Risks of carotid endarterectomy. Toronto Cerebrovascular Study Group

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logica dell'Università di Roma. L. De Zanche, A. Saia, G. Meneghetti, S. Manzoni, P. Tonin, Clinica Neurologica dell'Università di Padova. M. Nardini, M. D'Ettorre, A. Martini, G. Bonelli, Clinica Neurologica dell'Università di Siena. G.L. Brambilla, R. Rodriguez, Y. Baena, G. Sangiovanni, P. Paoletti, Clinica Neurochirurgica dell-Università di Pavia. G. Nappi, G. Bono, Clinica Neurologica dell'Università di Pavia. D. Inzitari, F. Cipriani, R. Capparelli, R. Taiuti, L. Amaducci, Clinica Neurologica dell'Università di Firenze. F. Tomasello, V. Albanese, A. Scuotto, P. Conforti, Clinica Neurochirurgica dell'Università di Napoli. L. Candelise, P. Perrone, G. Landi, M. Bracchi, Clinica Neurologica dell'Universitá di Milano.

Biostatistic Unit

F. Mariani, D. Bardelli, F. Bianchi, R. Cristofani, M. Vigotti (Pisa).

Consultant Neuroradiologists

L. Bozzao (Roma), F. Galligioni (Padova).

Consultant Neuropsychologist

P. Nichelli (Modena).

Risks of Carotid Endarterectomy

TORONTO CEREBROVASCULAR STUDY GROUP*

SUMMARY An objective, retrospective review of 358 carotid endarterectomies performed in the neurosurgical teaching units of the University of Toronto in the year 1982 demonstrated a perioperative stroke rate of 3.9% and a death rate of 1.5%.

Most (82%) surgical neurological complications occurred after the immediate post-operative period (24 hours). This high incidence of delayed stroke suggests that most perioperative strokes are embolic rather than hemodynamic. Careful operative technique and the use of anticoagulants and antiplatelet agents may be more important in preventing postoperative deficits than intraoperative monitoring and intraluminal shunting.

Our figures and those of current published data indicate that a 5–6% combined morbidity and mortality should be expected in carotid endarterectomy. These data are critical both to decision making with the individual patient as well as in the planning of future carotid surgery trials.

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EVALUATION OF CAROTID ENDARTERECTOMY for stroke prevention requires realistic expectations about perioperative morbidity and mortality. Published stroke and death rates vary from less than 2%,[1, 2] to almost 25%.[3] Surgeons tend to report lower figures,[4–8] while higher rates emerge from citywide[3, 9] or multi-centre experience,[10] usually reported by neurologists.

Although carotid endarterectomy as an effective means of stroke prevention has been practiced for years, its efficacy has never been properly evaluated.[11] The need for a prospective study using modern methodology is long overdue. Feasibility and study design require knowledge of expected stroke and death rates for a relatively large group of surgeons.

This study reports results in a large consecutive series of procedures performed in the Toronto teaching hospitals and differs from most previous studies with respect to the objective manner in which data was collected and analysed.

Methods

All surgeons in the five adult neurosurgical teaching units of the University of Toronto agreed to participate in the study. Consecutive cases of carotid endarterectomy in the calendar year 1982 were reviewed. Protocols were devised which identified cases by study. number only, omitting identity of the patient, surgeon and hospital.

A study coordinator (MCZ) experienced in stroke research, transferred relevant information from the hospital charts to data entry forms using pre-determined definitions of carotid stroke and transient ischemic attack (TIA).

Questionable or missing entries were reviewed by the principal investigators (a neurosurgeon and a neurologist) who requested additional information as necessary. The principal investigators remained "blind" and only the study coordinator had direct access to hospital charts. Participating neurosurgeons agreed to protocol design and authorised chart review on their own cases. They did not review data entry forms, nor did they have any input into their completion.

Neurological deficits lasting more than 24 hours were classified as cerebral infarction, providing the corresponding computed tomography (CT) did not show evidence of hemorrhage. The designation of cerebral infarctions as "major" and "minor" retrospectively, on the basis of persisting neurological deficit, is too subjective to be reliable. Focal neurological deficits lasting less than 24 hours were classified as transient ischemic attacks. Perioperative neurological complications were defined as those occurring during hospital admission, with onset up to twelve days postoperatively.

From the Toronto Cerebrovascular Study Group,* University of Toronto.

Address correspondence to: D.W. Rowed, M.D., Sunnybrook Medical Centre, 2075 Bayview Avenue, Toronto, Ontario, Canada M4N 3M5.

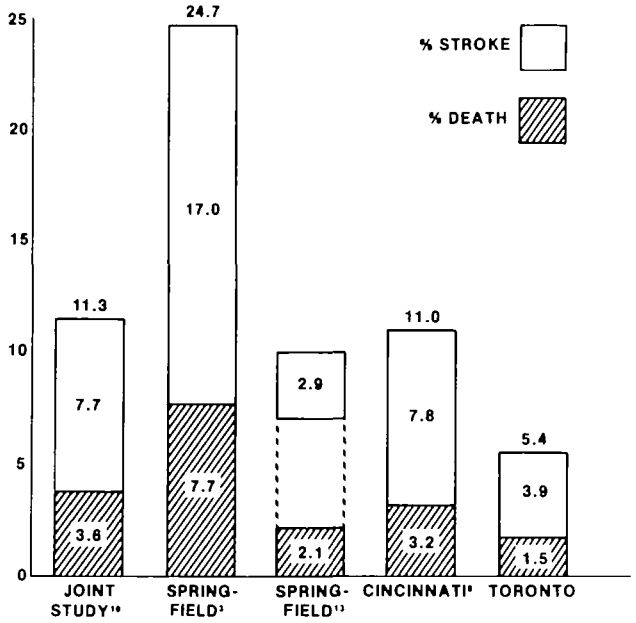

FIGURE 1. *Stroke and death rates in the perioperative period.*

Results

Patients and Procedures

Three hundred and fifty-eight endarterectomies were performed on 333 patients. There were 230 men (mean age 67 years) and 103 women (mean age 64 years).

Presenting Symptoms

Ninety percent of the patients presented with symptoms appropriate to the territory of the operated artery and only 3% were completely asymptomatic. Either carotid TIAs or carotid territory infarction (with mild residual neurological deficit) were the indication for operation in two-thirds of the patients. Most of the cases of monocular blindness were transient with a few cases of permanent monocular visual deficit. Seventy percent of the patients had severe stenosis (diameter reduced by more than 75%).

Preoperative Angiography

Three hundred and fifty-eight angiograms were performed on 333 patients (table 1). In 83% of cases there was either severe internal carotid artery stenosis, ulceration, or apparent occlusion. All apparently occluded arteries were found to be patent at operation, ie there were no cases of thrombo-endarterectomy. Findings were designated "uncertain" when they did not allow classification into any one of the other categories.

In most patients angiography revealed less severe disease on the contralateral side. Contralateral carotid arteries were normal in 34% (121) patients and showed severe stenosis or ulceration in only 15% (55). The contralateral internal carotid artery appeared occluded in 45 (13%) cases. No deaths were attributable to cerebral angiography. Two patients (0.6%) suffered cerebral infarction following angiography, and four (1.4%) experienced TIAs.

TABLE 1 *Preoperative Angiographic Findings*

	Number
>75% Stenosis	
without ulcer	204
with ulcer	46
<75% Stenosis	
without ulcer	56
with ulcer	33
Ulcer without stenosis	4
Occlusion	9
Uncertain	5
Normal	1
	358

Surgical Complications

There were 70 documented complications in the 30 days following carotid surgery. TIAs occurred in 18 patients, completed strokes in 16 (14 cerebral infarctions, 2 cerebral hemorrhages), myocardial infarction in 7 and in 1 case cardiac arrest occurred with complete recovery. In 28 patients, other complications included post-operative neck hematomas, transient cranial nerve palsies and pneumonia.

In 5 patients these post-operative complications proved fatal including 3 strokes (2 cerebral hemorrhages and 1 cerebral infarction), 1 myocardial infarction and 1 patient with bowel perforation.

The peri-operative non-fatal stroke rate was therefore 13/333 (3.9%) and the mortality rate was 5/333 (1.5%). Seventeen of 18 (94%) TIAs, 9 of 14 (64%) cerebral infarctions and both cerebral hemorrhages were of delayed onset (later than 24 hours) (table 2).

Most post-operative neurological deficits occurred in the distribution of the operated internal carotid artery (Table 3). One brainstem infarction occurred in a patient with severe posterior circulation atherosclerosis, which had been visualized on preoperative angiography.

Eight of 16 neurosurgeons participating in the study performed 314/358 procedures (88%) and had a 5.1% procedural complication rate whereas the remaining 8 surgeons performed only 44 procedures (12%) with a 4.5% stroke and death rate. Case numbers for some individual surgeons were small but their results appear to have been comparable to those surgeons who performed more endarterectomies.

TABLE 2 *Timing of Onset Cerebral Complications*

	0–24 (hours)	1–4 (days)	5–12 (days)
TIA	1	12	5
Cerebral infarction	5	5	4
Cerebral hemorrhage	0	1	1

TABLE 3 *Arterial Territory of Postoperative Neurological Deficits*

	TIA	Infarct	Hemorrhage
Ipsilateral carotid	15	11	2
Contralateral carotid	3	2	0
Vertebrobasilar	0	1	0

Discussion

The overall incidence of stroke and death and the frequency of delayed postoperative stroke require comment because of their management implications.

Stroke and Death Rate

Perioperative mortality in our series (1.5%) is comparable to that reported from single institutions.[1, 4, 5, 7, 8, 12] Multicentre series show a 2–5 fold higher mortality.[3, 9, 10, 13] In the largest retrospective series yet reported (3328 patients) the overall stroke and death rate was 6%, almost identical to that reported here.[14]

The non-fatal stroke rate of 3.9% is also within the range of other reported series from single institutions[2, 6, 7] though multicentre series have stroke rates as high as 17%[3] (fig. 2).

A mortality rate of 1.5% is frequently reported[4, 5, 11, 14] and is undoubtedly assessed accurately. However, retrospective reviews probably underestimate the incidence of non-fatal stroke. Comparison of studies is impeded when strokes are subdivided into "major" and "minor" groups,[5, 15, 16] since the judgement is subjective and probably inaccurate when made retrospectively.[5, 12, 13, 15] "Minor" deficits have included cases of severe and prolonged disability, yet were included with TIAs in data analysis.[12, 15–17]

Stroke rates may be higher in multicentre series because reporting is more objective and avoids the dismissal of some strokes as "minor." Stroke rate is usually at least double the death rate.[3, 7, 9, 10, 12, 18–20] Equal stroke and death rates suggest that some strokes may have been missed.[2, 4, 5]

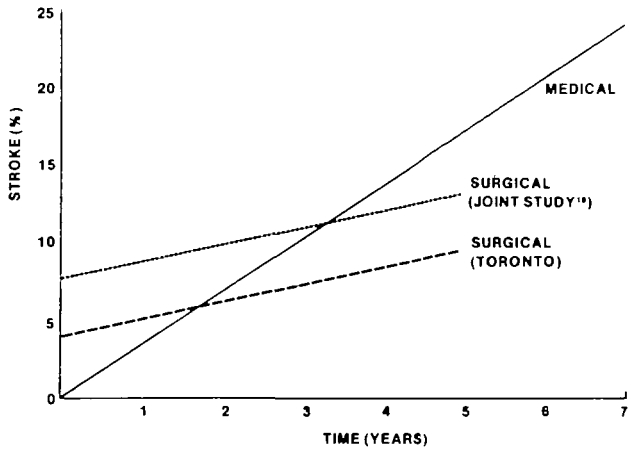

FIGURE 2. *Comparison of stroke rate in surgical and non-surgical (medical) groups.*

Perioperative stroke rate may vary due to differences in surgical and anaesthetic technique, such as routine[2, 7] or selective[5] intra-luminal shunting, patch grafts,[5, 14] and appropriate use of intraoperative anticoagulants.[22] In the present series, intraoperative heparin was used routinely and shunts were seldom employed.

Complication rate may also reflect differences in patient selection. Various medical and neurological risk factors[5] such as uncontrolled hypertension,[23] symptomatic coronary artery disease,[15] and recent or progressive neurological deficit[24] might be expected to adversely effect outcome.

Asymptomatic patients may suffer less perioperative morbidity and mortality than symptomatic patients.[16] Brott and Thalinger,[9] in a series containing approximately equal numbers of symptomatic and asymptomatic cases, found that the asymptomatic patients suffered approximately half as many perioperative strokes as the symptomatic group. Nevertheless, a recent multicenter review detected a 6% combined morbidity and mortality rate in asymptomatic patients.[14]

Delayed Postoperative Strokes

The timing of onset of postoperative neurological deficit is frequently not reported. Sixty-nine percent of the persisting neurological deficits (9 infarctions and 2 hemorrhages) in the present series were not present immediately after surgery. These figures are comparable to other series which report timing of onset.[9, 17] The immediate postoperative period is a time of careful patient monitoring, so deficits present during this period are not likely to escape detection.

"Delayed" cerebral infarction (not detected in the immediate post-operative period) is probably embolic in most instances.[17] The ipsilateral hemispheric location and time of onset of the two cerebral hemorrhages in our series is consistent with hemorrhagic transformation of small embolic infarction.[25] Since most postoperative deficits are probably due to artery-to-artery emboli, intraoperative monitoring for ischemia and intraoperative shunting or other measures directed at preventing cerebral ischemia during occlusion, will not have much effect on the incidence of perioperative stroke. Meticulous surgical technique[8] and appropriate use of anticoagulants[22] and platelet antiaggregants[8] are probably more important in reducing subsequent stroke.

Risks and Benefits

In the Joint Study of Extracranial Arterial Occlusion, patients who survived carotid endarterectomy without stroke experienced a two-thirds reduction in future stroke rate. Stroke rate in the territory of the symptomatic vessel was even further reduced. Later mortality was largely cardiac and therefore not affected by surgery.[10]

Surgery entails more risk in the perioperative period than medical management, so more time must elapse before improvement in stroke-free survival is appar-

ent. It is essential to know the expected perioperative stroke and death rates to determine this "break-even point." Risk of stroke from angiography is not relevant because potential surgical candidates require angiography for decision making regardless of subsequent management. Stroke risk from angiography has been reduced since the advent of digital subtraction.

In the Joint Study, the annual stroke rate was 1.1% in the surgically treated group, and 3.5% in the medically treated group. This would predict a "break-even point" at approximately 3.3 years. If the perioperative stroke rate from the present study is used to calculate the "break-even point" the time is reduced to about 1.7 years (figure 2).

Medically treated patients in the Joint Study had an annual stroke and death rate of 7.1%, but for surgically treated patients, this was 5.4%. The "break-even point" is reached in about 2.6 years (figure 3).

Many will consider reduction of stroke risk alone an appropriate measure of the efficacy of endarterectomy. Others may insist that the effect of surgery on combined stroke and death is a more appropriate index.[9, 26] Provided perioperative morbidity and mortality remain sufficiently low, carotid surgery will confer a benefit, regardless of the index chosen. These data were derived before the era of platelet antiaggregants drugs which have been demonstrated to reduce spontaneous stroke rate in symptomatic patients.[27, 28] Comparison of carotid endarterectomy with current medical management might show that reaching the "break-even point" requires longer than suggested by the Joint Study data.[10]

Asymptomatic cervical bruit and asymptomatic carotid plaque are associated with an increased, but low, incidence of stroke (1–2% per annum).[26, 29–31] Perioperative stroke and death rates from the present study suggest that the time to the "break-even point" in asymptomatic patients is unacceptably long. Carotid endarterectomy, therefore, appears to be an unattractive alternative to medical management in asymptomatic patients, particularly since they are likely to experience TIAs prior to a completed stroke.[26]

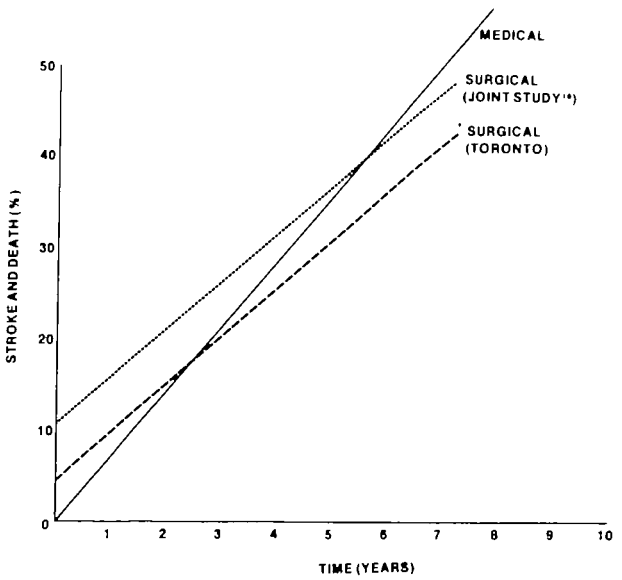

FIGURE 3. *Comparison of combined stroke and death rate in surgical and non-surgical (medical) groups.*

Despite a large body of data on carotid endarterectomy for symptomatic patients, proof of efficacy is still wanting. The ability to standardise pooled data from many centres exists and warrants undertaking a prospective study. The present study provides data useful in study design, and indicates an expected morbidity and mortality rate for carotid surgery of 5–6%. We have now arrived at a time when such a prospective study should be undertaken.

Toronto Cerebrovascular Study Group

Principal Investigators:
D.W. Rowed, M.D. FRCS(C)
J.W. Norris, M.D. FRCP
M.C. Ziliotto, Research Associate

Co-investigators:
St. Michael's Hospital
W.J. Horsey, M.D. FRCS(C)
A.R. Hudson, M.D. FRCS(C)
P.J. Muller, M.D. FRCS(C)
W.S. Tucker, M.D. FRCS(C)
Sunnybrook Medical Centre
D.W. Rowed, M.D. FRCS(C)
M.L. Schwartz, M.D. FRCS(C)
C.H. Tator, M.D. FRCS(C)
Toronto General Hospital
F. Gentili, M.D. FRCS(C)
W.M. Lougheed, M.D. FRCS(C)
I.B. Schacter, M.D. FRCS(C)
R.R. Tasker, M.D. FRCS(C)
Toronto Western Hospital
J.R. Fleming, M.D. FRCS(C)
H. Nauta, M.D. FACS
H. Schutz, M.D. FRCS(C)
Wellesley Hospital
R.G. Perrin, M.D. FRCS(C)
H.S. Smyth, M.D. FRCS(C)

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