Utility of Electron Beam Computed Tomography to Stratify Patients Presenting to the Emergency Room With Chest Pain

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Electron beam computed tomography (EBCT) is a sensitive, accurate, quantitative, and reproducible method with which to detect coronary artery calcium clinically.[1–4] Studies have shown that the absence of coronary artery calcium is strong evidence for the lack of significant underlying coronary stenosis.[5] More recently, the prognostic value of EBCT has been demonstrated in both symptomatic and asymptomatic patients.[6–8] This study evaluates the potential use of EBCT to stratify patients presenting to the emergency room with acute chest pain syndromes.

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One hundred eighty-one patients admitted to the University of Illinois Hospital from the emergency room between October 1, 1994, and April 30, 1995, form the basis of this study. Inclusion criteria were: (1) admission diagnosis of chest pain of presumed cardiac origin or rule-out myocardial infarction, (2) normal or nondiagnostic electrocardiogram, and (3) willingness and ability to sign a consent form. Exclusion criteria were: (1) prior diagnosis of coronary artery disease as determined by history of myocardial infarction, percutaneous revasculization procedure, or coronary artery bypass surgery; (2) diagnostic changes (ST-segment changes or Q waves) on admission electrocardiogram; (3) elevation of initial creatinine kinase-MB if obtained in the emergency room; (4) weight >250 pounds; and (5) known or suspected pregnancy. Patients evaluated and discharged directly from the emergency room were not included.

The chart of each patient was reviewed and if the patient was considered eligible, they were asked to participate in the study. After consent, an EBCT scan was performed within 7 days of hospital admission. Results of the scans were not made available to the treating physicians.

Serial serum creatinine kinase levels were determined every 8 hours for 24 hours. A standard 12-lead electrocardiogram was obtained on admission and again after 24 hours. Charts of the index hospitalization were reviewed for the following end points: (1) acute myocardial infarction (using World Health Organization criteria), (2) percutaneous revascularization procedure, (3) coronary artery bypass surgery, and (4) sudden cardiac death. Telephone contact was made with each patient 30 days from the hospital admission date. Inquiries regarding the patients' clinical status, emergency room visits, hospitalizations, and cardiac events after the index hospital admission were made. This protocol was approved by the institutional review board of the University of Illinois.

Electron beam computed tomography was performed using an Imatron C-100 scanner (Imitron Inc., South San Francisco, California). Two sets of 20 transverse 3-mm-thick slices were obtained in an axial fashion to image the entire heart. To increase sensitivity, an additional set of 20 transverse 3-mm-thick slices were obtained at the level of the proximal coronary arteries and the higher of the 2 scores were used. Coronary artery calcium was measured with a denistometric program available on the Imatron scanner. Areas of increased density overlying coronary arteries were evaluated. Lesions were scored according to the criteria of Agatston et al,[1] with calcium defined as present in pixels where the attenuation was ≥130 Houndsfield units. Coronary calcium was considered present when the calcium score was >1 based on a histopathologic correlative study that suggested a minimum requirement of 3 contiguous pixels (which correlates to 1.03 mm^2) for clinical studies.[9] Scans were interpreted by an experienced cardiologist who was blinded to the patients' clinical data. Baseline demographic variables are presented as mean ± 1 SD. Comparisons between event and nonevent groups were made by Student's *t* test for unpaired data.

Of the 181 patients admitted during the study period, 44 did not meet entry criteria. The most common reason for exclusion was a previous diagnosis of coronary artery disease. One hundred thirty-four of the remaining 137 patients consented to and were enrolled in the study. Their mean age was 53 ± 2 years. Eighty-four (63%) were women (mean age 54 ± 10 years) and 50 (37%) were men (mean age 52 ± 14 years). The patients had an average of 1.95 ± 0.5 traditional cardiac risk factors, including hyperlipidemia (serum cholesterol >220 ng/dl or use of lipid-lowering therapy) (25%), diabetes mellitus (27%), positive family history of myocardial infarction (35%), systemic hypertension (64%), and cigarette use (4%). African-Americans made up 71%, Hispanic 19%, white 9%, and Oriental 1%.

Of the 134 patients, 48 (36%) had a negative EBCT scan. There were 21 men with a mean age of 42 ±13 years and 27 women with a mean age of 47 ± 9 years. Among these 48 patients, there was 1 event (2%). This was a 45-year-old man with a peak creatinine kinase of 453 and a negative electrocardiogram. This patient had a history of cocaine abuse and his toxicology screen was positive for cocaine on admission. Excluding this patient, there were no events in

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the group of patients with a negative scan resulting in a negative predictive value of 100%.

The remaining 86 patients (64%) had a positive EBCT scan. There were 29 men (mean age 59 ± 11 years) and 57 women (mean age 56 ± 12 years). Patients with a positive scan were older than those with a negative scan ($p < 0.001$). The mean score was 379 ± 1,005 (range 1 to 7,623). The mean score for women was 184 ± 366 and the mean score for men was 762 ± 1,602 ($p = 0.011$). Of these 86 patients, there were 7 coronary events (6 women and 1 man) within 30 days (8%). The mean age of patients with events was 59 ± 11 years and their mean EBCT score was 322 ± 424. There were 4 acute myocardial infarctions, 2 coronary artery bypass graft surgeries, and 1 percutaneous revascularization. One acute myocardial infarction occurred during the 30-day follow-up period and the remaining events occurred during the index hospitalization.

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The primary end point of this study was to evaluate the predictive value of a negative EBCT scan in terms of risk-stratifying patients who present to the emergency room with chest pain. In our series, the negative predictive value was 98%. The only event occurred in a known cocaine user who had a positive toxicology screen at the time of admission. EBCT should not be used as a risk stratification method in this patient population. Excluding this patient, there were no events during the index hospitalization or at a 30-day follow-up in patients who had a coronary artery calcium score of 0. Thus, excluding the cocaine user, this test was perfect in predicting which patients may be safely discharged from the emergency room with a negative predictive value of 100%.

Investigators have previously associated coronary artery calcium by EBCT with increased risk of events in both symptomatic and asymptomatic patients. A multicenter study of 491 symptomatic patients who underwent both coronary angiography and EBCT demonstrated that nearly all of the coronary heart disease–related events occurred in patients in the upper 2 quartiles of coronary artery calcium scores.[6] In fact, patients with a coronary artery calcium score higher than the median were 6 times as likely to have a coronary heart disease–related event as those whose scores were below the median. In a study of 1,173 asymptomatic patients who were followed for a mean of 19 months, coronary artery calcium score on EBCT predicted future cardiovascular disease-related events.[8] This investigation showed the relative risks for future cardiovascular events were 26 and 35, respectively, for coronary artery calcium scores of >100 and >160. In this study, other indicators of cardiovascular risk, including high cholesterol, low high-density lipoprotein cholesterol, systemic hypertension, smoking, diabetes mellitus, and family history did not show a strongly positive correlation with subsequent atherosclerotic coronary events. In our study, we found the group of patients with a positive coronary artery calcium score to have an 8% 30-day event rate. The mean score in our patients with a positive scan was 243, comparable to the high-risk group identified by Arad et al (>160)[8] and the upper 2 quartiles in the multicenter study (75 to 397 and >397).[6] The identification of this high-risk subgroup is consistent with previous studies and clinically may allow for more appropriate evaluation and aggressive treatment in patients admitted from the emergency room to the hospital with chest pain. Two of the events, both myocardial infarctions, occurred in patients with relatively low scores of 30 and 31. Both patients were women and active smokers. Reduced sensitivity of EBCT scanning has been described in younger women[10] and active smokers,[11] and caution is advised in generalizing the results to these 2 groups. This study contained a high portion of African-American women. The results may not be applicable to white men who make up the largest group seen in emergency rooms for chest pain in most United States hospitals.

This pilot study has demonstrated that EBCT scanning performed as part of the emergency room evaluation of patients with chest pain and a normal or nondiagnostic electrocardiogram is a practical technique that can accurately distinguish between very low (2%) and high (8%) risks for adverse cardiac events. Compared with clinical variables alone, this new technique has a greater specificity that may allow for early discharge of patients directly from the emergency room without coronary artery calcium.

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