SUMMARY To determine the impact of echocardiography in management of patients with systemic embolism, we retrospectively reviewed medical records and echocardiograms of 191 consecutive patients with suspected systemic embolism. One hundred sixteen patients had two dimensional echocardiograms and 75 patients had M-mode echocardiograms only. Patients were divided into three groups: Group 1 had no cardiovascular disease; Group 2 had cardiovascular disease, and Group 3 had hypertension only. Changes in therapy following echocardiogram were defined as initiation or discontinuation of anticoagulants or antiplatelet agents, cardioversion, or surgical intervention. M-mode echocardiogram did not identify any heart as a likely source of systemic embolism. Two dimensional echocardiogram defined 13 hearts as likely sources of emboli. All of these patients had known cardiovascular disease. Four of 13 patients (30.7%) whose hearts were likely sources of emboli had a change in therapy compared with 42 of 126 patients (33.3%) with low probability echocardiograms. We conclude that M-mode echocardiogram has no role in evaluation of patients with systemic embolism. Two dimensional echocardiogram may identify the heart as a source of emboli in patients with cardiovascular disease but does not alter early management.

Influence of Echocardiography on Management of Patients with Systemic Emboli

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Echocardiography is frequently used to evaluate the heart as a potential source for systemic embolism. Systemic embolism may result from such structural cardiac abnormalities as mitral stenosis, mitral myxoma, intracavity thrombus, and the vegetations of infective endocarditis. Other less firmly established sources of systemic embolism include mitral valve prolapse, aortic valve calcification, and mitral annulus calcification. Echocardiography is an effective tool for the diagnosis of these abnormalities. Despite the usefulness of echocardiography, recent studies have shown it to have a limited yield in defining cardiac causes of systemic emboli in unselected patients.

This study was undertaken to determine the impact of echocardiography on the management of patients with suspected systemic embolism. The study also defines the cost-effectiveness of echocardiography when used for this purpose. Based on our results, recommendations are made for effective use of echocardiography in patients with systemic embolism.

Methods

Between January 1978 and October 1980, 4128 echocardiographic examinations were performed at the Medical College of Virginia. Patients were considered to be candidates for inclusion in the study if the physician requesting the echocardiogram asked that the heart be evaluated as a source of emboli. When the reason for requesting an echo was not specified, it was the practice of our laboratory to make inquiry of the requesting physician. There were 193 of these requests. Two patients were excluded from the study because adequate medical records could not be located.

The study group consisted of 191 patients. One hundred sixteen patients had two dimensional echocardiograms (2DE) and 75 had M-mode echocardiograms (MME) only. Patients who had both MME and 2DE were considered in the 2DE group. Patients ranged in age from 21 to 90 years with a mean age of 60 years. There were 99 males and 92 females. One hundred fifty-one patients were suspected of having cerebral emboli and 34 were suspected of having emboli to organs other than the brain. Six patients were felt to have both cerebral and non-cerebral emboli.

Chart Review

The clinical chart of each patient was reviewed. Information from the chart was used to assign each patient to a clinical group and therapy group. Echocardiographic findings were not used in group assignment. Criteria for assignment to a clinical group are outlined below:

Clinical Group 1: No cardiovascular disease
Clinical Group 2: Cardiovascular disease
Clinical Group 3: No cardiovascular disease other than hypertension

There were 29 patients in Group 1, 116 patients in Group 2, and 46 patients in Group 3.

Patients with prior cardiovascular disease (clinical Group 2) were placed into subgroups according to their type of disease. Subgroups were defined as described below:

Subgroup 2A: Coronary artery disease (58 patients). Patients were included in this subgroup if there were historical or electrocardiographic evidence of prior myocardial infarction.

Subgroup 2B: Valvular heart disease. No prosthetic heart valve (9 patients).
Subgroup 2C: Valvular heart disease with a prosthetic valve (25 patients).

Subgroup 2D: Atrial fibrillation (54 patients). Patients were included in this subgroup if there was a history of atrial fibrillation or atrial fibrillation on an electrocardiogram.

Subgroup 2E: Cardiomyopathy (5 patients). Clinically diagnosed.


Patients with more than one form of cardiovascular disease were included in each of the appropriate subgroups. Thus, a patient with mitral stenosis and atrial fibrillation was included in both Subgroup 2B and Subgroup 2D.

Charts were reviewed to determine if patients had a change in therapy based on the echocardiogram. The therapeutic measures which were evaluated were the use of warfarin, antiplatelet agents (aspirin, dipyridamole or sulfinpyrazone) or of cardioversion, surgical excision of an intracardiac thrombus, or implantation or replacement of a valvular prosthesis. A patient was said to have had a change in therapy if initiation or discontinuation of any of the above therapeutic measures followed the echocardiogram. We considered only therapeutic measures undertaken during the hospitalization in which the echocardiogram was obtained.

Analysis of Echocardiograms

Echocardiographic findings stratified each heart as to its likelihood as a source for systemic embolism. A heart was defined to have been a high probability source for emboli if the echocardiogram revealed mitral valve prolapse, aortic valve calcification, or enlarged left atrium. Mitral valve prolapse has been found to be associated with cerebral ischemic events but a cause-effect relationship as a source for emboli originating from the heart has not been conclusively established. For this reason mitral valve prolapse was designated as being of intermediate probability as a source for systemic emboli.

A heart was said to be a low probability source for emboli if no findings were present on echocardiography that would place the heart in a high probability or intermediate probability category. Data was analyzed separately for all patients and for those under age 40.

MME were obtained with an Irex System II, and 2DE were obtained with a Varian V3000. On each 2DE examination, attempts were made to obtain images in the long axis, short axis, and apical four chamber views.

Estimation of Cost-Effectiveness

An estimate of the cost-effectiveness of echocardiography as a method for determining the likelihood of the heart being a source for systemic embolism is based on the 1980 fee for 2DE in our laboratory of $240. In 1980 the fee for an MME was $140. The cost per each high probability heart is determined by the equation:

\[
\text{Cost} = \frac{\text{(fee per echo) \times \text{(total number of echos)}}}{\text{(number of high probability echos)}}
\]

Statistical Analysis

Data were summarized in contingency tables and the strength of the hypothesized relation was analyzed using Fisher’s exact test.

Results

Echocardiograph Findings

The yield of echocardiography in identifying hearts that were of high probability as a source for emboli is shown in table 1. MME did not identify any heart as a high probability source of emboli. 2DE identified the heart as a high probability source for emboli in 13 of 116 (11.2%) studied. All of these echocardiograms were from the group of patients with prior cardiovascular disease (Group 2). No heart was identified as a high probability source for emboli from the groups without prior cardiovascular disease (Group 1) or from those with hypertension only (Group 3). Thus, echocardiography is more likely to identify the heart as a source for emboli in patients with cardiovascular disease than in those without heart disease or those with only hypertension \((p < 0.05)\). There was no statistically significant difference in the yield in patients under the age of 40 years.

Echocardiographic findings in the 13 patients whose
hearts were high probability sources of emboli were as follows: four patients had left ventricular aneurysm, two of these also had a left ventricular thrombus. One patient with a cardiomyopathy had a left ventricular thrombus. Two patients had mitral stenosis one of whom also had a left atrial thrombus. One patient who did not have mitral stenosis had a left atrial thrombus. Vegetations were found on the native valves of two patients and three patients had prosthetic valve vegetations. No cardiac myxomas were found.

Six patients were found to have mitral valve prolapse. Two of these patients had other findings on their echocardiograms which caused them to be placed in the high probability group. One patient had associated left ventricular aneurysm and the other patient had endocarditis. Four of these patients were under 40 years of age.

Influence of Echocardiography on Patient Management

Changes in patient management following echocardiography for patients with high and low probability echocardiograms is shown in table 2. Four of the 13 patients (30.7%) with hearts identified as high probability source for emboli had a change in therapy following the echocardiogram while change in therapy was found after a low probability echocardiogram in 42 of 126 patients (33.3%). These percentages were not significantly different (p > 0.1).

Patients with Cardiovascular Disease

We examined the clinical subgroups in Group 2 in greater detail to determine if patients with specific cardiovascular disease might have a higher yield from echocardiography or have a greater likelihood of a change in management. There was a sufficient number of patients to draw meaningful conclusions in only the subgroups of patients with coronary artery disease, prosthetic heart valves or atrial fibrillation. In none of these subgroups was the likelihood of obtaining a high probability echocardiogram significantly greater than for the entire Group 2 (p > 0.1). Similarly, patients in these subgroups were no more likely to have a change in therapy after echocardiography than for the entire Group 2 (p > 0.1). Subgroups of patients with valvular heart disease without prosthetic valves, cardiomyopathy or endocarditis each had nine or fewer patients. No meaningful conclusions regarding yield from echocardiography or likelihood of change of therapy could be made for these small groups.

Influence of Echocardiographic Findings on Patient Management

We examined specific echocardiographic findings to determine which findings would result in a change in therapy. Mitral valve prolapse (6 patients), aortic valve calcification (14 patients), left atrial dilatation (47 patients), mitral stenosis (2 patients), left ventricular aneurysm (4 patients), left atrial thrombus (2 patients), left ventricular thrombus (5 patients), valvular vegetation (3 patients), and prosthetic valve vegetation (2 patients) were evaluated. Though the number of patients with each finding was small, none of these findings was more likely to be associated with a change in therapy than was found in the group of patients with low probability echocardiograms (p < 0.1).

Cost-Effectiveness

The cost to identify each high probability study was computed. When 2DE was performed on each patient for whom it was requested, the cost per high probability echo was $2142. This cost could be reduced to $1477 if echocardiography was performed only on patients with cardiovascular disease.

Discussion

This study shows that echocardiography has a low yield, high cost, and the findings do not influence early therapy in patients with systemic embolism. The low yield of echocardiography in our study is

<table>
<thead>
<tr>
<th>Clinical group</th>
<th>Type of echocardiograph</th>
<th>Total</th>
<th>Number with change in management (%)</th>
<th>Total</th>
<th>Number with change in management (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(no cardiovascular disease)</td>
<td>2DE</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>MME</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Group 2</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>(cardiovascular disease)</td>
<td>2DE</td>
<td>13</td>
<td>4 (30.7)</td>
<td>40</td>
<td>15 (37.5)</td>
</tr>
<tr>
<td></td>
<td>MME</td>
<td>0</td>
<td></td>
<td>25</td>
<td>9 (36.0)</td>
</tr>
<tr>
<td>Group 3</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>(hypertension only)</td>
<td>2DE</td>
<td>0</td>
<td></td>
<td>20</td>
<td>8 (40.0)</td>
</tr>
<tr>
<td></td>
<td>MME</td>
<td>0</td>
<td></td>
<td>20</td>
<td>4 (20.0)</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>13</td>
<td>4 (30.7)</td>
<td>126</td>
<td>42 (33.3)</td>
</tr>
</tbody>
</table>

Abbreviations: *Echos = Echocardiograms; 2DE = two dimensional echocardiography; MME = M-mode echocardiography.
similar to that reported by Lovett and Greenland. In this study, MME failed to reveal a single heart as a high probability source for embolism. With 2DE the heart was a probable source for embolism in only 11.2% of patients studied. Greenland, et al. used 2DE and MME to study 95 consecutive patients admitted with stroke. 2DE identified only two patients whose hearts met our criteria for a high probability as a source for emboli. Both of these patients had clinical heart disease. MME in their study failed to identify any heart which would fall in our high probability category. The total yield in our study was higher than Greenland's. A likely explanation is that we included only those patients in whom a physician requested that the heart be evaluated as a source of emboli whereas Greenland studied all patients admitted with stroke.

Lovett, et al. studied 138 patients and identified 12 whose hearts would have met our criterion for high probability as a source of emboli. These patients had an intracardiac thrombus, atrial myxoma or vegetations. The yield of MME and 2DE in their study is similar to ours.

Hearts which are likely to be sources of emboli are detected by echocardiography at considerable expense. If 2DE studies were performed only on patients with cardiovascular disease, the cost to identify each high probability echocardiogram would have been $1477. 2DE was performed on all patients for whom it was requested raising the cost to $2142 for each high probability study. These figures probably underestimate the current costs of echocardiography because at our institution the percentage of all echos performed for this purpose has increased from 4.7% during the study period to 17.7% for the months of December 1981 and January 1982. This study agrees with the high costs generated by Larson who computed an annual cost 100 million dollars if MME and 2DE were performed on all patients with a first stroke. This cost soars higher when echocardiography is performed on patients with other diseases with embolic pathogenesis.

Despite frequent use of echocardiography at a considerable cost, we found that it seldom affected treatment of patients with systemic embolism. The patients whose echocardiogram identified their heart as a likely source of emboli were no more likely to have a change in therapy than those whose hearts were of low probability as a source of emboli. However, certain precautions must be taken in interpreting these data. The foremost being that in a retrospective study, questions are asked after the fact and rationale for drug use is difficult to determine. Several of the evaluated therapeutic modalities like aspirin have indications unrelated to treatment for embolism. Secondly, early management of patients with systemic embolism tends to be the same irrespective of the source. Thirdly, certain changes in therapy would be missed in retrospective review of patient record. For example, our method would not assess instances in which echocardiogram persuaded the clinician to continue antiplatelet agents. Also some alterations in patients management would have been made without regard to echocardiographic findings.

We conclude that M-mode echocardiography should not be used to identify the heart as a source of emboli. Routine two dimensional echocardiography has a low yield even in patients with known cardiovascular disease. Low yield and high cost warrants a prudent use of echocardiography in management of patients with systemic embolism.

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