Can DWI-ASPECTS Substitute for Lesion Volume in Acute Stroke?

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Background and Purpose—The extent of diffusion lesion on pretreatment imaging is a risk factor for poor outcome and hemorrhagic transformation after thrombolysis, and volumes of 70 to 100 mL have been advocated as cutoffs. However, estimating diffusion-weighted imaging (DWI) lesion volume (Vol_{DWI}) in the acute setting may be cumbersome. We aimed to determine whether the DWI-Alberta Stroke Program Early CT Score (DWI-ASPECTS) can substitute for Vol_{DWI}.

Methods—DWI-ASPECTS and Vol_{DWI} were measured retrospectively on pretreatment MRI (median onset-to-MRI delay=122 minutes) in 330 consecutively treated patients with middle cerebral artery stroke.

Results—DWI-ASPECTS and Vol_{DWI} were strongly correlated (p=−0.82), but each DWI-ASPECTS point corresponded to a wide range of Vol_{DWI}. All patients with DWI-ASPECTS ≥7 (n=207) had Vol_{DWI} <70 mL, whereas 32 of the 34 patients with DWI-ASPECTS <4 had Vol_{DWI} >100 mL. However, intermediate DWI-ASPECTS (4–6; n=89) corresponded to highly variable Vol_{DWI} (median, 66 mL; interquartile range, 40–98).

Conclusions—Although each DWI-ASPECTS point corresponds to a wide range of volumes, DWI-ASPECTS <4 or ≥7 may be used as reliable surrogates of Vol_{DWI} >100 or <70 mL, respectively. (Stroke. 2013;44:3565-3567.)

Key Words: ASPECTS ■ diffusion-weighted imaging ■ stroke ■ thrombolytic therapy

In acute anterior circulation stroke, the extent of the diffusion-weighted imaging (DWI) lesion is a predictor of poor outcome and symptomatic hemorrhage after reperfusion therapy.1,2 Specifically, volumes of 70 and 100 mL have been advocated as reliable cutoffs.3,4 Accordingly, the DWI lesion volume (Vol_{DWI}) is used as exclusion criterion in ongoing recanalization trials. However, manual outlining for Vol_{DWI} measurements is time consuming, whereas automated tools are not widely available and may imply manual correction.5 Conversely, the semiquantitative DWI-Alberta Stroke Program Early Computed Tomography Score (DWI-ASPECTS) is increasingly used because it is straightforward, reproducible,6 and assessable at bedside. One study showed that DWI-ASPECTS <4 predicted Vol_{DWI} ≥100 mL within 48 hours after stroke onset.7 Our aim was to determine whether DWI-ASPECTS can reliably substitute for Vol_{DWI}. In the first 6 hours, we assessed the relationships between DWI-ASPECTS and Vol_{DWI} in patients with middle cerebral artery stroke. We particularly focused on one hand, on DWI-ASPECTS cutoff points previously reported to be associated with Vol_{DWI} >100 mL (<4), hemorrhagic transformation (<62 and <83), or outcome (<5, <6, <7, and <810) and, on the other hand, on the 70 and 100 mL Vol_{DWI} cutoffs.3,4,11

Patients and Methods

Data were extracted from a monocentric prospective register of consecutive patients treated by intravenous and intra-arterial thrombolysis for ischemic stroke (2001–2013), where MRI was implemented as first-line pretherapeutic imaging. Patients were included if they had a middle cerebral artery stroke confirmed by pretreatment MRI (1.5 Tesla; DWI: 3 directions; b=0–1000 s/mm2; 6-mm contiguous slices). DWI-ASPECTS was scored by a stroke neurologist and Vol_{DWI} measured by a neuroradiologist using a semiautomated method.12 In 20% of the population, DWI-ASPECTS and Vol_{DWI} were reassessed independently by another neuroradiologist. Interobserver agreement for DWI-ASPECTS and Vol_{DWI} was assessed using weighted-κ and intraclass correlation coefficients, respectively. Correlation between DWI-ASPECTS and Vol_{DWI} was determined using Spearman rank correlation coefficient. Based on the current literature, specific ASPECTS bins1,2,7,10 were assessed against Vol_{DWI} values, with particular focus on the 70 and 100 mL cut-offs.3,4,11

Results

During the study period, 473 patients underwent intravenous and intra-arterial thrombolysis for acute stroke. Excluded patients (n=143; posterior circulation or pure anterior cerebral artery stroke, n=83 and no pretreatment MRI, n=60) did not differ from included patients on baseline characteristics (data not shown). The remaining 330 patients (178 [54%]...
men; median [interquartile range] age, 68 [56–79] years; admission National Institutes of Health Stroke Scale score, 15 [10–20]) had onset-to-MRI delay of 122 (90–164) minutes. Medians (interquartile range) for DWI-ASPECTS and Vol\_DWI were 7 (6–8) and 23.3 mL (9.6–63.4), respectively. Weighted-κ and interobserver intraclass correlation coefficient were 0.94 (95% confidence interval, 0.91–0.96) and 0.98 (95% confidence interval, 0.98–0.99), respectively. There was a strong negative correlation between Vol\_DWI and DWI-ASPECTS (ρ = −0.82; 95% confidence interval, −0.86 to −0.77; P < 0.001). The Table shows that the highest Vol\_DWI in the 207 patients with DWI-ASPECTS ≥7 was 67 mL, whereas the lowest Vol\_DWI in the 34 patients with DWI-ASPECTS <4 was 93 mL (Figure). However, Vol\_DWI values were extremely variable in the 88 patients with ASPECTS 4 to 6 (median [interquartile range], 66 [41–97]; range, 10–197 mL). Post hoc analysis showed similar results for Vol\_DWI versus modified DWI-W-ASPECTS\(^1\) (142/330 [43%] patients had lesion in the corona radiata).

**Discussion**

Although each DWI-ASPECTS point corresponded to a wide range of Vol\_DWI, all patients with extensive changes on DWI-ASPECTS (0–3) had large Vol\_DWI, whereas all patients with limited DWI-ASPECTS changes (≥7) had Vol\_DWI <70 mL. DWI-ASPECTS is increasingly used for description or prognostic purposes in stroke populations. Although not designed to substitute for Vol\_DWI, DWI-ASPECTS does provide some semiquantitative estimate of it. However, DWI-ASPECTS overlooks lesions within the striatocapsular region and only partially covers the middle cerebral artery territory. This explains the wide range of true lesion volumes for a given DWI-ASPECTS point found here, in line with other studies.\(^2\)

Our finding that DWI-ASPECTS <4 invariably predicted Vol\_DWI ≥93 mL is entirely consistent with 1 previous report\(^3\) and highly relevant to the Diffusion and perfusion imaging Evaluation For Understanding Stroke Evolution (DEFUSE)-2 malignant profile 100 mL cut point. However, patients with DWI-ASPECTS ≥7 all had Vol\_DWI <70 mL, which corresponds to the cut point incorporated in the target mismatch definition.\(^4\) Although debated,\(^1\) these volume cut-offs are proposed to identify poor or good responders to reperfusion therapy,\(^2\) and particularly the 100-mL cut point serves as an exclusion criterion in several ongoing trials. However, fully automated softwares to calculate Vol\_DWI are not yet commonly used and can fail in real time. This may lead to imbalanced groups on baseline characteristics in trials where randomization is based on automated MR-image segmentation.\(^1\) Failure of automated volumetry may also restrain patient’s inclusion in trials. To overcome these difficulties, DWI-ASPECTS <4 could replace the poorly reproducible greater than one third of the middle cerebral artery territory CT rule as an alternative exclusion criterion in MR-based trials.

The tight relationships between extreme DWI-ASPECTS values (ie, <4 or ≥7) and the >100-or <70-mL, respectively, cut points found here suggest that DWI-ASPECTS could serve as a surrogate for these volumes. This concerned almost 3 quarters (241/330) of the studied population and may have clinical relevance. However, in those patients with intermediate DWI-ASPECTS (4–6), Vol\_DWI straddled widely across the above cut point volumes, indicating that intermediate DWI-ASPECTS cannot substitute for Vol\_DWI to identify patients with target mismatch or malignant profile. Of note, no DWI-ASPECTS cut point identified lesion volume >145 mL,\(^5\) above which decompressive hemicraniectomy is indicated.

**Table. DWI-ASPECTS Cut Points and Corresponding Volumes**

<table>
<thead>
<tr>
<th>DWI-ASPECTS</th>
<th>Volume on DWI, mL</th>
<th>n</th>
<th>Median</th>
<th>IQR</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;4</td>
<td></td>
<td>34</td>
<td>164</td>
<td>125–214</td>
<td>93–287</td>
</tr>
<tr>
<td>≥4</td>
<td></td>
<td>296</td>
<td>19</td>
<td>9–47</td>
<td>0–197</td>
</tr>
<tr>
<td>&lt;5</td>
<td></td>
<td>52</td>
<td>145</td>
<td>104–186</td>
<td>60–287</td>
</tr>
<tr>
<td>≥5</td>
<td></td>
<td>278</td>
<td>18</td>
<td>8–37</td>
<td>0–197</td>
</tr>
<tr>
<td>&lt;6</td>
<td></td>
<td>81</td>
<td>114</td>
<td>84–171</td>
<td>29–287</td>
</tr>
<tr>
<td>≥6</td>
<td></td>
<td>249</td>
<td>16</td>
<td>7–30</td>
<td>0–166</td>
</tr>
<tr>
<td>&lt;7</td>
<td></td>
<td>123</td>
<td>92</td>
<td>49–148</td>
<td>10–287</td>
</tr>
<tr>
<td>≥7</td>
<td></td>
<td>207</td>
<td>13</td>
<td>6–23</td>
<td>0–67</td>
</tr>
<tr>
<td>&lt;8</td>
<td></td>
<td>187</td>
<td>50</td>
<td>24–109</td>
<td>3–287</td>
</tr>
<tr>
<td>≥8</td>
<td></td>
<td>143</td>
<td>9</td>
<td>5–18</td>
<td>0–67</td>
</tr>
</tbody>
</table>

DWI-ASPECTS indicates diffusion-weighted imaging-Alberta Stroke Program Early CT Score; and IQR, interquartile range.
Disclosures
None.

References
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*Stroke*. 2013;44:3565-3567; originally published online October 3, 2013;
doi: 10.1161/STROKEAHA.113.003047

*Stroke* is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
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Print ISSN: 0039-2499. Online ISSN: 1524-4628

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http://stroke.ahajournals.org/content/44/12/3565

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