ECHO-CARDIOGRAPHY 1988

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INTRODUCTION

We all are gathered here again for the 6th International Congress on Echocardiography after about ten years from the first that marked a basic milestone also at international level, showing the clinical, cultural and scientific standard of Italian cardiology. Actually, in the field of echocardiography that has actually replaced most current and traditional techniques (for instance, polygraphy) and stressed the limits of electrocardiography (as in myocardial infarction), the Italian Schools have set up applications and scientific centers of high cultural value, which is demonstrated by the contributions that many italian investigators have rendered to the international literature.

As for the first Congress, all the directors of Cardiology Schools, a lot of famous clinicians from the Italian universities, important representatives of hospital cardiology and many illustrious names of world cardiology are gathered here today and I wish to thank them all for having accepted our invitation.

In 1986 we decided to hold our Congress every two years. Now, for the first time an appointed Committee has chosen and awarded the six best oral presentations and the two best posters; once again national and international participation has been remarkably high with more than 200 communications submitted, all of an excellent quality: selecting them was a quite difficult task, since for organizational reasons it was only possible to accept 119.

As one can see from the program, this Congress is one more chance and a further step to promote culture and progress. The first international congress on echocardiography, was based on the theoretical-practical validity of echocardiography and its possible clinical applications. In a later stage the fast development of techniques and knowledge called for an assessment of the state of the art in this subject, also considering the widened range of application in fields of primary importance, specially after the introduction of computerized analysis. Our last Congress took place during a third stage of evolution, coming from more growth and progress that was a further, basic step after the preceding Congresses: we refer in particular to the employment of pathophysiological methods and the linking, instead of comparison, with other invasive and non-invasive techniques. This meeting falls in a phase in which echocardiography has not only reached a primary position in clinical and pathophysiological examination but has become an integrant part of cardiology as a whole; the subjects we are going to discuss are structural to modern cardiology, although we are still experiencing significant advancements.

We only need to recall the improvements in the field of pathophysiology of ischemic heart disease, the progress in the so-called interventional cardiology, the widespread use of the Doppler method with the introduction of color Doppler flow imaging, etc.

And now let's go over some essential points of this meeting. First of all, the further achievements in the field of pathophysiology of ischemic heart disease.

A Lecture presented at the Congress of the Italian Society of Cardiology in 1985

stressed the importance of acute appearance of regional mechanical alteration, a specific ischemic marker 'per se'. On that occasion we predicted the possibility to detect the existence of supersilent ischemia through ultrasound technique, e.g. without an electrical and clinical marker but only with a mechanical and metabolic marker. Closely connected with this is the expansion of pathophysiological knowledge in the field of reperfusion and the so called 'interventional cardiology', particularly with the employment of angioplasty, through various techniques. Obviously, the use of Doppler flow measurements represents another step forward not only for myocardial ischemia in humans but also for left ventricular function and intra- and extra-ventricular haemodynamics in physiological and pathological conditions.

Accordingly to what we did when I was honored to be Chairman of the Italian Society of Cardiology, this year we have invited two Societies: the Italian Society of Echocardiography and the Italian Society of Sports Cardiology. As for the first, the focus of interest concerns a highly relevant subject: 'The right ventricle', the great unknown. Today the right ventricle can be studied in a new way not only thanks to the technological progress that allows a more accurate image definition, but also thanks to the study of function both with conventional and with color Doppler techniques.

Special attention should be given to the motivations that led us to invite the Italian Society of Sports Cardiology; echocardiography in sports cardiology represents a method that allows a satisfactory investigation of the anatomical functional adaptation of the heart to physical exercise as an integrant part of cardiovascular fitness, the evaluation of which requires the knowledge of many parameters supplying dimensional and functional information. In recognizing the athlete's heart, the Italian Schools offered a conspicuous contribution; we could define it more accurately through sophisticated computerized three-dimensional examinations that stress the modified morphology with elongation of the longitudinal axis and the preservation of an ideal mass/volume ratio.

As we said at the beginning, the ultrasound technique has by now passed many tests, has proved to be successful and is now of common use along with other traditional methods. The comparison with nuclear magnetic resonance is still hard as we had already noticed during our previous Congress. In the last two years many efforts have been made towards the solution of certain problems, as we will hear from some reports.

However, we can say in advance that the difficulties presented by real time imaging display have not yet been overcome, while nuclear magnetic resonance provides a relatively static, not dynamic image proving to be less versatile than ultrasounds.

At last, before closing my opening address, I would like to thank my friend, Professor Harvey Feigenbaum, who has accepted the demanding duty of serving as co-chairman.

ARMANDO DAGIANTI

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ISCHEMIC HEART DISEASE: PATHOPHYSIOLOGY

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CHARACTERISTICS AND DETERMINANTS OF REGIONAL MYOCARDIAL DYSFUNCTION

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The focus of this review is to summarize recent findings on the functional consequences of acute regional ischemia. We have examined regional myocardial function primarily by concentrating on systolic wall thickening measured with sonomicrometry (1,2). Wall thickening provides an integrated measurement of mechanical function across all "layers" of the myocardium and it avoids a potential limitation of myocardial segment length measurements which may be influenced by improper alignment relative to local fiber orientation (3,4,5). Wall thickening also has the advantage of being measureable with clinical techniques (eg., echocardiography, digital ventriculography, or magnetic resonance imaging), thereby facilitating cautious extrapolation of experimental results to the clinical setting.

Transmural function within an ischemic area. Systolic wall thickening correlates closely with mean myocardial blood flow when coronary inflow is progressively restricted at rest (6,7,8,9,10,11), during exercise (12,13,14), or during isoproterenol administration (15). The relationship between mean transmural blood flow (in ml/min/g) and wall thickening (measured as percentage systolic excursion) is linear under all of these conditions. As shown in Figure 1, when myocardial work increases during exercise, the relationship between flow and function is shifted to the right but it converges to a similar point as the resting relationship when flow restriction is severe and wall motion is akinetic (12). Consequently the slope of the mean transmural blood flow-wall thickening relation appears to vary inversely with the level of myocardial oxygen demand. Expressed in normalized terms, however, the relationship between relative changes in wall thickening and relative changes in mean transmural blood flow is nearly identical across widely different hemodynamic and inotropic conditions (Figure 1). The linearity and reproduceability of the transmural flow-wall thickening relationship supports the generalization that wall thickening provides an accurate means of tracking the balance between oxygen supply and demand on a regional basis. Additional investigation, however, is required to verify that this conclusion applies in other circumstances, such as myocardial hypertrophy or heart failure. More importantly, the nature of the fundamental linkage between coronary blood flow and mechanical function also remains to be determined conclusively.

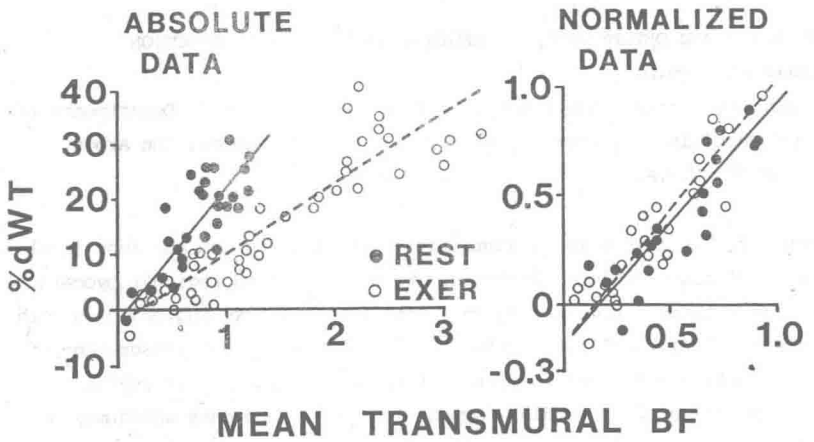

Fig. 1. Flow-function relationships with progressive levels of coronary stenosis at rest and during treadmill exercise (EXER) in chronically instrumented dogs. Percentage wall thickening (%dWT) is plotted versus mean transmural blood flow (BF) in absolute terms (ml/min/g) on the left and normalized as a fraction of control region BF on the right. Data from ref. 12.

A particularly striking feature of regional flow-wall thickening relations is the observation that subendocardial flow restriction dominates transmural function (8,9,11,16). Since autoregulated vasodilator reserve is exhausted in the subendocardium before the subepicardium (17), it is possible for subepicardial flow to be normal when subendocardial flow is markedly reduced. In these circumstances, transmural function is also markedly reduced because wall thickening correlates closely with subendocardial perfusion but poorly with subepicardial blood flow. The relationship between subendocardial blood flow and wall thickening is best described with a quadratic expression but the improvement over a linear fit is small (9,11), lending support for the recent proposal that transmural thickening can be used as a "subendocardial flowmeter" during ischemia (11).

Subepicardial function within an ischemic area. An unresolved question is the effect of subendocardial ischemia on contraction in overlying subepicardial muscle that is normally perfused (3,10,18,19). Is the poor correlation between subepicardial perfusion and transmural function due to "transmural tethering" (18) or is it the consequence of nonuniform wall thickening (20,21)? No consistent answer to this question has emerged from recent experimental studies, many of which involved measurement of epicardial segment shortening. The effect of subendocardial ischemia on nonischemic epicardial segment shortening, however, is strongly influenced by segment

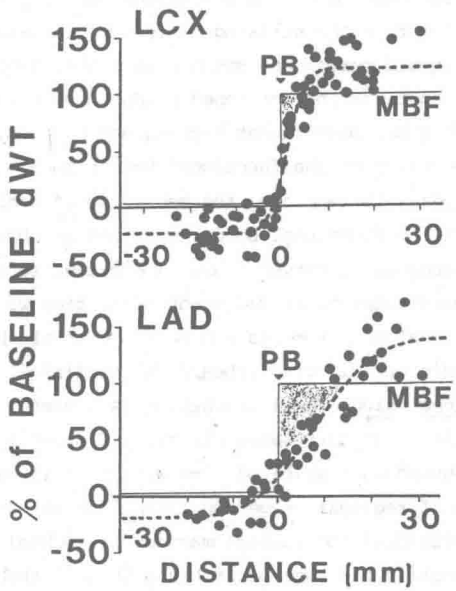

Fig. 2. Composite data sets and composite sigmoid curve fits from experiments with circumflex (LCX) and left anterior descending (LAD) occlusion. Ischemic zone is on the left in each graph. The shaded area represents the functional border zone which extended 4 mm into nonischemic muscle with LCX occlusion; LAD occlusion produced a functional border zone that extended 14 mm, involving substantially greater nonischemic myocardium. (MBF= myocardial flood flow; PB= perfusion boundary).

alignment relative to fiber orientation (3), explaining some of the disparities in different reports. Unfortunately, preliminary studies in which fiber orientation problems were minimized by measuring subepicardial wall thickening have also provided inconclusive results (22,23). Therefore, the relative importance of "transmural tethering" (or restriction of nonischemic epicardial motion) during acute ischemia remains in dispute. Long term changes in surviving muscle layers over subendocardial infarction have not been investigated at all.

Transmural function at the lateral ischemic boundary. Nonischemic regional dysfunction has been conclusively demonstrated at the lateral boundaries of an ischemic area (24,25,26,27,28,29). The perfusion boundary between ischemic and nonischemic myocardium is sharply delineated (30,31,32). Mechanical dysfunction extends beyond the perfusion boundary into nonischemic territory forming a less sharply delineated transition area defined in terms of contractile function (or "functional border zone"). Based on wall thickening measurements made with sonomicrometers, left circumflex occlusion produces a narrow functional border zone that is less than 1 cm in width at the endocardium (27,28). Left anterior descending occlusion, however, produces a wider zone of dysfunction that extends 2 cm or more into nonischemic myocardium (33). Data distributions and sigmoid curve fits (used to model the distribution of functional impairment) from experiments involving left

anterior descending and circumflex coronary occlusions are shown in Figure 2 to illustrate the striking difference in extent of nonischemic dysfunction. The sigmoid curves are shown with dashed lines and the shaded areas represent the "functional border zone" produced by coronary occlusion.

With other measurement techniques, however, different estimates of the size and severity of the functional border zone have been made (26). Controversy also persists regarding the mechanism of nonischemic dysfunction and to what extent the functional border zone can be changed with hemodynamic or pharmacologic interventions. The extent to which disparities depend on technical aspects of different modalities will have to be clarified before functional measurements can be used to reliably establish the boundaries of ischemic or infarcted myocardium in clinical settings.

Conclusion. Wall thickening is a useful parameter of regional contractile function. It correlates closely and directly with changes in mean transmural and subendocardial blood flow within an ischemic area, providing an effective index of regional oxygen supply-demand status in the myocardium. At the subepicardial and lateral margins of ischemic myocardium, nonischemic dysfunction has been described with wall thickening measurements and other parameters of regional function. The usual conventions of flow-function relations, determined for the central ischemic area, are not easily applied in these areas. Attributed frequently to "tethering" (ischemically dysfunctional muscle restraining motion in adjacent, normally perfused muscle), the relative importance of nonischemic dysfunction is a disputed issue. Resolution of this and related flow-function issues will be necessary to justify the use of regional function as a key "end-point" parameter in clinical studies.

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