Letters to the Editor

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The Best Method to Quantitate Angiographic Carotid Artery Stenosis?

To the Editor:

We read with interest the recent report by Alexandrov et al1 and the editorial by Barnett and Warlow2 concerning the measurement of carotid artery stenosis. After comparison between the duplex method and various angiographic measurements, Alexandrov and colleagues strongly advocated the duplex method. However, as the editorial points out, the results of NASCET3 and ECST4 have set the standard of indication for carotid endarterectomy (CEA) based on angiographic measurements only.

It is well known that the formulas used by NASCET3 and ECST4 give different measures of the degrees of stenosis in the same arteriogram.1,3,6 So far, most comparative studies between these two measurement methods have been limited to the group of severely and moderately stenosed bifurcations. Yet the threshold between mild and moderate stenosis may become more important, depending on the final outcome of the ongoing trials: how close to 30% will the limit be when surgery is recommended? In routine clinical work, a great part of the bifurcations evaluated by angiography belong to these groups of mild and moderate degrees of stenosis. It is therefore important to compare the two most widely used methods for measuring angiographic carotid artery stenosis in an unselected group of symptomatic patients with all degrees of stenosis.

With this aim, we evaluated the selective intra-arterial digital subtraction angiography films of 41 consecutive patients with hemispheric or retinal transient ischemic attacks or nondiabling stroke. Three observers measured the stenosis degree according to the NASCET and ECST criteria. In most cases three projections of each bifurcation were available, and the first observer selected the image of each bifurcation to be measured by all three investigators. Both measurements, using a magnifying glass film viewer, were independently performed twice by each observer with at least 3 weeks' interval between the separate sessions. After exclusion of two nondiagnostically imaged bifurcations, 80 bifurcations thus underwent 480 pairs of measurements. For statistical analysis, the measured stenosis percentages were divided into four clinically relevant classes: mild (0 to 29%), moderate (30% to 69%) or severe (70% to 99%) stenosis or occluded. The differences between the measurement techniques were tested by Wilcoxon matched-pairs signed ranks test and the kappa test.

According to the average NASCET stenosis (which was calculated from both of the measurements of all three measurers), 57 bifurcations were classified as mildly, 6 as moderately, and 11 as severely stenosed. Six internal carotid arteries were occluded. The difference between the stenosis degrees according to the ECST and NASCET methods was statistically significant for all three measurers (P=0.0001-0.01). The difference between the average ECST and NASCET stenoses was 8.8±7.9% (mean±SD; range, -3.2% to 31.3%), with the ECST method giving the greater degree of stenosis. The results are shown graphically in the Figure on the following page. When the bifurcations were divided into subgroups (mildly, moderately, and severely stenosed, according to the average NASCET stenosis), the difference between the two methods remained statistically significant only in the group of mildly stenosed bifurcations (mean, 10.7±8.2%), even though the ECST method gave slightly greater values also in the moderately (6.8±7.9%) and severely stenosed (4.3±1.9%) groups. By statistic kappa the intertechnique agreement varied from fair to good (0.55 to 0.75) for individual measurers.

When the average NASCET and ECST stenoses of the same bifurcation were compared, 15 bifurcations were classified as belonging to the no-surgery group (stenosis of <30%) by the NASCET method, but they were candidates for randomization and possible surgery (stenosis of 30% to 69%) by the ECST method, provided that the side correlated with the symptoms. One bifurcation would have definitely been recommended for surgery by the ECST measurement (stenosis of >70%) but was considered moderately stenosed by the NASCET method (30% to 69%) and could possibly have been treated conservatively.

It can be mathematically shown that the milder the stenosis, the greater the intertechnique variation caused by the difference between the reference diameters. This was also obvious in our study, in which the intertechnique difference was more prominent in the subgroup of mild stenoses, but when the bifurcation was severely stenosed, both measurement methods led to almost similar results.

In our hands, the ECST method gave an approximately 9% greater degree of stenosis than the NASCET method, which corresponds well with the results of Alexandrov et al1 (mean NASCET stenosis 63% and mean ECST stenosis 73%). We also found that the differences between these measurement methods became more important in the quantitation of mild stenosis. Barnett and Warlow, in their editorial,2 refer to the results in which 48% of ECST patients previously designated as "severe" became "moderate" when remeasured by the NASCET formula. In this light, according to the text in editorial and also according to our own experience, the percentages for carotid stenosis in the legend for the figure in the editorial stating that "Preliminary analysis of angiograms of patients randomized to no-surgery in ECST suggests that 70% stenosis measured by the ECST method is approximately equivalent to 82% stenosis measured using the NASCET method" have to be vice versa. Contradictory numbers for the same lesion are confusing, and uniformity in the way of measurement, both in scientific and routine work, is most desirable.

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Carotid Endarterectomy and the Measurement of Stenosis

To the Editors:

We thank Drs Barnett and Warlow for their extensive commentary1 on our article2; we will paraphrase and briefly reply to their key points.

1. There were a limited number of high-grade stenosis pathology specimens for analysis. We did not include lesser degrees of stenosis because these are rarely subjected to endarterectomy. However, as we indicated (on p 1295 of our article), due to the linear versus area relationship (Fig 3), the implied discrepancy between plaque planimetry and linear stenosis will most likely increase at lower levels of stenosis.

2. Carotid endarterectomy has only been proven for linear measurements, using selective angiography. The authors of the editorial point out that their two studies were performed on angiographic linear stenosis and whether they reflect "true" stenosis or are simply indexes is irrelevant. However, surely it is better for the measurement to reflect reality if it is possible. For instance, a 70% NASCET "index" is equivalent to an ECST 82% stenosis and represents a 90% area stenosis of the artery. An ECST stenosis below 45% is reported as a "negative" NASCET stenosis: Is it possible to operate on a "negative" stenosis? These methodological differences will become even more confusing when results are published for the moderate stenosis group, particularly if one trial shows a clear benefit for surgery and the other does not.

At no stage did we advocate "eyeballing" as a superior method, but would point out that this remains by far the most common method of measuring angiograms.

3. The conclusions are flawed because of a failure to appreciate the relationship between linear and area measurements. As Barnett and Warlow point out, there is indeed a correlation between linear NASCET and area NASCET (N=2), and then N=2 and planimetry (and similarly for ECST). We cannot agree, however, that the mismatch between our linear and area measurements is a "flaw," because this is the major point of our study. As a result of the quadratic relationship of linear to area measurements (Fig 3, not Fig 2 as the authors note), the discrepancy between them becomes greater toward the lower end of the curve.

Regarding the authors' interesting attempt to correlate the therapeutic benefit of NASCET and ECST (Figure, p 1282), we feel certain that there was a typographical error because they state that "70% stenosis measured using the ECST method is approximately equivalent to 82% stenosis measured using the NASCET method." In fact, ECST 70% is equivalent to about 50% NASCET stenosis. We can only assume that either the legend for the figure is incorrect or that the survival curves have been tabulated using an incorrect correlation.

The reader should note that it was not the intention of our paper to discredit either of these well-executed multicenter trials, but rather to emphasize that present linear angiographic methods do not reflect what is seen at surgery and that both techniques have their limitations.

The current methods represent only indexes of severity; they use two-dimensional images to describe what is an asymmetric, three-dimensional structure (the carotid plaque). However, angiography still remains the gold standard, so we should attempt to optimize the methodology to best reflect reality. The ECST method is the closest but requires a best "guessimate" for the carotid bulb; the NASCET method is more problematic since in one third of angiograms it is technically difficult10-12 or can produce a negative stenosis. We would also like to emphasize that ultrasound remains an accurate and effective method of presurgical screening.

The dilemma that clinicians face is well demonstrated by the angiogram of a patient recently randomized into NASCET...
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