Embolus Differentiation Using Multifrequency Transcranial Doppler

To the Editor:

Markus and Punter report disappointing results for differentiation between solid and gaseous emboli using both the default settings of the Embo-Dop multifrequency transcranial Doppler system, and the modified criteria recommended by Russell and Brucher. One reason for this poor performance is a fundamental limitation of the multifrequency technique, which cannot be overcome simply by altering the discrimination criteria. The multifrequency technique relies on the ultrasound beam pattern at all measurement frequencies (in the case of the Embo-Dop, 2 MHz and 2.5 MHz) being identical. Any deviation from this will mean that the ratio of the measured values of embolus-to-blood ratio (MEBR) at the 2 frequencies will not only depend on the composition of the embolus, but also on the part of the beam through which the embolus passes. Unfortunately, it is impossible to generate identical ultrasound beams at more than one frequency, because the detailed shape of a beam is determined by interference effects, which are in turn dependent on wavelength, and therefore frequency. In a recent study we compared the beam shapes generated by a multifrequency transducer at 2 MHz and 2.5 MHz, both with and without temporal bone placed in front of the transducer, and found that in either case the effects on the ratio of the MEBRs at the 2 frequencies was to introduce a measurement uncertainty of between 2 dB and 4 dB. Correct classification of solid emboli using the Embo-Dop system relies on this ratio lying within a band of values that is only 2.5 to 3 dB wide. This being the case, even if it were possible to make absolutely accurate measurements of MEBR at the 2 frequencies, and assuming the empirical thresholds are absolutely correct, ~20% of solid emboli would be misclassified as gaseous. In practice, other measurement errors are likely to increase the rate of misclassification, which would fit with the data from Markus and Punter’s study suggesting a misclassification rate of 25.8% for solid emboli.

The problem of distinguishing between signals from solid and gaseous emboli is clinically important, and the multifrequency technique an interesting approach. Unfortunately, its accuracy is limited by the impossibility of generating identical ultrasound beam shapes at different frequencies.

David H. Evans, PhD, DSc
Department of Cardiovascular Sciences
University of Leicester
Leicester, England

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David H. Evans

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