Interobserver Agreement of ASPECT Score Distribution for Noncontrast CT, CT Angiography, and CT Perfusion in Acute Stroke

Olga Finlayson, MD; Verity John, MD; Robert Yeung, MD; Dar Dowlatshahi, PhD, MD; Peter Howard, MD; Lijing Zhang, PhD; Rick Swartz, PhD, MD; Richard I. Aviv, MD, MBCHB

**Background and Purpose**—The Alberta Stroke program early CT score (ASPECTS) is a semiquantitative scale for estimating extent and distribution of early ischemic changes within the MCA territory in the acute stroke setting. Good interobserver agreement of total ASPECTS is demonstrated for noncontrast CT (NCCT) and other imaging modalities. Our purpose is to assess interobserver agreement for individual ASPECTS regions for different imaging modalities.

**Methods**—One hundred and eighty-one consecutive patients presenting with acute stroke symptoms within 4.5 hours of onset were included. Four readers assigned total and individual ASPECTS for NCCT, CT angiography source images (CTA-SI), and CTP maps of cerebral blood volume (CTP-CBV). Interobserver agreement was assessed by measuring internal consistency and concordance of total and individual ASPECTS using Cronbach’s α and intraclass correlation coefficient, respectively.

**Results**—Total ASPECTS demonstrated very good concordance and internal consistency for all 3 modalities. Intraclass correlation coefficient and Cronbach’s α were 0.834 and 0.859 for NCCT, 0.876 and 0.894 for CTA, and 0.903 and 0.911 for CTP-CBV, respectively. Performance for individual ASPECTS regions was inferior to total ASPECTS, but incremental improvement in interobserver reliability was demonstrated for NCCT, CTA-SI, and CTP-CBV, respectively. Highest concordance was shown for caudate, lentiform, and M1–M3, whereas performance for internal capsule and M4–M6 was poorer.

**Conclusions**—CTP-CBV demonstrates the highest interobserver agreement for individual ASPECTS regions. (Stroke. 2012;44:000-000.)

Key Words: ASPECTS ■ CTA source images ■ CT perfusion maps of cerebral blood volume ■ interobserver agreement ■ NCCT

ASPECTS is a semiquantitative scale developed to measure the extent and distribution of early ischemic changes within an MCA territory in the acute stroke setting.1 Although ASPECTS was designed for use with noncontrast CT (NCCT),2 a number of studies indicate its practicability for CT angiography source images (CTA-SI),3 CTP,3 and MRI-DWI.4 Several studies demonstrated good interobserver agreement of ASPECTS for NCCT3 and other imaging modalities.3,4 However, all these studies focused on total ASPECTS. The aim of the current study was to determine interobserver agreement for individual ASPECTS regions on NCCT, CTA-SI, and CTP maps of cerebral blood volume (CTP-CBV).

**Materials and Methods**

**Patients**
Consecutive patients presenting to the emergency department of a regional stroke center under code stroke designation within 4.5 hours of symptom onset between January 2007 and June 2008 were prospectively recruited. Exclusion criteria included intracranial hemorrhage or contraindications to contrast material. Patient demographics and clinical characteristics were recorded at the time of assessment. Informed consent was obtained from each patient or substitute decision maker. Institutional research ethics board approved the study protocol.

**Imaging**
The CT stroke protocol included NCCT, CTA-SI, and CTP maps. Description of imaging processing is available elsewhere.3 CBV was chosen for analysis because it was previously shown to most accurately determine the infarct extent.1

**Image Review**
Two neuroradiologists and 2 neurologists aware of side of symptoms reviewed each of NCCT, CTA-SI, and CTP-CBV maps in random order. Raters assigned total ASPECTS and a rating of 1 or 0 to each of 10 of ASPECTS regions, according to the ASPECTS methodology.1

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Statistical Analysis

SAS (version 9.2; SAS institute, Cary, NC) statistical software was used. Demographic results were expressed as the mean±SD and as proportions for categorical variables. Cronbach’s α was used as a measure of internal consistency/reliability, and intraclass correlation coefficient (ICC) as a measure of concordance of the total and individual ASPECTS for NCCT, CTA-SI, and CTP maps of cerebral blood volume (CTP-CBV) between the 4 readers.

Results

One hundred and eighty-one patients were included in the study; 98 (54.1%) were women. Mean age was 67 years (SD ±16 years, range 18–95 years). Median NIHSS score was 6 (range 0–28). One hundred and ten patients (60.8%) had a final diagnosis of stroke, 33 patients (18.2%) were diagnosed with a transient ischemic attack, and 38 (21%) had stroke mimics. tPA was administered to 49 patients (27.1%). Mean time from symptom onset to tPA treatment was 161 ±55 min. Table 1 shows study patients’ baseline demographic characteristics and cardiovascular risk factors. Among the 4 readers, the total number of patients with ASPECTS >7 was 74.6 to 90.0% for NCCT, 70.7 to 87.8% for CTA-SI, and 71.7 to 80.6% for CTP-CBV, respectively. Cronbach’s α and ICC for total ASPECTS were 0.834 and 0.859 for NCCT, 0.876 and 0.894 for CTA, and 0.903 and 0.911 for CTP-CBV, respectively.

Component ASPECTS performed less well than total ASPECTS (Table 2). For ICC among 4 readers, no regional scores had very good concordance for NCCT. ICC improved for CTA-SI and CTP-CBV with 2 and 3 regions demonstrating “very good” concordance, respectively. For NCCT, the lowest interrater concordance was seen in internal capsule (ICC 0.37). Good concordance was seen for caudate, lentiform, insula, and M1–M3 regions, and moderate concordance for M4–M6 regions. CTA-SI demonstrated similar distribution of concordance with lower concordance for internal capsule and M4–M6 regions. However, concordance for internal capsule, caudate, and lentiform was improved over NCCT. CTP-CBV demonstrated improved concordance for internal capsule and M4–M6 regions.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>n</th>
<th>%</th>
</tr>
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<tbody>
<tr>
<td>Female</td>
<td>98</td>
<td>54.1</td>
</tr>
<tr>
<td>Age ≤60</td>
<td>57</td>
<td>31.5</td>
</tr>
<tr>
<td>Age 61–70</td>
<td>39</td>
<td>21.5</td>
</tr>
<tr>
<td>Age 71–80</td>
<td>43</td>
<td>23.8</td>
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<tr>
<td>Age ≥81</td>
<td>42</td>
<td>23.2</td>
</tr>
<tr>
<td>Right-sided symptoms</td>
<td>82</td>
<td>45.3</td>
</tr>
<tr>
<td>Stroke</td>
<td>110</td>
<td>60.8</td>
</tr>
<tr>
<td>TIA</td>
<td>33</td>
<td>18.2</td>
</tr>
<tr>
<td>Stroke mimic</td>
<td>38</td>
<td>21</td>
</tr>
<tr>
<td>Cardiovascular risk factors</td>
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<tr>
<td>Hypertension</td>
<td>98</td>
<td>54.1</td>
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<tr>
<td>Diabetes mellitus</td>
<td>32</td>
<td>17.7</td>
</tr>
<tr>
<td>Coronary artery Ds</td>
<td>26</td>
<td>14.4</td>
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<tr>
<td>Atrial fibrillation</td>
<td>33</td>
<td>18.2</td>
</tr>
<tr>
<td>Smoking</td>
<td>32</td>
<td>17.7</td>
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<tr>
<td>Hypercholesterolemia</td>
<td>59</td>
<td>32.6</td>
</tr>
<tr>
<td>Prior stroke, TIA or both</td>
<td>29</td>
<td>16</td>
</tr>
</tbody>
</table>

CI indicates confidence interval; CTA-SI, CT angiography source images; CTA-BP, CTP maps of cerebral blood volume; ICC, intraclass correlation coefficient.
compared with both NCCT and CTA-SI with agreement similar to that of M1–M3 regions. Overall, caudate, lentiform, and M1–M3 regions demonstrated the highest concordance, whereas internal capsule showed the worst concordance. For CTP-CBV, individual ASPECTS reliability (Cronbach’s α range 0.6528–0.8574) and concordance (ICC range 0.644–0.850) were only slightly inferior to total ASPECTS reliability (Cronbach’s α 0.9110) and concordance (ICC 0.903).

**Discussion**

The present study demonstrated good interobserver agreement for total ASPECTS for NCCT, CTA-SI, and CTP-CBV that progressively increased for contrast-based modalities. This is consistent with prior observations.3,5,6 We are aware of only 1 prior abstract assessing interrater reliability for individual ASPECTS regions.11 In our study, more interobserver variability was demonstrated for individual ASPECTS regions than for total ASPECTS. Regional ASPECTS for CTP-CBV performed better for all individual regions compared with NCCT and most regions compared with CTA-SI. For CTP-CBV, interobserver agreement for individual ASPECTS was comparable with that of total ASPECTS. Using CTP-CBV in all acute stroke patients will improve detection and localization of stroke. Although infarct topography is important because of varied functional significance of different brain regions, CTP-CBV may be used in future studies to test the association between regional ASPECTS localization and stroke outcome prognostication.

**Disclosures**

None.

**References**

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