CT Angiography-Source Image Hypoattenuation Predicts Clinical Outcome in Posterior Circulation Strokes Treated With Intra-Arterial Therapy

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Background and Purpose—The aim of this study was to correlate CT angiography-source image (CTA-SI) parenchymal hypoattenuation with clinical outcome in patients with vertebrobasilar occlusion treated with intra-arterial thrombolysis.

Methods—In 16 patients with vertebrobasilar occlusion treated with intra-arterial thrombolysis, we graded CTA-SI parenchymal hypoattenuation in the medulla, pons, midbrain, thalamus, cerebellum, occipital lobe, inferior parietal lobe, and medial temporal lobe. The grading scale was: 0, no hypoattenuation; 1, <50% hypoattenuation; and 2, >50% hypoattenuation. On CTA, we assessed clot location and length and collaterals. Outcome was measured with modified Rankin score.

Results—Mean patient age was 68.3 years (range, 47 to 86 years), National Institutes of Health Stroke Scale was 28 (range, 11 to 40), time to CTA was 5.2 hours (range, 0.69 to 15.32), and time from CTA to intra-arterial thrombolysis was 5 hours (range, 2.25 to 10.38 hours). There were 4 basilar, 2 vertebral, and 10 combined occlusions. Eleven patients had near complete, 4 had partial, and one had no recanalization. Independent outcome predictors measured as modified Rankin score at 3 months were CTA-SI pons and midbrain scores (cumulative P<0.001). For outcome dichotomized into death versus survival, the CTA-SI pons score (P=0.0037) was the only independent predictor.

Conclusion—Hypoattenuation in the pons and midbrain on pretreatment CTA-SI correlates highly with clinical outcome in patients with vertebrobasilar occlusion treated with intra-arterial thrombolysis. (Stroke. 2008;39:3107-3109.)

Key Words: acute stroke ■ CT ■ ischemia ■ neuroradiology ■ perfusion ■ stroke ■ therapy

A cute vertebrobasilar artery occlusion (VBO) is a life-threatening condition that frequently results in death. Whether to attempt intra-arterial recanalization is a critical decision. Prior studies have suggested that recanalization and pretreatment neurological status (National Institutes of Health Stroke Scale [NIHSS] score) predict outcome.1,2 It is unclear whether other factors, including neuroimaging findings, predict outcome.1–4 Our purpose was to correlate parenchymal hypoattenuation on initial CT angiography-source image (CTA-SI), with clinical outcome, in patients with VBO, treated with intra-arterial thrombolysis (IAT).

Materials and Methods

Patient Selection

Sixteen patients with VBO underwent CTA before IAT between January 2003 and October 2006. Four patients received intravenous tissue plasminogen activator before IAT. For IAT, 13 patients were treated with wire manipulation and urokinase, 4 of 13 underwent additional angioplasty, and one of 4 was also treated with the Merci device: one with wire manipulation alone, one with the Merci device and urokinase, and one with the Merci device, wire manipulation, and angioplasty.

Image Acquisition and Analysis

CTA acquisitions were performed with multidetector CT scanners (LightSpeed; GE Healthcare, Milwaukee, Wis) as previously published.1

Two neuroradiologists graded CTA source images for hypoattenuation bilaterally in the medulla, pons, midbrain, thalamus, cerebellum, occipital lobe, inferior parietal lobe, and medial temporal lobe. Each side was graded: 0, no hypoattenuation; 1, <50% hypoattenuation; or 2, >50% hypoattenuation.

The CTA was assessed for clot location: proximal basilar artery—vertebrobasilar junction to anterior inferior cerebellar artery origins; middle basilar artery—anterior inferior cerebellar artery to superior cerebellar artery origins; distal basilar artery—superior cerebellar artery origins to basilar tip. For thrombus length, one point was assigned to each basilar segment and intracranial vertebral artery with clot. Presence of posterior communicating arteries (collaterals) was recorded.

Recanalization was graded on angiography following IAT using the Mori scale: 0, unchanged; 1, thrombus movement without...
reperfusion; 2, partial recanalization with <50% reperfusion; 3, partial recanalization with >50% reperfusion; and 4, complete recanalization and reperfusion.6

Clinical Measures
NIHSS scores at admission and modified Rankin Scale (mRS) scores at discharge and at 3 months (range, 1 to 7 months) were ascertained from medical records. Outcomes were dichotomized into death versus survival.

Statistical Analysis
Univariate Spearman correlation coefficients were calculated for 3-month mRS versus (1) CTA-SI hypoattenuation scores in 8 regions; (2) NIHSS; (3) age; (4) time to treatment; (5) thrombus length; (6) Mori score; (7) presence of posterior communicating arteries; (8) thrombus in the distal basilar artery; (9) thrombus in the proximal/midbasilar artery; and (10) gender (MedCalc software, version 9). The Student t test was used to analyze outcome dichotomized into death or survival versus 1 to 6 above (Microsoft Excel). Fisher exact test was used to compare dichotomized clinical outcome with 7 to 10 above (GraphPad Software). Stepwise logistic regression analyses were performed (SAS 9.1).

Results
Mean patient age was 68.3 years (range, 47 to 86 years), NIHSS was 28 (range, 11 to 40), time to CTA was 5.2 hours (range, 0.69 to 15.32 hours), and time from CTA to IAT was 5 hours (range, 2.25 to 10.38 hours). Seven of 16 patients were male. There were 4 basilar, 2 vertebral, and 10 combined occlusions. Eleven posttreatment angiograms were graded Mori 3, 4 Mori 2, and one Mori 0. Seven patients survived and 9 patients died. Eight of 9 patients with a combined pons/midbrain score of ≥3 died (Figure). Six of 7 patients with a pons/midbrain score of ≤2 survived.

In univariate analysis, CTA-SI pons score (r=0.73, P=0.005), CTA-SI midbrain score (r=0.64, P=0.013), and NIHSS (r=0.70, P=0.006) correlated with outcome mRS (Table 1). Stepwise linear regression demonstrated that independent predictors of outcome were the CTA-SI pons and midbrain scores (cumulative r=0.81, P<0.001).

Table 1. Univariate Analysis of Admission Characteristics Versus Final mRS*

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Correlation Coefficient (r)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>CTA-SI pons score</td>
<td>0.73</td>
<td>0.005</td>
</tr>
<tr>
<td>CTA-SI midbrain score</td>
<td>0.64</td>
<td>0.013</td>
</tr>
<tr>
<td>NIHSS</td>
<td>0.70</td>
<td>0.006</td>
</tr>
<tr>
<td>Age</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Gender</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Time to treatment</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>PCOM collaterals</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Thrombus length score</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Proximal/mid basilar thrombus</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Distal basilar thrombus</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Mori score</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>

*No other region CTA-SI scores correlated with mRS. When a stepwise linear regression was performed, the only independent predictors of outcome were the CTA-SI pons hypoattenuation score and CTA-SI midbrain hypoattenuation score with a cumulative r=0.81, P<0.001.

PCOM indicates posterior communicating artery; NS, nonsignificant.
Table 2. Clinical and Radiologic Variables versus Survival*

<table>
<thead>
<tr>
<th></th>
<th>Died (9)</th>
<th>Survived (7)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean CTA-SI score pons</td>
<td>3.1</td>
<td>0.7</td>
<td>0.001</td>
</tr>
<tr>
<td>Mean CTA-SI score midbrain</td>
<td>1.9</td>
<td>0.7</td>
<td>0.035</td>
</tr>
<tr>
<td>Mean NIHSS</td>
<td>34.8</td>
<td>19.3</td>
<td>0.006</td>
</tr>
<tr>
<td>Mean age, years</td>
<td>69.0</td>
<td>67.3</td>
<td>NS</td>
</tr>
<tr>
<td>Gender</td>
<td>4 M/5 F</td>
<td>3 M/4 F</td>
<td>NS</td>
</tr>
<tr>
<td>Mean time to treatment</td>
<td>10 hours</td>
<td>9 hours 12 minutes</td>
<td>NS</td>
</tr>
<tr>
<td>PCOM collaterals, no. of patients</td>
<td>7/9</td>
<td>7/7</td>
<td>NS</td>
</tr>
<tr>
<td>Mean thrombus length score</td>
<td>2.22</td>
<td>2.00</td>
<td>NS</td>
</tr>
<tr>
<td>Presence of proximal/mid basilar thrombus, no. of patients</td>
<td>5/9</td>
<td>4/7</td>
<td>NS</td>
</tr>
<tr>
<td>Presence of distal basilar thrombus, no. of patients</td>
<td>7/9</td>
<td>4/7</td>
<td>NS</td>
</tr>
<tr>
<td>Mean Mori score</td>
<td>2.78</td>
<td>2.29</td>
<td>NS</td>
</tr>
</tbody>
</table>

*No other region CTA-SI scores and no region noncontrast CT scores correlated with death versus survival. When a stepwise logistic regression analysis was performed, the only independent predictor of outcome was the CTA-SI pons hypoattenuation score (P=0.0037). NIHSS was not a significant independent outcome predictor.

PCOM indicates posterior communicating artery; M, male; F, female; NS, nonsignificant.

For dichotomized outcome, patients who died (versus survived) had higher mean CTA-SI scores in the pons (3.1 versus 0.7, P=0.001) and midbrain (1.9 versus 0.7, P=0.035) and higher mean NIHSS scores (34.8 versus 19.3, P=0.006; Table 2). Regression analysis demonstrated that the only independent predictor of outcome was the CTA-SI pons score (P=0.0037).

Discussion

We found that a novel CTA-SI score, the pons–midbrain index, was highly predictive of clinical outcome in patients with acute VBO treated with IAT.

Our findings agree with prior studies of anterior circulation strokes; they have demonstrated that initial CTA-SI lesion volume correlates with mRS at discharge, and a significantly higher number of patients with CTA-SI ASPECTS >6 (versus ≤6) have favorable outcome (mRS <2). Others have demonstrated that acute strokes have similar volumes on CTA-SI and diffusion-weighted imaging and suggest that CTA-SI hypoattenuation represents an infarct core that is mostly unsalvageable with IAT. That degree of CTA-SI hypoattenuation in the pons and midbrain correlates well with outcome supports this theory.

In the acute stroke setting, radiological workup must be performed rapidly. CTA-SI analysis does not add imaging time; CTA is already obtained because it is the best noninvasive technique for identifying large-vessel thrombus and for selecting which patients should undergo angiography for potential IAT. Scoring the pons and midbrain on CTA-SI requires 3 minutes.

Although the pons–midbrain index had the strongest correlation with outcome, we also found that, similar to prior studies, the NIHSS correlated with 3-month mRS and survival. Unlike prior studies, we were unable to demonstrate a correlation between recanalization and outcome.

There is no consensus regarding which other factors predict outcome in patients with VBO. Similar to Arnold et al, we were unable to demonstrate a correlation for age, gender, clot length, clot location, and collateral vessels versus 3-month mRS. By contrast, Brandt et al demonstrated that younger age, short occlusion length, and good collateral vessels correlated with survival. Schulte et al demonstrated a correlation between age and brainstem symptom duration versus survival.

Limitations are that time of imaging with respect to symptom onset and recanalization were variable, recanalization techniques were variable, and our study population was small.

Conclusions

In patients with VBO treated with IAT, extent of hypoattenuation in the pons and midbrain on CTA-SI correlates highly with clinical outcome.

Acknowledgments

We acknowledge Elkan Halpern, PhD, for assistance with our statistical analysis.

Disclosures

A.J.Y. received a NERF Boston Scientific Fellowship Award. R.G.N., Concentric Medical, Inc and CoAxia, Inc. M.H.L., GE Healthcare, Bracco, and Vernalis. L.H.S. is on CoAxia, Inc’s medical advisory board. R.G.G. received a National Institutes of Health research grant and is a consultant for Berlex. J.A.H. is on the Steering Committee of the Merci Registry.

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