Usefulness of Cardiovascular Investigations in Stroke Management
Clinical Relevance and Economic Implications

Andre Douen, MD, PhD, FRCPC; Nicole Pageau, RN, BSc; Sejla Medic, RN

Background and Purpose—There are no prospective randomized studies assessing the clinical relevance of routine cardiovascular investigations in stroke patients. The objective of this study was to evaluate the utilization, relevance, and economics of cardiovascular investigations in an ambulatory stroke clinic.

Methods—The outcome of cardiovascular investigations in 200 patients with stroke/transient ischemic attack diagnosed in a stroke prevention clinic was assessed. Transthoracic echocardiography (TTE) was assessed for detection of thrombus or mass, poor left ventricle function, and other structural abnormalities. ECG and Holter monitor were felt to be relevant if they showed atrial fibrillation/flutter. Investigations were deemed to be clinically pertinent if they brought about a shift in treatment paradigm.

Results—TTE and Holter were performed in 70% of cases and accounted for 94% of total cardiovascular cost. Relevant TTE findings were identified in 6 (4%) patients, which did not alter antithrombotic therapy. Only 2 new cases of atrial fibrillation were identified by both ECG and Holter.

Conclusions—TTE and Holter appear to be costly low-yield procedures in this clinical setting. Prospective analyses may help to provide cost effective criteria for selection of appropriate cardiovascular studies in stroke management. (Stroke. 2007;38:1956-1958.)

Key Words: ECG ■ ECHO ■ Holter ■ stroke ■ TIA

Although atrial fibrillation (AF) is the most common cause of cardioembolism,1,2 other conditions including severe left atrial dilatation, poor left ventricular function, valve disease, cardiac tumors, patent foramen ovale, and atrial septal defect have all been implicated.1,3–4 Consequently, cardiovascular investigations are routinely used in the assessment of ischemic stroke/transient ischemic attack (TIA).

One study assessing cardiac monitoring during acute stroke with 48-hour telemetry with or without Holter in an inpatient stroke investigative unit detected new arrhythmias in 6.5% of patients, half of whom had new-onset AF,5 pointing to the importance of cardiac monitoring in stroke work-up. However, the role of echocardiography in evaluation of embolic stroke is more controversial and the recommendations for management of patients with cardiac findings are quite varied.5–10 Whereas some suggest that transthoracic echocardiography (TTE) should be an essential test in all ischemic stroke patients,5 others conclude that TTE should be performed infrequently, particularly in older patients.6

Several studies have shown that transesophageal echocardiography has a higher detection rate for cardiac abnormalities than TTE,3,7,8 and 1 recent study with 231 patients reported a 16% detection of left atrial thrombus.9 However, this is in contrast to large prospective and retrospective studies of 869 and >20 000 patients, respectively, showing that the detection of left atrial thrombus with transesophageal echocardiography is ≈1%.3 Furthermore, transesophageal echocardiography comes with some risk and cost and many cardiac abnormalities detected by transesophageal echocardiography do not dictate specific therapy.3

The present study examines the role of cardiovascular investigations on stroke management in a large outpatient stroke prevention clinic.

Materials and Methods
We reviewed the charts of 200 patients with stroke or TIA diagnosed in the stroke prevention clinic over a 6-month period at the Trillium Health Centre, an Ontario Ministry of Health-designated Regional Stroke Centre. Diagnostic investigations studied included TTE, ECG, and Holter monitor, with specific attention to findings that might influence medical management, including detection of patent foramen ovale or atrial septal defect, left atrial spontaneous echocardiography contrast, mitral or aortic valve stenosis, or presence of vegetation, left atrial or left ventricular thrombus or mass, and poor left ventricular function (ejection fraction <40%); the latter may be assessed qualitatively or quantitatively.9 In this study, left ventricular...
function is as follows: grade 1, >60% (normal); grade 2, 40% to
59% (mildly impaired); grade 3, 20% to 39% (moderately impaired);
and grade 4, <20% (severely impaired).

Detection of AF/atrial flutter was considered the most important
finding for ECG/Holter monitor investigations for embolic stroke.
An investigation was felt to have a positive influence if it brought
about a change in treatment paradigm, ie, change from antiplatelet
therapy to anticoagulation.

Results
Transthoracic echocardiograms were performed in 71% (142/
200) of patients. Pertinent cardiac findings were uncovered in
only 6 (4%) patients (Table 1). TTE did not alter antithrombo-
tic therapy in any of the 142 patients studied.

Holter monitor was requested in 75% (149/200) of patients.
In only 3 of 149 cases (2%) were AF detected, consistent with
previously reported incidence of AF. Anticoagulation was
instituted after AF detection. However, in all 3 cases AF was
detected by ECG as well as Holter (Table 2).

The economic impact of cardiovascular investigations is
shown in Table 3. Costs (Canadian dollars) reflect the current
Ontario Health Insurance Plan rates of remuneration. TTE
and Holter studies accounted for 94% of total cardiovascular
costs ($52 115).

Discussion
The present study shows negligible clinical impact of TTE in
an outpatient stroke/TIA population consistent with previous
suggestions but discordant with a recent study that un-
covered cardiac abnormalities in 37.2% of patients, leading to
anticoagulation of these patients, and to the conclusion that
TTE should be an essential test in all ischemic stroke
patients. However, whereas these investigators suggest anti-
coagulation for a number cardiac pathologies, anticoagula-
tion is dubious for many cardiac abnormalities that might be
considered a “potential” source of embolism. The current
guidelines for antithrombotic therapy in ischemic stroke
suggests the use of antiplatelet therapy in patients with mitral
valve strands or prolapse, patent foramen ovale, aortic arch
atheroma. Furthermore, anticoagulation is not routinely rec-
ommended for stroke prophylaxis in heart failure patients,
and only weak levels of evidence (level C—consensus of
opinion of experts and/or small studies) suggests that anti-
coagulation should be considered in heart failure patients with
a history of systemic or pulmonary embolism. Consequently,
the decision to use anticoagulation for many of these cardiac
abnormalities is a matter of choice and not guided by any
randomized study or current guidelines.

In contrast to previous studies suggesting the importance of
early cardiac monitoring with 48-hour cardiac telemetry in
acute stroke inpatients, we found that Holter monitoring had
a low yield in this outpatient population and did not offer any
higher detection rate of AF above ECG (Table 2). There
could be population differences between these studies, ie,
inpatients versus outpatients in the present study. In addition,
because of the outpatient setting, 24-hour Holter monitor was
delayed by several days, as compared with immediate 48-
hour telemetry used with inpatients. Consequently, the tim-
ing and duration of cardiac monitoring might be a factor in
improving arrhythmia detection.

The search for a cardiac source of emboli is only relevant
if it directly influences medical management. Although there
is an indication for anticoagulation in stroke patients with AF
or recent MI, the data are less convincing with other cardiac
pathology. The mere detection of a cardiac abnormality by
echocardiography in a stroke patient is not proof of cause and
empiric use of anticoagulation needs to be weighed against
hemorrhagic risk. Additionally, it has recently been empha-
sized that many transesophageal echocardiography-guided
therapeutic strategies are not evidenced based.

### TABLE 1. Influence of TTE Findings on Antithrombotic Therapy in Stroke/TIA Patients

<table>
<thead>
<tr>
<th>Patient</th>
<th>Ischemic Event</th>
<th>TTE (Left Ventricular Function)</th>
<th>Prior Cardiac History</th>
<th>Antithrombotic Therapy Altered</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Left hemisphere TIA</td>
<td>Grade 4</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>2</td>
<td>Right hemisphere Stroke</td>
<td>Grade 3</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>3</td>
<td>Right hemisphere stroke</td>
<td>Grade 3</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>4</td>
<td>Right hemisphere TIA</td>
<td>Grade 3</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>5</td>
<td>Posterior circulation</td>
<td>Grade 2–3</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>6</td>
<td>Right hemisphere TIA</td>
<td>Grade 2–3</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

Estimated ejection fraction: grade 1, >60% (normal); grade 2, 40% to 59% (mildly impaired); grade 3, 20% to 39% (moderately impaired); grade 4, <20% (severely impaired).

Clinically relevant findings were detected in 6 of 142 studies conducted.

### TABLE 2. Comparison of the Detection of AF by Holter Monitor and ECG

<table>
<thead>
<tr>
<th>Patient</th>
<th>Cerebrovascular Event</th>
<th>Holter</th>
<th>ECG</th>
<th>History of AF</th>
<th>Antithrombotic Therapy Altered</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Right hemisphere TIA</td>
<td>(+)</td>
<td>(+)</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>2</td>
<td>Left hemisphere stroke</td>
<td>(+)</td>
<td>(+)</td>
<td>No</td>
<td>Anticoag—Antiplt</td>
</tr>
<tr>
<td>3</td>
<td>Posterior circulation TIA</td>
<td>(+)</td>
<td>(+)</td>
<td>No</td>
<td>Anticoag—Antiplt</td>
</tr>
</tbody>
</table>

Holter was conducted in 149 patients. AF was detected in 3 patients, by both ECG and Holter. Anticoag indicates anticoagulants; antiplt, antiplatelet agents.
In summary, the present study shows that TTE had no clinical impact and Holter did not appear to have any added advantage over ECG in this outpatient setting, yet TTE/Holter studies accounted for 94% of the cardiovascular cost for these patients. The overall cost might be higher if TTE was performed on every patient with ischemic stroke/TIA as recently suggested. Assessment of the clinical significance of cardiac abnormalities through a prospective trial may help to provide cost-effective criteria for selection of appropriate cardiovascular studies in stroke patients.

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Disclosures
None.

References

TABLE 3. Economic Impact of Vascular Investigations in Ambulatory Stroke/TIA Patients

<table>
<thead>
<tr>
<th>Investigations</th>
<th>Cost*/Study</th>
<th>No. of Studies Performed</th>
<th>Total Cost*</th>
</tr>
</thead>
<tbody>
<tr>
<td>TTE</td>
<td>$232.60</td>
<td>142</td>
<td>$33 029</td>
</tr>
<tr>
<td>Holter</td>
<td>$105.95</td>
<td>149</td>
<td>$15 786</td>
</tr>
<tr>
<td>ECG</td>
<td>$16.50</td>
<td>200</td>
<td>$3300</td>
</tr>
</tbody>
</table>

*Costs (Canadian dollars) based on Trillium Health Centre fees reflecting current Ontario Health Insurance Plan rates of remuneration (encompasses technical and professional fees).
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