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The analysis of 480 pairs of simultaneous measurements of different observers. The horizontal axis expresses the NASCET stenosis and the vertical axis the corresponding ECST stenosis of the same carotid bifurcation. △, ○, and □ indicate different observers; hollow symbols, first measurement; and filled symbols, second measurement.

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 (N²), and then N² 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 difficult to measure accurately 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...
Angiogram of patient randomized into NASCET.

(Figure, top of this page). The official NASCET reading was 27% and our ECST calculation 52%, yet the decision for surgery (with all its inherent risks) depends on which method of measurement is used. The publications of Drs Barnett and Warlow had clearly shown the benefits of surgery for the severe stenosis group. Their future publications for the moderate stenosis group should take into consideration these methodological differences in measuring carotid stenosis. Clinicians managing these patients may then at last have a uniform recommendation for treatment.

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The following is in response to the preceding two letters:

Alexandrov and his colleagues continue to express enthusiasm for what they describe as the “true” measure of stenosis. They support their opinions by repeating claims about the superiority of duplex and by pointing out the lack of uniformity between the NASCET and ECST measurements.

The European and North American trials have shown unequivocal surgical benefit for patients with severe carotid stenosis. The arguments brought forward about the “superiority of ultrasound” over the NASCET and ECST measurements of arteriograms are a combination of that which is impractical, simply semantics, and finally misleading. The procedure of endarterectomy as a method of preventing stroke has been validated by both NASCET and ECST based on two methods of measuring the reduction of the linear diameter in cerebral angiograms. The challenge for ultrasonographers who dismiss the measurement methods used by NASCET and ECST is to establish an ultrasound correlation that will be reproducible in all institutions. This requires that ultrasound must correlate accurately with the simple arteriographic measures that have been used in the validation of endarterectomy. When this is feasible, when it is used with predictable accuracy in a widespread manner, and perhaps when magnetic resonance angiography is fully developed, the use of invasive arteriography will become superfluous.

The ECST did not use ultrasound for the simple reason that it began in 1981, before the development of Doppler. NASCET, designed in 1987, had funds neither to standardize ultrasound equipment nor ensure that the existing equipment was used to perfection on every patient. NASCET’s 50 academic centers were not selected because of their specialized interest in ultrasound. Prerandomization ultrasounds were submitted to the principal ultrasonographer in the central office, and an attempt was made to correlate the degrees of stenosis seen from these studies to the arteriograms measured in the central office by the principal neuroradiologist. It is reasonable to claim that these ultrasonographic studies, and not those produced from very focused specialized ultrasonographic laboratories, reflect the “real world.”

The reason for waiting to obtain good images of the diseased artery is to estimate as closely as possible the risk attributable to the particular stenotic lesion. NASCET and ECST have done this. NASCET has shown that at 2 years, the risk of ipsilateral stroke for patients with a stenosis of 70-99% is 26%, and declines so that when the stenosis is 70% to 79% the risk is only 12%. ECST remeasured their lesions by the NASCET method (unpublished data) and has made nearly identical observations on attributable risk. Utilizing ultrasonography as practiced in the NASCET centers, there was wide discrepancy between the ultrasound observations and the arteriographic measurements in the same patients. Using the technology of 1987-1991, ultrasound in NASCET centers overestimated by 21% and underestimated by 33% the degree of stenosis seen in the arteriogram. The challenge to ultrasonographers is to close the gap that is apparent in attempting these correlations. In this regard the reader is referred to three recent reviews. All found discrepancies in correlation, and Moneta concluded that the “duplex scan of 70-99% stenosis as defined by NASCET requires the adoption of duplex criteria modified from those in current use.”

Alexandrov et al argue that they validated the “true” measure of stenosis from pathological specimens of severe lesions because the “lesser degrees of stenosis are rarely subjected to endarterectomy.” Sixty percent of ECST patients and 50% of NASCET patients submitted for endarterectomy had lesions that were less than severe. This ratio of severe to moderate patients is similar to a large community survey. NASCET and ECST may or may not confirm that patients with moderate disease are reasonable candidates for endarterectomy.
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