Early Two-Dimensional Echocardiography in Acute Myocardial Infarction

A Study of Left Ventricular Wall Motion Abnormalities

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SUMMARY

Two-dimensional echocardiography (2DE) was utilized in 49 patients with a first transmural myocardial infarction, within 6 hours ($\pm 3SD$) after admission and again at 48 hours, in order to correlate initial left ventricular wall motion (LVWM) abnormalities with subsequent in-hospital cardiac complications. Analysis of systolic endocardial motion was made in 15 left ventricular segments in each patient and a total wall motion (WM) score was derived as a measure of the extent of myocardial involvement. LVWM abnormalities in relation to Killip class, peak total serum creatine kinase (CK) and serum glutamic oxaloacetic transaminase (SGOT) enzyme levels were also studied.

Adequate echocardiograms for LVWM analysis were obtained in 43 patients. Thirteen patients had no infarct-related complications (group I) and 30 had complications (group II). The mean initial WM score in group I patients was 5.7 ± 2.6 which was significantly lower than the 13.5 ± 3.9 in group II ($p < 0.0001$). A WM score of ≥ 10 correlated with the occurrence of complications in 93% of patients. The WM score was significantly higher in admission Killip class 1 and 2 patients in group II compared with group I patients in class 1. However, no difference was noticed between the mean WM score of patients assigned to these 2 classes in group II. Peak CK and SGOT levels showed a poor correlation with the WM score in group I patients. In group II patients, only the peak SGOT levels correlated significantly with this score.

We conclude that in patients with acute infarction, 2DE soon after admission can identify those likely to have in-hospital cardiac complications.

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TWO-DIMENSIONAL echocardiography (2DE) has been shown to be a reliable non-invasive alternative to cineventriculography for the detection of left ventricular asynergy.¹⁾ It has been found to be valuable in the detection²⁾ and estimation of the extent of left ventricular asynergy.³⁾ It has also provided a method that seems to correlate well with the hemodynamic parameters of left ventricular function³⁾ and with thallium scintigraphic findings for the estimation of myocardial involvement in patients with acute myocardial infarction.⁴⁾

Major complications following acute myocardial infarction are determined by the amount of damaged myocardium.⁵⁾ Regional asynergy of the left ventricle detected by echocardiography during acute infarction also seems to be dependent on the extent of myocardial involvement resulting both from ischemia and infarction and its analysis by this method provides an index of left ventricular wall motion (LVWM) if not the exact infarct size.³⁾

As detected by 2DE, "regional cardiac dilatation" after acute myocardial infarction has been shown to produce significantly greater in-hospital patient mortality.⁶⁾ To investigate further possible application of 2DE in myocardial infarction, a prospective study of patients with acute infarction was undertaken. The aims of the study were to (a) determine the frequency with which echocardiograms can be obtained which are adequate to study LVWM abnormalities, (b) to relate LVWM abnormalities present soon after admission with subsequent in-hospital cardiac complications, and (c) to evaluate the relation of LVWM abnormalities to Killip class on admission and to peak levels of cardiac enzymes.

PATIENTS AND METHODS

Forty-nine consecutive patients aged 29 to 70 years (46 ± 9 , mean $\pm$ SD) admitted to the Coronary Care Unit with a first transmural myocardial infarction were studied prospectively. Patients with a history and/or electrocardiographic changes of an old infarct were excluded. They were admitted 2.8 ± 1.5 hours after the onset of chest pain. Myocardial infarction was diagnosed on the basis of (1) typical prolonged cardiac pain, (2) electrocardiographic changes (appearance of new Q waves), and (3) serial elevation of total serum creatine kinase (CK) and serum glutamic oxaloacetic transaminase (SGOT) to twice the normal level.

Patients did not routinely receive any antiarrhythmic therapy unless indicated. A standard 12-lead electrocardiogram was recorded on admission and twice daily thereafter for the first 72 hours. All patients were monitored continuously on an arrhythmia monitoring system (HP 78220) throughout this period.

Echocardiographic study:

2DE was performed on all patients within 12 hours (6 ± 3 hours) and again at 48 hours after admission, utilizing a commercially available 2.25 MHz phased array scanning system (Irex III). Real time images were recorded on 1/2 inch videotape (Sony cassette recorder). These images were then available for display and evaluation in real time, slow motion or single frame format. Each echocardiographic study included standard parasternal left ventricular long axis, multiple short axis, and 2 and 4 chamber apical views.⁷⁾ These views permit the analysis of anterior, lateral, septal, inferior, and apical regions of the left ventricle. In order to obtain a true image of the apex with a parasternal long axis study, the transducer was moved to a lower interspace and directed laterally.⁸⁾

To analyze wall motion (WM), the cross-sectional image of the left ventricle was divided into 15 segments (Fig. 1). The method used to identify these myocardial segments was similar to that described by Heger et al,²⁾ except that the apical 2 and 4 chamber views were also utilized to study additional lateral (segments 11, 12), anterior (segments 13, 14), and septal (segment 15) regions. The WM for each segment was assessed visually in each view and graded using the following terminology: 0=normal, 1=hypokinesis, 2=akinesis, 3=dyskinesis.³⁾ A normal endocardial surface demonstrates inward systolic movement. Hypokinesis was defined as 50% or greater reduction in movement compared with the motion of adjacent segments in each view. Segments were considered to be akinetic when no endocardial motion was seen. Dyskinesis was defined as paradoxical outward expansion during systole. The graded scores thus obtained for each of the 15 segments were summed and expressed as a total WM score. Since these segments could be visualized in more than one view, the scoring was arrived at by combining the interpretations of all views. If, in any patient, all regions of the endocardium were not sufficiently visualized for analysis, the study was considered unsatisfactory. All echocardiographic studies were reviewed by 2 experienced observers independently and a consensus interpretation was obtained. Assessment of cardiac failure was made according to the Killip classification⁹⁾ in each patient on admission and at 48 hours. Complications of acute infarction during hospitalization were recorded. These included (1) significant ven-

Fig. 1. Schematic diagrams of the echocardiographic planes studied. LV=left ventricle; RV=right ventricle; AO=aorta; p=papillary muscles; MV=mitral valve; I=inferior; S=superior; L=left; R=right. Numbers 1 to 15 indicate the segmental divisions of the left ventricular images.

tricular arrhythmias occurring more than 12 hours after admission, (2) conduction disturbances (atrioventricular), (3) recurrent angina 24 hours after infarction, (4) left ventricular failure, and (5) cardiogenic shock.

Six patients were excluded because of unsatisfactory echocardiographic data. Patients were divided into 2 groups for purposes of comparison. Group I comprised patients without complications and group II, patients who had in-hospital complications (Table I).

Statistical methods:

Values of all observations are expressed as mean $\pm$ SD. Statistical analysis was performed using the 't' test to compare the 2 groups. The "difference between 2 proportions" test was used to assess the significance between proportions.

RESULTS

The characteristics of patients admitted with acute infarction are shown in Table I.

Complications that occurred in group II patients are shown in Table II. All types of ventricular arrhythmias were seen within 12-36 hours after admission. Four patients died within 48 hours after admission.

Echocardiographic wall motion analysis:

Comparative total WM score and the respective Killip classes of patients in both groups at the time of initial and 48 hour studies are shown in Fig. 2.

Table I. Clinical Characteristics of Patients with Acute Myocardial Infarction

Characteristics	Group I (n=13)	Group II (n=30)
Age (years)* (range)	48 $\pm$ 7 (36-70)	46 $\pm$ 9 (29-70)
Anterior infarction	4	21
Inferior infarction	9	9
No. of patients in Killip	KI	KI KII KIII KIV
Class on admission	13	13 14 2 1
Peak CK (IU/L)*	2865 $\pm$ 1068†	2762 $\pm$ 1634
Peak SGOT (IU/L)*	237 $\pm$ 99††	428 $\pm$ 192

* Mean $\pm$ SD, KI to KIV=Killip classes; †=p-NS compared with II; ††=p<0.001 compared with II.

Table II. Complications Observed in Group II Patients

Complications	Patients (n)
1. Ventricular tachycardia	7
Ventricular fibrillation	1
2. Conduction disturbances (A-V)	7
3. Recurrent angina + PVCs	7
4. Left ventricular failure*	5
5. Cardiogenic shock+death	3

A-V=atrioventricular; PVCs=premature ventricular contractions; *=1 death.

Fig. 2. Echocardiographic total wall motion score (mean $\pm$ SD) of patients (pts) in the 2 groups on admission (A) and at 48 hours (B). KI-IV = Killip classes.

The WM score obtained in group I patients was significantly lower than the score in group II patients at the time of these two studies ($p < 0.0001$). There was no significant change between the WM score obtained at the initial and at the 48 hour study in either group of patients.

In 12 group I patients the initial WM score was < 10 (range 2-9) and in 1 it was 12. In 28 group II patients, this score was 10 or above (10-24), although in 2 patients it was 8. In 3 patients who later died of cardiogenic

Table III. Segmental Wall Motion Classification at the Initial Echocardiographic Study

Group	Total Segments	Normal	Hypokinesis	Akinesis	Dyskinesis
I	195 (n=13)	137* 70%	48** 25%	10*** 5%	0****
II	450 (n=30)	199 44.2%	114 25.3%	131 29.1%	6 1.3%

*= $p < 0.01$ as compared with II; **= p -NS as compared with II; ***= $p < 0.01$ as compared with II; ****= $p < 0.05$ as compared with II.

shock, the initial WM scores were 16, 18, and 20, respectively, while in 1 who died suddenly of acute left ventricular failure, it was 10.

Analysis of segmental wall motion at the time of the initial study is shown in Table III. A total of 645 segments, 195 in group I and 450 in group II were analyzed. A significant difference between the 2 groups was noticed in the number of normal and akinetic segments ($p < 0.01$). There were no dyskinetic regions in group I patients.

Analysis of the type of asynergy seen in all 43 patients (group I and II combined) revealed that 6 (14%) had only hypokinesis of the segments affected. Five of these 6 patients were in group I and 1 was in group II.

Echocardiographic correlations:

The average initial WM score in the 2 groups of patients assigned to different Killip classes on admission is shown in Fig. 2. There was a significant difference between the WM score of patients assigned to Killip class 1 in group I (5.7 ± 2.6) and group II (10.8 ± 2.8) ($p < 0.025$) and between the former and class 2 patients in group II (15.5 ± 3.8) ($p < 0.01$). However, within group II itself, no significant difference was noticed between the WM score of patients assigned to these 2 classes on admission. No comparisons were made with Killip class 3 and 4 patients due to their small number.

No significant correlation was found between the initial WM scores and peak CK ($r = 0.08$) and SGOT ($r = 0.002$) enzyme levels in group I patients. In group II patients, only the peak SGOT enzyme levels correlated significantly with WM score ($r = 0.42$) ($p < 0.025$), while the correlation of peak CK with the initial WM score was poor in these patients ($r = 0.1$).

DISCUSSION

The results of this study indicate that technically adequate two-dimensional echocardiographic images for LVWM analysis can be obtained in a majority (88%) of patients with acute myocardial infarction. A success rate of 84% has been reported by Heger et al³⁾ in a similar study.

We performed the initial 2DE at an earlier stage of myocardial infarction than others^{4),6)} and utilized more cross-sectional views to analyze left ventricular asynergy as compared to others.^{2),4)}

Our data indicate that the 2DE wall motion score obtained in patients with acute infarction soon after admission can identify those likely to have in-hospital complications. In the present study, 93% of patients with a WM score of ≥ 10 had cardiac complications. This score is obviously dependent on the probable extent of myocardial damage due to ischemia or infarction.

Although the WM score became significantly higher as the Killip class increased, there was a discrepancy in this score in patients assigned to class 1 on admission and their in-hospital course was also different. Thus, Killip class 1 patients in group II had a higher wall motion score and experienced complications compared with group I patients in the same class who suffered no complications. Moreover, although on admission, Killip classification separated group II patients into class 1 and 2, the difference in average WM score between patients in these 2 classes was not significant and indeed they all had in-hospital cardiac complications. It may therefore be inferred that Killip class on admission may not always be useful in identifying patients at high risk for complications for which 2DE appeared to be a more reliable prognostic tool.

In the present study, the peak CK levels did not correlate significantly with the WM score in either group of patients, although SGOT levels showed a significant correlation with this score in those patients with complications. Results of cardiac enzymes are usually available at a later stage of infarction and there is a physiological time delay in the elevation of these enzymes. These are serious limitations to their use in the early detection of patients prone to subsequent complications.

It is therefore apparent that in the absence of a dependable guide to predict in-hospital complications, the 2DE wall motion score developed by us is fairly reliable. Since the WM analysis done at 48 hours did not add any additional information, an initial 2DE on admission is sufficient for this purpose.

Although analysis of LVWM revealed some form of asynergy in all our patients with infarction as was also reported by others,³⁾ the form of asynergy differed from that described in the other studies.¹⁰⁾ Fourteen % of our patients had hypokinesis as the only abnormality in the segments affected. In contrast, Weiss et al,¹⁰⁾ correlating echocardiographic WM abnormalities with autopsy findings in patients with transmural infarction, have reported seeing only akinesis or dyskinesis in the regions affected by this type of infarct. Although our study is not strictly comparable to that of Weiss et al, it appears that hypokinesis may sometimes be the only abnormality seen in the regions involved as a result of transmural infarction.

We are aware of the limitations of subjective diagnosis of hypokinesis and the difficulty in distinguishing normal from hypokinetic wall motion. Unusual endocardial motion patterns around the basal inferior and posterior walls, especially in subjects suspected of having mitral valve prolapse, have been observed.¹¹⁾ None of our patients had mitral valve prolapse and in all patients with infarction, the hypokinetic wall motion corresponded with the

electrocardiographic zone of infarction. It therefore appears that this information should not be ignored despite its limitations in the diagnosis of hypokinesia.

We conclude that (1) echocardiographic images technically adequate for the analysis of LVWM abnormalities can be obtained in a majority (88%) of patients with acute infarction, (2) patients with an initial WM score of ≥ 10 are more prone to in-hospital cardiac complications and can be effectively identified by 2DE soon after admission. Based on the WM score, it might be possible to commence suitable treatment in those who appear to have an extensive infarct, even before the onset of clinical deterioration.

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