modality is best suited for patients who are at low risk for ACS. Selection criteria should include an EKG without ischemic changes and negative cardiac enzymes [24]. Therefore it should be expected that by design, low risk patients will continue to be evaluated with non-invasive cardiac imaging, including coronary CTA and nuclear medicine stress studies (single-photon emission computed tomography (SPECT) or positron emission tomography (PET)).

Patients evaluated with coronary CTA have better clinical outcomes as compared to those who undergo nuclear medicine cardiac stress testing [25]. This is not surprising given CTAs ability to detect subclinical stenosis and given that CTA is used only in low-risk patients; therefore, CTA can identify a subset of patients with evidence of coronary atherosclerotic disease without significant stenosis who do not require immediate catheterization. As mentioned above, 14.6% of patients evaluated with coronary CTA at our institution were found to have evidence of coronary atherosclerotic disease without significant stenosis. Further research is needed to explore the most appropriate next steps for these patients, including whether they should be referred to primary care vs. cardiology, and how best to address risk reduction, including blood pressure control, smoking cessation, and initiation of statin therapy, which is the focus of this exploratory study.

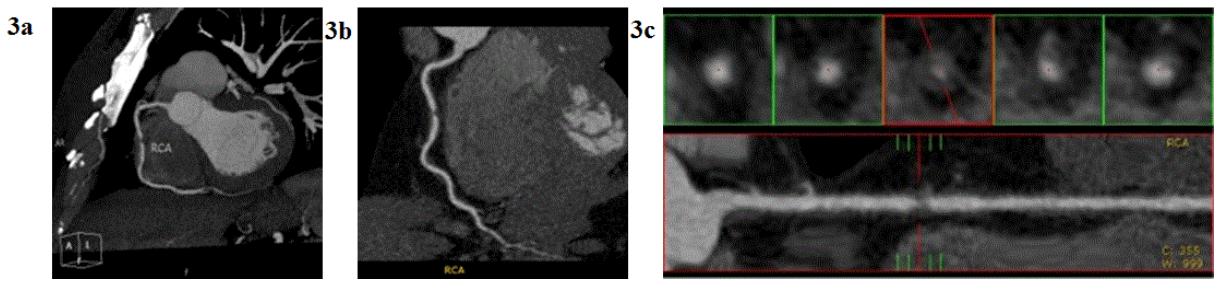

Figure 3: Soft plaque within the proximal RCA resulting in approximately 90% stenosis (A and B) with cross-sectional reformat demonstrating the stenosis (C).

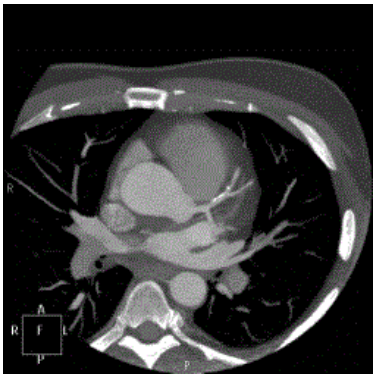

Figure 4: Superficial plaque along the LAD without significant stenosis.

Statins are the first-choice therapy for reducing cholesterol in patients with CAD [26]. Implementation of statin therapy results in significant reduction of coronary disease [14]. In our study, 2 of the 20 patients diagnosed with mild to moderate disease were previously on statin therapy according to electronic health records, 4 were prescribed fish oil, and 8 (40%) were prescribed statins after evaluation by an attending Cardiologist, either at hospital discharge or discharge from the ED's Chest Pain Unit. Further work is needed to evaluate the impact of close collaboration between the ED and Cardiologist in evaluation, treatment, and long-term care of patients with low risk chest pain who are found to have evidence of cardiovascular disease.

Limitations

Limitations of this study include its performance at a single academic medical center that may not reflect experiences at other EDs. This is an observational, exploratory study performed using electronic health records from consecutive ED patients over three years; there is no comparison group, and we cannot address trends over time, such as changes in access to performing CTA or changes in the protocol for evaluating chest pain in the ED. Also, we included information on follow-up that was gathered from the patients' electronic medical records at our institution alone; we do not have any information on patients who sought further medical care at other hospitals, nor were conversations that may have included this information available for review. Therefore, it is possible that risk reduction was discussed with patients but not included in the electronic health record. We do not have a record of the number of patients who were unable to undergo CTA due to atrial fibrillation, tachycardia, etc. Finally, we address plaque burden based on percent stenosis of a coronary vessel, we have not discussed the significance of multi-vessel disease or specific plaque morphology (e.g. vulnerable plaque).

Conclusion

The majority of ED patients with low risk chest pain in this study were found to have normal coronary arteries, which was not unexpected. An important number of patients (20/137, 14.6%), however, had evidence of coronary atherosclerotic disease without significant stenosis by CTA. Further research is needed to better understand the safest and most effective methods for CAD risk reduction in this important patient population.

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