Comparison of the ABC/2 Estimation Technique to Computer-Assisted Volumetric Analysis of Intraparenchymal and Subdural Hematomas Complicating the GUSTO-1 Trial

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Background and Purpose—The volume of an intracerebral hemorrhage has been shown to be an important independent predictor of mortality in several reports.1–5 A technique for estimating hematoma volume, known as the ABC/2 method, has been proven a reliable, simple bedside technique for the volume measurement of intraparenchymal intracerebral hemorrhage.6–8 Subdural hematomas also carry a significant mortality risk but are more amenable to surgical evacuation. A reliable, simple bedside measurement of subdural hematoma volume may prove a valuable tool in prognostication and management of patients with this entity.

Methods—Computed tomographic (CT) brain scans of 244 patients suffering from intracranial hemorrhage in the GUSTO-1 trial were systematically reviewed. The volumes of 298 intraparenchymal hematomas were measured by the ABC/2 technique, and the volumes of 44 subdural hematomas were measured by an adaptation of this technique and compared to computer-assisted volumetric analysis.

Results—Excellent correlation between the techniques were achieved for both subdural ($r=0.842$; slope, 0.982) and intraparenchymal hematoma volume measurements ($r=0.929$; slope, 1.11).

Conclusions—The ABC/2 method is a simple and accurate technique for the measurement of intraparenchymal hematoma volume, and a simple adaptation allows for a similarly accurate measurement of subdural hematoma volume as well. (Stroke. 1998;29:1799-1801.)

Key Words: cerebral hemorrhage • subdural hemorrhage • computer-assisted image processing

The volume of an intracerebral hematoma has been shown to be an independent predictor of mortality in prediction models studying various populations of patients with intracerebral hemorrhage.1–4 A simple estimation method of intracerebral hematoma volume, known as the ABC/2 or XYZ/2 method, was first reported by Kwak et al6 and later by Broderick et al,7 and validated by Kothari et al.8 To our knowledge, this technique has not yet been adapted or validated for use in the measurement of subdural hematoma volume. Because subdural hematomas are potentially highly morbid and generally more amenable to surgical evacuation, the availability of a simple, accurate bedside technique for determination of their volume may be useful in patient management and prognostication. This study compares the estimation method of hematoma volume to a computer-assisted volumetric analysis in a large series of intracranial hemorrhages, both intraparenchymal and subdural, complicating systemic thrombolytic therapy for acute myocardial infarction in the GUSTO-1 trial.

Subjects and Methods
All available CT brain scans from patients suffering from intracranial hemorrhage while enrolled in the GUSTO-1 trial9 were reviewed by at least 1 of the 3 principal investigators (J.M.G., C.A.S., or M.A.S.). In total, 244 CT scans containing 298 intraparenchymal hematomas and 44 subdural hematomas were reviewed. This CT scan population represents a highly diverse variable quality collection of studies from all over the world, ideally suited for testing the widespread applicability of the ABC/2 technique. Details regarding the anatomic locations of the intraparenchymal hematomas in this population have been published elsewhere.10 Hematoma margins were handtraced and 2 methods of hematoma volume measurement were employed.

For intraparenchymal hematomas, the ABC/2 technique (as previously described) was applied. Specifically, a representative slice at the center of the hematoma was selected. The maximum linear length (A) in cm was multiplied by the maximum width (B) in cm and the maximum depth (C) in cm. The depth (C) was determined by multiplying the number of slices on which hematoma was visible by the slice thickness listed on the CT scan. To obtain the volume in cm$^3$, the final product was divided by 2.

For subdural hematoma, the ABC/2 technique was adapted; again, a representative slice near the center of the hematoma was selected. The linear distance in cm between each corner of the subdural

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crescent was used to determine the length (A). The width (B) was measured as the maximum thickness in cm of hematoma (B) from the inner table of the skull perpendicular to the length. The depth (C) was determined by multiplying the number of slices on which hematoma was visible by the slice thickness listed on the CT scan. To obtain the volume in cm³, the final product was divided by 2 (Figure 1).

Computer-assisted volumetric analysis (propriety software, Center for Computer-Assisted Neurosurgery, Cleveland Clinic Foundation, run on Sun Microsystems Sparkstation I) was performed on all hematomas, with each slice containing hematoma traced by the same technician (J.P.W.), modeled after the technique of Hier et al.¹¹

Results
For 298 individual intraparenchymal hematomas occurring in 244 patients, mean volume was 68.7 cm³ by the standard ABC/2 estimate technique, versus 63.3 cm³ by the computer-assisted volumetric technique, with \( r = 0.929 \) and slope, 1.11. (Figure 2). The mean volume of the 44 subdural hematomas was 91.0 cm³ by the modified ABC/2 estimate technique versus 82.4 cm³ by the computer-assisted technique, with \( r = 0.842 \) and slope, 0.982. (Figure 3).

Discussion
Excellent correlation between the ABC/2 technique and the computer-assisted volumetric technique for the measurement of intraparenchymal hematoma volume was observed and is comparable to previously reported results.⁵,⁸ There was also an excellent correlation between the ABC/2 technique and the computer-assisted technique for subdural hematomas. This relationship was accurate particularly at the hematoma volumes typically associated with acute clinical symptoms; it demonstrates the validity and applicability to a rather diverse variable quality CT scan population which included imaging studies from various hospitals around the world.

Subdural hemorrhage after systemic thrombolytic therapy, like intraparenchymal hemorrhage, carries a significant mortality risk but may be more amenable to surgical evacuation. However, because higher volume intracranial hemorrhages have a poorer outcome,⁴ the adaptation of the relatively simple ABC/2 method to measure volumes may be a useful adjunct to clinical and radiographic information currently used in determining prognosis and management of affected patients.

Conclusion
We conclude that the ABC/2 technique, adapted as described in this article, is a simple, accurate bedside method for the measurement of subdural hematoma volume. We also confirm the precision and applicability of the ABC/2 technique for intraparenchymal hematoma volume measurement in a heterogeneous variable quality group of brain CT scans.

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References


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