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

Constance de Margerie-Mellon, MD*; Guillaume Turc, MD*; Marie Tisserand, MD; Olivier Naggara, PhD; David Calvet, PhD; Laurence Legrand, MD; Jean-François Meder, PhD; Jean-Louis Mas, MD; Jean-Claude Baron, ScD; Catherine Oppenheim, PhD

**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 cut-offs. 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 \(\geq 7\) (\(n=207\)) 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 \(\geq 7\) 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. Specifically, volumes of 70 and 100 mL have been advocated as reliable cut-offs. 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. Conversely, the semiquantitative DWI-Alberta Stroke Program Early Computed Tomography Score (DWI-ASPECTS) is increasingly used because it is straightforward, reproducible, and assessable at bedside. One study showed that DWI-ASPECTS <4 predicted Vol_{DWI} \(\geq 100\) mL within 48 hours after stroke onset. 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 cut points previously reported to be associated with Vol_{DWI} >100 mL (<4), hemorrhagic transformation (<6 and <8), or outcome (<5, <6, <7, and <8) and, on the other hand, on the 70 and 100 mL Vol_{DWI} cut-offs.

**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. 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-\(\kappa\) 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 bins were assessed against Vol_{DWI} values, with particular focus on the 70 and 100 mL cut-offs.

**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-$\kappa$ 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 ($\rho$=−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$^7$ (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.$^2,^7$

Our finding that DWI-ASPECTS <4 invariably predicted Vol$_{DWI}$ ≥93 mL is entirely consistent with 1 previous report$^7$ 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 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,$^1^5$ above which decompressive hemicraniectomy is indicated.

Limitations of our study include its retrospective and single-center nature, and the focus on patients who underwent thrombolysis, which limits generalizability to nonthrombolized patients and may, in part, explain the low proportion of patients with large Vol$_{DWI}$ and consequently the relative large 95% confidence interval for patients with low ASPECTS.

In conclusion, in the first 6 hours, each DWI-ASPECTS point corresponds to a wide range of Vol$_{DWI}$. However, extreme DWI-ASPECTS scores could serve as surrogates for important volume cut points. Further studies are needed prospectively to confirm this observation and to strengthen the value of existing Vol$_{DWI}$ cut points in predicting outcomes after recanalization.$^{11}$

<table>
<thead>
<tr>
<th>DWI-ASPECTS</th>
<th>Volume on DWI, mL</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>Median</td>
</tr>
<tr>
<td>&lt;4</td>
<td>34</td>
</tr>
<tr>
<td>≥4</td>
<td>296</td>
</tr>
<tr>
<td>&lt;5</td>
<td>52</td>
</tr>
<tr>
<td>≥5</td>
<td>278</td>
</tr>
<tr>
<td>&lt;6</td>
<td>81</td>
</tr>
<tr>
<td>≥6</td>
<td>249</td>
</tr>
<tr>
<td>&lt;7</td>
<td>123</td>
</tr>
<tr>
<td>≥7</td>
<td>207</td>
</tr>
<tr>
<td>&lt;8</td>
<td>187</td>
</tr>
<tr>
<td>≥8</td>
<td>143</td>
</tr>
</tbody>
</table>

Vol$_{DWI}$ indicates diffusion-weighted imaging-Alberta Stroke Program Early CT Score; and IQR, interquartile range.

![Figure](http://stroke.ahajournals.org/)

**Figure.** Box and whisker plot of diffusion-weighted imaging (DWI) lesion volume (Vol$_{DWI}$) and DWI-Alberta Stroke Program Early CT Score (ASPECTS). Boxes indicate interquartile range; whiskers, extreme values; horizontal lines, median; and points, mean.
Disclosures

None.

References


Can DWI-ASPECTS Substitute for Lesion Volume in Acute Stroke?
Constance de Margerie-Mellon, Guillaume Turc, Marie Tisserand, Olivier Naggara, David Calvet, Laurence Legrand, Jean-François Meder, Jean-Louis Mas, Jean-Claude Baron and Catherine Oppenheim

*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
Copyright © 2013 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/44/12/3565

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/