PATHOPHYSIOLOGY AND NATURAL HISTORY
MYOCARDIAL INFARCTION

Spontaneous morphologic changes in left ventricular thrombi: a prospective two-dimensional echocardiographic study

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ABSTRACT Previous retrospective echocardiographic studies have reported a higher embolic potential of left ventricular thrombi with protruding configuration and patterns of mobility. The present study was performed to prospectively assess the shape and mobility patterns of left ventricular thrombi and their spontaneous changes with time. Two-dimensional echocardiograms were obtained in 109 consecutive patients with acute anterior myocardial infarction within 24 hr of the onset of symptoms, every 24 hr until day 5, every 48 hr until day 15, and then every month for a follow-up of 1 to 29 (mean 14 ± 8) months in the survivors. None of the patients were treated with anticoagulants or platelet inhibitors during the study period. Left ventricular thrombi, detected in 59 patients (54%), appeared from 1 to 362 (mean 12 ± 47) days after myocardial infarction. At first detection, the shape was mural in 21 patients and protruding in 38; patterns of mobility were present in eight patients. During follow-up, changes in the shape of the thrombi were noted in 24 patients (41%; from mural to protruding in nine, from protruding to mural in 15). These variations were encountered between 2 and 490 (mean 64 ± 117) days after the first observation of the thrombus. Patterns of mobility, previously detected in eight patients, disappeared in five of eight within 2 to 28 (mean 14 ± 11) days. New evidence of thrombus motion, absent in prior observations, appeared in 12 other patients; at subsequent follow-up from 2 to 273 (mean 12 ± 90) days later, this feature disappeared in eight of these latter 12 patients. We conclude that spontaneous variations in shape and mobility patterns are common in left ventricular thrombi complicating acute anterior myocardial infarction. Retrospective analysis of these morphologic features appears unsuitable to identify the thrombi more prone to embolization.


LEFT VENTRICULAR thrombosis represents a common complication of acute anterior myocardial infarction.1–5 Two-dimensional echocardiography has demonstrated good sensitivity and specificity in the diagnosis of left ventricular thrombi.6–9 Ultrasound, which gives anatomic information, also allows noninvasive assessment of the morphologic characteristics of these intracardiac masses. For this reason the technique has been recently employed in an attempt to identify the anatomic markers of the thrombi with a higher risk of embolization. Previous echocardiographic studies, mainly based on retrospective data, have indicated a positive relationship between some morphologic features of the thrombi, such as presence of mobility and protruding shape, and their embolic potential.10–12 Based on these results, the utility of two-dimensional echocardiography in discriminating patients at higher risk of embolic complication and in outlining the indications for anticoagulant therapy has been emphasized.12, 13 However, no prospective follow-up study concerning shape and mobility patterns of left ventricular thrombi in a large series of patients has so far been carried out. Moreover, the antithrombotic treatment may conceivably alter the natural evolution of these anatomic patterns. In the present study we evaluated, through serial two-dimensional echocardiographic examinations, a large population of patients with acute anterior myocardial infarction who were not treated with anticoagulants or platelet inhibitors to prospectively assess the shape and mobility of left ventricular thrombi and the spontaneous changes with time in these morphologic characteristics.
Methods

Patients. One hundred and ten consecutive patients admitted to the Coronary Care Unit of the Ente Ospedaliero Galliera-Genova within 24 hr of transmural anterior myocardial infarction were included in the study. A satisfactory two-dimensional echocardiogram could be obtained in all but one patient who was therefore excluded from further evaluation. The remaining 109 patients (81 men, 28 women; age range from 35 to 91 years, mean 64 ± 8 years) composed our study population. The diagnosis of acute anterior myocardial infarction was based on typical history of chest pain, electrocardiographic changes (appearance of Q waves greater than 0.04 sec in the anterior leads), and serial elevation of serum enzyme levels. In no case was there evidence of a previous anterior myocardial infarction; four patients had had a prior inferior myocardial infarction. In the acute phase of infarction or during follow-up, patients did not receive anticoagulants or platelet inhibitors.

Two-dimensional echocardiography. Two-dimensional echocardiograms were obtained by three experienced echocardiographers using an Advanced Technology Laboratory (ATL) Mark 300 mechanical sector scanner with a 3 MHz transducer. Ultrasonographic examinations were obtained, in each patient, within 24 hr of symptom onset, and then every 24 hr until day 5, every 48 hr until day 15, and subsequently every month for a follow-up of 1 to 29 (mean 14 ± 8) months in the survivors. Other than from the standard views (parasternal long- and short-axis, apical four- and two-chamber views) images were obtained from the apical short-axis view and from multiple sector orientations intermediate between the apical four- and two-chamber views. Particular care was taken to adjust both the depth and the gain and reject settings to better explore the left ventricular apex and to optimize the definition of the epicardium, endocardium, and margins of the thrombus. When a thrombus was detected, care was taken to visualize it in multiple scanning planes by appropriately rotating the transducer and varying its angulation or position to optimize the assessment of the exact configuration of the intracardiac mass. Similar modalities of examination were adopted during the subsequent ultrasonic evaluation of the thrombus. A total of 1655 echocardiograms were obtained in our study population. The videotaped echocardiograms were independently reviewed (Sony U-matic videotape VO-5800 PS) in real-time, slow-motion, and stop-frame mode by two of the three echocardiographers who were unaware of each other’s interpretations; their agreement was required before a thrombus was considered to be present.

Left ventricular thrombi. The diagnosis of left ventricular thrombus was based on the presence of an echodense mass with defined margins that was adjacent to asynergic myocardium, clearly identifiable throughout the cardiac cycle, and distinguishable from muscle trabeculations, chordal structures, or false masses resulting from tangential views of the left ventricular wall. To minimize false-positive diagnoses, doubtful cases were considered to be negative for thrombus.

The shape of the thrombus was defined and its motion detected according to the echocardiographic criteria described in previous articles.10-12, 14 A thrombus was defined as protruding when it predominantly projected into the left ventricular cavity (figure 1, A) and as mural when it appeared flat and parallel to the endocardial surface (figure 1, B). Patterns of mobility were considered present when a portion of the thrombus showed motion independent from that of the adjacent endocardium, either opposite in direction or freely erratic (figure 1, A). Initial classification of the shape and mobility patterns was made on the basis of the first echocardiogram considered positive for thrombus.

Concerning the definition of the thrombus shape, interobserver and intraobserver agreement in the analysis of all echocardiograms was 91% and 95%, respectively. Interobserver and intraobserver agreement for the detection of thrombus motion (presence or absence) was 90% and 94%, respectively. The shape of a thrombus was estimated to have changed when both observers independently noted its variation, from mural to protruding or vice versa, in the analysis of the same subsequent examinations of a patient. The assessment of changes in mobility patterns, in other words the new appearance of thrombus motion undetected on previous echocardiograms or the disappearance of its previously noted mobility, also required the agreement of both observers. The comparison of equivalent ultrasonic images of the thrombus, that is visualization of the intracardiac mass with similar sector orientation and transducer position, was considered crucial in defining the presence of changes in its morphologic patterns.

Left ventricular wall motion. The method of evaluation of left ventricular wall motion in patients with myocardial infarction in our laboratory, following recommendations from previous reports,15, 16 has been described elsewhere.9 The wall motion index was calculated by the method proposed by Gibson et al.16 An aneurysm was defined as an abnormality in the contour of the left ventricle during both diastole and systole, with dyskinetic or akinetic motion.

Statistical analysis. Continuous data are expressed as mean ± SD. Differences between two means were analyzed by the appropriate Student’s t test; differences between proportions were evaluated by the chi-square test.

Results

Left ventricular thrombi. Left ventricular thrombosis was detected in 59 patients (54%). It appeared from 1
at the first identification of the thrombus in eight patients (14%). In five of these patients they disappeared from 2 to 28 (mean 14 ± 11) days after detection (figure 5). On the other hand, new evidence of a mobile portion of the thrombus, undetected in previous examinations, was observed in 12 patients from 6 to 153 (mean 35 ± 54) days after the first observation of the thrombus. In eight of these 12 patients the patterns of mobility vanished from 2 to 273 (mean 12 ± 90) days after their appearance.

Left ventricular wall motion. Prevalence and degree of left ventricular wall motion abnormalities were similar in patients with thrombi of different shapes (table 1). Moreover, no difference was observed when the occurrence of such abnormalities in patients with and without patterns of thrombus motion were analyzed (table 1).

With regard to the 24 patients showing changes in thrombus shape during follow-up, the wall motion index and incidence of apical dyskinesis and/or left ventricular aneurysm were not different from those observed in the remaining patients without variations in thrombus configuration (table 2).

The changes in thrombus shape were accompanied by a simultaneous variation in the wall motion index in nine patients (decrease in seven; increase in two; in

FIGURE 2. Two-dimensional echocardiographic images and accompanying diagrams illustrating the change in thrombus shape (from mural to protruding configuration) observed in one patient during the study period. A, A large mural thrombus, adjacent to the left ventricular apex, is visible (arrow). B, Thrombus shape has changed to a protruding configuration. LA = left atrium; LV = left ventricle; T = thrombus; calibration = 1 cm.

to a maximum of 362 (mean 12 ± 47) days after acute myocardial infarction. The thrombus was identified within the first week of evaluation in 49 patients (83%), within the second week in three (5%), and during later follow up (mean 75 ± 128 days) in seven (12%). In six patients (10%) the first observation of thrombus was made after discharge from hospital.

Shape. At the first echocardiographic diagnosis, 21 thrombi (36%) were defined as mural and 38 (64%) as protruding.

During the study period, changes in thrombus shape were observed in 24 patients (41%). Specifically, in nine patients the shape changed from mural to protruding (figure 2), and in 15 it changed from protruding to mural (figure 3). In four patients the shape of the thrombus repeatedly varied during follow-up (figure 4). Changes in thrombus configuration were noted both in the early and in the late phases of the follow-up, occurring from 2 to 490 (mean 64 ± 117) days after the appearance of thrombus. In 14 patients they occurred during hospitalization, while in 10 they were observed during further evaluation (mean 173 ± 160 days after acute myocardial infarction).

Mobility patterns. Patterns of mobility were observed

FIGURE 3. Two-dimensional echocardiographic images and accompanying diagrams illustrating a case of change in thrombus shape (from protruding to mural configuration). A, A protruding left ventricular thrombus (arrow) is visible extending from the septum to the apex. B, Sixteen days later, the thrombus shows a mural shape. LA = left atrium; LV = left ventricle; T = thrombus; calibration = 1 cm.
two patients a large, previously undetected left ventricular aneurysm developed, and in five there was new evidence of apical dyskinesis. Similar changes in wall motion were observed among the patients showing no variations in thrombus shape during the study period: the wall motion index decreased in 12 patients and increased in three, an aneurysm developed in four, and new evidence of apical dyskinesis was present in nine.

**Peripheral embolism.** During the study period, in seven patients (6%) there was clinical evidence of peripheral embolism, including stroke in three, transient ischemic attack in three, and lower limb embolism in one. In five of these patients a left ventricular thrombus had been previously diagnosed. The echocardiographic examination, performed in these patients from 1 to 11 (mean 5 ± 4) days before the embolic complication, revealed a mural thrombus in three patients and a protruding mass in two; in one of these two latter patients patterns of mobility were also present. In the remaining two patients with no evidence of left ventricular thrombus, episodes of transient ischemic attacks were observed; instrumental investigations revealed a thrombosis of the left internal carotid artery in one, while no cerebral damage or vascular abnormalities were found in the other.

**Sensitivity and specificity.** Thirty-three patients died during the study period. Autopsy was performed in 25 of them. The interpretation of the echocardiographic images (positive for left ventricular thrombus in 17 patients and negative in eight) were confirmed by autopsy in 24 cases. In one patient, a laminated mural thrombus undetected with ultrasound was found at autopsy. Sensitivity and specificity of two-dimensional echocardiography in diagnosing the presence of thrombus were 94% and 100%, respectively.

**Discussion**

The evaluation of our study population was prospective, based on frequent serial echocardiographic examinations over a long follow-up period. In addition,

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**FIGURE 4.** Two-dimensional echocardiographic images and accompanying diagrams showing the repeated changes in thrombus shape observed in the same patient during the study period. *A*, A large mural thrombus, adjacent to the left ventricular apex, is visible (arrow). *B*, Ten days later, thrombus shape appears predominantly protruding owing to the presence of two big portions projecting into the left ventricular cavity (arrows). *C*, The two protruding portions have disappeared; thrombus shape now appears mural. Ao = aorta; LA = left atrium; LV = left ventricle; T = thrombus; calibration = 1 cm.

**FIGURE 5.** Two-dimensional echocardiographic images and accompanying diagrams illustrating the disappearance of mobility of a thrombus observed in one patient during the study period. *A*, Protruding thrombus with a pedunculated portion (arrow) that on real-time imaging showed free intracavitary motion. *B*, Five days later, the pedunculated mobile portion disappeared. No pattern of thrombus motion was observed on real-time imaging. LA = left atrium; LV = left ventricle; T = thrombus; calibration = 1 cm.
none of our patients were treated with anticoagulants or platelet inhibitors. These conditions allowed us to better assess the prevalence and time of appearance of left ventricular thrombi, to correctly define their anatomic characteristics, and to identify their spontaneous morphologic changes with time.

Left ventricular thrombi were detected in 54% of the patients. This percentage is slightly higher than those reported in previous similar echocardiographic studies. The following observations may explain this difference. The comparison of repeated echocardiograms obtained in each patient at short time intervals helped to minimize the percentage of equivocal examinations. Second, the late appearance of thrombi was noted in a certain percentage of our study population. The occurrence of these thrombi may be missed in retrospective and nonserial studies and in those in which the echocardiographic evaluations are performed only in the early phase of myocardial infarction or at any time before discharge from hospital. Thus, the prevalence of this complication may be underestimated. Finally, the absence of antithrombotic treatment may have influenced the prevalence of thrombi in our patients. This hypothesis seems to find support in the results obtained by Nordrehaug et al. in two groups of patients with acute anterior myocardial infarction randomly receiving high-dose anticoagulants or placebo.

Our study shows that spontaneous time-course variations in the morphologic aspects of left ventricular thrombi, such as shape and mobility patterns, are common in patients with anterior myocardial infarction in the absence of anticoagulation. Changes in the shape of the thrombi, either from mural to protruding or vice versa, were present in a significant percentage (41%) of patients. Similarly, the new appearance of intracavitary motion of a portion of a thrombus, undetected in previous evaluations, or its disappearance was frequent among those patients showing echocardiographic features of thrombus mobility within the study period. These morphologic changes may be observed either early after thrombus development or during later follow-up.

The accurate approach adopted in the evaluation of thrombus morphology, the homogeneity of the modalities of examination used in our patients, and the comparison of many echocardiographic images obtained at short time intervals helped to minimize possible bogus detection of changes in thrombus configuration due to the possible variability of repeated echocardiograms obtained by different operators. In this regard, it must also be pointed out that most variations in shape were

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**Table 1**

<table>
<thead>
<tr>
<th>Shape of LV thrombi</th>
<th>Mobility of LV thrombi</th>
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<tbody>
<tr>
<td></td>
<td>Mobile (n = 20)</td>
</tr>
<tr>
<td>WMI Mural (n = 21)</td>
<td>0.64 ± 0.27</td>
</tr>
<tr>
<td>LV aneurysm</td>
<td>14 (67%)</td>
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<tr>
<td>Apical dyskinesis</td>
<td>8 (38%)</td>
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</tbody>
</table>

Patients are subdivided according to the shape and mobility patterns of the thrombi. WMI = wall motion index.

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**Table 2**

<table>
<thead>
<tr>
<th>Changes in LV thrombus shape</th>
<th>Changes in LV thrombus mobility</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Yes (n = 24)</td>
</tr>
<tr>
<td>WMI</td>
<td>0.65 ± 0.32</td>
</tr>
<tr>
<td>LV aneurysm</td>
<td>13 (54%)</td>
</tr>
<tr>
<td>Apical dyskinesis</td>
<td>8 (33%)</td>
</tr>
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</table>

Patients are subdivided according to the presence or absence of changes in shape and mobility of the thrombi during the study period. WMI = wall motion index.
accompanied by concomitant significant modifications in thrombus size (figures 2 to 4); similarly, the detection of changes in mobility patterns frequently corresponded to the appearance or disappearance of a considerable mobile portion of the thrombus (figure 5). Finally, it must be taken into account that in the independent analyses of the echocardiograms, morphologic changes in the intracavitary mass were considered to be present only when observed on comparable ultrasonic images.

Recent echocardiographic studies analyzing mainly retrospective and nonserial data have indicated a positive relationship between the embolic potential of left ventricular thrombi and their protruding shape and/or intracavitary motion.10-12 Our results seem to call into question these previous reports. The frequent occurrence of variations in shape and mobility patterns makes the retrospective analysis of these features an unsuitable means of identifying the morphologic characteristics of those thrombi most likely to be associated with embolization.

The number of patients with clinical symptoms consistent with peripheral embolization is small and makes confirmation of any relation with the morphologic features of the thrombi unfeasible. However, it should be noted that among the five patients with left ventricular thrombus and embolic complication the echocardiograms obtained a short time before the event revealed patterns of protruding shape and/or mobility in two cases. According to our results, Keating et al.19 reported an equal percentage of layered and pedunculated masses among patients with myocardial infarction and peripheral embolism in the absence of antithrombotic treatment. In the evaluation of these data, it must be noted that we cannot exclude that episodes of microembolization, in the absence of clinical symptoms, have occurred in other patients; indeed, in accordance with the previous similar studies,10-12, 19, 21 only patients with symptoms consistent with peripheral embolization were referred for further diagnostic procedures for a better definition of the extent and source of this complication.

The prevalence and degree of left ventricular wall motion abnormalities have been reported to influence the development of left ventricular thrombi: a higher incidence of thrombi occurs after acute infarction among patients with more severely compromised left ventricular wall motion.9, 24, 25 Concerning the morphologic characteristics of the thrombi, our present data suggest that the extent and type of left ventricular wall motion, as assessed through the evaluation of the wall motion index and detection of left ventricular aneu-

rism or apical dyskinesis, do not influence the shape of the thrombus, the appearance of thrombus mobility, or their possible variations with time in patients who are not taking antithrombotic drugs.

In conclusion, our results show that spontaneous changes in the shape and mobility patterns of thrombi are common after acute anterior myocardial infarction in patients not treated with anticoagulants or platelet inhibitors. These anatomic variations may be detected both at short and long time intervals after the appearance of the thrombus. The retrospective assessment of the morphologic characteristics appears to be unsuitable in identifying those thrombi that are most likely to embolize.

References


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