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Patient Selection for Carotid Endarterectomy How Far Is Risk Modeling Applicable to the Individual?

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Background and Purpose—Risk-factor modeling has been proposed to identify patients with carotid stenosis who will most benefit from surgery. Validation by independent institutions performing carotid endarterectomy is necessary to determine the applicability of such models to the individual patient.

Methods—A series of patients with a recently symptomatic high-grade carotid stenosis were selected for surgery according to current guidelines and were consecutively operated on in a single institution. In addition, a prognostic model was applied to the patients to analyze the concordance of both selection methods.

- *Results*—The study included 134 patients operated on between 1999 and 2001. The risk model predicted that 49% of the patients should have been excluded from surgery because the operation was found to be possibly harmful in 1 patient (1%) and not significantly beneficial in 65 patients (48%). This resulted from the predominant negative weight of the surgical risk factors in the model. However, this predominance was negated in our series by the fact that only 1 major complication (0.75%) occurred during follow-up.
- *Conclusions*—Exclusion of single patients on the basis of risk modeling may be problematic when the rate of perioperative complications is very low. (*Stroke*. 2003;34:524-527.)

Key Words: carotid endarterectomy ■ carotid stenosis ■ patient selection ■ risk assessment

The best indication for carotid endarterectomy (CEA) is a recently symptomatic high-grade carotid stenosis.^{1–4} Provided that no major complication occurs during the operation, most patients find themselves efficiently protected against stroke in the following years.^{5,6} The operative technique is well standardized, and the risk of restenosis is very low in experienced centers.5 However, from an epidemiological point of view, there is a need to better select the surgical candidates because only 20% to 25% of patients medically treated have a stroke or die of stroke during the following 3 years. This means that preventive surgery remains without benefit for at least 4 of 5 operated patients. This proportion could even be increased by the ability of new statins to combat hypercholesterolemia and stabilize atherosclerotic plaques more efficiently than at the time of the North American Symptomatic Carotid Endarterectomy Trial (NASCET) and European Carotid Surgery Trial (ECST).7

According to current guidelines,^{8,9} CEA is recommended for patients with a symptomatic high-grade stenosis when the estimated rate of perioperative complications does not exceed 6%. Because the risk of stroke is highest during the first 2 to 3 years, life expectancy should be at least 2 years when the operation is proposed. In an effort to identify the best surgical candidates, ie, patients with high risk of stroke on medical treatment alone and with low risk of operative complications and death, Rothwell et al¹⁰ developed a prognostic model based on a balance of medical and surgical risk factors. The statistical data were gathered from 2060 ECST patients with 0% to 69% carotid stenosis.^{1,2} The model was tested and validated in 990 ECST patients with 70% to 99% carotid stenosis assigned to endarterectomy (n=596) or medical treatment only (n=394).¹⁰ To the best of our knowledge, the model has not yet been validated by independent institutions performing CEA. It has recently been used to select patients with carotid stenosis for endovascular angioplasty and stenting, although this may be questionable.¹¹

In the present study, the selection model of Rothwell et al¹⁰ was prospectively applied to a consecutive series of patients investigated for carotid stenosis in a single institution and selected for CEA according to current guidelines.^{8,9} Our objectives were to compare the results of both selection methods and to evaluate the accuracy of the prognostic model for the individual patient in light of our surgical results.

Subjects and Methods

All patients investigated by Doppler or duplex sonography during the last 3 years in our institution were considered for inclusion in the study when a symptomatic 70% to 99% carotid stenosis was found. The ultrasonographic diagnosis was confirmed by MR angiography or digital subtraction angiography in the patients selected for operation.^{12,13} The preoperative workup and technical details of CEA

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have been described previously.^{14,15} All operations were performed by the same surgeon (A.B.) or under his direct supervision. Clinical and sonographic follow-up controls were assumed by board-certified neurologists of the local Department of Neurology at 1 and 6 weeks. Major stroke (defined according to ECST as fatal or lasting >7 days) or death in the first 31 days after surgery were the clinical end points considered for comparison of our standard selection method with the prognostic model of Rothwell et al.¹⁰ All patients gave written consent to operation and participation in the study. The Ethics Committee of our hospital approved the study protocol.

The selection criteria of Rothwell et al were prospectively applied to all patients without influencing the decision to operate. The model is based on 2 sets of predictive clinical and angiographic variables. Risk points are attributed to each variable and summed and respectively subtracted to obtain a predictive score. The medical arm aims at predicting the risk of ischemic stroke on medical treatment and includes 4 variables: cerebral versus ocular events (1 point), plaque surface irregularity (1 point), any event within the past 2 months (1 point), and carotid stenosis of 80% to 89% (1 point) or 90% to 99% (2 points). The surgical arm aims at predicting the risk of major stroke or death within 30 days of surgery and includes 3 variables: female sex (1 point), peripheral vascular disease (1 point), and systolic blood pressure >180 mm Hg (1 point). The predictive score is obtained by summing the medical risk points and subtracting half the sum of the surgical risk points (minimum, 0 points; maximum, 5 points). Validation of the model showed that CEA is possibly harmful for scores of ≤ 1.0 , not significantly beneficial for scores between 1.5 and 3.5, and significantly beneficial for scores of ≥ 4 .

Results

Of 241 consecutive patients diagnosed with a high-grade carotid artery stenosis in our institution during the last 3 years, 85 were excluded from the study because their stenosis was asymptomatic. In the remaining 156 patients with symptomatic disease, 50 were women (32%) and 106 were men (68%); their mean age was 70.2 years (range, 32 to 83 years). One hundred thirty-four patients underwent CEA, 8 were denied surgery, and 14 refused the operation. One death but no major strokes occurred in the consecutive series of 134 operated patients during the first 31 days after surgery, yielding a major perioperative complication rate of 0.75%. The only fatal evolution in this series concerned a 59-year-old man who suddenly died of myocardial infarction 48 hours after the operation. Three patients (2.2%) had a perioperative minor stroke (transient ischemic attacks), and 6 patients (4.4%) experienced a noncerebral complication (3 heart failures, 2 recurrent nerve pareses, 1 wound abscess). No acute occlusion of the operated artery was observed on early postoperative ultrasounds. In 2 patients (1.5%), a mild (<50%) recurrent stenosis was noted on sonography done 6 weeks postoperatively. Eight patients were denied surgery (5.9% of 156 patients with symptomatic carotid stenosis) because they presented either a reduced life expectancy (4 patients) or severe neurological deficits after stroke (4 patients) precluding the benefit of CEA.

The Table shows the distribution of medical and surgical risk points in the 134 operated patients according to the model of Rothwell et al.¹⁰ In the medical arm, 86.6% of the patients had 4 or 5 medical risk points, reflecting a proportionately high risk of stroke on medical treatment alone. In the surgical arm, a majority of patients (67.9%) had 1 or 2 surgical risk points. A high systolic blood pressure was rarely found preoperatively in our collective, so only 1.5% of the

Distribution of Medical and Surgical Risk Points in 134 Operated Patients According to the Prognostic Model of Rothwell et al¹⁰

	No. of Patients	%	
Medical risk points			
5	54	40.3	
4	62	46.3	
3	16	11.9	
2	2	1.5	
1	0	0	
0	0	0	
Surgical risk points			
0	41	30.6	
1	66	49.3	
2	25	18.6	
3	2	1.5	

patients were attributed the maximal 3 surgical risk points. The Figure shows the prognostic score distribution resulting from the combination of medical and surgical risk points. The operation was predicted to be significantly beneficial for 69 patients (51%) who obtained a score of \geq 4. The only patient who died after surgery belonged to this group, with a score of 5. The model predicted no significant benefit of CEA for 64 patients (48%) with a score between 1.5 and 3.5. Only 1 patient (1%) fell into the zone of possibly harmful surgery (score of \leq 1). This 53-year-old woman presented an evidently symptomatic 60% carotid artery stenosis without other surgical risk factors. She was operated on without complication.

Discussion

Our results reveal that, if the predictive model of Rothwell et al¹⁰ would have been systematically applied to our patients for making a decision concerning CEA, one half of them would have been excluded from surgery because the benefit of the operation would have been deemed uncertain. This discrepancy fundamentally questions the way of indicating



Score distribution in 134 patients with high-grade symptomatic carotid stenosis selected for CEA. Risk model predicted the operation to be harmful (score, 0 to 1) for 1 patient (1%), not significantly beneficial (score, 1.5 to 3.5) for 64 patients (48%), and significantly beneficial (score, 4 to 5) for 69 patients (51%).

CEA in our institution, which corresponds to ECST, NASCET, and the guidelines of the American Heart Association.^{1,3,8,9} Should we admit that we have operated on too many patients? Was the operation really of no benefit for these patients?

The success of CEA is determined by the quality of patient selection and the rate of surgical complications. The predictive model of Rothwell et al takes both aspects into account by balancing the risks of selecting a patient for medical treatment with the risks of exposing him or her to surgery. The model presents itself as an easy and universal tool to identify the best surgical candidates for CEA. It appears also very attractive from an epidemiological and economic point of view because it aims at reducing the number of patients with carotid stenosis treated by CEA.

Differences in individual characteristics cannot explain our difficulty to apply the Rothwell et al model to our collective. The model was based on data gathered from ECST.^{1,2} Our institution is also located in Europe, so most patients were probably of white Caucasian origin in both studies. The mode of recruitment was different: multicentric in ECST versus monocentric and consecutive in our study. This makes our results more homogeneous although our sample is smaller than ECST. In the medical arm of the Rothwell et al study, 67% of patients had 2 or 3 medical risk points, whereas only 19% had 4 or 5 points (versus 86.6% in our study). This fact points to a stricter selection of patients with high medical risks and therefore to better discrimination of patients for surgery in our collective than in ECST. In the surgical arm of the Rothwell et al study, the distribution of surgical risk points was approximately the same as in our study: 39.9% of patients with 0 points versus 30.6% in our study and 1% of patients with maximal 3 points versus 1.5% in our study. The proportion of women was the same (30% in ECST versus 32% in our study). In view of these results, we can admit that our "classical" selection method actually fits well with the criteria proposed by the model of Rothwell et al.

The main difference between our study and ECST lies in the rate of major surgical complications after CEA. In the final results of ECST, 122 of 1745 operated patients had a major stroke or died in the perioperative period, yielding a surgical complication rate of 7%.² The preliminary ECST results used by Rothwell et al to validate their predictive model were even worse, with 65 adverse events in 596 operated patients, corresponding to a complication rate of 10.9%.¹⁰ This has to be compared with a rate of major perioperative complications of 0.75% in our series as assessed by an independent neurologist (P=0.0018, Fisher's exact test). This difference explains our difficulty with the application of the Rothwell et al model. Our patients have not been exposed to high surgical risks, whereas if not operated on, they would have been exposed to a significant risk of stroke. Some of them would even have suffered a major stroke or have died of stroke. Once an important matter of controversy, CEA has matured to a safe and effective intervention that bears a very small perioperative risk of $\approx 1\%$ in experienced centers. This renders the operation attractive for people who live with an appreciable risk of stroke. We remain convinced that our decision to operate on these patients was correct and adequate from an individual and ethical point of view.

Our results illustrate the difficulty for the physician in applying large-scale epidemiological data to the individual case. We are conscious that important differences exist in the quality of surgical performance of CEA and that continuous efforts are necessary to maintain the benefit of this prophylactic intervention for patients harboring a high-grade carotid stenosis.^{16–21} However, our results demonstrate that the applicability and utility of the predictive model of Rothwell et al are not warranted in institutions where the rate of surgical complications is very low. In this situation, the most useful criteria for recommending surgery remain the presence of a high-grade stenosis and a reasonable life expectancy.

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