LEFT VENTRICULAR MURAL THROMBUS

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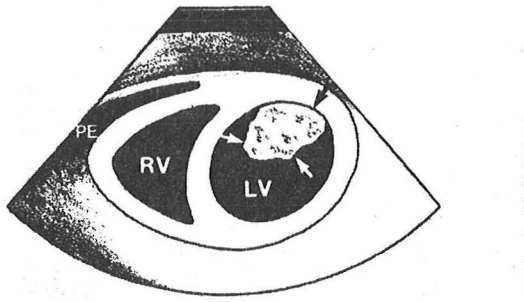

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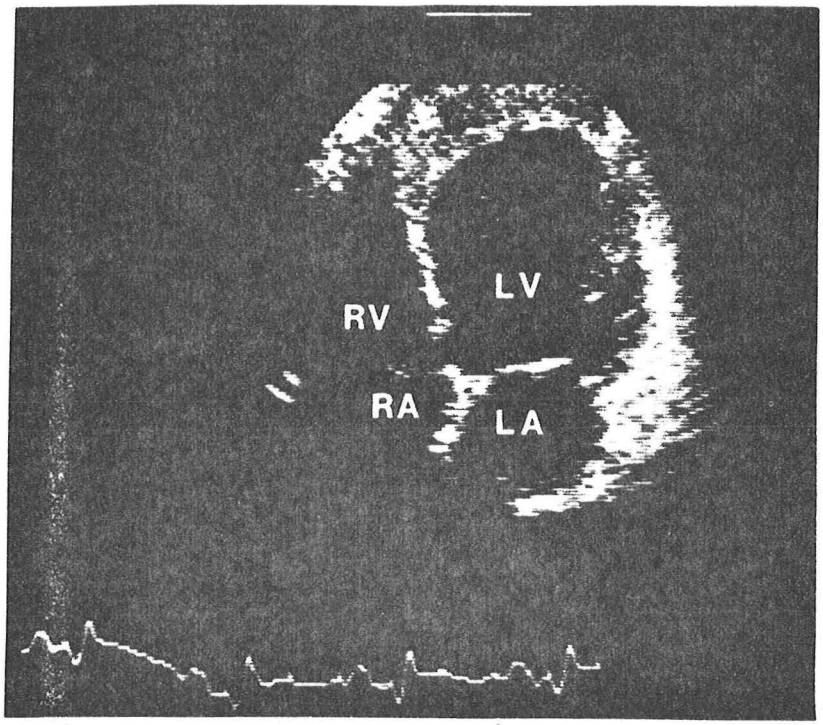

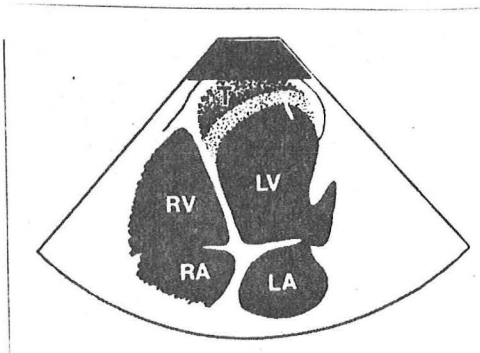

At the apex it was forming itself into a kind of aneurysm, becoming there very thin: that part was lined with a thrombus just the shape of the pouch in which it lay.

John Hunter, 1757

CONTENTS

Introduction

Mural thrombus of the left ventricle is a common post mortem finding in certain cardiac diseases. Until recently, however, its presence was apparent only if an embolic event occurred, or as a coincidental finding during contrast ventriculography at cardiac catheterization. Such circumstances have been frustrating for the clinical cardiologist because they can have a significant morbidity and occasional mortality. Furthermore, it has been known for several years that anticoagulant therapy for left ventricular thrombus produces a significant reduction in systemic embolism.

The advent of more sophisticated noninvasive diagnostic techniques utilizing radionuclides, computerized tomography and, in particular, two-dimensional echocardiography, has resulted in the identification of left ventricular mural thrombus prior to the occurrence of systemic embolization. As a result, considerable time has been given to its re-evaluation recently.

Because left ventricular mural thrombus is associated with conditions such as ventricular aneurysm, acute myocardial infarction and congestive cardiomyopathy, and because its management involves the use of anticoagulants, a comprehensive review incorporates partial overlap into these areas. The following represents a review of the clinical entity of left ventricular mural thrombus as it stands today, with some comments on the optimal method of diagnosing its existence and on the necessity for treatment.

Incidence

Because left ventricular mural thrombus is invariably associated with disease involving the endocardium and/or myocardium of the left ventricle, and because the management of these different diseases has changed over the years, the precise incidence of left ventricular thrombus in 1982 is difficult to determine. Furthermore, techniques of diagnosis have become much more sophisticated in the past few years. In determining the incidence of left ventricular thrombus, not only the method of detection but also the associated clinical circumstance must be taken into account.

Table 1 is a list of the associated diseases and clinical states, primarily cardiovascular, with which left ventricular thrombus has been associated.[1-14] Consideration today will be confined to the more common conditions associated with mural thrombus, i.e., left ventricular aneurysm, acute myocardial infarction, and congestive cardiomyopathy.

Table 1. Diseases and clinical states associated with left ventricular mural thrombus.

Acute myocardial infarction
Left ventricular aneurysm
Congestive cardiomyopathy (including alcoholic)
Blunt chest trauma
Systemic Lupus Erythematosus
Carcinoid heart disease
Postpartum heart disease
Chagas' disease
Beri-beri
Amyloidosis
Infectious myocarditis
Endomyocardial fibrosis
Becker's disease
Löffler's disease
Sarcoidosis
Endomyocardial biopsy
Diverticulum of the left ventricle
Agnogenic myeloid metaplasia

From references 1-14

The earliest reports of a ventricular aneurysm were published in 1757 by Dominicus Galeati and John Hunter.[15,16] Hunter, in describing a heart, said, "At the apex it was forming itself into a kind of aneurysm, becoming there very thin: that part was lined with a thrombus just the shape of the pouch in which it lay." Cumulative autopsy studies show the incidence of left ventricular aneurysm to be approximately 2 per cent of the general autopsy population and approximately 20 per cent of patients with acute myocardial infarction.[3,17-20] Table 2 lists the frequency of left ventricular thrombi seen at post mortem. The incidence ranges from 14 to 74 per cent, with a mean of 46 per cent. It is clear from the table, however, that the specific pathological association and especially the existence of left ventricular aneurysm is related to the frequency with which the observation was made. Furthermore, Parkinson and Bedford wrote in 1938 that early figures underestimated the frequency of left ventricular aneurysms and thus, mural thrombus at autopsy.[24]

Table 2. Incidence of left ventricular thrombus in autopsy reports.

	Specific path association	Per cent
Garvin (1941)[1]	Heart disease	74
Hellerstein and Martin (1947)[21]	Myocardial infarction	45
Jordan et al (1952)[2]	Myocardial infarction	33
Phares et al (1953)[17]	LV aneurysm	68
Schlister et al (1954)[3]	LV aneurysm	54
Elster et al (1955)[17a]	Cardiomyopathy	50
Fowler et al (1961)[17b]	Cardiomyopathy	28
Abrams et al (1963)[18]	LV aneurysm	14
Dubnow et al (1965)[19]	LV aneurysm	65
Davis and Ebert (1972)[20]	LV aneurysm	44
Roberts and Ferrans (1975)[22]	Cardiomyopathy	47
Cabin and Roberts (1980)[23]	LV aneurysm	39

The next table suggests that this may still be the case.

Table 3 lists the few clinical studies that have attempted to determine the incidence of left ventricular thrombus. The frequency with which the surgeon notes the existence of mural thrombus at left ventricular aneurysmectomy ranges from 50 to 70 per cent. With one exception, these data would appear to be consistent with the published autopsy data of patients with left ventricular aneurysms concerning the frequency of mural thrombus.

The paucity of data in patients with acute myocardial infarction regarding the incidence of mural thrombus is also shown in Table 3. For the present, the frequency with which left ventricular thrombus can be diagnosed ranges from 10 to 41 per cent, depending upon the technique used for diagnosis. Furthermore, the relative sensitivities and specificities of the various diagnostic techniques must be taken into account. I shall return to this later.

Table 3. Incidence of left ventricular thrombus in clinical reports.

	Identification	Per cent
In left ventricular aneurysm		
Cooley and Hallman (1968)[25]	Surgery	95
Favaloro et al (1968)[26]	Surgery	50
Kluge et al (1971)[27]	Surgery	69
Loop et al (1973)[28]	Surgery	53
Swan et al (1978)[29]	Surgery	53
Simpson et al (1980)[30]	Surgery	66
Reeder et al (1981)[31]	2DE	48
In acute MI		
Hamby et al (1974)[32]	Angiography	10
DeMaria et al (1979)[33]	2DE	20
Asinger et al (1981)[34]	2DE	37
Visser et al (1982)[35]	2DE	19
McEntee et al (1982)[36]	2DE	18
Ezekowitz et al (1982)[37]	Indium-III	41
In congestive cardiomyopathy		
Gottdiener et al (1982)[38]	2DE	36

Little detail is available on clinical studies of the incidence of mural thrombus in patients with congestive cardiomyopathy. An incidence of 36 per cent reported in an abstract recently is less than the approximately 42 per cent reported from autopsy studies.[17a,17b,22,38]

Thus, the overall incidence of left ventricular mural thrombus is approximate. The surgical data would appear to be the most reliable regarding its incidence of between 50 and 70 per cent

in patients with left ventricular aneurysms. The frequency of 10 to 40 per cent in patients with an acute myocardial infarction would appear to be an underestimate.

Pathology

A discussion of the pathological aspects of left ventricular mural thrombus is in essence a discourse on the pathological states that result in the formation of mural thrombus of the left ventricle. As Table 1 shows, a detailed review of the cardiac pathology of all the conditions associated with left ventricular thrombus would be inappropriate. Thus, discussion is confined to the more common conditions associated with mural thrombus. Details regarding the rest may be obtained from the references at the end of the text.

In our patient populations, the most common circumstances under which left ventricular mural thrombus is seen are the so-called "dyskinetic states" of the left ventricle that are seen in coronary artery disease. These all occur as a consequence of myocardial infarction, and may be encountered clinically in the chronic state as a left ventricular aneurysm or in the acute state as a complication of an acute myocardial infarction. Other causes of left ventricular aneurysm have been listed elsewhere.[4,7,8,12,22]

Jordan and colleagues in 1952 reported that factors increasing the incidence of left ventricular thrombi included the time of occurrence, the site and the size of the infarction.[2] An acute infarction involving a large portion of the anterior left ventricular wall carries the greatest risk of thrombus formation. Recent clinical studies have been confined to acute transmural infarctions, presumably on the assumption that a subendocardial myocardial infarction does not produce a so-called "dyskinetic state." Studies in our laboratory illustrating an absence of abnormal wall motion detected by two-dimensional echocardiography in patients with subendocardial infarctions would appear to confirm this assumption.[39]

Thus, the person at greatest risk for the development of a left ventricular mural thrombus is one who has had a large, recent, anterior transmural myocardial infarction. The same individual is also at risk to progress to a left ventricular aneurysm, more than 60 per cent of which involve the anterior with or without the apical segments of the left ventricular wall.[3]

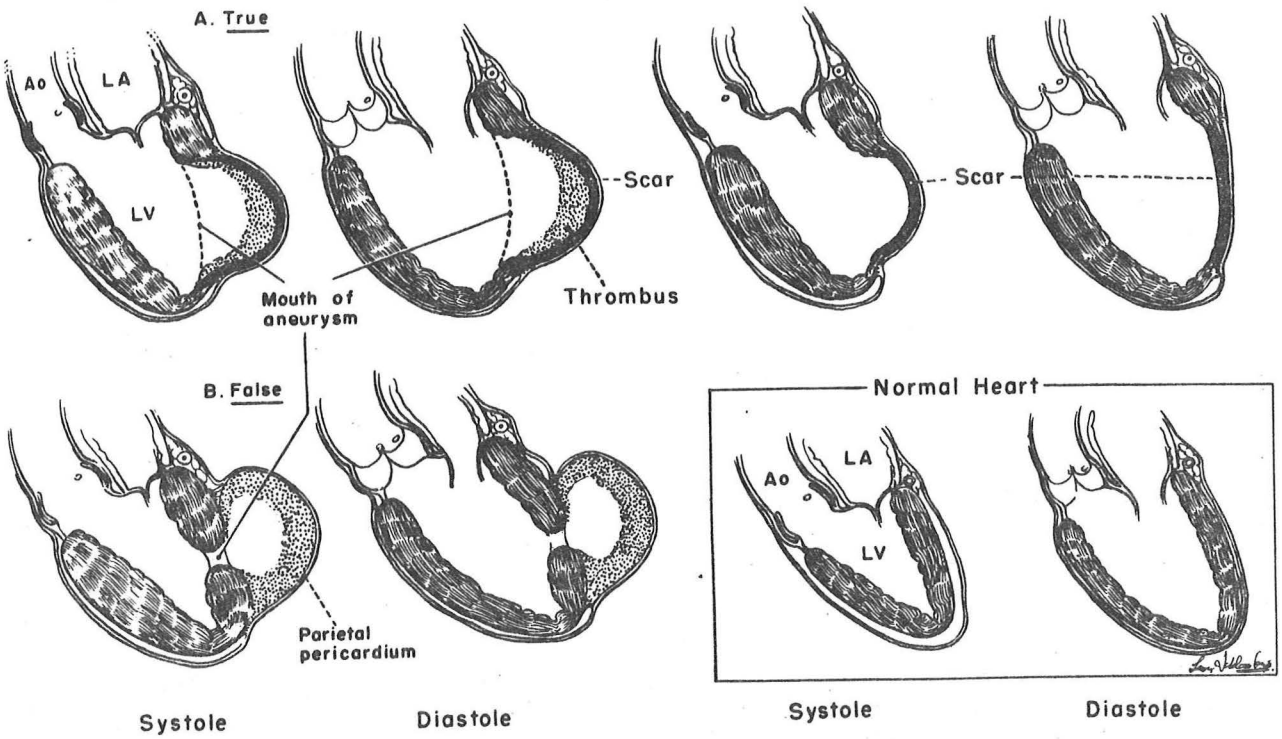

Figure 1. Diagrams of hearts in systole and diastole with true and false anatomic, and functional left ventricular aneurysms and healed myocardial infarction. A diagram of the normal heart in systole and diastole are shown for comparison. (From Cabin and Roberts.[40])

Cabin and Roberts have suggested the following definition of *a left ventricular aneurysm as a localized cavitary (other than when filled with thrombus) protrusion of the left ventricular wall.*[40] They further recommend the distinction between *anatomic* and *functional* as shown in Figure 1. The figure illustrates *a true anatomic aneurysm* which protrudes during both systole and diastole, has a mouth that is as wide or wider than the maximum diameter of the aneurysm, has a wall that was formerly the wall of the ventricle, and is composed of fibrous tissue with or without residual myocardial fibers. This is in contrast to a false anatomic aneurysm, or *pseudoaneurysm,* which protrudes during both systole and diastole, has a mouth that is considerably smaller than the maximum diameter of the aneurysm and represents a myocardial rupture site, has a wall that is made up of parietal pericardium, and never contains myocardial fibers, virtually always contains thrombus, and often ruptures. A true aneurysm may or may not contain thrombus and almost never ruptures once the wall is healed. The *functional left ventricular aneurysm* protrudes during ventricular systole but not diastole, and consists of fibrous tissue with or without myocardial fibers.

A further distinction between these two types may be made during dynamic observation, at angiography, scintigraphy, two-

dimensional echocardiography, or surgery. An anatomic aneurysm appears as a localized protrusion of the left ventricular wall during diastole, and during systole the aneurysm may not move at all (akinesia) or may protrude even further than in diastole (dyskinesia). A functional aneurysm conversely protrudes only during systole (dyskinesia).

In the same study, Cabin and Roberts attempt to explain why the frequency of systemic embolization is higher in patients with a congestive cardiomyopathy than in patients with a left ventricular aneurysm.[40] The explanation is illustrated in Figures 2 and 3. They suggest that in patients with a dilated cardiomyopathy, portions of left ventricular thrombi frequently embolize because they over-lie areas of contracting myocardium, have a relatively small area of attachment to the ventricular wall, and protrude into the intraventricular cavity, thus exposing the thrombus continuously to blood flow. Conversely, intraaneurysmal thrombus embolizes relatively infrequently because of its location in a portion of the ventricular wall which does not contract normally, thus propelling its contents towards the outflow tract, due to the paucity of myocardial contractile fibers. Further, more of the surface of the thrombus is attached to the ventricular wall, and the thrombus does not protrude into the ventricular cavity.

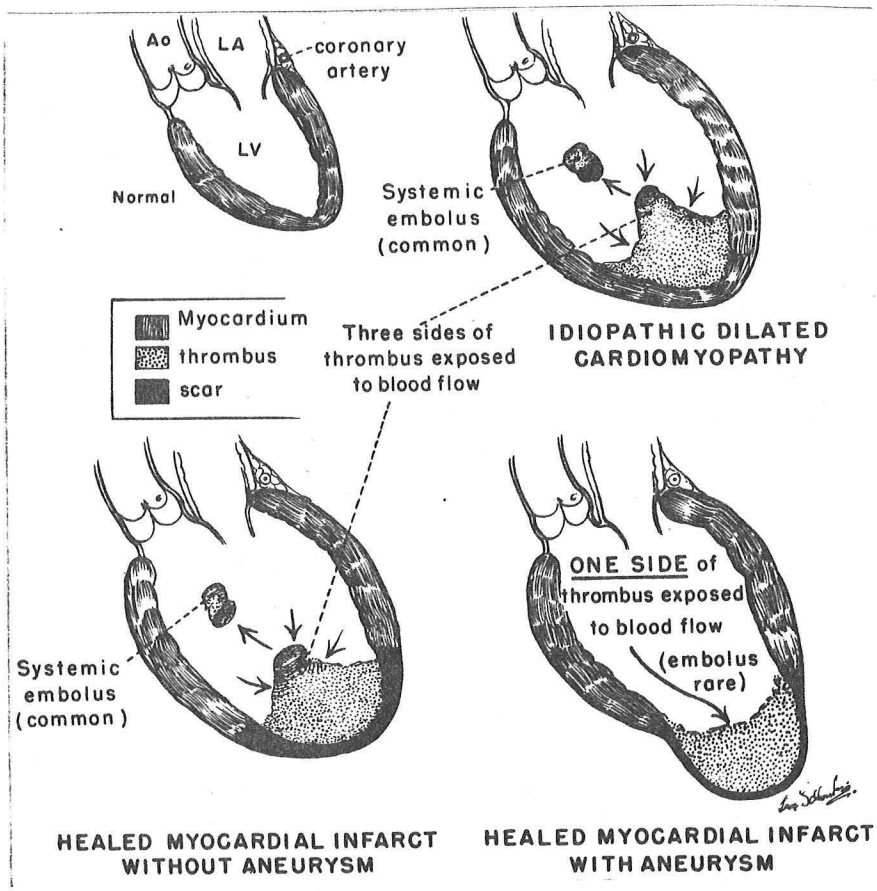

Figure 2. Diagrams of hearts with congestive (ideopathic dilated) cardiomyopathy, healed myocardial infarction without aneurysm, and healed myocardial infarction with aneurysm. The left ventricle in each contains thrombus. A diagram of a normal heart is shown for comparison. (from Cabin and Roberts[40]).

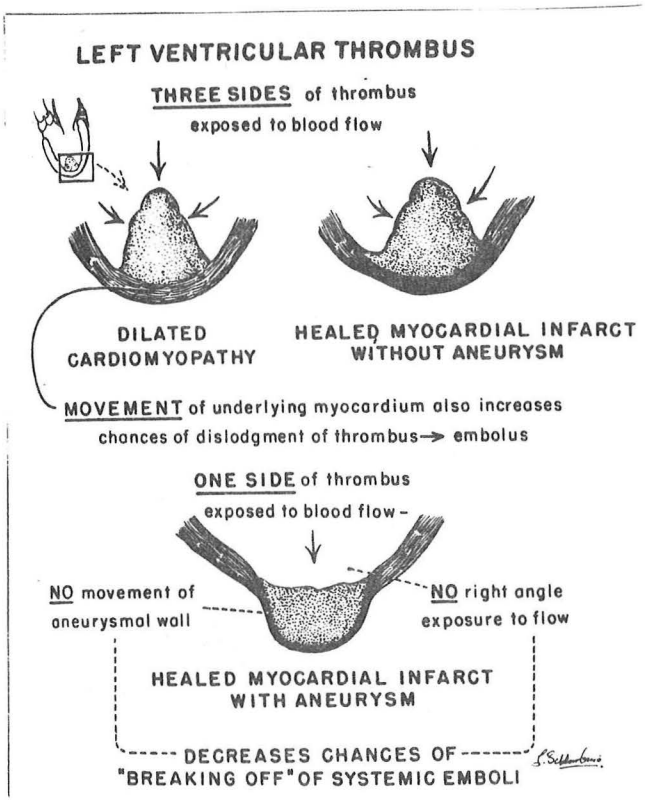

Figure 3. Close-up views of the apical positions of the heart shown in Figure 2 (from Cabin and Roberts[40]).

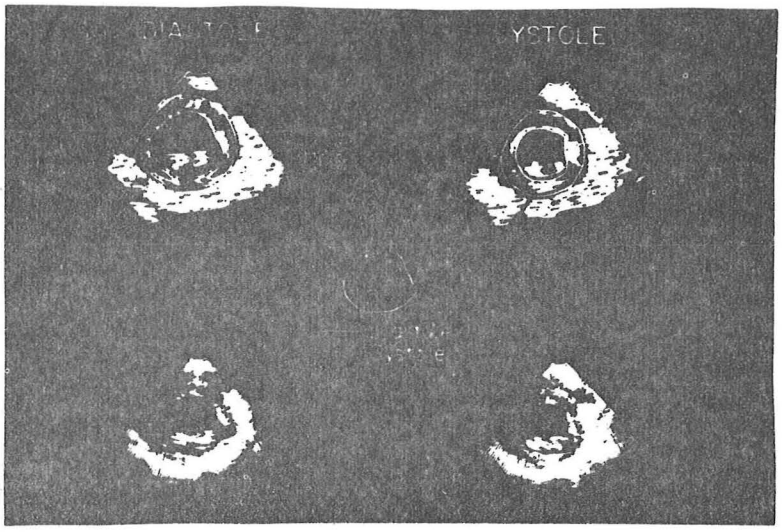

Figure 4. Short-axis, two-dimensional echocardiographic views of a patient with an acute anterolateral myocardial infarction. The upper drawings are schematic representations of the end-diastolic and end-systolic frames shown at the lower left and right. The central line drawing shows regional myocardial dilatation in the upper right quadrant, particularly in systole (from Nixon et al[39]).

The pathogenesis of a left ventricular aneurysm has only recently been clarified.[41] Previously, some investigators had suggested that an aneurysm forms late after infarction due to stretching of the scar, while others felt that the thin, acutely infarcted wall dilates early and scar tissue forms with the dilatation.[42] Early infarct expansion during the acute phase of myocardial infarction has been documented by serial noninvasive studies in laboratories including our own.[39,43] Figure 4 is an example of this phenomenon in a patient who has suffered an anterior myocardial infarction.

Hackman and Bulkley used a rat model to determine the true course of changes in left ventricular shape early and late after myocardial infarction induced by left coronary arterial ligation.[41] Figure 5 illustrates the relationship between aneurysmal shape changes and time after onset of myocardial infarction. The study shows the left ventricular aneurysmal shape changes precede the laying down of scar tissue in the myocardium. The shape changes occur within the first five days post infarction, without significant changes in shape thereafter. An incidental result of the study was that induction of a transmural myocardial infarction was necessary for aneurysm formation.[44]

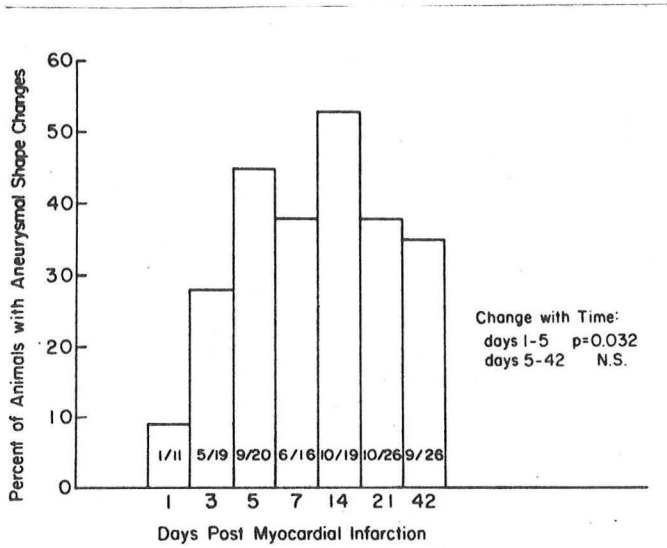

Figure 5. Relationship of prevalence of aneurysmal shape changes to time after myocardial infarction. The numbers in the bars represent changes/total number of transmural infarcts at that time after ligation. The increase in shape changes from days 1 to 5 is significant, with no significant change thereafter (from Hackman and Bulkley[44]).

The importance of this latter study is that it may now be possible by one single noninvasive study early after hospital admission to predict which patients with larger, anterior transmural myocardial infarctions go on to develop left ventricular aneurysms and are thus at risk for the development of mural thrombus.

Recently, it has been shown that unstable angina may now be included in the general category of a dyskinetic state. In patients whose chest pain is relieved by conventional medical means, left ventricular segmental wall motion abnormalities identified by two-dimensional echocardiography may persist after unstable angina.[45] It is not known whether this particular dyskinetic state is associated with thrombus formation.

Clinical Features

For many years, attention was called to the presence of left ventricular mural thrombus by its morbid sequelae, i.e., the development of arterial embolic phenomena. Only in the last few years with the availability of more sophisticated noninvasive techniques has it been possible to diagnose the existence of mural thrombus and instigate treatment prior to the development of its sequelae.

The classical clinical features of the disease states associated with left ventricular thrombus, and listed in Table 1, and in particular acute myocardial infarction, left ventricular aneurysm, and congestive cardiomyopathy, may be found elsewhere. It is my intention to evaluate the various diagnostic techniques currently available as objectively as possible and make recommendations regarding therapy as a result of the studies performed utilizing these new techniques.

Diagnosis

Contrast Angiography

Left ventricular contrast cineangiography is currently considered to be the clinical gold standard for the diagnosis of left ventricular aneurysm.[46] For several years, the accuracy of cineangiography in the identification of left ventricular mural thrombus lay in doubt. In 1974, Hamby et al attempted to answer this question.[32] Figure 6 shows a typical example of a mural thrombus identified by cineangiography from this study. Compared to autopsy and surgical reports, an overall incidence of 10 per cent in this study is quite low even when only taking patients with previous myocardial infarctions into account. Only 7 of the 22 patients studied by angiography went to surgery, and left ventricular thrombus was found in all 7 patients. However, they emphasize that the true incidence of mural thrombus is probably higher than noted in their study. This latter observation was also made by Swan and colleagues in their review of the management of left ventricular aneurysm.[29]

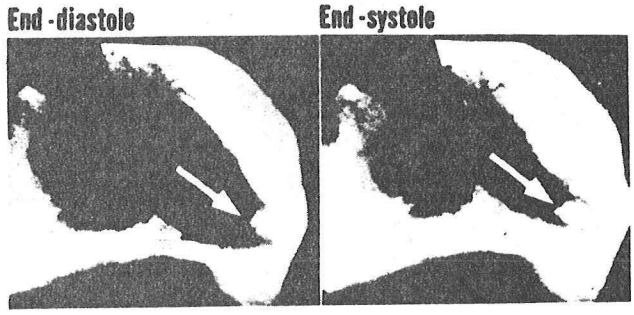

Figure 6. The right anterior oblique projection of a left ventricular cineangiogram at end-diastole and end-systole. The arrow indicates a distinct apical filling defect.

Reeder and his colleagues at the Mayo Clinic have addressed this question recently.[37] They surveyed 100 cases undergoing aneurysmectomy. An angiographic filling defect identified as mural thrombus was noted in 28 patients. Of these 28 patients, 15 had confirmation of the presence of thrombus at surgery. Furthermore, of the 72 patients who had no filling defects identified at angiography, 33 were found to have thrombus present at surgery. Thus, in this study for the accuracy with which left ventricular mural thrombus may be detected, the cineangiogram has a sensitivity of 31 per cent, a specificity of 75 per cent, and a predictive accuracy of 54 per cent. A second study by the same group involving patients with congestive cardiomyopathy, healed myocardial infarction, or left ventricular aneurysm showed the predictive accuracy of the angiogram to be 57 per cent.[47] These relatively low predictive values would suggest that contrast angiography is not the ideal diagnostic technique for the diagnosis of left ventricular thrombus.

Two-dimensional echocardiography

It is the advent of two-dimensional echocardiography that is primarily responsible for converting left ventricular mural thrombus from a morphological to a clinical entity.

The value of two-dimensional echocardiography in the identification of the dyskinetic states of left ventricular aneurysm,[48] chronic ischemic heart disease,[49] and acute myocardial infarction[39] are well accepted. In a recently published study of 422 patients from Amsterdam, two-dimensional echocardiography has a sensitivity of 93 per cent and a specificity of 94 per cent compared to angiography in the diagnosis of left ventricular aneurysm.[50]

After early case reports of mural thrombus in patients with left ventricular aneurysm,[51,52] after acute myocardial infarction,[53] and in congestive cardiomyopathy,[54] further studies attempting to define the incidence of left ventricular thrombus formation in differing clinical settings and the sensitivity and specificity of the technique have been carried out. Figure 7 shows an example of a left ventricular aneurysm lined with mural thrombus identified by two-dimensional echocardiography.

The incidence of left ventricular thrombus detected by this technique has already been discussed previously. Table 4 lists the studies attempting to define the sensitivity and specificity of two-dimensional echocardiography in diagnosing mural thrombus. It should be pointed out that only studies using post mortem and/or surgery for comparison have been included. The mean values for the technique are a sensitivity of 75 per cent,

a specificity of 87 per cent, and a predictive accuracy of 84 per cent, which represent an improvement over cineangiography, but problems of false positive and false negative results remain.

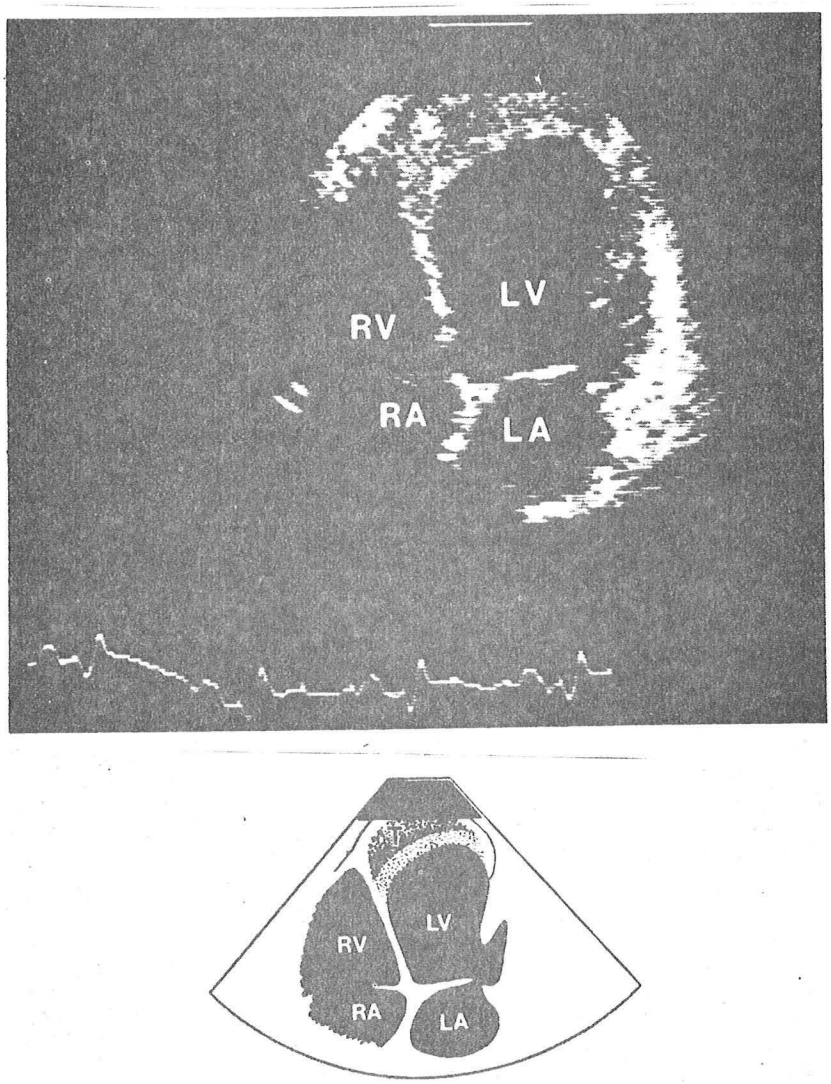

Figure 7. Apical, four-chamber, two-dimensional echocardiographic view of a left ventricular (LV) aneurysm with layered mural thrombus (T) (from Asinger et al[58]).

Table 4. Studies defining sensitivities, specificities, and predictive accuracy of two-dimensional echocardiography in the diagnosis of left ventricular mural thrombus.

Author	*n*	sens	spec	pred. accuracy
Risser, 1981[55]	86	50	95	64
Reeder, 1981[47]	14	100	50	79
Starling, 1982[56]	18	60	100	100*
Ezekowitz, 1982[37]	53	77	96	91
Stratton, 1982[57]	78	86	95	86
Range		50-100	50-100	64-100
Mean		75	87	84

*This is the only study that reported no false positive diagnoses.

Asinger and his colleagues addressed the question of false positive findings on echocardiography.[58] In reviewing 25 cases of left ventricular thrombus identified by echocardiography and confirmed by other means, they suggest that the number of false positive results may be reduced or abolished by identifying the features listed in Table 5. The serial identification of an acoustically distinct echo mass that has a margin distinct from the ventricular wall and an intracavitary margin with free motion, has an apical location and is associated with a wall motion abnormality is likely to be a mural thrombus. Starling's study included in Table 4 shows that careful observation and study may rule out false positive diagnoses.[56]

Table 5. Two-dimensional echocardiographic features of left ventricular mural thrombus.

1. Associated wall motion abnormality
2. Apical location
3. Distinct thrombus margin
4. Acoustically distinct from myocardium
5. Free motion of an intracavitary thrombus margin
6. Variation noted on serial examination

From Asinger et al.[58]

The same group also addressed the issues of whether thrombus size and thrombus age affected the incidence of false negative results.[59] They showed in a series of animal experiments that the tissue acoustic properties of recently formed thrombus are not a limitation to their echocardiographic detection. However, they did find that mural thrombi less than 6 mm in diameter were difficult to detect. There is no doubt that thrombi of greater than 1 cm in diameter are more easily diagnosed with certainty.[57]

Radionuclide scintigraphy

It is apparent that if left ventricular mural thrombus can be identified by contrast cineangiography, then it may be identified by radionuclide scintigraphic studies. It would also be reasonable to suggest that, as the techniques are similar from a diagnostic point of view, their respective sensitivities and specificities would be close. Stratton and his colleagues in Seattle reevaluated the multiple gated acquisition (MUGA) scintigrams of 39 patients with proven left ventricular mural thrombus.[60] An example of one study is shown in Figure 8. Their data show that gated scintigraphy has a sensitivity of 62 per cent and a specificity of 92 per cent for the diagnosis of mural thrombus, findings very similar to those for contrast angiography.

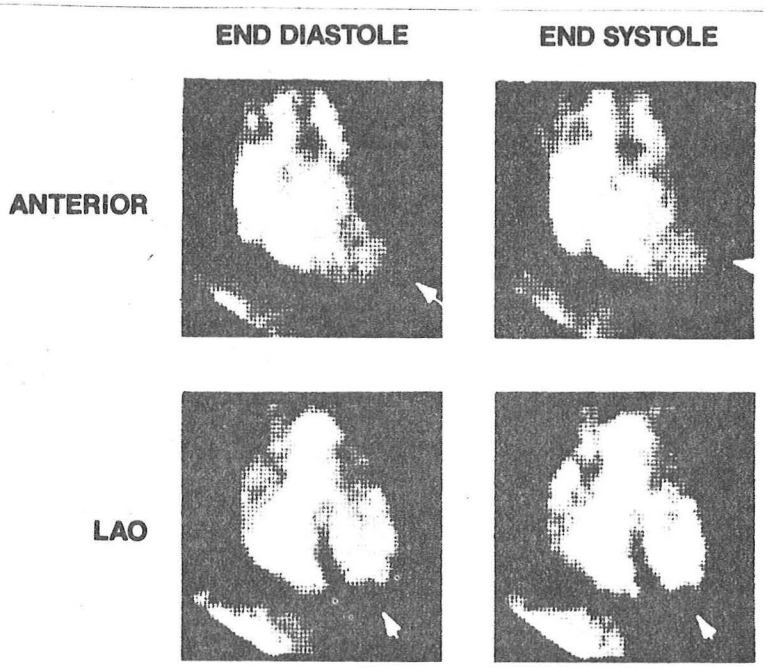

Figure 8. Filling defects seen at both end-diastole and end-systole in the anterior and left anterior oblique (LAO) views of a radionuclide MUGA scintigram of a patient with left ventricular mural thrombus.

Starling and his colleagues, in the study listed in Table 4, combined two-dimensional echocardiographic and radionuclide scintigraphic study data to show that the combined techniques have a sensitivity of 80 per cent and specificity of 100 per cent, data that are better than the individual techniques separately.[56]

Indium-III labelled platelets

Indium-III is a radionuclide that is an effective platelet label, and thus may be used for the detection of hematologically active vascular thrombi.[61] In a preliminary report, Ezekowitz and his colleagues showed that indium-III cardiac scintigraphy is feasible and is a capable and reliable method of identifying left ventricular mural thrombus.[62] Figure 9 is an example of a positive indium-III scintigram. The sensitivity and specificity of this technique for the diagnosis of mural thrombus have also been examined by Ezekowitz and his group.[37] In a study of 53 patients with left ventricular aneurysms and the confirmed presence of left ventricular thrombus, the sensitivity was 71 per cent and the specificity was 100 per cent with a predictive accuracy of 100 per cent. These data have been confirmed by Stratton et al.[57]

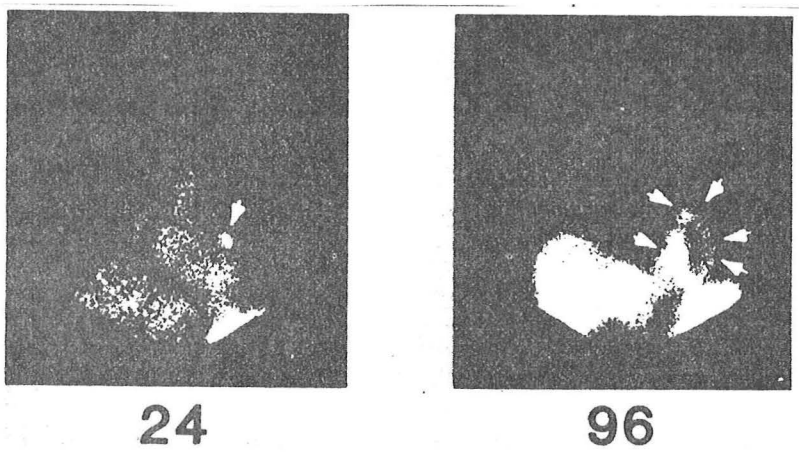

Figure 9. A positive indium-III platelet anterior view scan for left ventricular mural thrombus. Twenty-four hours after injection of labelled platelets, cardiac blood pool activity is seen clearly; an area of increased activity is present in the middle of the anterior scan denoting thrombus. At 96 hrs cardiac blood pool activity decreases and intense platelet deposition throughout a large apical thrombus is seen (from Stratton et al[57]).

Thus there are no false positive diagnoses by this technique. A possible explanation for the false negative results may be the presence of hematological inactive mural thrombi, particularly in patients with left ventricular aneurysms. Ezekowitz et al conclude that indium scintigraphy, which has the better specificity and two-dimensional echocardiography, which has the better sensitivity, should be utilized in combination to identify left ventricular mural thrombus.[37] Unfortunately, they did not combine the results of their study to determine overall sensitivity, their specificity known to be 100 per cent.

Computerized tomography

Filling defects in the left ventricular cavity have been identified as mural thrombus in a few preliminary reports of computerized tomography.[63-65] Figure 10 is an example. Tomoda and colleagues[63] and Nair et al[64] both identified 3 cases of proven left ventricular thrombi by this technique. Nair and his colleagues felt that the advantages of the technique are that it has a high degree of reproducibility, requires minimal technical skill, and may be performed rapidly.[64] The disadvantages are primarily the degradation of the image over three minutes and the necessity to gate the imaging to the cardiac cycle. The sensitivity, specificity, and predictive accuracy of this technique are necessary for a complete evaluation of the technique.

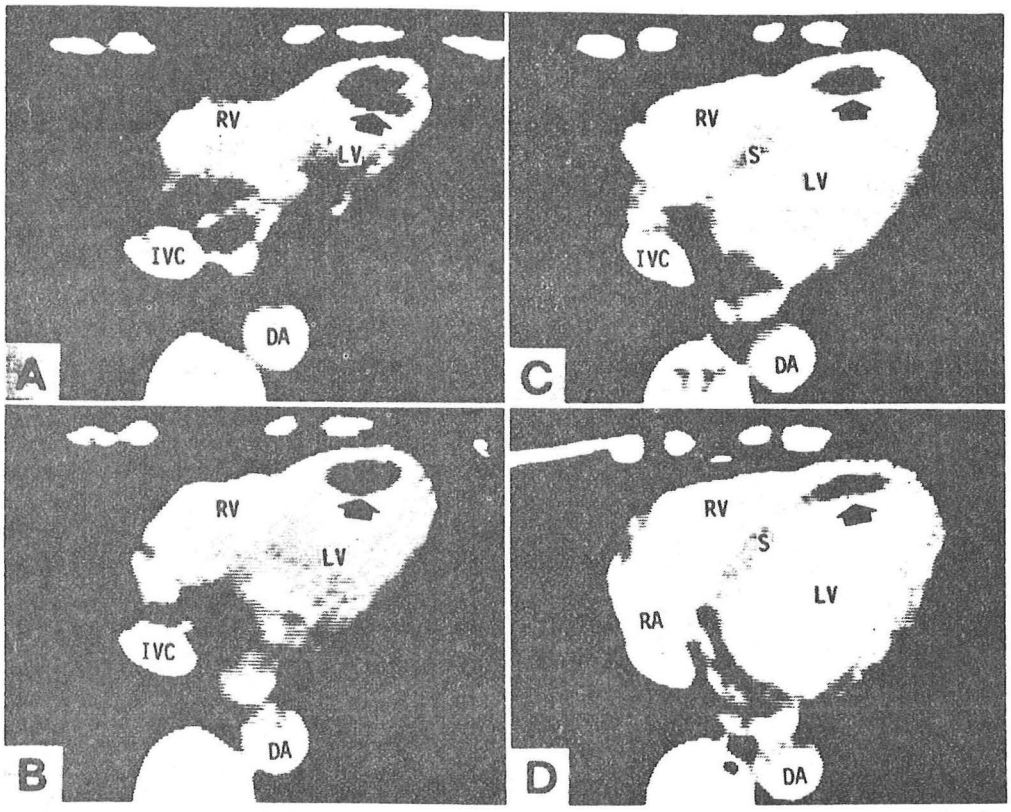

Figure 10. Computerized tomograms at different levels showing a 1.4x2.5x2.6 cm mural thrombus in the apical area of the left ventricle (LV). (From Tomoda et al[63]).

Arterial Embolization

A significant complication of chronic ischemic heart disease, acute myocardial infarction, and congestive cardiomyopathy is the occurrence of arterial embolization. Table 6 shows the cumulative incidence of systemic emboli from available autopsy and clinical studies in these three clinical settings.

Table 6. Incidence of systemic embolization in patients with left ventricular mural thrombus.

	Diagnosis	Per cent range
Left ventricular aneurysm	Autopsy	4-52
	Clinical	0-36
Myocardial infarction	Autopsy	34-56
	Clinical	0-24
Congestive cardiomyopathy	Autopsy	17-40
	Clinical	11

In left ventricular aneurysm, the autopsy incidence ranges from 4 to 52 per cent [3,17-20,40] and the clinical incidence from 0 to 36 per cent. [20,25-28,30,32,57,60,66,67] Reeder et al [31] have suggested that the higher incidence found at autopsy is due to clinically silent embolic events only discovered at post mortem examination. In acute myocardial infarction, the incidence at autopsy ranges from 34 to 56 per cent, [21,68] compared to the clinical incidence from 0 to 24 per cent. [34-36,66,69] The autopsy studies were both done in the era prior to anticoagulation, coronary care units, and early mobilization following myocardial infarction. These factors coupled with the incidence of silent embolic episodes no doubt explains the discrepancy in these numbers. Abelmann states that thrombo-embolic complications are frequent in patients with chronic congestive cardiomyopathy. [70] Autopsy studies would tend to confirm this, reporting incidences of 17-40 per cent. [17a,17b] Regan and colleagues have reported that thromboembolic phenomena occur in 80 per cent of patients with alcoholic cardiomyopathy. [11] It should be borne in mind that the source of embolic phenomena in patients with congestive cardiomyopathy is not confined to the left ventricle.

In summary, although the clinical incidence of systemic embolization in patients with left ventricular mural thrombus identified with left ventricular aneurysm, acute myocardial infarction and congestive cardiomyopathy is less than the post mortem incidence,

it is nevertheless sufficiently frequent to warrant the clinical evaluation of such patients for the diagnosis of left ventricular thrombus to determine which patients require anticoagulation.

Recently, the issue of whether patients with episodes of focal cerebral ischemia or stroke should undergo evaluation to rule out left ventricular mural thrombus has been addressed.[71,72] Both studies concluded that in the absence of other clinical evidence of cardiac disease, routine investigation by techniques such as two-dimensional echocardiography is not warranted.

Anticoagulation

The use of anticoagulants in patients with left ventricular aneurysms and mural thrombus continues to be debated. There is no doubt that the incidence of left ventricular mural thrombus is high in patients with left ventricular aneurysms. Furthermore, it has been shown recently that the aneurysm *per se* does not affect the patient's survival rate.[73] Thus, the value of anticoagulants must be balanced against the comparatively low incidence of embolic sequelae of mural thrombus. Both Simpson et al[30] and Cabin and Roberts[40] in studies of small numbers of patients with left ventricular aneurysms suggest that long term use of anticoagulants is unnecessary. However, both groups ignore the fact that their respective incidences of emboli are low compared to other studies of larger numbers of patients. Reeder and colleagues[31] illustrate in Figure 11 the effects of long term anticoagulation on the presence of left ventricular mural thrombi showing a lower incidence of thrombus with a longer period of anticoagulation. They suggest that long term anticoagulation is beneficial. Until a prospective randomized trial of patients with aneurysm and mural thrombus is conducted, the value of anticoagulation will remain uncertain.

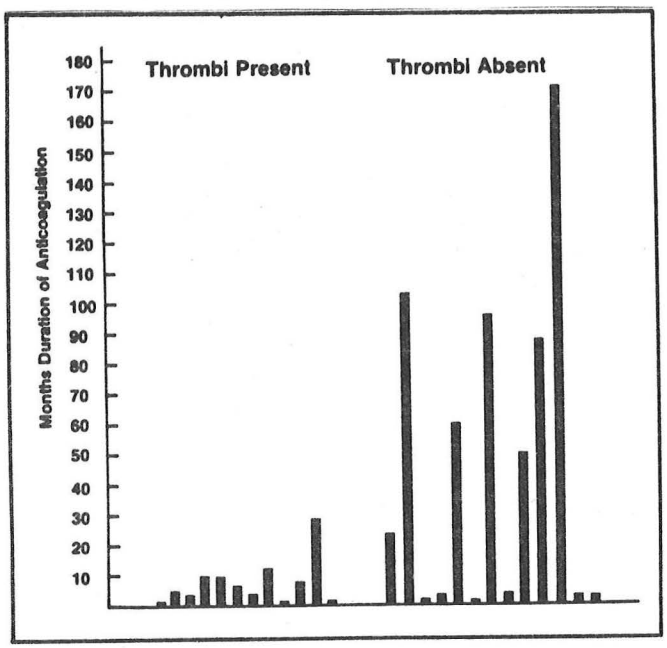

Figure 11. Relationship of left ventricular mural thrombus and duration of anticoagulation in patients with left ventricular aneurysm. From Reeder et al.[31]

Despite decades of debate, the results of the treatment of acute myocardial infarction with anticoagulants remains inconclusive. Several studies have shown that anticoagulants have no effect on mortality after infarction.[75-76] However, all these studies have shown a significant reduction in the incidence of arterial emboli phenomena in the anticoagulated group. Several recent serial two-dimensional echocardiographic studies have

shown that left ventricular mural thrombus may appear or may dissolve during anticoagulant administration.[34,35,47,57,60,69] Nevertheless, it would seem appropriate in patients with large, acute, transmural, anterior myocardial infarctions to examine for the presence of a left ventricular mural thrombus by an appropriate technique or series of techniques to determine which patients should be treated with anticoagulants.

The issue regarding anticoagulation in patients with congestive cardiomyopathy is more clear cut. The high incidence of thromboembolic phenomena in these patients dictates the administration of anticoagulants to all patients in this clinical setting who have no contraindications to their administration.

Summary

The following conclusions may be drawn from this review of the incidence, pathological and clinical circumstances, sequelae, and treatment of left ventricular mural thrombus.

1. The identification of mural thrombus in patients with left ventricular aneurysm and mural thrombus probably warrants long term anticoagulation. Surgical aneurysmectomy may rarely be necessary if anticoagulation fails to prevent recurrent emboli.

2. In patients with acute, large, anterior or antero-apical, transmural myocardial infarctions, serial noninvasive evaluations are warranted to define a group of patients at high risk for the development of left ventricular aneurysm and/or mural thrombus. Anticoagulants are indicated in patients who develop mural thrombus as a complication of their infarction.

3. Patients with congestive cardiomyopathy require long term anticoagulation, provided there are no contraindications to their administration.

References

1. Garvin CF: Mural thrombi in the heart. Am Heart J 21: 713, 1941.

2. Jordan RA, Miller RD, Edwards JE, Parker RL: Thromboembolism in acute and healed myocardial infarction. Circulation 6:1, 1952.

3. Schlichter J, Hellerstein HK, Katz LN: Aneurysm of the heart: a correlative study of one hundred and two cases. Medicine 33:43, 1954.

4. Davies JNP: Some considerations regarding obscure diseases affecting the mural endocardium. Am Heart J 59:600, 1960.

5. Woodward TE, Togo Y, Lee Y-C, Hornick RB: Specific microbial infections of the myocardium and pericardium. A study of 82 patients. Arch Intern Med 120:270, 1967.

6. Goodwin JF: Congestive and hypertrophic cardiomyopathies. Lancet 1:731, 1970.

7. Buja LM, Khoi NB, Roberts WC: Clinically significant cardiac amyloidosis. Am J Cardiol 26:394, 1970.

8. Bell WE, Ehmke DA: Diverticulum of the left ventricle in a child with fatal cerebral embolization. Southern Med J 64:537, 1971.

9. Brooksby IAB, Jenkins BS, Coltart DJ, Webb-Pebloe MM: Left ventricular endomyocardial biopsy. Lancet 4:1222, 1974.

10. Puigbo JJ, Valecillos R, Hirschhault E, Giordano H, Boccalandro I, Suarez C, Aparicio JM: Diagnosis of Chagas' cardiomyopathy. Noninvasive techniques. Postgrad Med J 53:527, 1977.

11. Regan TJ, Ettinger PO, Lyons MM, Moschos CB, Weisse AB: Ethyl alcohol as a cardiac risk factor. Cur Probl Cardiol 2:1, 1977.

12. Wynne JW, Ryerson GG, Dalovisio J: Myocardial sarcoidosis complicated by mural thrombosis. Thorax 34:127, 1979.

13. Kessler KM, Mallon SM, Bolooki H, Myerburg RJ: Pedunculated right ventricular thrombus due to repeated blunt chest trauma. Am Heart J 102:1064, 1981.

14. Baker KM, Hess CE, Ayers CR, Johns DW, Mentzer RM, Wellsons HA, Taylor GJ, Martin RP: Left ventricular mural thrombus in a patient with thrombocytosis and agnogenic myeloid metaplasia. Arch Int Med 141:1527, 1981.

15. Galeati DG: De bononiensi scientiarum et artium instituto atque academia commentarii. De morbis duobus. 4:26, 1757.

16. Hunter J: An account of the dissection of morbid bodys. A manuscript in the Library of the Royal College of Surgeons, London, 32:30, 1757.

17. Phares W, Edwards JE, Burchell HB: Cardiac aneurysms: clinicopathological studies. Mayo Clin Proc 28:264, 1963.

17a. Elster SK, Horn H, Tuchman LR: Cardiac hypertrophy and insufficiency of unknown origin. Am J Med 18:900, 1955.

17b. Fowler NO, Gueron M, Rowlands DT: Primary myocardial disease. Circulation 13:498, 1961.

18. Abrams DL, Edelist A, Luria MH, Miller AJ: Ventricular aneurysm. A reappraisal based on study of sixty-five consecutive autopsied cases. Circulation 27:164, 1963.

19. Dubnow MH, Burchell HB, Titus JL: Postinfarction ventricular aneurysm. A clinicopathological and electrocardiographic study of 80 cases. Am Heart J 70:753, 1965.

20. Davis RW, Ebert PA: Ventricular aneurysm. A clinicopathologic correlation. Am J Cardiol 29:1, 1972.

21. Hellerstein HK, Martin JW: Incidence of thromboembolic lesions accompanying myocardial infarction. Am Heart J 33:443, 1947.

22. Roberts WC, Ferrans VJ: Pathologic anatomy of the cardiomyopathies. Ideopathic dilated and hypertrophic types, infiltrative types and endomyocardial disease with and without eosinophilia. Human Path 6:287, 1975.

23. Cabin HS, Roberts WC: True left ventricular aneurysm and healed myocardial infarction. Am J Cardiol 46:754, 1980.

24. Parkinson J, Bedford OE: Cardiac aneurysms. Quart J Med 7:455, 1938.

25. Cooley DA, Hallman GL: Surgical treatment of left ventricular aneurysm: experience with excision of post-infarction lesions in 80 patients. Prog Cardiovasc Dis 11:222, 1968.

26. Favaloro RG, Effler DB, Groves LK, Westcott RN, Suarez E, Lozado J: Ventricular aneurysm - clinical experience. Ann Thorac Surg 6:227, 1968.

27. Kluge TH, Ullal SR, Hill JD, Kirth WJ, Gerbode F: Dyskinesis and aneurysm of the left ventricle. Surgical experience in 36 patients. J Cardiovasc Surg 12:273, 1971.

28. Loop FD, Effler DB, Navia JA, Sheldon WC, Groves LK: Aneurysms of the left ventricle: survival and results of a ten-year surgical experience. Ann Surg 178:399, 1973.

29. Swan HJC, Magnusson PT, Buchbinder MA, Matloff JM, Gray RJ: Aneurysm of the cardiac ventricle: its management by medical and surgical intervention. Western J Med 129:26, 1978.

30. Simpson MT, Oberman A, Kouchoukas NT, Rogers WT: Prevalence of mural thrombi and systemic embolization with left ventricular aneurysm: effect of anticoagulant therapy. Chest 77:463, 1980.

31. Reeder GS, Lengel M, Tajik AJ, Seward JB, Smith HC, Danielson GK: Mural thrombus in left ventricular aneurysm. Incidence, role of angiography and relation between anticoagulation and embolization. Mayo Clin Proc 56:77, 1981.

32. Hamby RI, Wisoff BG, Davison ET, Hartstein ML: Coronary artery disease and left ventricular mural thrombi: clinical, hemodynamic and angiocardiographic aspects. Chest 66:488, 1974.

33. DeMaria AN, Bommer W, Neumann A, Grehl T, Weinart L, DeNardo S, Amsterdam EA, Mason DT: Left ventricular thrombi identified by cross-sectional echocardiography. Ann Intern Med 90:14, 1979.

34. Asinger RW, Mikell FL, Elsperger J, Hodges M: Incidence of left ventricular thrombosis after acute transmural myocardial infarction: serial evaluation by two-dimensional echocardiography. N Engl J Med 305:297, 1981.

35. Visser CA, Kan G, Durrer D: Incidence and natural history of left ventricular thrombus during the first three days and four months after acute myocardial infarction (abstr). Circulation 64:IV-94, 1981.

36. McEntee CW, Van Reet CW, Winters WL, Nelson JG, Waggoner AD, Miller RR, Quinones MA: Incidence and natural history of mural thrombi in acute myocardial infarction by two-dimensional echocardiography (abstr). Circulation 64:IV-93, 1981.

37. Ezekowitz MD, Wilson DA, Smith EO, Burow RD, Harrison LH, Parker DE, Elkins RC, Peyton M, Taylor FB: Comparison of indium-III platelet scintigraphy and two-dimensional echocardiography in the diagnosis of left ventricular thrombi. N Engl J Med 306:1509, 1982.

38. Gottdiener J, VanVoorhees L, Gay J, DiBianco R, Fletcher R: Incidence and embolic potential of left ventricular thrombus in cardiomyopathy: assessment by two-dimensional echocardiography (abstr). Am J Cardiol 49:1029, 1982.

39. Nixon JV, Narahara KA, Smitherman TC: Estimation of myocardial involvement in patients with acute myocardial infarction by two-dimensional echocardiography. Circulation 62:1248, 1980.

40. Cabin HS, Roberts WC: Left ventricular aneurysm, intraaneurysmal thrombus and systemic embolus in coronary heart disease. Chest 77:586, 1980.

41. Hockman JS, Bulkley BH: Pathogenesis of left ventricular aneurysms: an experimental study in the rat model. Am J Cardiol 50:83, 1982.

42. Robbins SL, Cotran RS: Pathologic basis of disease. Philadelphia, WB Saunders, 657, 1979.

43. Eaton LW, Weiss JL, Bulkley BH, Garrison JB, Weisfeldt ML: Regional cardiac dilatation after acute myocardial infarction. Recognition by two-dimensional echocardiography. N Engl J Med 300:57, 1979.

44. Hockman JS, Bulkley BH: Expansion of acute myocardial infarction: an experimental study. Circulation 65:1446, 1982.

45. Nixon JV, Brown CN, Smitherman TC: Identification of transient and persistent segmental wall motion abnormalities in patients with unstable angina by two-dimensional echocardiography. Circulation 65:1497, 1982.

46. Gorlin R, Klein MD, Sullivan JM: Prospective correlative study of ventricular aneurysm. Mechanistic concept and clinical recognition. Am J Med 42:512, 1967.

47. Reeder GS, Tajik AJ, Seward JB: Left ventricular mural thrombus. Two-dimensional echocardiographic diagnosis. Mayo Clin Proc 56:82, 1981.

48. Weyman AE, Peskoe SM, Williams ES, Dillon JC, Feigenbaum H: Detection of left ventricular aneurysms by cross-sectional echocardiography. Circulation 54:936, 1976.

49. Kisslo JA, Robertson D, Gilbert BW, VonRamm D, Behar VS: A comparison of real time, two-dimensional left ventricular echocardiography and cineangiography in detecting left ventricular asynergy. Circulation 55:134, 1977.

50. Visser CA, Kan G, David GK, Lie KI, Durrer D: Echocardiographic-cineangiographic correlation in detecting left ventricular aneurysm: a prospective study of 422 patients. Am J Cardiol 50:337, 1982.

51. Ports TA, Cogan J, Schiller NB, Rapaport E: Echocardiography of left ventricular masses. Circulation 58:528, 1978.

52. Lewin RF, Vidne B, Sclarowsky S, Agmon J: Two-dimensional echocardiographic detection of a left ventricular aneurysm associated with mobile pedunculated thrombi. Chest 77:704, 1980.

53. Come PC, Markis JE, Ving HS, Sacks B, McArdle C, Ramilez A: Echocardiographic diagnosis of left ventricular thrombi. Am Heart J 100:524, 1980.

54. Van den Bos AA, Vletter WB, Hagemeijer F: Progressive development of a left ventricular thrombus. Chest 74:307, 1978.

55. Risser T, Wynne J, Sloss LJ, Goldman L, Neumann A, Van der Vanter S, Koster JK, Cohn LH, Collins JJ: Accuracy of two-dimensional echocardiography in screening for intracardiac thrombus (abstr). Circulation 64:IV-93, 1981.

56. Starling MR, Crawford MH, Sorensen SG, Grover FL: Detection of left ventricular mural thrombus: comparative value of invasive and noninvasive techniques (abstr). Am J Cardiol 49:936, 1982.

57. Stratton JR, Lighty GW, Perlman AS, Ritchie JL: Detection of left ventricular thrombus by two-dimensional echocardiography: sensitivity, specificity and causes of uncertainty. Circulation 66:156, 1982.

58. Asinger RW, Mikell FL, Sharma B, Hodges M: Observations on detecting left ventricular thrombus with two-dimensional echocardiography: emphasis on avoidance of false positive diagnoses. Am J Cardiol 47:145, 1981.

59. Mikell FL, Asinger RW, Elsperger KJ, Anderson WR, Hodges M: Tissue acoutic properties of fresh left ventricular thrombi and visualization by two-dimensional echocardiography: experimental observations. Am J Cardiol 49:1157, 1982.

60. Stratton JR, Ritchie JL, Hammermeister KE, Kennedy JW, Hamilton GW: Detection of left ventricular thrombi with radionuclide angiography. Am J Cardiol 48:565, 1981.

61. Goodwin PA, Bushbert JT, Doherty PW, Lipton MJ, Conley FK, Diamanti DI, Meares CF: Indium-III labelled antologous platelets for location of vascular thrombi in humans. J Nucl Med 19:626, 1978.

62. Ezekowitz MD, Leonard JC, Smith EO, Allen EW, Taylor FB: Identification of left ventricular thrombi in man using indium-III-labelled antologous platelets. A preliminary report. Circulation 63:803, 1971.

63. Tomada H, Hoshiai M, Furuya H, Shotsu A, Ootaki M, Matsuama S: Evaluation of left ventricular thrombus with computed tomography. Am J Cardiol 48:573, 1981.

64. Nair CK, Sketch MH, Mahoney PD, Lynch JD, Mooss AN, Kenney NP: Detection of left ventricular thrombi by computerised tomography. Br Heart J 45:535, 1981.

65. Goldstein JA, Lipton MJ, Schiller NB, Ports TA, Brundage BH: Evaluation of intracardiac thrombi with contrast enhanced computed tomography and echocardiography (abstr). Am J Cardiol 49:972, 1982.

66. Haugland JM, Asinger RW, Mikell FL, Elsperger J, Hodges M: Embolic potential of left ventricular thrombus detected by two-dimensional echocardiography (abstr). Am J Cardiol 47: 471, 1981.

67. Drobac M, Rokowski H, Gilbert BW, Silver MD: Two-dimensional echocardiographic recognition of mural thrombi: in-vivo and in-vitro studies (abstr). Am J Cardiol 45:435, 1980.

68. Miller RD, Jordan RA, Parker RL, Edwards JE: Thromboembolism in acute and in healed myocardial infarction. II. Systemic and pulmonary arterial occlusion. Circulation 6:7, 1952.

69. Friedman MJ, Carlson K, Marcus FE, Woolfenden JM: Clinical correlations in patients with acute myocardial infarction and left ventricular thrombus detected by two-dimensional echocardiography. Am J Cardiol 72:894, 1982.

70. Abelmann WH: Treatment of congestive cardiomyopathy. Postgrad Med J 54:477, 1978.

71. Lovett JL, Sandok BA, Giulani ER, Nasser FN: Two-dimensional echocardiography in patients with focal cerebral ischemia. Ann Intern Med 95:1, 1981.

72. Greenland P, Knopman DS, Mikell FL, Asinger RW, Anderson DC, Good DC: Echocardiography in diagnostic assessment of stroke. Ann Intern Med 95:51, 1981.

73. Faxon DP, Ryan TJ, Davis KB, McCabe CH, Myers W, Lesperance J, Shaw R, Tong TGL: Prognostic significations of angiographically documented left ventricular aneurysm from the coronary artery surgery study (CASS). Am J Cardiol 50:157, 1982.

74. Harvald B, Hilden T, Lund E: Long-term anticoagulant therapy after myocardial infarction. Lancet 3:626, 1962.

75. Report of the Working Party on Anticoagulant Therapy in Coronary Thrombosis to the Medical Research Council: Assessment of short-time anticoagulant administration after cardiac infarction. Br Med J 1:335, 1969.

76. Results of a Cooperative Clinical Trial: Anticoagulants in acute myocardial infarction. JAMA 225:724, 1973.