

Impact of Window Setting Optimization on Accuracy of Computed Tomography and Computed Tomography Angiography Source Image-based Alberta Stroke Program Early Computed Tomography Score

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The use of narrower window width settings on computed tomography (CT) improves sensitivity for detection of early ischemic changes in acute ischemic stroke. This study analyzed the effect of optimization of window settings on the accuracy of Alberta Stroke Program Early Computed Tomography Score (ASPECTS) performed on non-contrast CT (NCCT) and CT angiography source images (CTA-SI). ASPECTS was calculated on NCCT and CTA-SI with standard and optimized window width/center settings in a consecutive series of patients with acute ischemic stroke. The difference between CT-based ASPECTS and ASPECTS performed on follow-up magnetic resonance imaging (MRI) were calculated to determine the disparity between initial estimates of the extent of ischemia on CT and follow-up lesion imaging by MRI. Forty-four patients were included into the study. The mean difference with respect to follow-up MRI-ASPECTS was 4.1 ± 2.2 for standard NCCT-ASPECTS, 3.7 ± 2.3 for optimized NCCT-ASPECTS, 3.0 ± 2.2 for standard CTA-SI-ASPECTS, and 2.7 ± 2.1 for optimized CTA-SI-ASPECTS. The improvement introduced by the optimization of window settings and use of CTA-SI was statistically significant ($P < .01$). Our data indicate that the accuracy of ASPECTS is improved with optimized window display settings. This improvement is irrespective of experience or specialty of the rater performing the assessment. **Key Words:** Early ischemic changes—window width and center.

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The Alberta Stroke Program Early Computed Tomography Score (ASPECTS) is a semiquantitative grading system developed to quantify the extent of early ischemic

changes (EIC) in the middle cerebral artery territory.¹ ASPECTS performed on noncontrast computed tomography (NCCT) obtained within the initial hours of symptom onset correlate with, yet underestimate, the final lesion volume on follow-up images.² Performing ASPECTS on computed tomography angiography source images (CTA-SI) increases the sensitivity and accuracy for the detection of EIC and thereby improves predictions for final infarct size.²⁻⁴ The aim of this study was to determine whether the use of optimized window settings had an effect on the accuracy of ASPECTS performed on admission NCCT and CTA-SI.

Methods

We retrospectively analyzed a consecutive series of ischemic stroke patients who received intravenous

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Received November 3, 2011; revision received April 21, 2012; accepted May 17, 2012.

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1052-3057/\$ - see front matter

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<http://dx.doi.org/10.1016/j.jstrokecerebrovasdis.2012.05.012>

(IV) or intra-arterial thrombolysis over a 4-year period in our institution. All patients presenting with symptoms consistent with acute ischemic stroke routinely undergo NCCT and CTA in our center. The present study was restricted to patients who sustained a stroke within the middle cerebral artery territory and underwent magnetic resonance imaging (MRI) within 14 days after receiving thrombolytic treatment. The study protocol was approved by the local Institutional Review Board.

NCCT and CTA were performed using a commercially available multidetector row scanner (SOMATOM Emotion Duo or Sensation 16; Siemens, Erlangen, Germany). Image acquisition parameters of NCCT were sequential mode, 5-mm slice thickness, 120-130 kV, and 200 mAs. CTA was obtained with a helical scanning technique after a single bolus injection of 100-130 mL of nonionic contrast medium into an antecubital vein at a rate of 3-4 mL/second with a dynamic contrast bolus detection technique used for timing of acquisition (CareBolus; Siemens Medical Systems). CTA parameters were as follows: SOMATOM Emotion Duo: 130 kV foramen magnum to vertex, 50 mAs, slice thickness 2 mm, reconstruction increment 0.7 mm; Sensation 16: 120 kV aortic arch to vertex, 100 mAs, slice width 1 mm, slice collimation 0.75 mm, reconstruction increment 0.7 mm. MRI was performed with a 1.5-T scanner (Magnetom TIM; Siemens). The protocol included axial T2-weighted turbo spin echo (repetition time [TR]/echo time [TE], 3800/90 ms; matrix, 256×256), fluid-attenuated inversion-recovery (FLAIR) (TR/TE/inversion time [TI]: 9000/100/2100 ms; matrix, 224×256), and diffusion-weighted imaging (DWI) (single-shot echo planar, applied 3 b values with a maximum of 1000 s/mm² and a TR/TE of 4800/120 ms; matrix, 96×256) sequences all with a slice thickness of 5 mm, a 10% interslice distance, and a 220- to 240-mm field of view.

Three stroke neurologists, 1 neurology resident, and 1 radiologist retrospectively assigned 4 separate ASPECTS to CT examinations of the patients obtained at the time of admission in the following order: (1) NCCT with standard window width (W)/center (C) settings (W: 80; C: 20), (2) NCCT with optimized window width/center settings, (3) CTA-SI with standard window width/center settings (W: 80; C: 40), and (4) CTA-SI with optimized window width/center settings. Optimization of window width/center settings was left to the discretion of the rater and thus showed a certain amount of variability among raters and patients. The raters were aware of the patients' neurologic deficits, but were blinded to their previous ASPECTS ratings and MRI data. The patient order was random and different for each set of CT-based evaluations. Follow-up ASPECTS was graded on MRI DWI or FLAIR images by a neuroradiologist (K.K.O.) who was blinded to clinical and CT data and had not performed any of the CT-based ASPECTS ratings described above. In addition to stroke patients, raters

have performed the same 4 sets of CT-based ASPECTS assessments in a set of 20 age- and sex-matched controls who had undergone NCCT, CTA, and MRI during the study period and were found to have no abnormalities on their imaging studies.

Intraclass correlation coefficients were used to assess the interexaminer agreement of CT-based ASPECTS ratings. The absolute value of the difference between MRI-based ASPECTS and CT-based ASPECTS were calculated for all ratings to determine the degree of disparity between initial estimates of EIC on CT and the follow-up lesion on MRI. The Friedman test was used to analyze the effect of window setting optimization on the amount of difference between initial and follow-up images. All numerical variables were expressed as mean $\pm$ standard deviation (SD) or median (interquartile range [IQR]) as appropriate. A 2-tailed *P* value of $<.05$ was considered significant. Statistical analyses were performed using SPSS version 16.0 (IBM, Armonk, NY).

Results

A total of 44 patients met the inclusion criteria. Table 1 summarizes the clinical characteristics of the study cohort. The mean age of the study population was 62 ± 13 years. Thirty-two patients (73%) were treated with IV thrombolysis, 5 (11%) with intra-arterial thrombolysis, and 7 (16%) with combined IV and intra-arterial thrombolysis. The mean time from symptom onset to CT was 81 ± 33 minutes, and that to CTA was 90 ± 38 minutes. MRI was performed after a median delay of 1.2 days (IQR, 0.5-3.0 days).

Table 2 summarizes the interexaminer agreement of CT-based ASPECTS ratings and pooled results of all examiners with respect to differences between CT- and MRI-based ASPECTS. The mean and median ASPECTS on follow-up MRI was 4.6 ± 2.4 and 5 (IQR, 3-7). The greatest difference was evident when ASPECTS was determined on NCCT with standard window settings. This difference sequentially decreased when scores were assessed on NCCT after window setting optimization, CTA-SI without optimization and CTA-SI with optimization ($P < .01$). Pairwise comparisons, corrected for multiple comparisons, revealed statistically significant improvement between each pair of ratings ($P < .005$) (Figs 1 and 2). The improvement introduced by window setting optimization and use of CTA-SI was consistent among all raters, irrespective of experience or specialty (Fig 2). The raters adjusted the window settings to mean values of W: 22 ± 12 C: 37 ± 3 for NCCT and W: 43 ± 14 C: 45 ± 4 for CTA-SI during evaluation of ASPECTS at optimized window settings.

The median and mean ASPECTS were 10 (10-10) and 10.0 ± 0.0 for NCCT, 10 (10-10) and 9.8 ± 0.4 for NCCT-optimized, 10 (10-10) and 9.8 ± 0.5 for CTA-SI, and 10

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