the intracardiac — most probably endocardial — repolarization process in the cases of disturbed FMD and consecutive ST depression is now only a matter of speculation and needs to be elucidated.

The whole study, which compares stress echo and stress ECG, provides further and partly philosophical answers. Old and widely used traditional ECG techniques, in combining with others, can probably bring surprising new aspects to known or newly defined diagnostic parameters and may also put the whole question into a new dimension\textsuperscript{[9,10]}. On the other hand, the newly established stress laboratories might be the exact sites to integrate traditional ECG information with new techniques: the old electro-anatomic measurements with the newly explored physiological ones.

In conclusion, the Pisa echo lab, with its novel provocative paper by A. Palinka\textquotesingle s et al.\textsuperscript{[11]} is starting to tell us a new exciting story. This comes almost 20 years after the pioneering work of the same group\textsuperscript{[11]}, who opened the Pandora\textquotesingle s box of pharmacological stress echo for the diagnosis of coronary artery disease, now universally accepted in guidelines of scientific societies\textsuperscript{[12,13]}. The return of the ECG signal to the echo lab is also the revenge of the \textquoteleft stunned\textquoteright clinical cardiologist against the hypertechnological diagnosis of today.

Sometimes, they (both ECG and clinical integration) return!

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calcification, those with calcium had a 5-year mortality of 87% compared to 58% for those without. But fluoroscopic assessment of coronary calcium, for many reasons, including only fair diagnostic accuracy and radiation burden, was never endorsed as a non-invasive method of assessing coronary disease. Technological advances, especially the development of electron beam computed tomography (EBCT), have dramatically improved our ability to evaluate calcification of the coronary vessels leading to considerable interest in the practical clinical value of assessing coronary calcium.

Electron beam computed tomography uses an electron gun and stationary tungsten targets to acquire serial transaxial images in 100 ms with a thickness of 3 mm to 6 mm for the detection of coronary calcium. The scans are triggered by the ECG signal (usually 80% of the R-R interval). This technique, which is more than five times faster than regular CT, coupled with breath-holding sequences, reduces the effects of cardiac and respiratory motion observed with conventional CT processes and yields high resolution images with limitation of artefact. The extent of vascular calcification is usually measured by calculation of a calcium score such as that described by Agatston\(^5\). In this method the calcium score is calculated by examining 3 mm tomographic slices of a patient’s coronary artery tree to identify areas of calcified plaque defined as lesions with a CT density of \(>1 \text{ mm}^2\). The calcium score for each region of interest is determined by multiplying the calcified area by a density coefficient and the total calcium score is calculated by adding all the partial scores obtained in each region of interest. But how does this quantitative assessment of coronary calcium relate to disease activity and clinical events?

Vliegenthart \textit{et al}.\(^6\) in this issue have demonstrated a strong and graded association between the extent of coronary calcium, determined by the Agatston scoring system, and the risk of hard cardiac events in a cross-sectional population based study. Thus a further piece is added to the jigsaw being assembled depicting the role of coronary calcium scanning in the current practice of cardiology. Sufficient information has been gathered to demonstrate with reasonable clarity where calcium scanning stands in the context of other forms of non-invasive testing, but the full picture is far from complete.

Many different roles have been proposed for EBCT in the evaluation of coronary artery disease:

- As a method of establishing a diagnosis or coronary artery disease in symptomatic patients, or detecting the presence of coronary disease in asymptomatic patients (high-risk screening and general population screening)
- As a prognostic tool in symptomatic and asymptomatic patients, allowing targeted prevention through identification of asymptomatic individuals at risk of developing clinical manifestations of coronary disease, including death and myocardial infarction
- As a means of monitoring response to preventative and other treatments such as HMG CoA reductase inhibitor medication

**Electron beam computed tomography in diagnosis of coronary artery disease**

Numerous studies have been published to date in this field. A meta-analysis by Nallamothu \textit{et al}.\(^7\) of nine studies estimating the accuracy of EBCT in diagnosing obstructive coronary artery disease showed that the pooled sensitivity was 92.3% and the pooled specificity was 51.2%. This assessment of the diagnostic performance of EBCT is consistent with the weighted average sensitivity of 80.4% and specificity of 39.9% (pooled values 90.5% and 49.2% respectively) produced by the ACC/AHA expert committee on electron-beam CT for the diagnosis and prognosis of coronary artery disease\(^8\). As one would expect, sensitivity and specificity changed as the threshold for defining an abnormal test varied. Thus for a threshold that resulted in a sensitivity of 80% the specificity was as high as 71%. The ACC/AHA consensus document on electron-beam CT for the diagnosis and prognosis of coronary artery disease states that EBCT has equivalent predictive value as exercise tolerance test in the diagnosis of coronary disease in symptomatic populations.

The values reported above are based on a definition of coronary artery disease as \(>50\%\) luminal stenosis (except one study which used \(>75\%\) stenosis). It is recognized that atherosclerotic disease may be not only present, but quite extensive without what is considered significant luminal obstruction\(^9\). In this, coronary calcium scanning has an advantage over currently available non-invasive studies such as exercise tolerance test, perfusion imaging or stress echo which can only identify the presence of flow limiting lesions, as coronary calcium scores correlate with the atherosclerotic plaque burden rather than the severity of individual stenoses\(^10\). Thus, detection of non-obstructive coronary disease may allow earlier intervention such as lifestyle modification, cholesterol lowering treatment (statins) and newer treatment strategies which may slow or avert development of more significant disease and/or clinical events.
Most of the studies included in these meta-analyses examined patients referred for coronary angiography to investigate chest pain, but also included post MI evaluation, pre-operative risk assessment and transplant work-up.

Interestingly EBCT was shown to have significantly greater accuracy in detecting coronary artery disease in patients with cardiomyopathy who underwent evaluation as part of pre-transplant assessment. Although Vliegenthart et al. and others\cite{11} have demonstrated an association between calcium score and clinically evident coronary disease there are significant ethical difficulties in prospectively investigating the diagnostic performance of EBCT to detect coronary artery disease in the general population using coronary angiography as the gold standard.

Electron beam computed tomography and prognosis

Coronary calcium reflects the overall disease burden, which we know to correlate with future death and infarction\cite{12,13}. Furthermore, evaluation of coronary calcium has been shown to allow identification of patients with prognostically important disease, left main stem and three-vessel disease\cite{4}, and severe calcification predicts inducible ischaemia even in asymptomatic individuals\cite{15}. Therefore, it would seem intuitively correct that the coronary calcium scores could be useful in determining prognosis.

To date there have only been two relatively small studies\cite{16,17} published which examine the quantitative assessment of coronary calcium by EBCT in asymptomatic patients with known coronary disease in terms of prognosis. Both have shown the calcium score to yield independent prognostic information in these patients, with a risk ratio of 3·4 (CI 1·3–8·7) for hard events\cite{16} for patients with a calcium score above the median.

The impact of calcium score on the development of future events has been more extensively prospectively investigated in asymptomatic populations\cite{18–21}. A recent meta-analysis observed a summary risk ratio of 4·2 (CI 1·6–11·3) for hard events for patients with a calcium score above the median\cite{18}. There are, however, some inconsistencies between the studies. While Arad et al.\cite{14} found the odds ratio for all events (including revascularization) to be almost an order of magnitude higher (OR 19·7 with EBCT >160)\cite{19} than those typically associated with conventional risk factors, the South Bay Heart Watch investigators, did not find that the coronary calcium score added incremental prognostic information when predicting hard events (death or myocardial infarction)\cite{20}. They found the coronary calcium score to be equivalent to standard risk factor assessment, and neither method to be an accurate predictor of hard events in an asymptomatic high risk population. It should be noted, however, that this population was highly selected and all were above the 75th centile of risk. Wong et al.\cite{21} observed a graded relationship between quartiles of coronary calcium score and relative risk of all events with relative risks of 4·5 and 8·8 for the third and fourth quartile respectively, adjusted for age, gender and other risk factors.

One of the difficulties in applying the results of these studies to clinical practice is the variation in cut-off points for coronary calcium scores. This is compounded by the fact that the extent of coronary calcification is influenced by age and gender, making an isolated absolute calcium score difficult to interpret. Raggi et al.\cite{22} determined the relative risk of hard events for calcium scores adjusted for age and gender by using calcium score percentiles, and found that this improved the predictive value of the coronary calcium score, which was substantially better than traditional risk factors in predicting hard events in their analyses. Age and gender stratified calcium score distributions have been published which should enhance the ability to interpret EBCT calcium scores in clinical practice in the future\cite{23}. Although a cross-sectional rather than prospective study, the Rotterdam calcification study\cite{6} contributes important information concerning the prognostic value of coronary calcification because it is population-based, and because of the large proportion of elderly subjects included in the study. It would appear that the relative age (in terms of degree of calcification) of one’s arteries is more useful in predicting future events than absolute chronological age.

Electron beam computed tomography to monitor progression of atherosclerosis and to assess the effect of treatment

Electron beam computed tomography has been proposed as a means of monitoring atherosclerotic disease burden progression, or regression, non-invasively over time. A recent review of the available data examining EBCT in this capacity was optimistic\cite{24}. Studies of progression demonstrate significant annual progression (22% to 52% per year). Two studies\cite{25,26} which have been published in abstract form suggest that hard events occur predominantly in those patients with significant progression
compared to those without). Furthermore treatment with statins has been shown to reduce the rate of progression of atherosclerosis determined by calcium score. Interscan variability and reproducibility of the Agatston score remain appreciable problems to be overcome before EBCT is routinely used for this purpose. An alternative volumetric scoring system to the conventional Agatston score shows improved reproducibility and may prove the preferred option to assess progression. The first large randomized trial to use EBCT derived calcium-volume scores to assess the rate of progression/regression of atherosclerosis, BELLES (Beyond Endorsed Lipid Lowering with EBCT Scanning) is currently underway and may be the benchmark for future similar studies.

**Electron beam computed tomography in the context of current risk assessment practices**

How does EBCT slot in with existing non-invasive and invasive tests? Quantitative assessment of calcium by EBCT appears to add independent prognostic information to that provided by conventional risk factor assessment in the majority of studies.[18,19,21,22]

In the relatively small number of patients examined, the extent of coronary calcification also added prognostic information to that obtained at coronary angiography[16,17] and has the advantage of being non-invasive technique. While it is equivalent to exercise testing in the diagnosis of coronary disease, less is known about how EBCT compares to exercise testing or stress myocardial imaging techniques in predicting prognosis. It has several theoretical advantages, results are largely operator independent, scans can be performed in as little as 10 min, and the patient does not have to exercise or receive a pharmacological stressor. One study has shown that patients with very high calcium scores are at increased risk of hard events, which is greater than the risk associated with a severe perfusion defect on myocardial perfusion imaging in historical controls.[29]

Such findings need to be prospectively investigated before the true position of EBCT in risk assessment algorithms is clear. At present the lack of a standardized scoring and grading system and universally accepted cut-off points make the position even more difficult to define.

**Summary**

On the basis of existing knowledge, EBCT assessment of coronary calcium holds much promise as an investigative tool for the cardiologist. However, further prospective investigation is necessary to consolidate its position as a method of assessing prognosis, to determine the most accurate and reproducible method of quantifying the results, and to identify the most appropriate cut-off points for diagnosis and prognosis of coronary disease. EBCT may also prove to be a very useful non-invasive tool to monitor response to atherosclerosis-modifying therapy such as lipid lowering therapy or ACE inhibitor therapy. As this technology has advanced over the past decade or so, a further application of electron beam computed tomography is now non-invasive coronary lumen imaging. Although as yet not sufficiently developed to advocate its routine use as an alternative to invasive coronary arteriography, the proponents of EBCT may not be wildly misdirected in their vision of the future with the EBCT scanner providing a ‘one-stop shop’ for the investigation of coronary disease.

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Catheter ablation of macroreentrant atrial tachycardia in patients following atriotomy

See doi:10.1053/euahr.2002.3168 for the article to which this Editorial refers

Macreentrant right atrial tachycardia is a common late complication of surgical correction or palliation of congenital heart disease, and its prevalence increases as the time following surgery increases. These arrhythmias are often refractory to pharmacological therapy.

Macreentrant atrial tachycardia following surgical repair of congenital heart disease (‘incisional tachycardia’ or ‘atypical atrial flutter’) has been thought to be due to reentry around the atriotomy scar or around a septal patch following atrial septal defect closure. Catheter ablation has been useful in selected patients, but these procedures have been limited in many patients due to the presence of multiple or unstable ( unmappable) atrial tachycardias, especially in patients with more complicated surgeries (i.e. Fontan procedure). Two approaches were initially explored for catheter ablation of macroreentrant atrial tachycardias following atriotomy. In one approach, mapping focuses on identifying an isolated diastolic atrial potential, presumably originating from an isolated zone of slow conduction. Entrainment pacing is used to confirm participation of that site in the reentrant circuit. In one series, this approach successfully ablated at least one tachycardia in 73% of the patients. However, atrial tachycardia recurred in 53% of the patients with acute ablation success (mean time to recurrence 4-1 months).

The second approach is based on the concept that atrial tachycardia in patients following atriotomy results from reentry around the atriotomy scar.