**Letters to the Editor**

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**Intracerebral Hemorrhage Volume Measurement**

We recently demonstrated that the volume of intracerebral hemorrhage, as calculated from the computed tomographic (CT) film using the formula for an ellipsoid, is an accurate and powerful predictor of 30-day mortality following intracerebral hemorrhage. Since publication of our article in the July 1993 issue of *Stroke*, we have received several inquiries regarding clarification of our method of volume measurement. The formula for an ellipsoid is \( \frac{4}{3} \pi (a \times b \times c) \), where \( a \), \( b \), and \( c \) represent the respective radii of the intracerebral hemorrhage in three dimensions. Although this formula is relatively simple and easy to use, one of our colleagues, Dr Bill Cahill, has pointed out that the formula for an ellipsoid can be further simplified to \( ABC/2 \), where \( A \), \( B \), and \( C \) represent the *diameters of the hemorrhage in three directions*. The latter formula is essentially equal to \( ABC/2 \). Grotta and colleagues have independently used the formula \( ABC/2 \) for estimation of intracerebral hemorrhage volume in another model of outcome following intracerebral hemorrhage. These investigators have also demonstrated the ease and power of this bedside method of volume estimation.

Thus, accurate determination of intracerebral hemorrhage volume can be determined very simply and quickly in the following manner. The CT slice with the largest area of hemorrhage is identified. The longest diameter of the hemorrhage on this slice is measured using the CT measurement scale on the film. The diameter of the hemorrhage that is 90° to the longest diameter represents the second diameter. Finally, the number of 1-cm CT slices on which the hemorrhage is visualized provides the third diameter (eg, a hemorrhage seen on three 1-cm slices would have a diameter of 3 cm). The three diameters are multiplied and then divided by 2 to obtain the volume of intracerebral hemorrhage. This method correlates quite well with a sophisticated but time-consuming planimetric method of volume measurement \((r=0.94)\), as noted in our article.

We are hopeful that the simplicity and accuracy of this method will lead to its frequent use as a bedside predictor of outcome for physicians caring for patients with intracerebral hemorrhage. As Lisk and colleagues suggest, models of outcome using the volume of intracerebral hemorrhage will be critical for patient selection in future randomized surgical trials.

**TCD Velocities and Arterial Pressures in AVM Feeder Vessels**

In a carefully performed study, Fleischer et al demonstrated a relationship between cerebral arteriovenous malformation (AVM) feeding mean arterial pressures (FMAP) and parent artery blood flow velocity, measured using transcranial Doppler (TCD). They showed an inverse correlation between FMAP- and TCD-derived velocities, the correlation being closer when peak systolic \((r=-0.62)\) as opposed to mean velocities \((r=-0.35)\) were considered. This correlation is perhaps weaker than the authors had initially hoped; thus, it seems that TCD-derived blood velocities in AVM feeder vessels may not be of such powerful prognostic value.

Methodological reasons for the worse-than-expected correlation were discussed, but the authors failed to mention the errors incurred in their TCD measurements not attempting to correct for the angle of insonation of the feeder vessels. The maximum amplitude TCD signal was analyzed and presumably this was thought to relate to an arterial segment whose vector of blood flow was closest to the direction of the ultrasound beam. Assuming angles of under 30° \((\text{cosine } 30=0.87)\), the potential error is small (less than 15%). However, at larger angles the error in perceived velocity increases disproportionately. In patients with AVMS, it is our experience (from studies using transcranial color-coded sonography and magnetic resonance angiography) that the anatomy can be distorted with tortuosity of the feeder vessels, which may run at greater angles to the ultrasound beam. In addition, the anterior and posterior cerebral arteries run at greater angles than the middle cerebral artery, and determination of "true" blood flow velocities in these vessels should incorporate a correction for the insonation angle. Because the authors measured the angiographic diameter of the feeder vessels at the point of insonation, they may also be able to measure the angle of the insonated arterial segment to the presumed path of the ultrasound beam. Thus, reanalysis of their data to include a correction for the insonation angle may yield a closer relationship between FMAP and the TCD-derived blood flow velocities.

**References**


**Response**

We thank Martin and Gaunt for their constructive and insightful comments regarding an important possible source of error in...
Intracerebral hemorrhage volume measurement.
J P Broderick, T G Brott and J C Grotta

Stroke. 1994;25:1081
doi: 10.1161/01.STR.25.5.1081.b

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://stroke.ahajournals.org/content/25/5/1081.2.citation

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