emergency medical services (EMS), and many in the population are unfamiliar with CPR. Response time for EMS in rural settings is much longer than that in metropolitan areas. In addition, vasopressin was found to be superior in patients with asystole, which represents only 20%–40% of cardiac arrests. The lack of benefit in patients presenting with ventricular fibrillation is surprising and unexplained. These results, however, are new and innovative and allow new approaches to the treatment of patients with out-of-hospital cardiac arrest. Research in this area is extremely important, and, unfortunately, extremely difficult to accomplish. There remains a considerable need for further funding and a national effort to improve the outcome for this extremely high-risk group of patients. ■

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Atherosclerosis

Computed Tomography to Evaluate Asymptomatic Coronary Plaques

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Relationship Between Stress-Induced Myocardial Ischemia and Atherosclerosis Measured by Coronary Calcium Tomography

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Imaging with multislice spiral computed tomography (MSCT) and electron beam computed tomography (EBCT) can demonstrate the presence of coronary calcium. In addition, the newer generation of 16- and 64-slice MSCT scanning technologies can image for both calcified and noncalcified plaque, providing the ability to detect the presence of coronary artery disease in the presymptomatic phase. However, debate continues about how to factor the information gleaned from a calcium score or non-invasive CT coronary angiography test into the Framingham risk model and results of stress testing, identify patients who may be at risk for adverse coronary events, including fatal and non-fatal myocardial infarction and the need for coronary revascularization. Berman and colleagues conducted an important study to "assess the relationship between stress-induced myocardial ischemia on myocardial perfusion single-photon emission computed tomography (MPS) and magnitude of coronary artery calcification in patients undergoing both tests."

The study included 1195 patients who were referred for MPS for clinical reasons and within 6 months underwent coronary calcium scoring with either MSCT (Volume Zoom; Siemans AG, Malvern, PA) or EBCT (Imatron C-150 or e-Speed;™ GE Healthcare Technologies, Waukesha, WI). Patients were excluded if they had previous coronary artery bypass surgery or percutaneous intervention, history of myocardial infarction, known valvular heart disease, or primary cardiomyopathy. Patients underwent MPS with either a symptom-limited Bruce protocol or with adenosine. An ischemic MPS was defined when 5% or more of the ventricle became ischemic and a moderate-to-severe ischemic response was noted when more than 10% of the ventricle was judged ischemic using a summed-difference scoring system. The calcium scanning protocol called for the acquisition of 30 to 40 3 mm (EBCT) or 2.5 mm (MSCT) slices to cover the entire heart. Foci of calcium were designated if at least 3 contiguous pixels of peak density greater than or equal to 130 Housefield units (HU) were observed within the coronary tree.

Of the 1195 patients studied, only 45 (3.8%) presented with typical angina, 380 (31.8%) with atypical angina, and 112 (9.4%) with non-anginal chest pain. Asymptomatic patients numbered 609 (51%). Seventy-six of the 1195 (6.3%) had an ischemic MPS, indicating that the population studied was at a low risk for coronary events. Among patients within the highest coronary calcium score group (> 1000), only 19.9% and 8.6% had an ischemic and moderate-to-severe MPS, respectively. In patients with a calcium score of 0, 1.6% had ischemic and 0.4% had moderate-to-severe ischemia on MPS. See Figure 1.

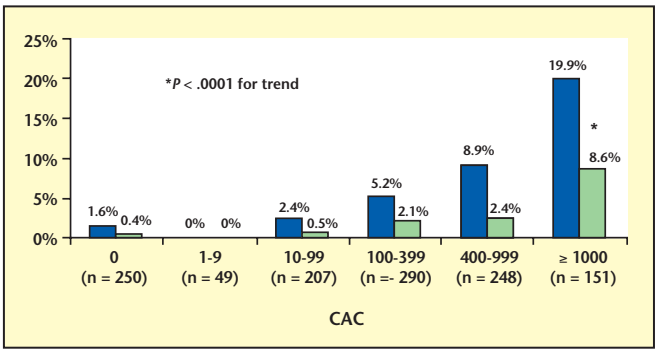


Figure 1. *The frequency of an ischemic myocardial perfusion single-photon emission computed tomography (≥ 5% ischemic, blue bars) and of a moderate to severe ischemia (> 10% ischemic, green bars) for patients divided into 6 coronary artery calcium (CAC) score groupings. Reproduced with permission from Berman et al.*

In patients who had a normal MPS, there was wide distribution of coronary calcium scores, with 22% having a score of 0, 4% having a score of 1-9, 18% having scores of 10-99, 25% having scores of 100-399, 20% with scores of 400-999, and 11% with scores of 1000 or higher. Among the smaller population of patients with an ischemic MPS, 5% had scores of 0, none had scores of 1-9, 7% had scores of 10-99, 20% had scores of 100-399, 29% had scores of 400-999, and 39% had scores of 1000 or more. See Figure 2.

There are no data available in this study on major adverse coronary events such as fatal and non-fatal myocardial infarction, acute coronary syndromes, and need for revascularization. Therefore no conclusion is made relating MPS and calcium scoring to coronary event rates.

The investigators did draw the following conclusions.

- Referral of patients for MPS is generally not needed when the calcium score is lower than 100, whereas a calcium score greater than 400 is associated with a higher risk of an ischemic MPS and therefore should be performed even in asymptomatic patients.
- A "grey zone" exists between calcium scores of 100 and 400, when clinical factors such as gender, symptoms, and coronary risk factors may need to be taken into account.
- The wide range of calcium scores in patients with normal MPS studies exposes an important limitation of stress testing in that it does not screen for subclinical coronary atherosclerosis.

It is clear that stress myocardial perfusion scanning and coronary calcium assessment represent evaluations of very different aspects of coronary atherosclerosis. Stress testing is used to determine the risk of a physiologically significant coronary artery obstruction and calcium scoring is used to define the presence of and relative quantity or volume of atherosclerosis within the coronary vascular tree. In this study of patients who presented for the most part with no symptoms or atypical symptoms, the utility of stress myocardial perfusion scanning seems to be low, with only 6.3% having an abnormal MPS. In patients with higher calcium scores (400-999), only 7% and 12.2% in the asymptomatic and symptomatic groups, respectively, underwent an ischemic MPS exam. Above a calcium score of 1000 the prevalence of ischemic MPS is 15.3% in the asymptomatic population and 32.5% in the symptomatic patients. See Figure 3.

The use of coronary calcium scoring seems to be very useful in identifying the presence of coronary atherosclerosis in the asymptomatic patient with risk factors. With 10% to 15% of patients presenting with acute myocardial infarction having no conventional risk factors, perhaps a case can be made for widespread use of coronary calcium scoring with any coronary risk factor. Identifying those patients with coronary calcium in the presymptomatic phase would allow for early initiation of

Figure 2. *Distribution of coronary artery calcium (CAC) scores for the 1119 patients manifesting a normal myocardial perfusion single-photon emission computed tomography (MPS) (left) and the 76 patients with an ischemic MPS (right). Reproduced with permission from Berman et al.*

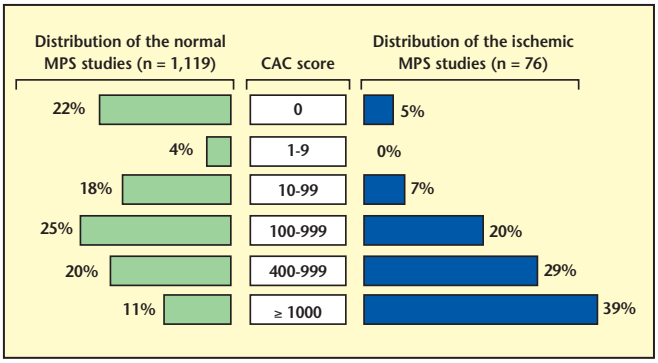
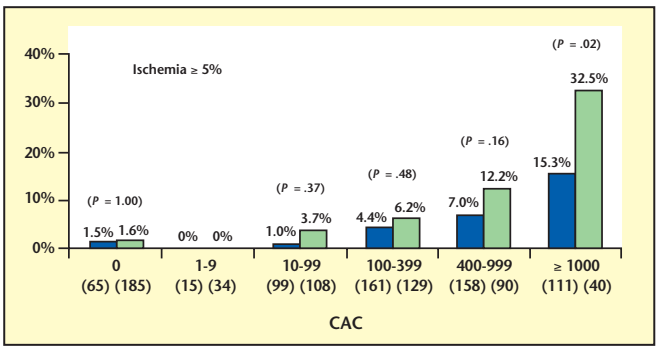


Figure 3. *The frequency of an ischemic myocardial perfusion single-photon emission computed tomography for each of the 6 coronary artery calcium (CAC) score subgroups, further subdivided on the basis of symptoms (chest pain and/or shortness of breath) being absent (blue bars) or present (green bars). Reproduced with permission from Berman et al.*



prevention therapies, particularly aggressive lipid reduction. The utility of MPS in the asymptomatic patient, like those observed in this study, seems to be very limited unless they have high coronary calcium scores.

In order to better understand the use of serial calcium scoring and MPS in asymptomatic patients, it is important to obtain data on short- and long-term coronary event rates in a variety of patient subsets, particularly those with high calcium scores and normal MPS and those with low calcium scores and abnormal MPS. This would be useful in identifying those patients who would benefit from diagnostic coronary angiography and revascularization. For now, it seems that a reasonable approach is to consider the use of a coronary calcium scan as a screen for the presence of coronary artery disease in patients with risk factors for coronary disease. MPS is useful in determining the presence of obstructive disease in symptomatic or diabetic patients but seems to have limited utility in asymptomatic patients, with the exception of those with the highest coronary calcium scores. Reducing the use of MPS as a screening test for coronary artery disease may provide some cost savings, thus offsetting to some extent the cost of greater utilization of coronary calcium scoring.

Before the practice of calcium scoring enters wide use, the age range for useful screening and the frequency with which it should be performed will need to be determined. Non-invasive CT coronary angiography is now being investigated to assess its value as a screening and diagnostic tool. With its high negative predictive value for obstructive coronary disease and ability to detect both calcified and non-calcified coronary plaque, the utility of non-invasive CT coronary angiography in patients with coronary risk factors is currently being investigated by groups such as ours. ■