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Cost-Effectiveness of Coronary Computed Tomography and Cardiac Stress Imaging in the Emergency Department

A Decision Analytic Model Comparing Diagnostic Strategies for Chest Pain in Patients at Low Risk of Acute Coronary Syndromes

Virginia L. Priest, BS,* Paul A. Scuffham, PhD,* Rory Hachamovitch, MS, MD,‡
Thomas H. Marwick, MD, PhD†‡

Brisbane, Queensland, Australia; and Cleveland, Ohio

Emergency department presentations with chest pain are expensive and often unrelated to coronary artery disease (CAD). Coronary computed tomographic angiography (CTA) may allow earlier discharge of low-risk patients, resulting in cost savings. We modeled clinical and economic outcomes of diagnostic strategies in patients with chest pain and at low risk of CAD: exercise electrocardiography (ECG), stress single-photon emission computed tomography (SPECT), stress echocardiography, and a CTA strategy comprising an initial CTA scan with confirmatory SPECT for indeterminate results. Our results suggest that a 2-step diagnostic strategy of CTA with SPECT for intermediate scans is likely to be less costly and more effective for the diagnosis of a patient group at low risk of CAD and a prevalence of 2% to 30%. The CTA strategies were cost saving (lower costs, higher quality-adjusted life-years) compared with stress ECG, echocardiography, and SPECT. Confirming intermediate/indeterminate CTA scans with SPECT results in cost savings and quality-adjusted life-year gains due to reduced hospitalization of patients who returned false-positive initial CTA test. However, CTA may be associated with a higher event rate in negative patients than SPECT, and the diagnostic and prognostic information for the use of CTA in the emergency department is evolving. Large comparative, randomized, controlled trials of the different diagnostic strategies are needed to compare the long-term costs and consequences of each strategy in a population of defined low-risk patients in the emergency department.

Annually, more than 6 million patients in the United States present to emergency departments (EDs) with chest pain (1). Conservative diagnostic strategies lead to high admission rates (>70%), with many lacking a discharge diagnosis of acute coronary syndrome (ACS) (2). Admission costs are augmented by increasing volumes of imaging tests, and the costs to adopt new technologies. Despite the conservative approach, a small proportion of patients (0.4% to 4%) with ACS are misdiagnosed and discharged without appropriate intervention with double the risk-adjusted mortality of admitted patients (3). Failure to diagnose ischemia as the cause of chest pain is the leading cause of malpractice suits against ED physicians in the United States (4). The adoption of dedicated chest pain centers and chest pain evaluation proto-

cols in the ED may extend the group to include patients with lower probabilities of chest pain.

Patients presenting with chest pain suggestive of ischemia but with no history of coronary artery disease (CAD) and no enzyme or electrocardiographic abnormalities are generally at low risk but can include individuals with CAD. Of several technologies available for the diagnostic workup of these patients, provocative testing such as exercise electrocardiography (ECG), exercise or pharmacological echocardiography (echo), and single-photon emission computed tomography (SPECT) provide functional information about infarction and inducible ischemia, and the strong evidence base for these tests in the prediction of outcomes supports their use in risk stratification (5,6). However, all these strategies require a period of observation before stress testing is safe, and the healthcare costs associated with these protocols for acute chest pain evaluation have been estimated to be between US$10 and US$12 billion per year in the United States (1). Because coronary computed tomographic angiography (CTA) does not need cardiac stress testing, it has the advantage of avoiding this observation period. Although the negative predictive value of a normal scan is reported to be high, the predictive value of a positive test result is variable and low in the presence of a low prevalence of CAD. Therefore, patients with lesions of intermediate severity may require further investigations to identify the true positive patients (7). We sought to identify the relative cost-effectiveness of diagnostic imaging strategies in a low-risk patient population presenting to the ED with chest pain.

Methods

A decision analytic model using standard software (TreeAge Pro, Williamstown, Massachusetts) was developed to estimate and compare the cost and health outcomes of strategies used to identify patients with chest pain who, on presentation to the ED, are assessed as having a low risk of CAD (after exclusion of patients with proven ACS on the basis of electrocardiographic changes). Diagnostic strategies compared were exercise ECG, exercise and pharmacological stress echo, and SPECT, a CTA-only strategy and CTA with confirmatory exercise SPECT for intermediate or indeterminate scans (CTA with SPECT) (Fig. 1). Cost and health outcomes (including death and infarction) relating to CAD and its correct diagnosis were assessed at 12 months to capture the immediate consequences of diagnosis and because published evidence of patient outcomes is available at this time point to inform the model.

Disease progression. ACCURACY OF THE TESTS. Sensitivities and specificities of the various tests were obtained from key studies in the literature (Table 1). The diagnostic accuracy of exercise ECG was sourced from relevant guidelines, and those for stress echo
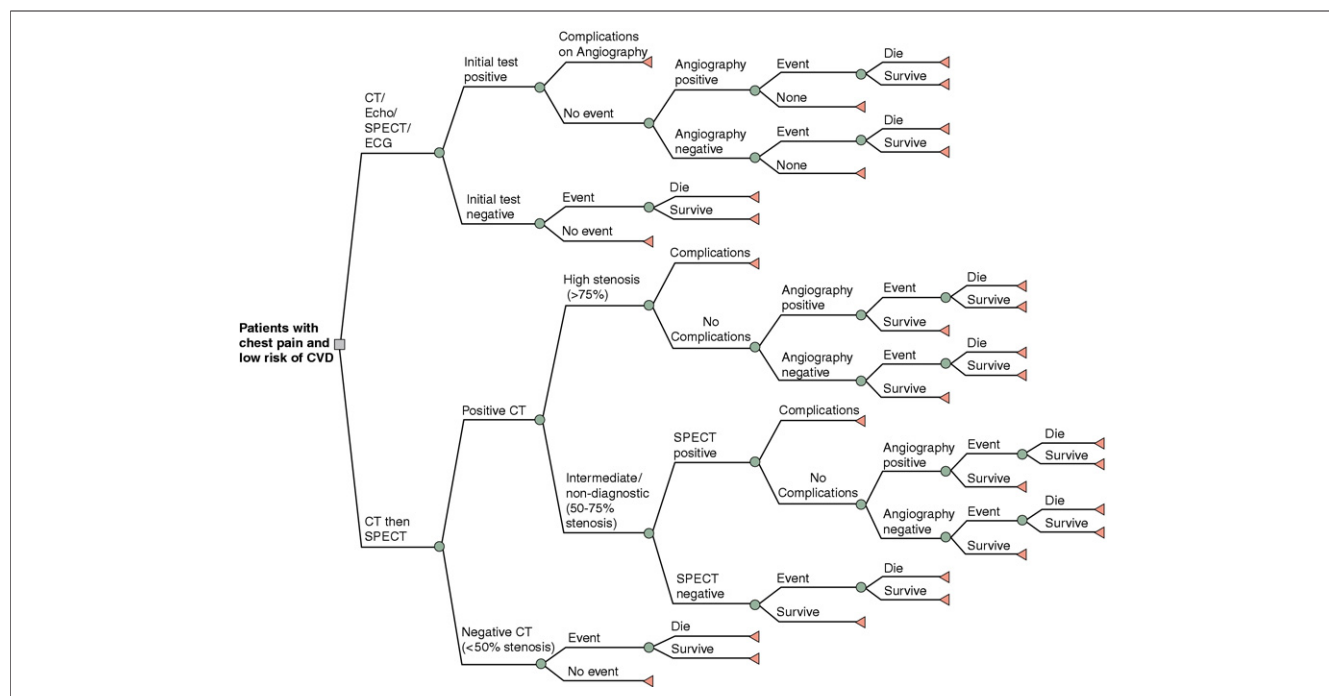

Figure 1. Schematic of the Decision Analytic Tree for 12-Month Disease Progression

Patients can be allocated to 1 of 5 pathways—CT followed by selective use of SPECT, or, CT, stress echo, SPECT or stress ECG (summarized in a single cloned node). CT = computed tomography; CVD = cardiovascular disease; ECG = electrocardiogram; SPECT = single-photon emission computed tomography.