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,4 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.1–10 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.8 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
considered a "potential" source of embolism. The current evidence for ECG/Holter monitor investigations for embolic stroke is dubious for many cardiac abnormalities that might be considered cardiac abnormalities in 37.2% of patients, leading to anticoagulation of these patients, and to the conclusion that anticoagulation of these patients is a matter of choice and not guided by any randomized study or current guidelines.

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
Transesophageal 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 antithrombotic 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 uncovered 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 anticoagulation for a number cardiac pathologies, anticoagulation 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 recommended 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 anticoagulation 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 timing 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 emphasized 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); and 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>Anticoagulation</td>
</tr>
<tr>
<td>3</td>
<td>Posterior circulation TIA</td>
<td>(+)</td>
<td>(+)</td>
<td>No</td>
<td>Anticoagulation</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.
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</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>$3,300</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).

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.\(^5\) 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.

Sources of Funding
N.P. and S.M. were supported through unrestricted educational grants from Boehringer Ingleheim and Sanofi-Aventis.

Disclosures
None.

References
Usefulness of Cardiovascular Investigations in Stroke Management: Clinical Relevance and Economic Implications
Andre Douen, Nicole Pageau and Sejla Medic

Stroke. 2007;38:1956-1958; originally published online April 19, 2007; doi: 10.1161/STROKEAHA.106.477760
Stroke is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 2007 American Heart Association, Inc. All rights reserved.
Print ISSN: 0039-2499. Online ISSN: 1524-4628

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://stroke.ahajournals.org/content/38/6/1956

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in Stroke can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to Stroke is online at:
http://stroke.ahajournals.org/subscriptions/