Stroke Care Delivery in Institutions Participating in the Registry of the Canadian Stroke Network

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Background and Purpose—Guidelines and performance indicators have been established for acute stroke care. However, little is known about the process of stroke care delivery in Canada.

Methods—The Registry of the Canadian Stroke Network (RCSN) captured detailed clinical data on patients with stroke and transient ischemic attack seen at 21 acute care institutions across Canada. Data from phase 1 of the RCSN (June 2001 to February 2002) were used to determine the use of evidence-based acute stroke care interventions in participating institutions.

Results—Overall, 4439 patients were seen during the study time frame and 1701 (38%) consented to full data collection. Thirty-one percent received care on a stroke unit or from a mobile stroke team. Among patients with ischemic stroke, 7% received thrombolysis, 80% underwent carotid imaging, 89% received antithrombotic agents, and 54% of those with atrial fibrillation received warfarin. There were significant intersite variations in the delivery of all of these interventions except for the use of antithrombotic agents, and these persisted after adjustment for age, sex, stroke type, and other comorbid conditions.

Conclusions—Patients in institutions participating in the RCSN received high-quality stroke care based on a number of performance measures. However, gaps exist in the provision of other elements of stroke care, particularly organized inpatient stroke care and warfarin for atrial fibrillation. Future research should explore explanations for these findings and focus on solutions to deficiencies in care. (Stroke. 2004;35:1756-1762.)

Key Words: stroke • quality of health care
acute stroke care and included interventions such as thrombolytic and antiplatelet agents in eligible patients, warfarin in those with atrial fibrillation, organized inpatient stroke care (either a stroke ward or a mobile stroke team), and testing for carotid stenosis. We determined the proportion of patients who received each of these interventions and compared the use of stroke care interventions among the 21 participating institutions.

Materials and Methods

Data Source: Registry of the Canadian Stroke Network

The RCSN was established by the Canadian Stroke Network (www.canadianstrokenetwork.ca), which is funded by the Canadian Networks of Centres of Excellence (www.nce.gc.ca). Phase 1 of the RCSN took place between June 2001 and February 2002, and included 21 participating sites from 8 Canadian provinces. Potential sites were identified by soliciting applications from stroke neurologists who were members of the Canadian Stroke Consortium. The Steering Committee then selected sites based on their anticipated volumes and commitment to the RCSN and also attempted to ensure representation from most Canadian provinces. These sites had more resources and stroke expertise than the typical Canadian acute care institution. All participating sites were urban tertiary care institutions with specific stroke care resources: all had a neurologist with expertise in stroke, 81% were teaching hospitals, 67% had a mobile interdisciplinary acute stroke team, and 57% had an acute stroke ward. Although these institutions represented only 3% of acute care institutions in Canada, analyses of Canadian administrative data indicate that ~20% of all admitted stroke patients in the country are seen at these Registry institutions (J.V. Tu, unpublished data, 2000). Approval was obtained from the research ethics board at each participating institution. A stroke neurologist served as a project leader at each site and trained neurology research nurses performed patient recruitment and data entry based on chart review and patient and family interviews.

The RCSN recruited consecutive patients from participating sites with acute ischemic stroke, transient ischemic attack (TIA), intracerebral hemorrhage, and subarachnoid hemorrhage, and collected data on patient demographics and medical history, stroke subtype and severity, and prehospital, emergency, and in-hospital interventions and outcomes. Although all stroke and TIA patients were eligible for inclusion in the Registry, signed patient consent was required for full data collection, and only ~40% of potentially eligible patients consented to participate in the Registry. A minimal amount of data (including age, sex, stroke type, and use of thrombolyis) was obtained on all patients, including those who did not consent to full data collection. Inter-rater reliability testing was performed on ~10% of charts, and agreement was “substantial” to “almost perfect” for key variables including age, sex, time of stroke onset and hospital arrival, use of thrombolysis, and death in hospital. Data were entered electronically, and the aggregate anonymous database was managed at the Institute for Clinical Evaluative Sciences in Toronto, Ontario.

Performance Indicators for Stroke Care

The literature was reviewed for relevant performance indicators for stroke care delivery during the acute hospitalization phase, and the following 5 quality indicators were selected for evaluation.13–17,26,28

First, we evaluated the proportion of all stroke patients who received organized stroke care, defined as either a dedicated stroke ward or a mobile stroke team. Second, we determined the use of thrombolysis in patients with ischemic stroke presenting within 3 hours of stroke symptom onset. Third, we evaluated the use of antithrombotic agents (aspirin, other antiplatelet agents, or warfarin) at the time of discharge from hospital in patients with ischemic stroke or TIA. Fourth, we evaluated the proportion of patients with ischemic stroke or TIA and atrial fibrillation (documented either on past medical history or during the index stroke hospitalization) who received warfarin therapy at discharge. Both antithrombotic and warfarin use were also evaluated in “ideal” patients, defined a priori as those without potential contraindications to therapy such as a history of cirrhosis, peptic ulcer disease, previous gastrointestinal bleeding, or other bleeding disorder. Finally, we determined the proportion of patients with ischemic stroke or TIA who underwent carotid imaging (defined as carotid Doppler ultrasound, magnetic resonance or computed tomography angiography, or catheter angiography of the cerebral vessels) during the index stroke hospitalization; we did not capture data on testing performed after discharge from hospital. Because carotid imaging is not routinely recommended for the evaluation of posterior circulation events, secondary analyses assessed the use of carotid imaging in the subgroup of patients with carotid territory stroke or TIA. Other indicators and outcomes assessed included the time interval from stroke onset to hospital arrival, the use of prehospital emergency medical services, and the proportion of patients arriving within 2 hours of stroke onset.

Statistical Analysis

The main outcome measure was the proportion of stroke patients in the RCSN who received each of the performance indicators for stroke care. All Registry patients (consented and nonconsented) were included in the analysis of thrombolysis rates; the remainder of the analyses included only those patients who consented to full data collection.

Secondary analyses used χ² tests to compare the use of these interventions among participating institutions, with censoring of results from hospitals with <30 eligible cases or with >10% missing data for a given variable. For the use of thrombolysis, antithrombotic agents, carotid imaging, and organized stroke care, multiple logistic regression was used to compare care in different institutions with adjustment for age, sex, level of consciousness (as a surrogate for stroke severity), stroke type, and comorbidity. Analysis of use of thrombolysis, antithrombotic agents, and carotid imaging was limited to those with ischemic stroke. Regression modeling was performed using each performance indicator as the dependent variable, with predictor variables added using backward selection. The Charlson index was used to summarize comorbid illness. It was selected for this purpose because it is a widely used and well-validated index of comorbidity, which has been found to correlate with mortality in some studies. It provides a weighted summary score from 0 (no comorbid illness) to 31, based on the presence or absence of each of 17 medical conditions. Previous studies of individuals with stroke have found that the majority of patients (>75%) have Charlson scores of 0 or 1, indicating minimal comorbidity. SAS (version 8.02) was used for all analyses.

Results

During the study time period, 4439 patients were enrolled in the registry, and 1701 (38%) consented to full data collection. The mean age of patients in the study sample was 67 years and 46% were female (Table 1). There was a high prevalence of stroke risk factors documented on medical history, and there were interinstitutional variations in patient risk factors and stroke type and severity (Table 1). Compared with patients who did not consent to participate in the RCSN, participating patients were younger (median age of 69 versus 72 years, P = 0.0001), were more likely to speak English or French as a first language (90% versus 84%, P = 0.0017), and were more likely to be alert on admission (78% versus 66%, P = 0.0001).

Overall, 60% of patients were transported to hospital by ambulance, and 24% arrived within 2 hours of stroke onset (Table 2). The majority (86%) of Registry patients was admitted to hospital. Of these, 18% were admitted to an acute stroke unit, 21% were seen by a mobile stroke team, and 31% received some form of organized stroke care (either ward or...
team), with a range of 0% to 88% across the country (P<0.0001) (Table 3). An acute stroke ward was available at 12 of 21 participating institutions; at these sites, 34% of patients received stroke ward care.

Among patients with ischemic stroke, 7% received thrombolysis, and this ranged from 0% to 12% across the country (P<0.0001) (Table 2). Among patients who arrived within 3 hours of stroke onset, 14% received thrombolysis, with a range of 0% to 29%. In this group, the main reported reasons for failure to administer thrombolysis were stroke severity (almost all patients in this category had minimal symptoms or were rapidly improving) (65%), symptoms present for >3 hours at the time of stroke team assessment (15%), and comorbid conditions (6%).

The majority (89%) of patients with ischemic stroke or transient ischemic attack was prescribed antithrombotic agents at discharge from hospital, with a range of 76% to 94% (P=0.01) (Table 3). The results were similar when patients with contraindications such as gastrointestinal bleeding were excluded (90% overall, range 80% to 96%). Among patients with a history of atrial fibrillation before admission or during hospitalization, 54% were prescribed warfarin in hospital or at discharge, and results were similar in “ideal” patients without contraindications to warfarin therapy, with 57% receiving warfarin at discharge (Table 3). The number of eligible patients at each site was too small to permit the evaluation of interinstitutional variations in warfarin use. Eighty percent of patients with ischemic stroke or TIA underwent carotid imaging during the index hospitalization, with a range of 62% to 97% among study hospitals (P<0.001); results were similar when the analysis was limited to patients with carotid territory symptoms, with 82% undergoing carotid imaging. There were no differences in the rates of antithrombotic use and warfarin for atrial fibrillation or carotid imaging between patients who received care on a stroke unit or from a stroke team versus those who received usual medical care.

In the multivariate analyses with adjustment for age, sex, level of consciousness, and comorbidity, there were persistent intersite variations in the use of organized stroke care, thrombolysis, warfarin and carotid imaging, but not in the use of antithrombotic agents. Older age and higher Charlson comorbidity index scores were not associated with variations in the use of any interventions; however, women were less likely than men to receive stroke unit care (adjusted odds ratio 0.63; 95% confidence interval: 0.44 to 0.90) and thrombolysis (adjusted odds ratio 0.66; 95% CI, 0.44 to 0.99).

**Discussion**

We found that patients seen at the institutions participating in the RCSN received high-quality stroke care based on a number of performance indicators. Specifically, 90% of “ideal” patients received antithrombotic agents at discharge from hospital, 80% underwent carotid imaging in hospital, and 14% of potentially eligible patients received thrombolysis. However, we also found gaps in the provision of other components of stroke care: only 18% of Registry patients were admitted to an acute stroke unit, only one third of Registry patients received any form of organized inpatient stroke care, and only 54% of those with atrial fibrillation received warfarin at discharge. In addition, there were significant variations among participating sites in the provision of organized stroke care, thrombolysis, and carotid imaging, and these did not appear to be fully explained by variations in case mix among the sites.

Variations and deficiencies in stroke care delivery have been documented in many other jurisdictions. An Australian stroke audit found that 78% of those with ischemic stroke or TIA received antiplatelet agents, with low rates of warfarin use for those with atrial fibrillation (33%), stroke unit care (23%), and thrombolysis (1%). A study of US Medicare patients hospitalized with stroke or transient ischemic attack found rates of discharge antithrombotic use ranging from 74% to 91% across the country, whereas studies from the Scottish Stroke Outcomes Study Group and the United Kingdom General Practitioner Research Database have found...
underuse and regional variations in the use of antithrombotic agents, multidisciplinary teams, and neuroimaging. More recently, the UK National Sentinel Stroke Audit found that 36% of patients across the United Kingdom were admitted to stroke units and 91% were prescribed antithrombotic agents at discharge, with wide interinstitutional variations in the organization and delivery of care.

Variations in care may be explained in part by appropriate patient selection resulting in exclusion of patients with contraindications to the therapy under consideration. The detailed clinical data in the Registry of the Canadian Stroke Network allowed us to examine the use of interventions among "ideal" patients without contraindications to therapy and to explore predictors of use for each intervention. The use of tPA was relatively high (14%) in those presenting to hospital within 3 hours of stroke onset, and the majority of patients who did not receive tPA were excluded on the basis of eligibility criteria derived from the NINDS tPA study. Similarly, the use of carotid imaging in 80% of patients may be appropriate, given that such imaging is not required for

### TABLE 2. Emergency Department Stroke Care Performance Indicators

<table>
<thead>
<tr>
<th>Variable</th>
<th>All Canada</th>
<th>Range Among Institutions*</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arrive by ambulance, n/n eligible patients (%)</td>
<td>60</td>
<td>24/64 (38) 43/45 (96)</td>
<td>&lt;.00001</td>
</tr>
<tr>
<td>Arrival within 2 hours of stroke onset, n/n eligible patients (%)</td>
<td>24</td>
<td>5/42 (13) 24/56 (42)</td>
<td>&lt;.00001</td>
</tr>
<tr>
<td>Thrombolysis given, n/n eligible patients† (%)</td>
<td>4</td>
<td>0/119 (0) 8/68 (12)</td>
<td>&lt;.00001</td>
</tr>
<tr>
<td>In subgroup with ischemic stroke</td>
<td>7</td>
<td>0/80 (0) 8/64 (12)</td>
<td>&lt;.00001</td>
</tr>
<tr>
<td>In subgroup with ischemic stroke and symptoms&lt;3 hours</td>
<td>14</td>
<td>0/44 (0) 11/38 (29)</td>
<td>&lt;.00001</td>
</tr>
<tr>
<td>If ischemic stroke and symptoms&lt;2 hours on ER arrival, reason thrombolysis not given† (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stroke severity (too mild, rapidly improving, too severe)</td>
<td>65</td>
<td>25 92</td>
<td>&lt;.0100</td>
</tr>
<tr>
<td>Symptoms&gt;3 hours at time thrombolysis decision made</td>
<td>15</td>
<td>0 57</td>
<td>&lt;.0220</td>
</tr>
<tr>
<td>Comorbid illness</td>
<td>6</td>
<td>0 29</td>
<td>&lt;.1774</td>
</tr>
<tr>
<td>&quot;Code stroke&quot; not initiated</td>
<td>3</td>
<td>0 25</td>
<td>0.0905</td>
</tr>
<tr>
<td>Other‡</td>
<td>10</td>
<td>0 30</td>
<td>0.0026</td>
</tr>
</tbody>
</table>

*Two institutions with <30 eligible patients are censored in reporting the "range among institutions.
†Ten institutions with <30 eligible patients or >10% missing data are censored in reporting the "range among institutions" for this variable.
‡"Other" reasons include recent surgery or trauma, bleeding disorders, and other unspecified reasons.
ER indicates emergency room.

### TABLE 3. In-Hospital Stroke Care Performance Indicators

<table>
<thead>
<tr>
<th>Performance Indicator</th>
<th>All Canada</th>
<th>Range Among Institutions*</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Care on acute stroke ward, n/n eligible patients (%)</td>
<td>18</td>
<td>0/199 (0) 43/51 (85)</td>
<td>&lt;.00001</td>
</tr>
<tr>
<td>Care on stroke ward or by stroke team, n/n eligible patients (%)</td>
<td>31</td>
<td>0/68 (0) 45/51 (88)</td>
<td>&lt;.00001</td>
</tr>
<tr>
<td>Care on stroke ward or by stroke team in subgroup of institutions where stroke ward or team care available,† n/n eligible patients (%)</td>
<td>44</td>
<td>4/41 (10) 45/51 (88)</td>
<td>&lt;.00001</td>
</tr>
<tr>
<td>Antithrombotic therapy at discharge,§‡ n/n eligible patients (%)</td>
<td>89</td>
<td>55/73 (76) 119/127 (94)</td>
<td>0.0109</td>
</tr>
<tr>
<td>Antithrombotic therapy in &quot;ideal&quot; patients,§¶ n/n eligible patients (%)</td>
<td>90</td>
<td>54/68 (80) 80/83 (96)</td>
<td>0.0129</td>
</tr>
<tr>
<td>Warfarin for atrial fibrillation§ (%)</td>
<td>54</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Warfarin for atrial fibrillation in &quot;ideal&quot; patients§¶ (%)</td>
<td>57</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Carotid imaging,§¶ n/n eligible patients (%)</td>
<td>80</td>
<td>39/63 (62) 193/199 (97)</td>
<td>&lt;.00001</td>
</tr>
</tbody>
</table>

*Three institutions with <30 eligible patients are not reported in the "range among institutions.
†Analysis limited to 14 institutions with an acute stroke ward or stroke team.
‡Antithrombotic therapy includes aspirin, clopidogrel, ticlopidine, dipyridamole, and warfarin; carotid imaging indicates carotid Doppler, cerebral angiography or magnetic resonance angiography performed during the index hospitalization.
§"Ideal" patients are those without a history of bleeding disorder, peptic ulcer disease, or cirrhosis.
¶Seven institutions with <30 eligible patients or >10% missing data for the variable of interest are censored in reporting the "range among institutions."
patients in whom the results are unlikely to change management, such as those who are not candidates for carotid endarterectomy because of disabling stroke or other comorbid illness. Additional patients may have undergone carotid imaging soon after discharge, and this would not have been captured by the database. Warfarin was used in only 54% of those with atrial fibrillation; discussion with neurologists participating in the Registry suggests that this may be explained in part by uncertainty about the relative benefits of warfarin versus antiplatelet agents for secondary stroke prevention in elderly patients with severe strokes and a higher perceived risk of complications. However, even after adjustment for stroke type and other prognostic factors, we observed persistent inter-site variations in the use of stroke care interventions, suggesting that patient factors are not the sole explanation for the observed variations in stroke care delivery.

Other explanations for variations in care include the availability and organization of local resources. The use of thrombolysis and antithrombotic agents in RCSN patients was higher than that observed in some previous stroke audits, and likely reflects the specialized nature of the participating institutions. However, even among these highly selected institutions, some administered no thrombolysis at all. Discussions with the participating neurologists revealed that in some cases this was attributable to insufficient personnel with expertise in administering thrombolysis, or an institutional or departmental concern about the efficacy of tPA. Furthermore, only 57% of these selected institutions had an acute stroke ward and only 67% had either a stroke ward or a mobile stroke team, and the availability of acute stroke units among other institutions in Canada is almost certainly much lower: a 1999 survey of all Ontario hospitals found that an acute stroke ward existed in only 4% of acute care institutions. In conclusion, Canadian stroke patients at these specialized institutions received high-quality stroke care based on a number of performance measures. However, gaps and significant interinstitutional variations exist in the provision of other elements of evidence-based stroke care. These data provide a benchmark against which quality improvement in Canadian hospitals can be measured. Future research should explore explanations for these observed differences, evaluate their effect on stroke patient outcomes, and focus on solutions to deficiencies in care.
Appendix

The following persons and institutions participated in phase 1 of the Registry of the Canadian Stroke Network:

**Participating Centers**
- **Queen Elizabeth II Health Sciences Centre**, Halifax, NS: S. Phillips, MD (Principal Investigator), G. Gubitz, MD (Principal Investigator), W. Simpkin, RN (Coordinator)
- **Saint John Regional Hospital**, St. John, NB: P. Bailey, MD (Principal Investigator), P. Cook, RN (Coordinator), S. Alward, RN (Coordinator)
- **Hopital Notre-Dame du CHUM**, Montreal, QC: L. Lebrun, MD (Principal Investigator), M. Desrochers, RN (Coordinator), L. Mercille, RN (Coordinator)
- **Hopital de l’Enfant-Jesus**, Quebec City, QC: D. Simard, MD (Principal Investigator), A. Mackey, MD (Principal Investigator), S. Dube, RN (Coordinator), B. Leger, RN (Coordinator)
- **Hopital Charles le Mouyne**, Greenfield Park, QC: L. Berger, MD (Principal Investigator), L. Moisan, RN (Coordinator), Y. Serraspino, RN (Coordinator), D. Truong, RN (Coordinator)
- **Montreal General Hospital and SMBD-Jewish General Hospital**, Montreal, QC: R. Cote, MD (Principal Investigator), J. Minuk, MD (Principal Investigator), C. Wong, RN (Coordinator)
- **Sunnybrook & Women’s College Health Sciences Centre**, Toronto, ON: S. Black, MD (Principal Investigator), N. Jiang, (Coordinator), J. Bray (Coordinator), M. Kerr-Taylor, RN (Coordinator)
- **University Health Network/Toronto Western Hospital**, Toronto, ON: F. Silver, MD (Principal Investigator), P. Urzua, RN (Coordinator), G. Gutierrez, RN (Coordinator), R. Wiegner, RN (Coordinator)
- **London Health Sciences Centre**, London, ON: V. Hachinski, MD (Principal Investigator), N. Absolon, RN (Coordinator), L. Cotton, RN (Coordinator)
- **The Ottawa Hospital**, Ottawa, ON: A. Douen, MD (Principal Investigator), M. Sharma, MD (Principal Investigator), N. Pageau, RN (Coordinator), M. Savage, RN (Coordinator)
- **Kingston General Hospital**, Kingston, ON: D. Howe, MD (Principal Investigator), D. Brunet, MD (Principal Investigator), S. Weatherby, RN (Coordinator)
- **Hamilton Health Sciences Centre**, Hamilton, ON: W. Oczkowski, MD (Principal Investigator), N. Pyette, RN (Coordinator), L. Gould, RPN (Coordinator)
- **Trillium Health Sciences Centre**, Mississauga, ON: D. Selchen, MD (Principal Investigator), H. Hinks, RN (Coordinator), T. Stokes, RN (Coordinator)
- **Winnipeg Regional Health Authority**, Winnipeg, MB: B. Anderson, MD (Principal Investigator), D. Gladish, RN (Coordinator), J. Goussénn, RN (Coordinator), P. Piki, RN (Coordinator)
- **Royal University Hospital**, Saskatoon, SK: C. Voll, MD (Principal Investigator), S. Bishop, RN (Coordinator), L. Schmidt, RN (Coordinator), B. Kwiatkowski, RN (Coordinator)
- **Foothills Medical Centre**, Calgary, AB: M. Hill, MD (Principal Investigator), L. Sinclair, RN (Coordinator), M. Schebel, RN (Coordinator), A. Cole-Haskayne, RN (Coordinator)
- **University of Alberta Hospital**, Edmonton, AB: A. Shuaib, MD, (Principal Investigator), A. Nasser, RN (Coordinator)
- **Lion’s Gate Hospital**, Vancouver, BC: D. Cameron, MD (Principal Investigator), C. Tadey, RN (Coordinator)
- **Vancouver General Hospital**, Vancouver, BC: P. Teal, MD (Principal Investigator), T. Steele, BSN, RN (Coordinator)
- **St. Paul’s Hospital**, Vancouver, BC: D. Johnston, MD (Principal Investigator), M. Wong, MD (Principal Investigator), H. Connolly, RN (Coordinator)
- **Capital Health Region**, Victoria, BC: A. Penn, MD (Principal Investigator), M. Laporte, RN (Coordinator)

**Coordinating Centre at the Institute for Clinical Evaluative Sciences, Ontario**: M. Kapral, F. Silver, J. Fang, A. Laupacis, J. Richards, J. Tu

**Steering Committee**: F. Silver (Chair, phase 1), A. Hakim, M. Hill, M. Kapral (Chair, phase 2), A. Laupacis, M. Lewis, N. Mayo, S. Phillips, (Chair, phase 1), G. Taylor, J. Tu, K. Willis

**Data Privacy and Security Committee**: D. Willison, ScD (Chair), A. Buchan, MD, A. Laupacis, MD, P. Peladeau, A. Penn, J. Richards, F. Silver, J. Williams


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References


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