The Value of XYZ/2 Technique Compared With Computer-Assisted Volumetric Analysis to Estimate the Volume of Chronic Subdural Hematoma

Hasan Kamil Sucu, MD; Metin Gokmen, MD; Fazil Gelal, MD

Background and Purpose—A simple estimation method of intracerebral hematoma volume known as XYZ/2 method has been described previously. This method has also been shown to be valid for the estimation of acute subdural hematoma volume. However, chronic subdural hematomas differ in shape and extension from acute subdural hematomas, which makes the validity of the same method in the estimation of hematoma volume questionable. We aimed to determine the value of XYZ/2 method to estimate the volume of chronic subdural hematoma when compared with computer-assisted volumetric analysis.

Methods—Computed tomography scans of 28 patients with unilateral hemispheric chronic subdural hematoma were reviewed. Hematoma volumes were measured using 5 different XYZ/2 formulas and compared with volumes measured by computer-assisted analysis. Nonparametric correlation coefficient (Spearman’s ρ) was used in statistical comparison.

Results—All 5 formulas showed excellent correlation with the gold standard, proving the validity of XYZ/2 method in the estimation of chronic subdural hematoma volume (level of significance <0.001). Our results suggest that maximum hematoma length and width, which are not necessarily on the same slice, should be used rather than length and width of hematoma on the central slice when using XYZ/2 method in patients with chronic subdural hematoma.

Conclusion—This study proves the validity of XYZ/2 technique for the estimation of chronic subdural hematoma volume as well. (Stroke. 2005;36:998-1000.)

Key Words: blood volume | computed tomography | image processing, computer-assisted | hematoma

Although surgery of chronic subdural hematoma (CSDH) is simple, it is widely accepted that surgery is not indicated in all of these patients. Furthermore, presence of residual subdural hematoma after the operation is not an indication for reoperation; it has been reported that evacuation of 20% of the hematoma is considered sufficient. A simple and accurate method for bedside determination of the volume of CSDHs may be useful in patient management in the preoperative and postoperative period.

A simple estimation method of intracerebral and epidural hematoma volume, known as XYZ/2 or ABC/2, method had been described previously. Recently, Gebel et al have shown that this method, with minor adaptation, would be suitable for the estimation of subdural hematoma volume as well. Later, Kasner supported this method and provided a convincing mathematical explanation for it. The series of Gebel et al consisted of patients with acute subdural hematomas. However, CSDHs differ in shape and extension from acute ones, which makes the validity of the same method in the estimation of hematoma volume questionable. CSDHs are not always symmetric crescents. Because of their chronic nature and traction of developing membranes, they may assume asymmetric shapes such as a comma, pear, or lens on axial computed tomography (CT) slices. CSDH, unlike acute subdural hematoma, usually extends as far as the cranial vault. Above the superior temporal line, axial CT slices are no longer perpendicular to cranium or subdural hematoma; they run rather obliquely because of the curvature of the cranial vault. Therefore, the width of the subdural hematoma measured on a slice close to vertex is thicker than it actually is. Because the width of hematoma is a variable used in XYZ/2 formula, question arises as to whether the width as measured on the axial slice or the real (corrected) width as calculated by taking the curvature of the vault into consideration should be used in the formula.

Although XYZ/2 technique had been proven to be reliable in the estimation of acute subdural hematoma volume, its value to estimate the volume of CSDH has not been studied previously. In this study, we aimed to determine the validity of this technique to measure CSDH volume by comparing it to computer-assisted volumetric analysis, which was considered as gold standard.

Subjects and Methods
We reviewed the CT scans of 28 patients with unilateral hemispheric CSDH who had been operated on in the neurosurgery department of our hospital over the last 2 years. Six patients were excluded because it was not possible to reliably delineate the isodense hematoma from
the brain parenchyma on the CT scans. The remaining 22 patients were included in the study.

Computer-assisted volumetric analysis was considered as gold standard. Hematoma margins were hand-traced by the radiologist on each axial slice. Using "Dicom Works" computer program, the area of the traced hematoma was found in squared centimeters. Product of the area by the corresponding slice thickness gave the volume of the hematoma on that particular slice in cubed centimeters. The sum of the volumes on each slice gave the total volume of the hematoma.

We created 5 different XYZ/2 formulas to find out which formula would give the closest estimation of hematoma volume compared with the gold standard. These were: (1) \( XY_1 Z_1 /2 \); (2) \( XY_2 Z_2 /2 \); (3) \( XY_3 Z_3 /2 \); (4) \( XY_1 Z_2 /2 \); and (5) \( XY_1 Z_3 /2 \). \( X \) indicates depth of hematoma; \( Y_1 \) maximum length of hematoma on any slice; \( Y_2 \), maximum width of hematoma on any slice; \( Y_3 \), length of hematoma on the slice that has maximum corrected width; \( Z_1 \), depth of hematoma on the slice that is at the center; \( Z_2 \), length of hematoma on the slice that has maximum corrected width; \( Z_3 \), corrected width of hematoma on the slice that is at the center; and \( Z_4 \), corrected width of hematoma on the slice which has maximum corrected width.

Depth of hematoma was determined by multiplying the number of slices on which hematoma was visible by the slice thickness. The slice at equal distance to the first and last slices represented the center of hematoma; in case of even number of slices, the slice in the middle with a thicker hematoma was considered the central slice. When subdural hematoma was crescentic, the linear distance between each corner of subdural crescent was used to determine the length, as suggested by Gebel et al.6

The real (corrected) width of hematoma was calculated using the equation:

\[ Z_c = Z \times h \sqrt{a^2 - a_2^2 + h^2}. \]

\( Z \) indicates width of hematoma on the axial representative slice. Figure 1 shows schematic and geometrical drawings explaining how the corrected width of hematoma was calculated. Schematic drawing represents coronal view of the calvarium where shaded area is subdural hematoma (Figure 1a). The geometrical basis for the equation to calculate corrected width is shown in (b). The geometrical drawing is considered analogous to one half of the schematic drawing, where \( Z \) is (real) width of hematoma measured perpendicular to calvarium; \( a \), half of the biparietal diameter (distance between inner tables) on the representative slice; \( a_2 \), half of the biparietal diameter above the representative slice; and \( h \), distance between 2 consecutive slices.

Figure 1b was drawn assuming that calvarial and cortical surfaces delineating hematoma between 2 consecutive slices were parallel straight lines in Figure 1a. In Figure 1b, \( \Delta ABE \) and \( \Delta ADC \) are similar triangles: \([EB][AE] = [AC][DC].\)

Therefore, \( |AC| \), \( |DC| \), \( |AB| \), \( |AE| \), \( |EB| \) stands for \( Z \); \( |DC| \) stands for \( Z_2 \); \( |EB| \) stands for \( h \); \( |AE| \) is hypotenuse of \( \Delta ABE \); \( |AE| = \sqrt{|AB|^2 + |EB|^2} \); and \( |AB| = \sqrt{|a-a_2|^2 + h^2} \).

When values are substituted, \( Z(Z, = \sqrt{|a-a_2|^2 + h^2}/h \); and \( Z_c = Z \times h \sqrt{a^2 - a_2^2 + h^2} \).

Product of the 3 variables was measured in centimeters, and division of the final product by 2 yielded hematoma volume in cubed centimeters. The volumes calculated using each of these 5 formulas were statistically compared with volumes measured by computer assistance. Nonparametric correlation coefficient (Spearman’s \( \rho \)) was used in comparison.

### Results

Depth of hematoma ranged between 5 and 9.5 cm, with a mean of 7.5±1.3 cm. Length of hematoma ranged between 11.0 and 14.4 cm, with a mean of 13.1±1.0 cm. Width of hematoma ranged between 1.1 and 4.4 cm, with a mean of 2.2±0.9 cm. Corrected width of hematoma ranged between 0.8 and 3.5 cm, with a mean of 2.1±0.8 cm. (mean±SDs).

Table shows median, minimum, maximum, and 25th and 75th percentile values of hematoma volumes measured by the gold standard and 5 different XYZ/2 formulas. Correlation (Spearman’s rho) coefficients for hematoma volumes obtained by each of 5 XYZ/2 formulas versus computer-assisted volumetric analysis are: \( XY_1 Z_2 /2 = 0.932 \); \( XY_2 Z_2 /2 = 0.888 \); \( XY_3 Z_2 /2 = 0.874 \); \( XY_1 Z_3 /2 = 0.887 \); and \( XY_1 Z_3 /2 = 0.912 \). Each of these coefficients were significant at a level <0.001.

Graphic representation showing the comparison of the best correlating formula (\( XY_1 Z_2 /2 \)) to the gold standard is depicted in Figure 2.

### Discussion

All 5 formulas showed excellent correlation with the gold standard, proving the validity of XYZ/2 method in the estimation of CSDH volume (level of significance <0.001). However, the best correlating formula was \( XY_1 Z_2 /2 \) (correlation coefficient 0.932). Therefore, it is evident that using the

---

### Hematoma Volume Measured Using Computer-Assisted Analysis (gold standard) and 5 Different XYZ/2 Techniques

<table>
<thead>
<tr>
<th>Techniques</th>
<th>Median</th>
<th>Minimum</th>
<th>Maximum</th>
<th>25th Percentile</th>
<th>75th Percentile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gold standard</td>
<td>100</td>
<td>70</td>
<td>132</td>
<td>67</td>
<td>133</td>
</tr>
<tr>
<td>( XY_1 Z_2 /2 )</td>
<td>106</td>
<td>70</td>
<td>144</td>
<td>60</td>
<td>132</td>
</tr>
<tr>
<td>( XY_2 Z_2 /2 )</td>
<td>100</td>
<td>70</td>
<td>132</td>
<td>60</td>
<td>132</td>
</tr>
<tr>
<td>( XY_3 Z_2 /2 )</td>
<td>90</td>
<td>70</td>
<td>132</td>
<td>52</td>
<td>132</td>
</tr>
<tr>
<td>( XY_1 Z_3 /2 )</td>
<td>97</td>
<td>57</td>
<td>136</td>
<td>57</td>
<td>136</td>
</tr>
<tr>
<td>( XY_2 Z_3 /2 )</td>
<td>105</td>
<td>64</td>
<td>136</td>
<td>64</td>
<td>136</td>
</tr>
</tbody>
</table>

---

Figure 1. Schematic and geometrical drawings explaining how the corrected width of hematoma is calculated. Schematic drawing represents coronal view of the calvarium where shaded area is subdural hematoma (a). The geometrical basis for the equation to calculate corrected width is shown in (b). The geometrical drawing is considered analogous to one half of the schematic drawing, where \( Z \) is (real) width of hematoma measured perpendicular to calvarium; \( a \), half of the biparietal diameter (distance between inner tables) on the representative slice; \( a_2 \), half of the biparietal diameter above the representative slice; and \( h \), distance between 2 consecutive slices.
formula depth × maximum length × maximum width on any slice/2 will give the closest estimation of CSDH volume. Although the formula using the corrected width of hematoma (XY1Z4/2) showed the second best correlation, it is clear that calculating corrected width is time consuming and unnecessary. When using XYZ/2 method, Kothari et al4 used the slice with maximum hematoma length, whereas Gebel et al6 used the central slice to measure length and width of hematoma in patients with intracerebral and acute subdural hematomas, respectively. Our results suggest that maximum hematoma length and width, which are not necessarily on the same slice, should be used rather than length and width of hematoma on the central slice when using XYZ/2 method in patients with CSDH. Asymmetric shape of CSDH may justify this finding because the slice with the maximum hematoma length may not necessarily be in the center of hematoma in such cases.

There are 2 main limitations in the measurement of CSDH volume by CT. First of all, CSDH may be isodense or slightly hypodense relative to brain, making their delineation from the parenchyma difficult. In that case, one cannot reliably trace the margins of the hematoma nor measure its volume by computer assistance or XYZ/2 technique. We excluded 6 patients from the study for that reason. Second, determining the uppermost extension of CSDH may prove difficult because the axial slices at vertex run almost tangential to the hematoma. Despite these limitations, CT estimation of CSDH volume may be sufficient in most of the cases. When hematoma margins cannot be traced or when a precise volume measurement is required, MRI should be the method of choice because of its superior contrast resolution and multiplanar capabilities.

**Conclusion**

This study proves the validity of XYZ/2 technique for the estimation of CSDH volume as well for the estimation of intracerebral or acute subdural hematoma volume.

**References**

The Value of XYZ/2 Technique Compared With Computer-Assisted Volumetric Analysis to Estimate the Volume of Chronic Subdural Hematoma
Hasan Kamil Sucu, Metin Gokmen and Fazil Gelal

Stroke. 2005;36:998-1000; originally published online April 7, 2005;
doi: 10.1161/01.STR.0000162714.46038.0f

Stroke is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 2005 American Heart Association, Inc. All rights reserved.
Print ISSN: 0039-2499. Online ISSN: 1524-4628

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/36/5/998

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in Stroke can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to Stroke is online at:
http://stroke.ahajournals.org//subscriptions/