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Review

Coronary computed tomography as a cost–effective test strategy for coronary artery disease assessment – A systematic review

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ABSTRACT

Cardiovascular imaging imparts a huge burden on healthcare spending. Coronary CT angiography (CCTA) may provide a cost effective means of diagnosing coronary artery disease (CAD) and reducing downstream cost of testing. We performed a systematic search of literature for randomized controlled trials or prospective or retrospective non-randomized comparative studies or case series, decision analytic models and technology reports in which some or all of the patients underwent CCTA and looking at the cost effectiveness, comparative effectiveness and downstream test utilization associated with the use of CCTA. We found 42 articles matching our criteria. CCTA either as first line or as a layering test may represent a cost effective strategy for initial evaluation of patients with CAD prevalence of 10%–50% in both near-term and long-term diagnostic periods. For CAD prevalence ≥70%, ICA as initial test may represent cost effective strategy for diagnosis of stable chest pain. CCTA may represent cost-effective strategy when performed as a layering test to equivocal initial stress imaging before performing ICA. Use of CCTA is cost- and time-effective strategy for evaluation of low risk (<30% CAD prevalence) acute chest pain patients in emergency department and can be used for safe exclusion of acute coronary syndrome (ACS). Use of coronary calcium score as an initial test may require further evidence to be deemed cost-effective strategy. CCTA may represent a cost effective and may be associated with less downstream testing for diagnosis of stable chest pain patients in low to intermediate risk patients whereas for low risk acute chest pain patients, use of CCTA is associated with expedited patient management, less cost and safe exclusion of ACS.

Contents

Abbreviations: ACS, acute coronary syndrome; CCTA, coronary computed tomography angiography; CAC, coronary artery calcium; CAD, coronary artery disease; ECHO, stress echocardiogram; ETT, exercise ECG treadmill; QALY, quality adjusted life years; ICA, invasive coronary angiography; MPI, myocardial perfusion imaging; SPECT, single-photon emission computed tomography.

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1. Introduction

Current estimates of US healthcare spending are at approximately 16% of gross domestic product (GDP), amounting approximately 2 trillion US dollar each year [1,2]. Cardiovascular disease healthcare cost is among the largest contributors of this spending, with an estimate of 475 billion US dollars spent in year 2009 alone [3]. The cost of cardiovascular imaging exceeds 100 billion US dollar each year in the US [4] and represents 29% of all the imaging workload [5]. The cause of this huge spending may be the lack of cost effective strategies for cardiovascular imaging. There are number of non-invasive and invasive imaging techniques available for the diagnosis of cardiovascular disease including invasive coronary angiography (ICA), single-photon emission computed tomography (SPECT) myocardial perfusion imaging (MPI), exercise ECG treadmill test (ETT), stress echocardiography (ECHO) and coronary computed tomography angiography (CCTA). What would be the optimum and cost effective way of utilizing these imaging modalities is still yet to be determined.

ICA plays a central role in the management of patients with coronary artery disease (CAD) and is currently the gold standard for confirming the presence of atheromatous coronary obstruction. Diagnostic ICA is associated with severe adverse events in 0.7%–1.5% of patients and associated death in 0.07% of patients [6,7] which may be unacceptable high especially in young and low risk individuals. Apart from high cost and radiation exposure, a large number of diagnostic ICAs result in normal or non-obstructive coronary arteries [8], perhaps due to poor selection of patients undergoing diagnostic ICA. Patel et al. [8] showed that only one third of patients undergoing diagnostic ICA had obstructive CAD in a registry of 398,978 patients without prior known CAD. This study also showed that patients with a positive result on a noninvasive test were moderately more likely to have obstructive CAD than those who did not undergo any testing (41.0% vs. 35.0%; $P < 0.001$; adjusted odds ratio, 1.28; 95% CI, 1.19–1.37). This fact highlights the need for judicious use of noninvasive testing in an attempt to reduce the number of unwanted costly diagnostic procedures such as ICA. CCTA is rapidly growing cardiac imaging technology gaining attention in the cardiology community due to its high diagnostic accuracy in the evaluation of atherosclerotic coronary artery disease compared to ICA (Table 1) [9–17]. However, there is concern that the use of CCTA will lead to unnecessary diagnostic testing, resulting in an increase in downstream test utilization and the overall cost of treatment. The current review article will assess the role of CCTA as a gatekeeper for diagnostic ICA and whether it will be a cost-effective strategy and reduce downstream test utilization.

We searched the literature electronically to identify published and unpublished articles (and abstracts from recent conference proceedings) from 2000 and onwards using MEDLINE, PUBMED, EMBASE, Google, abstracts from recent conference proceedings and the Cochrane Library (2000–2012), supplemented by relevant articles. We considered randomized controlled trials (RCTs), prospective or retrospective non-randomized comparative studies, decision analytic models, technology reports or case series in which some or all of the patients underwent CCTA. We selected the articles if they mentioned about the cost effectiveness, comparative effectiveness and downstream test utilization associated with the use of CCTA. We found 42 articles that met our criteria for inclusion. We evaluated the cost effectiveness of CCTA and subsequent downstream test utilization in stable chest pain patients (20 articles); and patients with acute chest pain presenting to the emergency department (ED) (18 articles). There were fewer articles that evaluated the cost effectiveness of CAC as an index initial test (4 articles).

2. CCTA as a gatekeeper for elective ICA

There are number of cardiac studies that can be used for CAD assessment such as ETT, ECHO, SPECT MPI, CCTA and ICA. All these tests can be used as an initial index for CAD assessment. A number of studies have looked at the cost effectiveness and downstream test utilization with CCTA as the index test for CAD assessment of patients (Table 2). Min et al. [18] reported a retrospective cohort study of category III tracking codes to assess the cost relating the clinical and economic outcome of CCTA (1938 patients) in the diagnosis of CAD compared with MPI (matched 7752 patients). They showed that adjusted total healthcare and CAD expenditures were 27% ($p < 0.001$) and 33% ($p < 0.001$) lower, respectively, for patients who underwent CCTA compared with patients who underwent MPI. There was no differences observed for rates of adverse cardiovascular events, including CAD hospitalizations (4.2% vs. 4.1%, p = NS), CAD outpatient visits (17.4% vs. 13.3%, p = NS), myocardial infarction (0.4% vs. 0.6%, p = NS), and new-onset angina (3.0% vs. 3.5%, p = NS) for patients who underwent CCTA and MPI respectively. Min et al. [19] in another retrospective observational study compared 1 year CAD costs (additional diagnostic coronary testing, CAD hospitalization and coronary procedural and revascularization costs) and clinical outcomes in individuals without known CAD who underwent CCTA (1647 patients) and matched patients who underwent MPI (6588 patients). Individuals who underwent CCTA incurred lowered healthcare costs (25.9% lower cost; average cost per patient $1075; 95% confidence interval: $243, $2570), more likely to undergo downstream testing with MPI (odds ratio, 6.65; 95% confidence interval: 5.05, 8.75; $p < 0.001$) less likely to undergo coronary revascularization (hazard ratio, 0.76; 95% CI: 0.75, 0.77; $p < 0.001$), with no significant difference between CCTA and MPI groups for rates of myocardial infarctions or CAD hospitalization, while the rates of angina were significantly lower in the CCTA group (4.3% vs. 6.4%, $p < 0.001$). The population in both of the above studies were relatively young (mean age 51 years). Shreibati et al. [20] performed a retrospective, observational cohort study using claims data from a 20% random sample of 2005–2008 Medicare fee-for-service beneficiaries 66 years or older with no claims for CAD in the preceding year, who received non-emergent, noninvasive testing for CAD ($n = 282,830$) and compared utilization and spending associated with functional (stress testing) and anatomical (CCTA) noninvasive cardiac testing. Compared with stress MPI, CCTA was associated with an increased likelihood of subsequent cardiac catheterization (22.9% vs. 12.1%; $P < 0.001$), percutaneous coronary intervention (7.8% vs. 3.4%; $P < 0.001$), and coronary artery bypass graft surgery (3.7% vs. 1.3%; $P < 0.001$). CCTA was also associated with higher total healthcare spending ($4200 [$3193–$5267]; $P < 0.001$). However, the authors note that the patients undergoing CCTA had higher prior year spending (in the one year prior to the index study), so this may represent physician practice more than the influence of the test itself. At 180 days, CCTA was associated with a similar likelihood of all-cause mortality