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## **Geographic Variation in the Rate of Carotid Endarterectomy in Canada Editorial Comment**

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# Geographic Variation in the Rate of Carotid Endarterectomy in Canada

Thomas E. Feasby, MD; Hude Quan, MD, PhD; William A. Ghali, MD, MPH

**Background and Purpose**—Carotid endarterectomy (CEA) is an important method of stroke prevention, but its usage in Canada is not well known. The indications for CEA have been well informed by the recent clinical trials, but the impact of this information on the rate and regional variation in the rate of CEA is unknown. This study sought to determine the rate and the regional variation in the rate of CEA in Canada, its provinces, and census divisions for 1994–1997.

**Methods**—Discharge data from all hospitals in Canada except Quebec were obtained from the Canadian Institute for Health Information for 1994–1997 and were searched for CEA by residential site. Rates and variations in rates were calculated.

**Results**—The national age- and sex-adjusted rate per 100 000 people of CEA for those aged  $\geq 40$  years rose from 31.7 in 1994 to 40.5 in 1997. Provincial rates in 1997 varied from a low of 25.7 in Saskatchewan to high of 82.8 in Prince Edward Island. The census division rates varied even more, from a low of 0 in several divisions to a high of 179.

**Conclusions**—The recent slight increase in CEA rates may reflect the release of new efficacy results for CEA, especially for asymptomatic carotid stenosis, but the rates are still far below US levels. The marked regional variation in rates may reflect differing views on the appropriateness of indications such as asymptomatic carotid stenosis for CEA and the inconsistency of published clinical practice guidelines. (*Stroke*. 2001;32:2417-2422.)

**Key Words:** carotid endarterectomy ■ carotid stenosis ■ geography ■ stroke prevention

Carotid endarterectomy (CEA) has been used to prevent stroke since its introduction in 1954.<sup>1</sup> Fueled by reports of case series which suggested that the procedure was effective, the rate of CEA increased dramatically until the mid 1980s.<sup>2</sup> However, the lack of randomized controlled trial evidence of efficacy and the high rate of complications in some series<sup>3</sup> led to skepticism about the value of the procedure, and the rates dropped.<sup>4</sup> A report that up to one third of CEAs might be inappropriate and another third might be of uncertain value<sup>5</sup> caused increased doubt.

These concerns led to several major randomized clinical trials in the 1990s that documented efficacy for CEA in both symptomatic<sup>6–9</sup> and asymptomatic<sup>10</sup> carotid stenosis, although some serious doubt remains about the real-world effectiveness of CEA in asymptomatic patients.<sup>11–13</sup> Perhaps in response to the randomized clinical trial evidence of efficacy, the rate of CEA began to rise in the 1990s.<sup>2,4,14</sup>

Little has been published about CEA utilization nationally in Canada, and nothing has been published with data from the last 10 years. However, the previous studies from Canada and the United States<sup>15–19</sup> showed marked regional variation in rates, which might have been expected because the factors involved in a decision to offer CEA to individuals are complex, and randomized controlled trial evidence of efficacy was lacking when those studies were done. Today, one

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might expect the variation to be much less because randomized clinical trial evidence of efficacy is available. This assumes, of course, that it has been adequately disseminated and has influenced practice.

This study was designed to examine the recent rates of CEA in Canada across both small regions, represented by census divisions, and large regions, represented by provinces, to determine the degree of regional variation.

## Methods

Hospital discharge data on all CEAs were obtained from the Canadian Institute for Health Information. This is a national database that includes information on all hospital discharges in Canada except for the province of Quebec. The latter province does not report data to the Canadian Institute for Health Information. The database does not include information on indications for surgery. Patients in the other 9 provinces and 2 territories for the fiscal years 1994–1997 were identified by searching the database for those years with code 50.12 of the Canadian Classification of Procedures.

The postal codes of all patients were used to determine the residential locations. The postal code conversion file was used to determine the patients' corresponding census divisions. Census divisions are geographic areas within provinces and territories, often counties or regional municipalities, and, in the case of some provinces, areas designated for the census by Statistics Canada.

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**TABLE 1. Rates of CEA in Canada for 1994–1997**

Year	1994	1995	1996	1997
Population $\geq 40$ y	8 666 767	8 916 267	9 163 207	9 430 659
CEA cases	2797	3670	3872	3794
Crude rate	32.3	41.2	42.3	40.2
Age- and sex-adjusted rate	31.7	40.8	42.3	40.5

Values are CEA cases per 100 000 aged  $\geq 40$  years.

The CEA rates for each province and territory and for each census division were calculated. The age- and sex-adjusted CEA rates per 100 000 people aged  $\geq 40$  years were calculated by the direct method of standardization. The 1996 Canadian census data were used as the standard population. The population denominators for each year for the rate calculations were obtained from Statistics Canada. The  $\chi^2$  test and the coefficient of variation (CV) and extremal quotient (EQ) statistics were used to test or quantify variation of the adjusted CEA rates across provinces and census divisions. The CV is the standard deviation of the rates divided by the mean. The EQ is the ratio of the highest to the lowest rate.

### Results

Of the total of 14 133 CEA cases, the postal code data for provincial assignment were missing in 14, and the data for census division assignment were missing in an additional 135. These cases were therefore omitted from the analysis.

The national age- and sex-adjusted rates for CEA for adults aged  $\geq 40$  years for Canada are shown in Table 1. There was a substantial increase from the 1994 rate of 31.7/100 000 to the rates in 1995–1997 of 40.54 to 42.26/100 000 ( $P < 0.001$ , for the rate in 1994 versus 1997).

CEA rates for 1994–1997 were also measured by province (Table 2), with the exception of Quebec. The numbers of cases for the Yukon Territories ( $n=4$ ) and the Northwest Territories ( $n=10$ ) over these 4 years were small. The rate for Ontario for 1995 was exactly the same as that found in the 1998 study by Tu et al.<sup>4</sup>

Overall, wide variation in provincial rates was seen. The EQ of  $>3$  for each year indicates a  $>3$ -fold variation between

the highest and lowest rates. Of note, the western provinces, in particular, showed large variations. The rates over 4 years in Manitoba and British Columbia were almost double those in Alberta and Saskatchewan. The rates for Ontario were close to the national average. A slight drop in the CV was seen in 1996–1997, suggesting a possible reduction in variation.

Comparisons of rates were also made between census divisions to determine the extent of small-area variation. This is shown on the map of Canada in the Figure. The map is somewhat distorted geographically because census divisions vary widely in area and sometimes bridge between islands and the mainland. The CEA rates are represented nationally by census division on the map. The CV for census divisions was 0.76. The EQ was infinity because the rate in some divisions was 0, but the median rate was 36.04 (range, 0 to 178.8). Curiously, many of the high-rate census divisions were found in areas remote from hospitals performing CEA in northern Ontario, Alberta, British Columbia, and parts of New Brunswick and Nova Scotia.

### Discussion

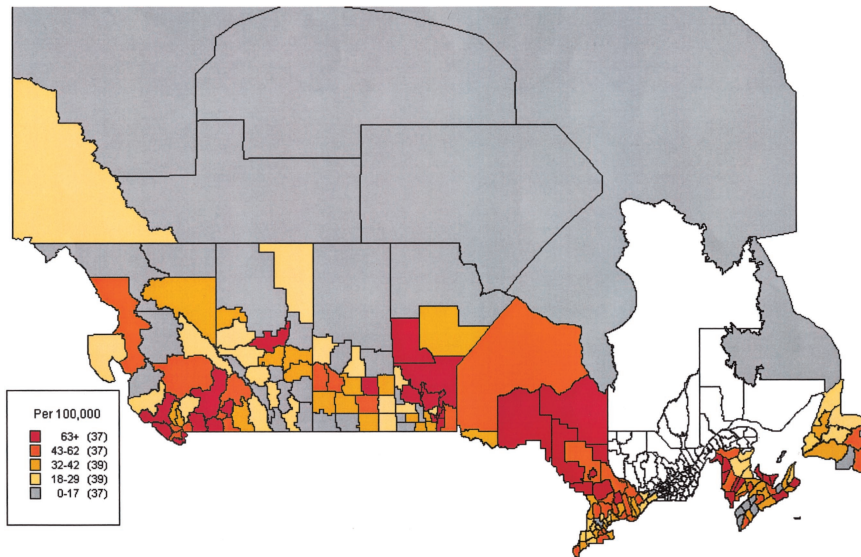
CEA is a common surgical procedure, and the rates of CEA in Canada appear to be increasing, having risen approximately 30% during 1994–1997, following an earlier trend noted by other investigators in Ontario and the United States.<sup>4,14</sup> Of note, we found that the rates in Canada are much lower than those in the United States. The adjusted CEA rate for Canada for 1995 was 40.8, whereas the rates in California and New York for 1995 were 99 and 96/100 000 for those aged  $\geq 40$  years, respectively.<sup>4</sup> We found that the Canadian CEA rate jumped from 31.7 to 40.8 from 1994 to 1995. A similar abrupt increase in rate found in Florida during the same time was attributed to the publication<sup>10</sup> and promotion<sup>20</sup> of the Asymptomatic Carotid Atherosclerosis Study (ACAS) trial results,<sup>14,21</sup> presumably resulting in a marked increase in the rate of CEA for asymptomatic carotid stenosis.

**TABLE 2. Rates of CEA by Province and Territory for 1994–1997**

	1994	1995	1996	1997
Newfoundland	22.7	37.4	39.5	35.4
Prince Edward Island	63.1	121.5	90.3	82.8
Nova Scotia	20.4	40.1	38.1	33.1
New Brunswick	42.8	51.8	51.7	42.9
Ontario	30.6	37.9	39.1	38.5
Manitoba	33.7	49.7	64.5	58.1
Saskatchewan	23.9	40.4	34.5	25.7
Alberta	19.8	26.7	27.7	31.7
British Columbia	42.4	49.3	51.9	49.6
Yukon Territories	9.0	9.4	18.2	0.0
Northwest Territories	27.9	6.6	0.0	29.6
$\chi^2$ (P)	178.4 (<0.001)	206.3 (<0.001)	213.4 (<0.001)	157.6 (<0.001)
CV*	0.48	0.54	0.39	0.40
EQ*	3.19	4.54	3.26	3.22

Values are CEA cases per 100 000 aged  $\geq 40$  years, adjusted for age and sex.

\*Yukon and Northwest Territories were excluded because of insufficient cases.



Map of Canada showing the rates of CEA by census division for 1996. Data for the province of Quebec were not available from the Canadian Institute for Health Information.

We found evidence of marked regional variation in the rates of CEA across Canada. The EQ >3 for all years indicates a >3-fold difference between the provinces with the highest and lowest rates. Even more variation was seen across smaller regions represented by census divisions. The drop in the CV in the last 2 years of this study may indicate that variation is decreasing.

Regional variation has been found for many other surgical and diagnostic procedures, from joint replacement to coronary angiography.<sup>22</sup> Marked variation has been viewed as a major quality of care issue.<sup>23</sup>

Why does such marked regional variation for CEA persist? If CEA were to be used appropriately, it would be provided to all those patients who might benefit (ie, appropriate cases) and to none of those who would not benefit (ie, inappropriate cases). Possible reasons for our finding of marked variation in rates include overuse in some areas and/or underuse in others. Both inappropriate use and lack of appropriate use might contribute to the variations in rates. Regional variation in the prevalence of cerebrovascular disease might also contribute to variation in the rate of CEA. The distribution of surgeons doing CEA could also be a factor, but we have not studied that yet.

However, assuming a reasonably even distribution of appropriate cases in the population, one might expect that the rate of CEA would not vary substantially. Does it vary because of uncertainty about indications for the procedure, as suggested by Wennberg et al<sup>24</sup>? This might explain the results of previous studies showing marked regional variation of CEA rates, which were all done on patients treated before the major efficacy trials of CEA of the 1990s were published. If uncertainty is the reason, our current finding of marked regional variation in CEA rates across census divisions and across provinces, as well as the much lower rate of CEA in Canada compared with the United States, is surprising, given the recent publication of several major randomized clinical trials of CEA establishing the efficacy of CEA for specific indications.<sup>6-10</sup> In addition, several sets of clinical practice guidelines have been published<sup>25,26</sup>

that should guide practice and might be expected to lead to more uniform rates.

Unfortunately, the randomized clinical trials of CEA have not resolved all the areas of uncertainty. While the trials of CEA for symptomatic carotid stenosis have clearly shown efficacy for patients with  $\geq 70\%$  carotid stenosis,<sup>6,8</sup> the results for those with 50% to 69% stenosis are less clear.<sup>7,9</sup> Even less striking are the efficacy results for those with asymptomatic stenosis,<sup>10</sup> and there has been considerable controversy about whether similar effectiveness can be achieved in clinical practice.<sup>11,12</sup> There is doubt whether the low perioperative mortality/morbidity rates achieved in the ACAS trial,<sup>10</sup> which are necessary for a net positive outcome, can be achieved in non-randomized clinical trial settings.<sup>12</sup> This controversy about the appropriate use of CEA in asymptomatic cases could contribute to regional variation in rates.

Clinical practice guidelines might also be expected to promote uniform rates of utilization of CEA, but unfortunately there is inconsistency among the published guidelines, especially regarding asymptomatic carotid stenosis. For instance, the guidelines of the American Heart Association<sup>26</sup> state that asymptomatic carotid stenosis is an appropriate indication for CEA. However, the guidelines of the Canadian Neurosurgical Society<sup>25</sup> consider asymptomatic carotid stenosis to be an uncertain indication. This inconsistency might lead to variations in practice and indeed might contribute to US/Canadian differences in rates. Of course, the clinical trial evidence of efficacy and clinical practice guidelines are only useful if they are known to and accepted by practitioners and thereby influence practice. Evidence suggests that there are major gaps in knowledge about CEA among practitioners.<sup>27</sup> Despite these reasons for uncertainty, studies trying to correlate measures of uncertainty with procedure rates have found no significant relationship.<sup>17,18</sup>

The finding of high rates of CEA in some areas suggests the possibility of overuse, that is, CEA might be provided inappropriately, when it is unlikely to be of benefit. This

has been examined in 2 studies.<sup>17,18</sup> In each study appropriateness was measured by the RAND/University of California at Los Angeles method,<sup>26</sup> which blends best evidence with expert opinion. This method develops appropriateness ratings for a large range of scenarios under which the procedure might be performed. The ratings are then applied to a series of cases retrospectively by chart review. The method was applied to a US national series of 1302 cases from 13 geographically separate regions and a US state sample from 23 adjacent counties from 1981. High rates of inappropriate use were found, but no correlation between high rates of inappropriate use and high rates of CEA<sup>17,18</sup> was found. These early studies of CEA appropriateness were done on cases treated long before publication of the recent randomized clinical trials. Similar findings have been published for other procedures.<sup>28,29</sup> However, some recent studies of appropriateness have shown that many inappropriate or uncertain cases still receive CEA,<sup>30</sup> often for asymptomatic carotid stenosis. The relationship between appropriateness and CEA rate should be reexamined now that evidence of efficacy is available.

Regional variation in rates might be due to differences in patient access to the procedure or differences in disease burden. Interestingly, we found no evidence that areas further from hospitals providing CEA had lower rates. In fact, many areas remote from hospitals providing CEA, in northern Ontario, for instance, had surprisingly high rates of CEA. However, rates for the Northwest Territories and the Yukon were very low, perhaps indicating low access to CEA in the far north.

Chassin<sup>31</sup> sought to explain geographic variations on the basis of differences in the attitudes and practices of surgeons, the "enthusiasm hypothesis." He found evidence in a large study of CEA in 1981<sup>22</sup> that high-use areas for CEA contained many more high-volume surgeons than did low-use areas. He found that high-use areas had 8 times as many high-volume surgeons (performing  $\geq 15$  CEAs per year) as the low-use areas. We do not yet know the distribution of high-volume surgeons in Canada. The results of that study suggest that areas of low use may actually suffer from underuse, that is, the failure to provide a procedure when it might be expected to confer some benefit. This is an important concern that was beyond the scope of our study to examine.

Marked regional variation in procedure rates is a quality of care issue, suggesting the possibility of both overuse and underuse. Measures to reduce variation have improved quality enormously in industry and are now being applied to medicine. The efficacy evidence is now largely available for CEA but may not have been adequately disseminated.<sup>27</sup> Renewed educational efforts are necessary to provide physicians with the best evidence. A clear message about the appropriate use of this important stroke prevention method must be widely broadcast, with the hope of reducing variation and improving quality. Feedback to surgeons of data on their performance compared with that of their peer group also may be effective in reducing variation and improving appropriateness.<sup>32</sup> The findings of our study indicate the need for more

research into the appropriateness of individual CEA procedures and also the development of high-profile multispecialty consensus clinical guidelines on indications for CEA, with special attention to the controversial issue of asymptomatic patients.

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## Editorial Comment

### Carotid Endarterectomy in the “Real World”: How Are We Doing?

Carotid endarterectomy (CEA) appeals to health analysts. The condition it addresses is prevalent, and the operation itself increasingly common. Important procedure complications such as death, myocardial infarction, and stroke are unequivocal and identifiable. Indications for its use, such as symptomatic versus asymptomatic carotid stenosis and the degree of carotid narrowing, are fairly easily abstracted from chart reviews. And finally, there is an abiding concern that the operation not be overused, or performed inappropriately or unsafely, in part because its complications can be so severe. Carotid endarterectomy is an important health issue, and it lends itself to health analysis.<sup>1–5</sup>

In the preceding article, Feasby and colleagues accessed a national database that tracks hospital discharge data in 11 of the 12 provinces and both northern territories of Canada. They found that there was a near cross-country jump in the rate of CEA from 1994 to 1995 (a response to the announcements and publication of positive CEA trial results) and that the rates remained higher throughout the next 2 years of the study period. The other finding was that there existed significant (up to 3-fold) variations in the annual rates of CEA between different provinces or territories, and even greater variations between different regions within provinces, with populations we have no reason to believe to be demographically dissimilar. Is this overuse of CEA in some regions and underuse in others? We don't have information about the number of hospitals, stroke specialists, carotid surgeons, or other resources important in the performance of CEA in the regions compared. The database used didn't include indications for CEA, but the authors nevertheless suspect that the regional variations found may result from a lack of consensus on, and dissemination of, the “right” indications for CEA in our country.

This may be true, but it is probable that the availability of resources and number of local CEA enthusiasts also have a significant impact on the regional CEA rates. For example, because there is no carotid surgeon in the 2 northern territories of our country, the investigation and treatment of stroke in those regions differs markedly from major Canadian cities.

Would dissemination of appropriateness criteria for CEA help level out these regional variations and improve the “effectiveness” of this intervention as practiced in our communities? In our region, this strategy was successful in almost eliminating inappropriate operations, significantly increasing the rate of clearly appropriate indications, and reducing surgical complication rates, although education was combined with the power influence of ongoing surveillance.<sup>6,7</sup> What has not changed over the 6 years of our study so far is the rate of CEAs for asymptomatic stenosis, which according to our criteria is classified as an “uncertain” indication requiring careful consideration of the individual patients and their risk factors and disease.<sup>8</sup> Seemingly irresistible to surgeons, asymptomatic carotid stenosis still makes up about 40% of the CEAs in our region each year, a rather high figure.<sup>9</sup>

Appropriateness criteria and the physicians interpreting them will never be perfect, but studies such as this one by Feasby et al are the best evidence we have that we can do better.

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