Importance of Two-dimensional Echocardiographic Assessment of Left Ventricular Systolic Function in Patients Presenting to the Emergency Room With Cardiac-Related Symptoms

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Background. This prospective study was designed to test the hypothesis that the assessment of left ventricular systolic function at the time of emergency room (ER) presentation provides valuable diagnostic and prognostic information in patients with cardiac-related symptoms.

Methods and Results. The study was based on a 2-year follow-up of 171 consecutive patients evaluated in the ER for such symptoms. In the course of follow-up, one third of the patients (55 of 171) suffered a major cardiac event. For those with left ventricular systolic dysfunction (LVSD), the age-adjusted rate of early events (occurring within 48 hours of presentation) was more than eight times higher than for those without LVSD (26.9% versus 3.3%, p<0.01). For events occurring after 48 hours of ER presentation, LVSD was associated with a nearly fourfold excess of cardiac events (23.9% versus 6.4%, p<0.01). Other than advanced age, the most important confounder for early events included an abnormal electrocardiogram diagnostic for acute myocardial infarction. Confounders for late events included advanced age and a history of hypertension. LVSD on two-dimensional echocardiography (2DE) was the only finding associated with early and late events after controlling for other risk factors. In addition, the prediction of these events derived from the combination of historical, clinical, echocardiographic, and 2DE findings was significantly improved when accounting for the presence or absence of LVSD (p<0.01).

Conclusions. We conclude that the 2DE assessment of left ventricular systolic function provides valuable diagnostic and prognostic information in subjects presenting to the ER with cardiac-related symptoms. (Circulation 1991;84:1615-1624)

Clinical and electrocardiographic (ECG) variables are routinely used for evaluating patients presenting to the emergency room (ER) with cardiac-related symptoms.1-12 Whereas such information has both diagnostic and prognostic information, the benefits of evaluating left ventricular systolic function in the ER are unknown. We hypothesized that the assessment of left ventricular systolic function at the time of ER presentation would provide diagnostic and prognostic information above and beyond that available from the historical, clinical, and ECG data. In this study, left ventricular systolic function was assessed using two-dimensional echocardiography (2DE), and the relation between left ventricular systolic function and cardiac events that occur during or soon after presentation to the ER versus those that occur later are described.

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Methods

Patient Sample

One hundred eighty-five consecutive patients who presented to the University of Virginia Medical Center ER with cardiac-related symptoms and who met the inclusion criteria were prospectively enrolled in this study. Among this group there were 202 ER visits. In the 14 patients with repeat ER visits, the first was used as the index visit. Men and women were considered eligible for the study if they were older than 30 and 40 years, respectively, and if the symptoms included chest pain or shortness of breath that lasted for at least 30 minutes within 4 hours of ER presentation. Subjects were not eligible for the study if symptoms could be explained by noncardiac causes, local trauma, or preexisting abnormalities on chest x-ray such as skeletal or pulmonary pathology.

Protocol

The protocol was approved by the Human Investigation Committee of the University of Virginia School of Medicine. All patients entered in the study gave informed consent. At the time of presentation to the ER, a member of the study team obtained a detailed history and performed a complete physical examination. In addition, a 12-lead electrocardiogram and serum enzyme measurements were obtained, and 2DE was performed.

All but one member of the study team had completed 3 years of internal medicine residency and all but one had at least 3 months of training in 2DE. A member of the study team was on call for the study 24 hours a day. The information obtained on 2DE was not divulged to the ER physician, who made the patient disposition based entirely on historical, clinical, and ECG data.

Variables Analyzed

The historical information used to evaluate the patients in this report included age, sex, and a history of hypertension and cigarette smoking. The clinical data included the presence of jugular venous distension, third heart sound, and pulmonary rales. Three observers blinded to the historical and clinical data evaluated the electrocardiograms and 2DE on separate occasions.

The electrocardiogram was classified as either normal or abnormal. An abnormal electrocardiogram was characterized as having one or more of the following specific abnormalities: ST elevation or depression more than 1.0 mm (without or with Q waves), Q waves without ST or T wave changes, T wave inversion more than 1.0 mm, nonspecific ST or T wave changes, left ventricular hypertrophy, left or right bundle branch block, and paced rhythm.13

The 2DE variables that were analyzed included left and right ventricular and left atrial sizes and left ventricular systolic function.14 For assessment of the latter, the left ventricle was divided into 12 segments (Figure 1) as described by us previously.15 Each segment was classified in two ways: having either normal or abnormal systolic function and assigning a wall motion score. Abnormal systolic function was considered to be present in a segment if it manifested both abnormal motion and thickening. Based on the degree of systolic dysfunction, the following scores were also assigned to each segment: 1 for normal systolic function; 2 for hypokinesia; 3 for akinesia; and 4 for dyskinesia.15 The scores for each segment were then added to determine the total left ventricular wall motion score. In this manner, a left ventricle showing normal systolic function would be assigned a wall motion score of 12. The worse the function, the higher would be the score.

Patient Follow-up

Follow-up was obtained over a 2-year period by contacting the patient, the patient’s family and physician, and by monitoring the hospital admissions. Study end points included cardiac-related death, nonfatal myocardial infarction confirmed by new Q waves or cardiac enzyme changes,13,16,17 life-threatening arrhythmias requiring medical or surgical intervention, and intractable angina pectoris requiring revascularization (either coronary artery bypass graft surgery or percutaneous transluminal coronary angioplasty). Events that occurred within 48 hours of ER presentation were defined as early events. Late events included those that occurred after 48 hours of ER presentation.

Statistical Methods

Since the exact time of onset of early cardiac events could not be precisely ascertained within the 48-hour period, logistic regression models were used to evaluate the association between early outcomes and each ER finding.18 Use of the logistic models was further supported by the completeness of patient follow-up during this brief period. Analysis for late events was based on proportional hazards regression models,19 since event times and lengths of follow-up could be easily distinguished among the study participants. All models were evaluated for fit, and the results suggested that they...
were useful for conducting tests of significance concerning the data obtained in the ER. Rates of early and late cardiac events were adjusted for age and selected ER findings using Cox models.20,21 Unadjusted survival rates were also derived using Kaplan-Meier life-table analysis.22 In addition, cross-sectional comparisons were made between the various ER findings using the logistic models, and correlates of left ventricular systolic dysfunction (LVSD) were examined. Age-adjusted rates of each ER finding were derived for patients without and with LVSD.

To further explore the independent effect of LVSD, the value of the ER findings for determining late and early events was evaluated in terms of their additive importance in the order in which they would normally be observed. The process began by examining the information from age alone, followed by the added contribution from the historical and clinical data, followed by the additional value of the electrocardiogram, and finally, by the additive information provided by 2DE. Tests of significance were based on increases in the likelihood ratio statistic due to the sequentially added information.23 For practical purposes, the percent change in the likelihood ratio statistic relates directly to the percent change in the overall prognostic power. All differences were considered significant at \( p < 0.05 \) and all tests of significance were two sided.

### Results

Of the 185 patients originally entered into the study, 12 were excluded from analysis because of technically inadequate 2DE studies and two were excluded because of a complete loss to follow-up. Among the remaining 171 patients who are described in this report, there were 88 men and 83 women with average ages of 59±14 and 62±14 years, respectively.

### All Events

Table 1 presents the rates of early and late cardiac events stratified by the type of event. In the 171 patients, 55 (32%) had adverse cardiac events within the 2-year follow-up period: 32 had events within 48 hours of ER presentation and 23 had events after 48 hours of ER presentation. Early events were largely composed of nonfatal myocardial infarctions (29 of 32). There were no deaths and no revascularization procedures. Three subjects with early events experienced life-threatening arrhythmias (ventricular tachycardia, complete heart block, and Mobitz type II block, respectively). Among the 23 late events, the incidence rates of nonfatal myocardial infarction (11) and death (10) were similar; two patients underwent revascularization for intractable angina, and there were no reports of arrhythmias.

### Early Events

Table 2 presents the age-adjusted rates of events occurring within 48 hours of ER presentation. There were no significant correlates of early cardiac events among the historical and clinical findings. An abnormal electrocardiogram was associated with a more than threefold excess of early events \( (p<0.01) \). Subjects with ST elevation had a sixfold excess of early events as compared to those without this finding \( (p<0.001) \). The presence of LVSD was the only 2DE finding that had a significant positive association with early cardiac events. There was more than an eightfold excess of early events among patients who presented in the ER with this finding \( (p<0.01) \). Among the patients without ST elevation, an age-adjusted sixfold excess of early events was observed in the presence of LVSD as compared to its absence \( (20.5\% \text{ versus } 3.4\%, p<0.01) \).

### Late Events

Table 3 provides the age-adjusted rates of events occurring after 48 hours of ER presentation. Among the historical data, subjects with a history of hypertension had a ninefold excess of cardiac events as compared to those without such a history \( (p<0.001) \). Jugular venous distention on physical examination was associated with more than a fourfold excess of cardiac events \( (p<0.001) \), whereas a threefold excess was observed in those with a third heart sound \( (p<0.01) \). Patients with an abnormal electrocardiogram experienced late cardiac events at a rate nearly three times higher than those with a normal electrocardiogram \( (p<0.05) \). Patients with ECG evidence of left ventric-
ular hypertrophy also experienced a threefold excess of events ($p<0.01$). The presence of abnormal 2DE findings was associated with an excess of late cardiac events. Although not statistically significant, the rate of events was more than doubled in the presence of left atrial and left ventricular enlargement. The presence of LVSD was associated with a nearly fourfold excess of late events as compared to its absence ($p<0.01$). This effect remained unaltered after removing subjects with left ventricular hypertrophy.

**Independent Effect of LVSD**

In Table 4, age-adjusted rates of various findings are given for subjects without and with LVSD. Patients with the latter finding were significantly more likely to have a third heart sound ($p<0.01$) and pulmonary rales ($p<0.05$). An abnormal electrocardiogram ($p<0.001$), ST elevation ($p<0.001$), and left bundle branch block ($p<0.01$) also occurred with greater frequency in the presence of LVSD. Patients with LVSD were also more likely to have enlargement of the left and right ventricles ($p<0.01$) and the left atrium ($p<0.001$) on 2DE.

Based on the associations among the ER findings and each cardiac event, the independent effect of LVSD on early and late outcomes was examined after adjusting for selected data. For early events, the most important confounders of LVSD included age and an abnormal electrocardiogram. After adjustment for these factors, the association between LVSD and early cardiac events was diminished slightly, but remained highly significant ($p<0.01$) (Figure 2A).

Figure 2B illustrates the relation between early events and the degree of LVSD, as exemplified by the left ventricular wall motion score. Whereas the event rate increased significantly in patients with a wall motion score of 13–24 compared to those with a score of 12, a further increase in events was not noted in patients with a score of more than 24. The results did not change appreciably after adjusting for age and presence of abnormal electrocardiogram.

or events that occurred after 48 hours of ER presentation, the most important confounders affecting the relation between LVSD and late cardiac outcomes included age and a history of hypertension. After adjusting for these factors, 91.5% of those with normal ventricular systolic function were free of a cardiac event at the end of 2 years of follow-up as compared to 72.6% of those who exhibited LVSD ($p<0.01$). Unadjusted and adjusted event-free survival based on the presence or absence of LVSD is depicted in Figure 3.

Figure 4A illustrates unadjusted late event-free survival based on the degree of LVSD as exemplified by the left ventricular wall motion score. The higher the observed score, the greater seems the likelihood of suffering an adverse cardiac event. When event-free survival in these patients with late events was adjusted for the confounding effects of age and hypertension, event rates among subjects with different degrees of LVSD became similar (Figure 4B), although differences between those with and without LVSD continued to remain highly significant ($p<0.01$).
TABLE 3. Age-Adjusted Percentage of Subjects Who Developed Cardiac Events After 48 Hours of ER Presentation

<table>
<thead>
<tr>
<th>Finding</th>
<th>Absent</th>
<th>Present</th>
</tr>
</thead>
<tbody>
<tr>
<td>Historical and clinical findings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>History of hypertension</td>
<td>3.0 (2/60)</td>
<td>26.8§ (21/79)</td>
</tr>
<tr>
<td>History of smoking</td>
<td>17.7 (13/60)</td>
<td>15.5 (10/79)</td>
</tr>
<tr>
<td>Jugular venous distension</td>
<td>12.0 (14/125)</td>
<td>50.6‡ (9/14)</td>
</tr>
<tr>
<td>Third heart sound</td>
<td>14.1 (18/130)</td>
<td>46.9§ (5/9)</td>
</tr>
<tr>
<td>Pulmonary rales</td>
<td>14.0 (12/99)</td>
<td>21.0 (11/40)</td>
</tr>
<tr>
<td>Electrocardiographic findings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal electrocardiogram</td>
<td>20.6† (20/85)</td>
<td>7.0 (3/54)</td>
</tr>
<tr>
<td>ST segment elevation*</td>
<td>. . . (0/0)</td>
<td>. . . (1/1)</td>
</tr>
<tr>
<td>Q waves</td>
<td>17.8 (22/127)</td>
<td>6.2 (1/12)</td>
</tr>
<tr>
<td>Non-specific ST changes</td>
<td>17.5 (22/124)</td>
<td>8.0 (1/15)</td>
</tr>
<tr>
<td>LV hypertrophy</td>
<td>12.2 (14/122)</td>
<td>41.4§ (9/17)</td>
</tr>
<tr>
<td>Left bundle branch block</td>
<td>15.8 (20/130)</td>
<td>25.1 (3/9)</td>
</tr>
<tr>
<td>Two-dimensional echocardiographic findings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LV enlargement</td>
<td>12.2 (13/109)</td>
<td>30.6 (10/30)</td>
</tr>
<tr>
<td>LV hypertrophy</td>
<td>14.8 (14/106)</td>
<td>20.8 (9/33)</td>
</tr>
<tr>
<td>RV enlargement</td>
<td>15.3 (17/110)</td>
<td>20.9 (6/29)</td>
</tr>
<tr>
<td>Left atrial enlargement</td>
<td>12.6 (12/104)</td>
<td>26.1 (11/35)</td>
</tr>
<tr>
<td>LV systolic dysfunction</td>
<td>6.4 (4/62)</td>
<td>23.9§ (9/77)</td>
</tr>
</tbody>
</table>

Number of events/subjects at risk in parentheses.
ER, emergency room; LV, left ventricular; RV, right ventricular.
*Insufficient data.
Significant excess of cardiac events: ‡p<0.001, §p<0.01.

Additive Prognostic Value of LVSD
The increases in the likelihood ratio statistic due to the sequential addition of the ER findings in the order in which they would normally be observed (age, historical and clinical, ECG, and 2DE) are presented in Figure 5. For early events (Figure 5A),

TABLE 4. Age-Adjusted Percentage of Subjects With and Without LVSD at Time of ER Presentation

<table>
<thead>
<tr>
<th>Finding</th>
<th>LVSD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Absent (n=64)</td>
</tr>
<tr>
<td>Historical and clinical findings</td>
<td></td>
</tr>
<tr>
<td>History of hypertension</td>
<td>56.3 (36)</td>
</tr>
<tr>
<td>History of smoking</td>
<td>50.8 (34)</td>
</tr>
<tr>
<td>Jugular venous distension</td>
<td>8.4 (5)</td>
</tr>
<tr>
<td>Third heart sound</td>
<td>0.0 (0)</td>
</tr>
<tr>
<td>Pulmonary rales</td>
<td>22.2 (13)</td>
</tr>
<tr>
<td>Electrocardiographic findings</td>
<td></td>
</tr>
<tr>
<td>Normal electrocardiogram</td>
<td>49.7* (34)</td>
</tr>
<tr>
<td>ST segment elevation</td>
<td>0.0 (0)</td>
</tr>
<tr>
<td>Q waves</td>
<td>3.2 (2)</td>
</tr>
<tr>
<td>Non-specific ST changes</td>
<td>15.5 (10)</td>
</tr>
<tr>
<td>LV hypertrophy</td>
<td>5.0 (3)</td>
</tr>
<tr>
<td>Left bundle branch block</td>
<td>1.6 (1)</td>
</tr>
<tr>
<td>Two-dimensional echocardiographic findings</td>
<td></td>
</tr>
<tr>
<td>LV enlargement</td>
<td>0.0 (0)</td>
</tr>
<tr>
<td>LV hypertrophy</td>
<td>21.7 (13)</td>
</tr>
<tr>
<td>RV enlargement</td>
<td>4.7 (3)</td>
</tr>
<tr>
<td>Left atrial enlargement</td>
<td>6.7 (4)</td>
</tr>
</tbody>
</table>

Number of subjects with the finding in parentheses.
LVSD, left ventricular systolic dysfunction; ER, emergency room; LV, left ventricular; RV, right ventricular.
Significant excess of cardiac events: *p<0.001, †p<0.01, ‡p<0.05.
age made a significant contribution to describing prognosis \((p<0.01)\). Older subjects had a higher risk of adverse cardiac outcomes than those who were younger. The additional prognostic value of other historical and clinical information was not apparent in this subset of patients. The presence of any rather than a specific abnormality on the electrocardiogram was the most important piece of information derived from the electrocardiogram after accounting for age and the clinical findings \((p<0.01)\). Presence of LVSD was the most useful 2DE finding, nearly doubling the value of the likelihood ratio statistic obtained from age, clinical, and the EKG data alone \((p<0.01)\).

For late events (Figure 5B), age had the same effect on cardiac outcomes as it did for early events \((p<0.001)\). The most useful additional historical or clinical finding in determining prognosis for late events included a history of hypertension. After adjusting for age, there was more than a twofold increase in the value of the likelihood ratio statistic when hypertension was included in the model \((p<0.001)\). In contrast, findings from the electrocardiogram had no marked prognostic value. Adding LVSD increased the likelihood ratio statistic obtained from age, historical, clinical, and the ECG variables by 30% \((p<0.01)\). Other 2DE findings failed to provide significant additional information in predicting late events. Separate and combined adjustment for the other ER findings failed to alter the preceding results.

**Discussion**

Our results indicate that one third of all patients presenting to the ER with symptoms suggestive of cardiac etiology suffered a major cardiac event within the ensuing two years. In addition, for those with normal left ventricular systolic function, less than 10% had cardiac events. In those with LVSD, nearly half suffered an event. Only one patient with normal left ventricular systolic function and a normal electrocardiogram had an event in the 2-year follow-up period. Regardless of the time an event was observed, the direct assessment of left ventricular function in the ER added significantly to the diagnostic and prognostic value of age and the historical, clinical, and ECG findings. These results imply that, in addition to routine clinical and ECG evaluation, left ventricular systolic function should also be assessed in patients presenting to the ER with cardiac-related symptoms.

![Figure 2](http://circ.ahajournals.org/)

**Figure 2.** Bar graphs showing event rates within 48 hours of presentation to the emergency room admission for those with and without left ventricular systolic dysfunction (panel A), and for those with different degrees of left ventricular systolic dysfunction (panel B). Both unadjusted rates and rates adjusted for age and the presence of an abnormal electrocardiogram (EKG) are depicted. *p<0.01 compared to no left ventricular systolic dysfunction and left ventricular wall motion score of 12.

![Figure 3](http://circ.ahajournals.org/)

**Figure 3.** Graph showing probability of surviving a cardiac event after 48 hours from emergency room presentation for those without and with left ventricular systolic dysfunction. Both unadjusted event-free survival and survival data adjusted for age and a history of hypertension are depicted. Both unadjusted and adjusted survival rates are significantly different between patients with and without left ventricular (LV) systolic dysfunction \((p<0.01)\).
Early Events

Of the 32 patients with early events, 29 suffered an acute myocardial infarction. No historical or clinical variable was useful in identifying these patients. Of the ECG abnormalities, ST elevation (without or with Q waves) was noted in only nine of these patients. The other 20 had either nonspecific findings, or evidence of left bundle branch block or paced rhythm, in the presence of which acute myocardial infarction could not be diagnosed. In contrast, only two patients with acute myocardial infarction failed to have LVSD. Both had non-Q wave infarction and neither suffered complications. All the 13 in-hospital complications (life-threatening arrhythmias, postinfarction angina, and cardiogenic shock) occurred in patients with LVSD on 2DE. Only in four such patients was ST elevation noted on the initial electrocardiogram performed in the ER.

It should not be surprising that the assessment of left ventricular systolic function doubled the prognostic value inherent in the combined clinical and ECG data. Regional LVSD occurs within seconds after coronary occlusion and may appear several hours prior to ECG abnormalities.24-26 Because most of the early events in our study were ischemic, abnormalities on 2DE would be expected to be more sensitive than would those on electrocardiography.

In terms of therapeutic intervention, it is becoming increasingly clear that thrombolytic agents should be
administered as early as possible in the evolution of acute myocardial infarction.27–31 A means of early diagnosis of this condition would, therefore, be useful. Our results suggest that 2DE could be of value in the diagnosis of acute myocardial infarction, particularly in those in whom the ECG changes have not yet evolved at the time of ER presentation. These findings are in agreement with previous studies examining the role of 2DE in the ER diagnosis of acute myocardial infarction.32–34 It is also possible that in such patients, the extent of LVSD could reflect the size of the myocardium at risk,35,36 and thus assist the physician in evaluating the risks and benefits of thrombolytic therapy.32

Late Events

Of identical concern are the patients in whom events occurred after 48 hours of ER presentation. Among the 139 subjects not experiencing early events, 23 (17%) had adverse outcomes in the two-year follow-up. Unlike those experiencing events within 48 hours, these patients were as likely to die as they were to suffer a nonfatal infarction. In addition, the historical and clinical profiles of these patients were different from those suffering early events. Victims of late events were more likely to have a history of hypertension and signs of congestive heart failure, such as jugular venous distension and a third heart sound. Apart from an increased incidence of left ventricular hypertrophy, the other ECG abnormalities in such patients were nonspecific. Despite the presence of congestive heart failure, which is a known prognosticator of adverse outcomes, LVSD on 2DE provided significant additional prognostic information in these patients. The results were similar for the patients who died and those who suffered an ischemic event (nonfatal infarction or revascularization).

Unfortunately, the evaluation of patients in the ER has been largely limited to stratifying them into high- and low-risk categories for acute events.9–12 The long-term prognosis has not been evaluated in these patients. This prospectively designed study suggests that the event rate in such patients is high, and that identifying LVSD at the time of ER presentation is useful in recognizing those who are more likely to suffer an event. For instance, this finding may be a more important marker of death than clinical and ECG abnormalities in patients with myocardial disorders such as ischemic or hypertensive cardiomyopathy. Similarly, in the 13 patients who suffered an ischemic event after 48 hours of ER presentation (11 with myocardial infarction and two undergoing revascularization), the presence of LVSD at the time of the ER visit may have reflected an acute ischemic episode that preceded the actual infarction or a need for revascularization.

Importance of the Degree of LVSD

Whereas the presence of LVSD was important in identifying early and late events, the degree of dysfunc-

tion did not seem to be as important. Most of the early events (29 of 32) were acute myocardial infarctions. The presence of regional dysynergy identifies the occurrence of an infarction. The number of segments exhibiting this finding does not necessarily add to the diagnosis of acute myocardial infarction. Consequently, one would not expect the degree of LVSD to be important in determining the occurrence of an infarction in these patients, although other events such as death may be related to the degree of LVSD.

In contrast to early events, one would have expected some relation between the occurrence of events and the degree of LVSD in patients experiencing late events who had clinical and other evidence of heart failure. Unadjusted event rates seem to support this expectation. When data are adjusted for the confounding effects of age and history of hypertension, however, the degree of LVSD (among those with this finding) no longer provides independent predictive power.

The reason for a loss of the prognostic power of the degree of LVSD in predicting late events once adjustment for advanced age and a history of hypertension is made is not readily apparent from our data. Among these patients, those with left ventricular wall motion score of more than 24 were significantly older (p<0.05) than those with lower wall motion scores despite having the same prevalence of hypertension. As such, controlling for age and hypertension may have been similar to controlling for duration of hypertension. As a consequence, subjects with wall motion scores of more than 24 may have been at greater risk of late events than those whose scores were lower (>12 but ≤24), because the higher scores may have been more often associated with older ages and a longer duration of hypertension.

Value of Other ER Findings

Although the presence or absence of LVSD was clearly related to early and late cardiac events in this patient sample, the value of routinely measured ER findings continues to be important. Our results indicate that, whereas historical and clinical data have questionable value in predicting early events, they provide important information in terms of late events. Similarly, while the electrocardiogram is very useful for predicting early events, it has lesser value for late events. The presence of LVSD, however, provides diagnostic and prognostic information for both early and late events over and above that already provided by age and the historical, clinical, and EKG data routinely observed in patients presenting to the ER with cardiac-related symptoms.

Logistics of Performing 2DE in the ER

Although it was not the purpose of this study to assess the logistics of performing 2DE in the ER, it may be worth discussing some of the concerns related to this issue. At the time this study was performed, there were approximately 42,000 annual visits to our ER, of whom about two thirds were nonsurgical. Of
the latter group, approximately 10% constituted patients who complained of chest pain. Of these patients, no more than five or six met our inclusion criteria over a 24-hour period. Despite being on call 24 hours at a time, therefore, members of the study team did not have to perform 2DE more than five or six times a day.

To identify patients with LVSD, physicians trained in performing and interpreting 2DE studies would be required to evaluate patients presenting to the ER with cardiac-related symptoms. This service could be provided by either a cardiologist or an ER physician trained in selected aspects of 2DE. Which of these two options is more practical and cost-effective needs to be determined. It is likely that the option chosen will depend as much on local hospital based factors as on training of the individual.

Clinical Implications of Our Findings

Our results suggest that a patient presenting to the ER with cardiac-related symptoms be initially given a physical examination and an electrocardiogram. If ECG findings diagnostic for acute myocardial infarction or physical findings of congestive heart failure are absent, evaluation of left ventricular systolic function becomes valuable. In our data, patients without ST elevation or findings of congestive heart failure had a significantly increased risk of both early and late events in the presence of LVSD. As a result, it would seem prudent that subjects with LVSD in whom an acute event is suspected should be admitted to the hospital. In patients with acute symptoms, the absence of LVSD can ease the decision to discharge a patient from the ER, particularly if the electrocardiogram is also normal. Patients with LVSD not suspected to have an acute event or an acute exacerbation of a chronic condition necessitating hospital admission should be aggressively evaluated as outpatients in the very near future. Patients with LVSD on 2DE should not be lost to follow-up.

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References

17. Weidner N: Laboratory diagnosis of acute myocardial infarction: Usefulness of determination of lactate dehydrogenase (LDH)-1 level and ratio of LDH-1 to total LDH. Arch Pathol Lab Med 1982;106:375-377
20. Lane PW, Nelder JA: Analysis of covariance and standardization as instances of prediction. Biometrics 1982;38:613-621


26. Lepeschkin E: *Modern Electrocardiography*. Baltimore, Williams & Wilkins, 1951


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