Estimated Cost Savings of Increased Use of Intravenous Tissue Plasminogen Activator for Acute Ischemic Stroke in Canada

Todd R. Yip, MD, MSc; Bart M. Demaerschalk, MD, MSc, FRCPC

**Background and Purpose**—Intravenous tissue plasminogen activator (tPA) is an economically worthwhile but underused treatment option for acute ischemic stroke. We sought to identify the extent of tPA use in Canadian medical centers and the potential savings associated with increased use nationally and by province.

**Methods**—We determined the nationwide annual incidence of ischemic stroke from the Canadian Institute of Health Information. The proportion of all ischemic stroke patients who received tPA was derived from published data. Economic analyses that report the expected annual cost savings of tPA were consulted. The analysis was conducted from the perspective of a universal health care system during 1 year. We estimated cost-savings with incrementally (eg, 2%, 4%, 6%, 8%, 10%, 15%, and 20%) increased use of tPA for acute ischemic stroke nationally and provincially.

**Results**—The current average national tPA utilization is 1.4%. For every increase of 2 percentage points in utilization, $757 204 (Canadian) could possibly be saved annually (95% CI maximum loss of $3 823 992 to a maximum savings of $2 201 252). With a 20% rate, $7.5 million (Canadian) could be saved nationwide the first year.

**Conclusions**—We estimate that even small increases in the proportion of all Canadian ischemic stroke patients receiving tPA could result in substantial realized savings for Canada’s health care system. (*Stroke. 2007;38:1952-1955.)*

**Key Words:** acute ischemic ■ costs ■ economics ■ medical ■ stroke ■ thrombolysis ■ tissue plasminogen activator

A acute ischemic stroke (AIS) is a leading cause of death and disability in Canada, with >55 000 new cases annually, for an annual cost to the Canadian economy of $2.7 billion (Canadian dollars).1

Intravenous thrombolysis with recombinant tissue plasminogen activator (tPA) is an effective treatment for AIS, with nearly 40% of tPA-treated patients returning to their pre-stroke level of function within 90 days.2 Nonetheless, only 1.4% of AIS patients received this medication in Canada during 1999 to 2001.2 Fortunately, many medical centers are implementing programs for AIS care that increase the access to tPA, with centers such as Kingston Regional Stroke Centre administering tPA to >20% of its stroke patients.3

Economic studies in the United States, Canada, and the United Kingdom demonstrate that health care costs for tPA-treated AIS patients are lower than those for their untreated counterparts because of the decreased need for long-term care and rehabilitation.4–7 Using a decision-analytic model, Demaerschalk et al8 estimated that $600 (Canadian) per patient was saved in Canada during the first year after tPA, compared with the medical costs for a stroke patient not treated with tPA.4 From this estimate, we extrapolated the national and provincial cost savings of increasing the proportion of stroke patients receiving tPA.

**Materials and Methods**

We calculated national and provincial cost savings estimates for tPA-treated AIS patients in the first year after treatment. The calculations were made with this formula:

National or provincial cost savings in year 1 = (annual incidence of ischemic stroke) × (cost savings in year 1 per treated patient) × (percentage of tPA-treated patients).

The annual incidence data for ischemic stroke were derived by multiplying by 0.88 the data for 1999 obtained from the Canadian Institute of Health Information for all causes of stroke (ICD-9 codes 430 to 438).8 We conservatively estimated a cost savings of $600 (Canadian) per tPA-treated stroke patient in the first poststroke year.4 Sinclair et al9 reported a substantially higher savings estimate of $3800 (Canadian) per tPA-treated patient over a lifetime (maximum 30 years). The cost-savings in the first year per tPA-treated AIS patient was converted from $600 (Canadian) for year 2000-based data to year 2005 Canadian dollars using the Bank of Canada Consumer Price Index.9 To reflect current and reported proportions of tPA-treated stroke patients, we tabulated national and provincial population cost estimates across a range, starting from 1.4% and including 2%, 4%, 6%, 8%, 10%, 15%, and up to 20%. The 20% estimated ceiling figure represents what is currently achievable at stroke centers.3

Received December 4, 2006; accepted December 11, 2006.

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A preliminary version of this research was presented in poster abstract format at the International Stroke Conference, February 5–7, 2004, in San Diego, California, and published in *Stroke* in February 2004.

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*Stroke* is available at http://www.strokeaha.org

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DOI: 10.1161/STROKEAHA.106.479477

1952
A sensitivity analysis was performed using a CI from the 5th to the 95th percentile ($600 CI, $3481 to $2004) estimated by Fagan et al.5 The 1996 United States-based interval was adjusted to 2005 US dollars according to the US Consumer Price Index, then converted to Canadian currency (US $0.859 = Can $1.00). These values were then multiplied by 0.91 to account for whole economy cost differences between Canada and the United States. This factor was determined by comparing published costs of Canadian and US stroke care.5,11,12

Results

In 1999, a total of 55,841 ischemic strokes occurred nationwide in Canada (Table 1). The cost savings estimate for 2005 was $678 (Canadian) per tPA-treated AIS patient during the first posttreatment year. On the basis of the Canadian Acti-vase for Stroke Effectiveness Study (CASES) rate of tPA use (1.4%), the estimated national cost savings for Canada for tPA-treated acute stroke patients after 1 year was >$500 000 (Table 1). With an increase to a 2% rate of tPA use, and for every 2 percentage point increase thereafter, >$750 000 (Canadian) could be saved during poststroke year 1. If 20% of ischemic stroke patients received tPA, >$7.5 million in Canadian health care funds could be saved nationwide the first year.

The estimated 95% CI was −$3424 (maximum cost savings) to $1971 (potential loss) in the first year per tPA-treated AIS patient. The results of the sensitivity analysis for the national estimates are illustrated in Table 2. By increasing the 1.4% proportion of tPA use to 20%, the maximum cost-savings to the national economy could be $38 million, with potential losses up to $22 million.

Discussion

Policy makers face challenges in balancing the burden of rising health costs with meeting the health needs of an aging population. Doing so requires an understanding of the complex evolving relationships between health care advances and the national economy. Economic analyses in North America and abroad indicate that thrombolysis for AIS is clinically and economically worthwhile.4–7 This finding is supported by our estimates that tPA use could save millions of dollars nationally. It also suggests the possibility of even greater savings with modest increases in tPA use. We have already published our estimates, which used similar methods, of the economic benefit of increasing the use of tPA for stroke in the US in 2005.13,14

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**TABLE 1. Estimated Canadian National and Provincial Cost Savings in First Year After Ischemic Stroke After Treatment With Intravenous Tissue Plasminogen Activator**

<table>
<thead>
<tr>
<th>Region</th>
<th>No. of Strokes</th>
<th>1.4</th>
<th>2</th>
<th>4</th>
<th>6</th>
<th>8</th>
<th>10</th>
<th>15</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>National</td>
<td>55 841</td>
<td>530 043</td>
<td>757 204</td>
<td>1 514 408</td>
<td>2 271 612</td>
<td>3 028 816</td>
<td>3 786 020</td>
<td>5 679 030</td>
<td>7 572 040</td>
</tr>
<tr>
<td>Province</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ontario</td>
<td>20 275</td>
<td>192 450</td>
<td>274 929</td>
<td>549 858</td>
<td>824 787</td>
<td>1 099 716</td>
<td>1 374 645</td>
<td>2 061 969</td>
<td>2 749 290</td>
</tr>
<tr>
<td>Quebec</td>
<td>14 382</td>
<td>136 514</td>
<td>195 020</td>
<td>390 040</td>
<td>585 060</td>
<td>780 080</td>
<td>975 100</td>
<td>1 462 649</td>
<td>1 950 199</td>
</tr>
<tr>
<td>British Columbia</td>
<td>7291</td>
<td>69 206</td>
<td>98 866</td>
<td>197 732</td>
<td>296 598</td>
<td>395 464</td>
<td>494 330</td>
<td>741 495</td>
<td>988 660</td>
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<tr>
<td>Alberta</td>
<td>4210</td>
<td>39 961</td>
<td>57 088</td>
<td>114 175</td>
<td>171 263</td>
<td>228 350</td>
<td>285 438</td>
<td>428 157</td>
<td>570 876</td>
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<td>2499</td>
<td>23 721</td>
<td>33 886</td>
<td>67 773</td>
<td>101 659</td>
<td>154 546</td>
<td>254 148</td>
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<td>31 174</td>
<td>62 349</td>
<td>93 523</td>
<td>124 698</td>
<td>155 872</td>
<td>233 808</td>
<td>311 744</td>
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<tr>
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<td>16 355</td>
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<td>46 728</td>
<td>70 092</td>
<td>93 456</td>
<td>116 819</td>
<td>175 229</td>
<td>233 639</td>
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<tr>
<td>New Brunswick</td>
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<td>23 323</td>
<td>46 646</td>
<td>69 970</td>
<td>93 293</td>
<td>116 616</td>
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<td>Newfoundland</td>
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<td>9872</td>
<td>14 102</td>
<td>28 205</td>
<td>42 307</td>
<td>56 410</td>
<td>70 512</td>
<td>105 768</td>
<td>141 024</td>
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<td>8733</td>
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<td>17 465</td>
<td>21 832</td>
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<td>...</td>
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<td>2170</td>
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<td>Northwest Territories*</td>
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<td>...</td>
<td>786</td>
<td>1180</td>
<td>1573</td>
<td>1966</td>
<td>2949</td>
<td>3932</td>
</tr>
<tr>
<td>Nunavut*</td>
<td>11</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>746</td>
<td>1119</td>
<td>1492</td>
</tr>
</tbody>
</table>

*Ellipses denote estimated savings of Can $678 or the equivalent of 1 or fewer patients receiving thrombolysis.

**TABLE 2. Estimated Canadian National Cost Savings and Losses in First Year After Ischemic Stroke in Patients Who Receive Intravenous Tissue Plasminogen Activator**

<table>
<thead>
<tr>
<th>Financial impact, Can $</th>
<th>1.4</th>
<th>2</th>
<th>4</th>
<th>6</th>
<th>8</th>
<th>10</th>
<th>15</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum cost savings</td>
<td>2 676 794</td>
<td>3 823 992</td>
<td>7 647 983</td>
<td>11 471 975</td>
<td>15 295 967</td>
<td>19 119 958</td>
<td>28 679 938</td>
<td>38 239 917</td>
</tr>
<tr>
<td>Possible loss</td>
<td>1 540 877</td>
<td>2 201 252</td>
<td>4 402 504</td>
<td>6 603 757</td>
<td>8 805 009</td>
<td>11 006 261</td>
<td>16 509 392</td>
<td>22 012 522</td>
</tr>
</tbody>
</table>

*N=55 841 ischemic stroke cases per year nationally.*

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A sensitivity analysis was performed using a CI from the 5th to the 95th percentile (−$600 CI, −$3481 to $2004) estimated by Fagan et al.5 The 1996 United States-based interval was adjusted to 2005 US dollars according to the US Consumer Price Index, then converted to Canadian currency (US $0.859 = Can $1.00). These values were then multiplied by 0.91 to account for whole economy cost differences between Canada and the United States. This factor was determined by comparing published costs of Canadian and US stroke care.5,11,12

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These savings reflect a small proportion of the overall cost of stroke; however, the savings are attributable to positive outcomes such as reduced disability and long-term care needs. Furthermore, these estimated savings could substantially offset the cost of establishing organized stroke care systems to increase access to tPA. In Ontario, Canada, the Coordinated Stroke Strategy (an acute stroke care system) was estimated to cost $15.3 million annually. Potential secondary gains from increasing tPA use include faster reallocation of hospital beds, reduced equipment and home modification needs, and reduced caregiver burden.\textsuperscript{15,16}

The maximum proportion of ischemic stroke patients who receive tPA was selected on the basis of estimates in the medical literature and on the best performance of North American stroke centers. Estimates of the proportion of stroke patients who present to a hospital within the first 3 hours are as high as 62\%.\textsuperscript{17-20} Estimates of the proportion of stroke patients who are eligible for tPA (who present in <3 hours) and receive tPA are as high as 35\%.\textsuperscript{19,20} Therefore, we propose a maximum figure of \(\approx 20\%\) (0.35\%\%62\% = 22\%). Our analysis has a few limitations. First, the stroke incidence data (1999) and the cost data (2000–2001) are outdated, and neither reflects the actual levels for the year 2006. We estimated, in earlier published work, that using outdated cost data likely results in an underestimate of the potential cost-savings.\textsuperscript{14} Second, the consumer index-based corrections likely do not reflect the actual changes in stroke care costs during this period. Third, the 95\% CIs were derived from US cost data. Although these data were adjusted to mitigate time- and nation-based differences, the estimates may deviate substantially from actual costs. Fourth, the direct costs of stroke care may have changed since 2000. For example, according to the Heart Disease and Stroke database of the Canadian Institute for Health Information, the average length of stay in a hospital after a stroke declined across Canada by nearly 5 days between 1994 and 1999.\textsuperscript{21} Fifth, the generalizability of the cost data, which were derived from Ontario-based sources, may have limited application to other geographic locations in Canada. Finally, the 95\% CI suggests that the costs of treating with tPA may actually exceed the savings rather than the reverse.

At the Caro Research Institute, an economic analysis was developed that estimated that widespread access to organized stroke care could prevent disability in 60,000 Canadians and save $8 billion net in health care costs over 20 years.\textsuperscript{22} In addition to the use of tPA, this optimal care included organized stroke units, rehabilitation strategies, improved public awareness of stroke, and prevention therapies. The potential savings for enhancing the proportion of acute stroke patients who receive tPA to 20\% is \(\approx 800\) million in 20 years, representing 10\% of the overall $8 billion estimate.

The challenge ahead lies in improving access to thrombolysis, a highly rated indicator of “best practice” stroke care identified by the Canadian Stroke Quality of Care Study expert panel.\textsuperscript{23} Research on barriers limiting tPA use, strategies to mitigate these barriers, and the experience of advanced stroke centers suggest that increasing the use of tPA is feasible.\textsuperscript{24,25} Efforts should be made to educate the public and paramedics about early recognition of stroke, to develop acute stroke therapy training programs for emergency departments, and to re-engineer hospital systems to optimize thrombolytic efficiency.\textsuperscript{24,25} Several Canadian initiatives are underway to coordinate interdisciplinary stroke teams to reduce morbidity and mortality in stroke patients, to control hospital costs, and to mitigate the need for long-term health care; these include the establishment of designated regional and district stroke centers, regular hospital feedback to identify gaps in care and encourage improvement toward feasible standards, and government-sponsored auditing.\textsuperscript{23,26}

Acknowledgments
Editing, proofreading, and reference verification were provided by the Section of Scientific Publications, Mayo Clinic.

Disclosures
B.M.D. received speaker honoraria from Genentech and Roche. The relationship is classified as “modest.”

References

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Stroke. 2007;38:1952-1955; originally published online May 3, 2007;
do: 10.1161/STROKEAHA.106.479477
Stroke is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
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Print ISSN: 0039-2499. Online ISSN: 1524-4628

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