patient with cardiac arrest, as initial presentation of the underlying cardiac disease, who receives an implantable cardioverter-defibrillator, cost cannot be evaluated, unless the first line therapeutic option for these patients is not an implantable cardio-verter-defibrillator. Another approach could be to randomize these patients to an implantable cardioverter-defibrillator or to other forms of therapies (drugs, surgery) an approach similar to that used by Wever and Hauer[6]. Randomization is not easy to undertake in patients with malignant ventricular arrhythmias as a therapy may be of particular benefit for a given patient.

The German CASH trial comparing implantable cardioverter-defibrillator to antiarrhythmic therapy, is ongoing. The AVID trial, comparing the implantable cardioverter-defibrillator to treatment with amiodarone or sotalol, is expected to answer to a number of questions related to the use of implantable cardioverter-defibrillators. Whatever the results of these trials may be, they will limit but not prevent the use of implantable cardioverter-defibrillators. The latter have been shown to be effective in their objective of terminating ventricular arrhythmias and may be the only appropriate therapy in a selected group of patients. Cost-effectiveness therefore becomes particularly important. The other limitations of Valenti et al.[5] concern the retrospective nature of the information collected during the 2 years preceding implantable cardioverter-defibrillator implantation and the 2 years following the implantation. Despite

the limitations of this approach, their attempt to evaluate the impact of implantable cardioverter-defibrillators on rehospitalization and cost represents a useful addition to the literature on this important therapeutic modality. The results of the MADIT trial which were presented recently at NASPE concern the prophylactic use of an implantable cardioverter-defibrillator in patients who suffered a myocardial infarction and who were at high risk of sudden cardiac death.

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Cardiac imaging in syndrome X: the problem of 'reverse redistribution'

The condition that we have come to know as 'syndrome X' (exertional chest pain, positive response to stress testing and normal coronary arteriograms) continues to capture the imagination of cardiologists and general physicians alike. Syndrome X is an ill-defined entity that most probably encompasses multiple diagnostic categories. These, however, have in common a clinical presentation with typical exertional chest pain in the presence of normal coronary arteriograms.

Syndrome X is an ever-challenging dilemma. Although to most clinicians syndrome X represents a relatively uncommon and benign condition, the management of angina with normal coronary arteriograms is often a frustrating experience. Mortality and serious cardiac events in patients with chest pain and normal coronary arteriograms are quite low but patients are frequently disabled by chest pain and return to work is poor[1]. The lack of an appropriate experimental model for syndrome X has made it extremely difficult for research groups to make significant progress regarding the true nature of the

syndrome. Due to the fact that patients with syndrome X often have typical exertional chest pain, ischaemia-like ST segment depression during stress testing and reversible myocardial perfusion abnormalities[2], myocardial ischaemia has been implicated in the pathogenesis of the condition. In different studies, however, objective evidence for myocardial ischaemia has usually been obtained in a small proportion of patients. In selected patients with angina and normal coronary arteriograms, myocardial ischaemia has been documented and shown to be associated with coronary microvessel endothelial dysfunction[3] (microvascular angina)[4]. Several studies have also suggested that the microcirculatory abnormalities observed in patients with syndrome X may result in heterogeneous intramyocardial blood flow distribution[5–8].

In this issue, Fragasso et al.[9] report a higher prevalence of transient perfusion abnormalities and reverse redistribution of thallium-201 in 35 patients defined as syndrome X (typical exercise-induced chest pain, positive exercise testing and angiographically smooth epicardial coronary arteries) compared to 32 patients with 'atypical' chest pain and negative responses to exercise stress testing. The high incidence of transient perfusion abnormalities in patients with syndrome X observed in this study confirms previous findings by different authors. Interestingly, however, compared to control patients, a larger proportion of patients with syndrome X in Fragasso's study[9] also showed the presence of the phenomenon known as 'reverse redistribution'. Reverse redistribution of thallium-201 in Fragasso et al.'s[9] study was defined as 'worsening of the perfusion pattern observed at rest, relative to that observed during stress'. The authors suggest that this scintigraphic finding is the expression of inhomogeneous myocardial perfusion.

Although the observations reported by Fragasso et al.[9] in patients with syndrome X are intriguing and may truly represent, as claimed by the authors, microcirculatory perfusion abnormalities, their study is purely observational and a number of important considerations are required to put their findings in context. First and foremost, the definition of reverse redistribution in the study is qualitative and no attempt has been made to provide quantitative measurements of the phenomenon. Moreover, planar thallium-201 scans were used in the majority of patients with just a few patients undergoing single photon tomographic scans. Planar thallium-201 scintigraphy has obvious limitations that preclude an accurate assessment of regional myocardial blood flow heterogeneity. Among these, attenuation, by chest structures, of the radiation emitted from the heart can clearly affect the results. This is particularly

relevant in women, in whom radiation attenuation by breast tissue may account for artefacts and the finding of 'reverse redistribution' in at least some patients. Indeed, spurious reverse redistribution may occur in normal individuals due to artefact and statistical noise. Fragasso et al.[9] have addressed this problem using adhesive bandages to try and minimize the effects of breast radiation attenuation in women. It is important in this regard that the prevalence of reverse redistribution in Fragasso's study was higher in syndrome X patients than in control patients, irrespective of the patients gender. Fragasso et al.[9] have acknowledged some of the limitations of thallium planar scintigraphy in their manuscript. They have also provided additional data which appear to support their suggestion that reverse redistribution is more common in syndrome X patients than in individuals with atypical chest pain, negative exercise testing and normal coronary arteriograms.

In contrast to patients with significant coronary artery stenoses, the postulated myocardial blood flow abnormalities in patients with chest pain and normal epicardial coronary arteriograms remain speculative. Several mechanisms have been suggested to explain the occurrence of reverse redistribution in patients with diverse cardiovascular abnormalities and also in 'normal' individuals. Among these, heterogeneous distribution of intramyocardial blood flow may play a role in patients with chest pain and normal epicardial coronary arteries. Fragasso et al.[9] postulate that a non-homogeneous blood flow distribution is the mechanism underlying the scintigraphic finding of reverse redistribution in their patients with syndrome X. Although appealing, their conclusions are speculative as no direct evidence is provided in the study that abnormalities of microvascular coronary blood flow were truly responsible for the clinical, electrocardiographic and scintigraphic findings in the syndrome X patients included in the study. Despite the common clinical presentation with chest pain and ST segment depression on exercise testing, syndrome X is clearly an heterogeneous entity and different pathophysiological mechanisms may play a role in different patients. Heterogeneous myocardial blood flow both at rest and during pharmacological stress is one of such mechanisms, as previously demonstrated by other authors using quantitative measurements of coronary blood flow[6,8].

The observations reported by Fragasso et al.[9] may have clinical and pathophysiological importance. However, in order that the true nature of these findings can be established, further studies in patients with syndrome X and documented coronary microvascular abnormalities are required. These

investigations should include comparisons of the results of quantitative tomographic techniques such as positron emission tomography, with those of tomographic thallium scintigraphy.

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Angioscopic morphological changes after coronary angioplasty of unstable plaques

Angioscopy is one of several ways to assess the morphology of stenoses. In order to perform coronary angioscopy, a guiding catheter must be used to deliver the angioscope to the stenosis. Generally, guidewires are used to keep the angioscope coaxial with the blood vessel.

Angioscopy provides information about changes in the vessel lumen, but processes going on in the vascular wall underlying the lumen are not visualized by angioscopy. However, despite this limitation much can be learned from direct visualization of the stenoses, for example detailed characterization of the vessel lumen and morphological changes of the intima of the vessel.

Angioscopy can distinguish intracoronary thrombus from atheromatous tissue better than any other form of coronary artery visualization. It is the most sensitive method with which to detect coronary thrombus and can be used to classify atheromatous plaques[1]. In addition, coronary dissection is detected more accurately by angioscopy than by coronary angiography.

den-Heijer and colleagues support the position stated above with a study of 13 patients undergoing angioplasty[2]. They showed significant progression of intimal dissection and thrombus formation by angioscopy, which was not detected by angiography. They make the point that angioscopy has superior sensitivity to detect damage to the intima and thrombosis and by doing so can reveal important intravascular events that apparently occur even after successful angioplasty.

Coronary angioscopy will not replace angiography as a reference standard for imaging atherosclerotic coronary arteries[3]. However, angioscopy does offer a full colour, three-dimensional perspective of the intracoronary surface morphology. It is possible that visualizing details, not reliably available from angiography alone, may ultimately be used to assess risk and make clinical decisions at the time of angiography.

Limitations of angioscopy are: (1) the need to occlude the vessel during imaging which sometimes produces myocardial ischaemia; (2) there is presently no method to quantify angioscopy findings; (3) compared to intracoronary ultrasound the limitations are that angioscopy does not assess the cross-sectional image of the vessel and thus does not permit analysis of the layers of the vascular wall nor does it allow classification of the plaques related to plaque content e.g. thrombus, lipid, fibrous tissue and calcium.