Changing Practice and Costs of Carotid Endarterectomy in Toronto, Canada

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Background and Purpose—During our annual audits of carotid endarterectomy (CEA) in Toronto metropolitan hospitals, we have been aware of major changes in the practice of this operation in recent years. To evaluate the effect of changing practice on costs of carotid endarterectomy, we have therefore compared the effects of changes in length of stay, complication rates, and other variables on cost during the last 3 years for which we have complete data.

Methods—We evaluated 757 consecutive patients, of whom 600 had CEA procedures in 3 teaching hospitals, and 190 procedures in 2 community hospitals in metropolitan Toronto. We estimated costs using a specially designed computer program, Transitional System Incorporated, including surgical complications, in patients admitted between January 1994 and December 1996.

Results—There was a significant decrease in length of stay in both groups of hospitals, mainly due to preoperative outpatient evaluation but also due to lower complication rates, which probably reflect an increase in asymptomatic surgery in both hospital groups. Costs fell from approximately $8000 per procedure to $5000 in asymptomatic patients and from approximately $10 000 to $7000 in symptomatic patients (Can $).

Conclusions—Major changes in the management of patients undergoing CEA have resulted in a significant decrease in both length of hospital stay and utilization of postoperative intensive care. At the same time, complication rates have significantly fallen, although our mortality and morbidity figures remain slightly higher than those from published multicenter trials. Future changes in surgical practice in Canada, including noninvasive carotid imaging, should produce even lower costs within the next few years. (Stroke. 1998;29:2014-2017.)

Key Words: costs and cost analysis ■ carotid endarterectomy

Despite endlessly shrinking healthcare budgets, costs continue to spiral, consuming a generous 14% of the gross domestic product in the United States and 8% in Canada. Rationing of healthcare services is politically and ethically unacceptable but the only alternative is to reduce costs of the individual patient. This has resulted in shorter, more cost-effective surgical procedures that minimize or even abolish the enormous daily expenses of hospital admission.

Nowhere is this more evident than in the most widely practiced operation in cerebrovascular surgery, carotid endarterectomy (CEA). Strategies used in recent years to improve cost effectiveness include drastic changes in preoperative, operative, and postoperative management, such as omitting routine postoperative intensive care and replacing standard angiography with noninvasive, often less-expensive imaging. However, in the scramble to save costs lies the implicit hazard of impairment of quality of care, about which there has been much recent debate.

We have been aware of continuing changes in the practice of CEA in recent years in major Toronto metropolitan hospitals since our first report and wanted to compare the difference between clinical practice in our centers and the guidelines developed by clinical trials in symptomatic and asymptomatic patients. We now have access to more accurate evaluation of hospital costs by a computerized system available only in recent years, and with the collaboration of vascular surgeons and neurosurgeons in 5 Toronto hospitals we have attempted to evaluate the impact of the changing practice of CEA on costs and quality of care.

Subjects and Methods

We evaluated all consecutive patients who underwent CEA in 3 Toronto teaching hospitals and 2 community hospitals during the 3-year period from 1994 through 1996. CEA procedures combined with coronary artery bypass grafts were not included in the analysis. We used the hospital computer database systems to retrieve the files of these patients and performed a retrospective chart review to assess demographic data (age, gender), length of hospital stay, neurological symptoms before surgery, complications of CEA, and subsequent medical treatment or surgical interventions during the hospital stay. We used the Modified Rankin Scale to define stroke severity, scoring >3 as a severe stroke.

The complications of carotid surgery were divided into major and minor categories. Major complications included death and stroke...
with sustained deficit over 24 hours. Minor complications encompassed transient ischemic attack, seizure, cranial nerve injury, neck hematoma, pulmonary edema, pneumonia, respiratory arrest with successful resuscitation, congestive heart failure, myocardial ischemia, hypertension, hypotension, and urinary tract infection.

Direct hospital charges comprised various categories, including operating room and personnel expenses, nursing, and immediate postoperative intensive care, as well as expenses related to diagnostic testing, pharmacy, and physician charges. Symptomatic and asymptomatic patients were evaluated separately to ascertain the difference in length of stay, complication rate, and CEA costs.

Computer analysis of costs was performed in cooperation with the administration of the Sunnybrook Health Science Center using Transitional System, Inc, software. The statistical analysis also included the \( \chi^2 \) and Student's \( t \) tests.

**Results**

During the period from January 1994 through December 1996, 757 consecutive patients underwent CEA in 5 Toronto hospitals. Six hundred procedures were performed in the 3 Toronto teaching hospitals and 190 in the 2 community hospitals, giving a total of 790 carotid procedures. A total of 604 procedures were performed in the 3 teaching hospitals. Although the length of hospital stay was significantly greater (\( P<0.009 \)) in the community hospitals in 1994, it was almost identical in both types of hospital by 1997. There were significantly more operations on asymptomatic patients in the community hospitals (\( P<0.006 \)), but the rate of serious complications in the 2 hospital groups was similar. In the teaching hospitals the major stroke and death rate was 3.0%, whereas in community hospitals it was 2.0% (Table 2) (a nonsignificant difference). Patients with no surgical complications were discharged earlier, at 4.3 ± 3 days (total hospital stay) compared to those with complications at 7.0 ± 1.1 days (\( P<0.0001 \)), and the costs were significantly higher (\( P<0.0001 \)) in those with surgical complications ($6769 ± 2815 versus $9758 ± 6955).

There was a significant reduction (\( P<0.0001 \)) in utilization, and hence costs, of postoperative intensive care units between 1994 and 1996. Data on costs and use of acute care facilities were available in only 1 hospital. In 1994 we evaluated 69 patients; 50 (72%) had postoperative intensive care, which consumed 23.9 ± 11.65 hours, with a mean cost of $2549 ± 1911. In 1996 we evaluated 73 patients; 59 (80%) had intensive care but stayed only 16.6 ± 4.8 hours, costing $1191 ± 1398.

Seventy-five percent (595) of the total study cohort were symptomatic (range, 63% to 80% among the hospitals) and 25% (195) were asymptomatic (range, 16% to 37%). Mean length of hospital stay was 5.7 ± 2.8 days in the symptomatic group and 4.1 ± 4.9 days in the asymptomatic group (\( P<0.01 \)), reflecting the higher complication rate in asymptomatic patients (Table 3). This is also reflected in the significantly increased costs of surgery in symptomatic patients ($7366 ± 5290 versus $5330 ± 1652 in asymptomatic patients).

**TABLE 1. Length of Stay, Hospital Costs, and Incidence of Stroke and Death in Asymptomatic Versus Symptomatic Carotid Endarterectomy, 1994–1996**

<table>
<thead>
<tr>
<th>Procedures</th>
<th>Year</th>
<th>n</th>
<th>Length of Stay, d</th>
<th>Stroke and Death, %</th>
<th>Costs, Can $</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asymptomatic</td>
<td>1994</td>
<td>32</td>
<td>5.8±0.4</td>
<td>0</td>
<td>7697±3135</td>
</tr>
<tr>
<td></td>
<td>1995</td>
<td>83</td>
<td>4.4±6.7</td>
<td>1.2</td>
<td>6518±1211</td>
</tr>
<tr>
<td></td>
<td>1996</td>
<td>80</td>
<td>3.1±1.8</td>
<td>1.25</td>
<td>5340±1052</td>
</tr>
<tr>
<td>Symptomatic</td>
<td>1994</td>
<td>206</td>
<td>7.4±13</td>
<td>6.8</td>
<td>10 349±7821</td>
</tr>
<tr>
<td></td>
<td>1995</td>
<td>183</td>
<td>5.6±4.5</td>
<td>2.7</td>
<td>8355±4369</td>
</tr>
<tr>
<td></td>
<td>1996</td>
<td>206</td>
<td>4.3±3.1</td>
<td>0.9</td>
<td>6857±3014</td>
</tr>
<tr>
<td>Overall</td>
<td>3 y</td>
<td>790</td>
<td>5.3±2.7</td>
<td>2.9</td>
<td>6839±3014</td>
</tr>
</tbody>
</table>

*Includes $1000 (Can $) for preoperative carotid angiography.
Anesthesia

Asymptomatic:Symptomatic (ratio)

No. 600 190

Major stroke and death 1% (n = 5)

Complication Asymptomatic Symptomatic P

With 595 Symptomatic Procedures

TABLE 3. Complication Rates in 195 Asymptomatic Compared with 595 Symptomatic Procedures

<table>
<thead>
<tr>
<th>Complication</th>
<th>Asymptomatic</th>
<th>Symptomatic</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major stroke and death</td>
<td>1% (n=2)</td>
<td>3.5% (n=21)</td>
<td>NS</td>
</tr>
<tr>
<td>All strokes and death</td>
<td>2.6% (n=5)</td>
<td>6.4% (n=38)</td>
<td>0.07</td>
</tr>
<tr>
<td>Minor complications</td>
<td>10.2% (n=20)</td>
<td>23.3 (n=139)</td>
<td>0.001</td>
</tr>
</tbody>
</table>

*% asymptomatic patients.

Vascular surgeons performed 491 procedures (62%) compared with 299 (38%) by neurosurgeons, with a lower complication rate for major stroke and death (2.4% versus 3.6%) (nonsignificant), but they operated on significantly more asymptomatic patients (32% versus 13%; P<0.0001).

Discussion

Our data clearly indicate that carotid endarterectomy is becoming less costly, but is it more cost effective and has the quality of care been compromised? It seems not, because parallel with decreased costs was a decreased incidence of complications, thus shortening the length of stay, a major factor in costs. There are several possible explanations for this finding.

It is unlikely that improvement of surgical techniques over the period of study is a major factor. Second, the forced reduction of length of stay could result in an apparent, rather than real, reduction of complications, which would occur after hospital discharge and escape recognition. However, we do not think this is the explanation, because we have posthospitalization follow-up on most patients, and few complications occurred. Third, the reduced overall costs of carotid surgery during the duration of the study could represent a dilution of high-risk symptomatic patients by low-risk asymptomatic patients, but our data (Table 1) indicate that the same number of symptomatic procedures were performed each year at decreasing costs. Fourth, selection of less risky patients over the 3-year period of this study was not a factor, since the age, sex, and comorbid disease probably did not change significantly from year to year.

Another factor is that most preoperative evaluations (carotid angiography in particular) are now performed as outpatient procedures, and this artificially reduces costs of hospitalization by transferring inpatient costs to outpatient costs, without any real cost savings. Although doubts have been cast on the accuracy of noninvasive imaging for preoperative assessment, these procedures are gaining credence and have almost replaced standard angiography in some centers. However, it is not the usual practice in Canada to use noninvasive substitutes such as carotid duplex with MR angiography. These two procedures cost $107 and $1000 (Can $), respectively, so their combined substitution for standard angiography (at $1000) would be unlikely to have a major impact on costs, except by possibly reducing complications.

We believe the major factor in cost reduction is the decreased use of acute postoperative intensive care facilities on a routine basis. Our data support this practice, but patient numbers are still relatively small, and prevention of one death from airway obstruction would not have a major impact on cost but would be of inestimable clinical importance. Considerable effort has been expended in recent years to reduce the costs of CEA, especially in the United States, where hospital practice is so often dictated by diagnosis related groups. Cost-cutting procedures include outpatient vascular imaging, more frequent use of regional anesthesia, and, most importantly, reduction of use of intensive care facilities postoperatively. Harbaugh and Harbaugh evaluated early discharge after CEA. They routinely monitored patients postoperatively for 2 hours, after which they were transferred to an “intermediate” care unit. No invasive monitoring was used after the patient left the recovery room. The mortality and morbidity data were unchanged from those obtained previously, when these patients were routinely monitored in postoperative intensive care.

In the study by Back et al carotid surgery was performed by a designated clinical pathway, where cerebral angiography was avoided, intensive postoperative care was minimized and regional anesthesia was preferred. There was no significant difference in stroke and death when the “pathway” patients were compared with those receiving standard care, but there was a highly significant decrease in costs. Unfortunately, none of these issues are completely resolved, since there are no randomized studies and the numbers of patients are invariably too small for adequate statistical analysis.

Both teaching and community hospitals showed a striking decrease in the length of hospital stay 1994 to 1996 (Table 2), and by 1996 duration of hospital stay was almost identical, even though regional anesthesia was commonly performed in community hospitals (74% versus 1%). This does not agree with the findings of other studies in which regional anesthesia was the preferred method and hospital stay was shorter. The higher proportion of asymptomatic surgery in community hospitals compared with teaching hospitals was sustained throughout the study period and was significantly different.
The stroke and death rates did not differ between the 2 hospital groups despite the tendency toward more hospitalization and accumulating data from continuing surgical trials have had a major impact on the practice of this procedure. The present study suggests that cost-cutting measures in recent years have not adversely affected outcome, but data are still needed to identify those rare complications with major human costs which necessitate special acute care postoperatively.

Acknowledgments
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References