Ability of Emergency Physicians to Detect Early Ischemic Changes of Acute Ischemic Stroke on Cranial Computed Tomography

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Key Words

Emergency physician · Stroke · Early ischemic changes · Computed tomography

Abstract

Objective: The objective of this study was to evaluate the ability of emergency physicians (EPs) to diagnose early ischemic changes due acute ischemic stroke on cranial computed tomography (CT). **Subjects and Methods:** Three EPs interpreted CT scans obtained within 3 h of symptom onset in 50 patients with acute stroke. The CT scans were interpreted by the EPs and compared to official neuroradiologist reports as a gold standard. κ statistics were calculated to determine agreement among the three readers. Sensitivities and specificities were analyzed for each reader. **Results:** The EPs' sensitivities were 50, 45.5, and 45.5%, and specificities were 64.3, 82.1, and 64.3%, respectively. Focal parenchymal hypodensity was the criterion for which the EPs were the most sensitive (77.3%). The ability of EPs to recognize early ischemic changes on CT scans in acute ischemic stroke was moderate based on sensitivities. **Conclusion:** Based on this study, EPs must be trained especially for recognizing early ischemic changes in acute ischemic stroke to improve their accuracy of interpretation.

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Introduction

Acute ischemic stroke (AIS) is one of the most common diseases among patients presenting to the Emergency Department with altered mental status and neurologic deficits. Intravenous tissue-plasminogen activator (i.v. rt-PA) has been the only approved treatment in AIS since 1996. Later that year, the National Institute of Neurological Disorders and Stroke (NINDS, a branch of the National Institutes of Health) convened a consensus conference on rapid identification and treatment of AIS, setting goals for stroke care in the United States. Head computerized tomography (CT) is still an important diagnostic modality for patients with suspected AIS and is often used before starting i.v. rt-PA within 3 h of ischemia [1, 2]. In the NINDS rt-PA Stroke Trial, the CT scan was used primarily to rule out intracranial hemorrhage (ICH) or other unexpected pathology that might masquerade as acute stroke. However, secondary analysis of the NINDS data and experience with the use of i.v. rt-PA 3 h after ischemic onset, most notably from the European Cooperative Acute Stroke Trial (ECASS), suggest that CT findings of advanced ischemia were associated with increased risk of ICH. Also, in ECASS, more subtle changes involving >33% of the middle cerebral artery (MCA) territory have

caused increased numbers of ICH [3, 4]. The ECASS investigators also suggest that subtle changes involving <33% of the MCA territory might help identify the best candidates for thrombolysis [5]. Signs of stroke can appear on noncontrast head CT within 6 h of symptom onset, and retrospective analysis of the NINDS study showed that 30% of the initial head CTs showed ischemic changes [6, 7]. Hyperdense MCA sign, loss of discrimination between gray and white matter in the basal ganglia, focal hypoattenuation, obscuration of the lentiform nucleus, cortical sulcal effacement, loss of the insular ribbon, and obscuration of the sylvian fissure compared to the contralateral hemisphere can be interpreted as early ischemic changes [8]. These CT findings were used to define and quantify early ischemic changes by the Alberta Stroke Program Early CT Score [9]. Although the presence of early ischemic changes on CT, regardless of their extent, is not a contraindication to treatment, it has been shown that detecting early ischemic changes within the early period of AIS is important for determining a patient's prognosis and complications [8, 10]. Because of the critical importance of excluding ICH and recognizing early ischemic changes on non-contrast CT, there is apprehension regarding the ability of emergency physicians (EPs) to correctly interpret CT scans in hyperacute stroke patients. Recent analysis showed that ICH could be missed by treating physicians and the EPs' interpretations were determined to be poor to fair compared to neuroradiologists' interpretations [11, 12].

In this study, we aimed to determine the ability of EPs to interpret early ischemic changes on CT during AIS.

Subjects and Methods

The baseline noncontrast head CTs of 50 patients presenting with stroke from January 2007 to January 2008 were obtained from the medical records. All the baseline CTs were taken within 3 h of symptom onset, and the patients were then diagnosed with AIS. The CT scans were performed on a spiral CT with one channel (Siemens Somatom AR). Section thickness was 2.5–3.5 mm through the posterior fossa and 5–10 mm for the supratentorial regions of the cerebral hemispheres.

Three EPs working in our research and training government hospital with an average of 3 years of experience after completion of residency training for emergency medicine were unblinded to clinical information of the patients and asked to interpret the CT scans for intracranial pathology. This took 1 h overall. The EPs' interpretations were compared to official neuroradiologist reports (as gold standard). The Ethics Committee at our tertiary care hospital approved the study protocol.

Sensitivity and specificity were calculated for each EP compared to the gold standard using 95% confidence intervals. Sensi-

Table 1. Sensitivity of early ischemic CT findings and 95% confidence intervals (CI)

Early ischemic changes	Sensitivity	95% CI
Hyperdense MCA	27.3	10.7–50.2
Shadowing or effacement of lentiform nucleus	22.7	7.8–45.4
Loss of insular ribbon sign	27.8	10.7–50.2
Effacement of sylvian fissure	36.4	17.2–59.3
Effacement of cortical sulci	63.6	40.7–82.8
Focal parenchymal hypodensity	77.3	54.6–92.2
Loss of gray-white differentiation at basal ganglia	36.4	17.2–59.3

tivities and specificities were calculated and the areas under receiver operating characteristic (ROC) curves were compared to each other for each early ischemic change. We analyzed all six early ischemic finding ROC curves in one graphic. Because the EPs' sensitivities in detecting hyperdense MCA, loss of insular ribbon, obscuration of the sylvian fissure, and loss of discrimination of gray and white matter in the basal ganglia findings on CT were equal, we showed both of them as a single line in figure 1.

The description of interobserver agreement included agreement rates and κ of the EPs' interpretations of the CT scans compared to the gold standard. A multiple observer κ coefficient with standard error was calculated for a dichotomous rating according to Fleiss [13] for all three observers combined. We defined $\kappa = 0.41$ –0.60 as moderate agreement, $\kappa < 0.40$ as poor agreement, and $\kappa > 0.80$ as excellent agreement. Statistical analysis was performed using MedCalc® v11.2.1 and Matlab 7.1 pocket program at a 95% confidence level with expected p values lower than 0.05.

Results

Of these 50 patients, 50% were female and their mean age was 72.86 ± 12.36 years (range of 39–90). The frequencies of the types of abnormalities found were as follows: effacement of the cortical sulci: 26%; focal parenchymal hypodensity: 26%; effacement of the sylvian fissure: 16%; hyperdense MCA: 12%; loss of insular ribbon sign: 12%; loss of gray-white matter distinction in the basal ganglia: 12%, and effacement or shadowing of the lentiform nucleus hypodensity: 8%.

The sensitivities with confidence intervals for each of the possible early CT changes detected by EPs are listed in table 1 and ROC curves of each of the early ischemic changes are shown in figure 1. The calculated sensitivities for interpreting early ischemic changes on noncontrast CT of each EP were 50, 45.5 and 45.5% (28.2–71.8, 24.4–67.8, 24.4–67.8, respectively), while those of specificities

Fig. 1. ROC curves of early ischemic changes. OLN = Obscuration of the lentiform nucleus; HMCA = hyperdense MCA sign; LIR = loss of the insular ribbon; OSF = obscuration of the sylvian fissure; LDGWM = loss of discrimination of gray and white matter in the basal ganglia; CSE = cortical sulcal effacement; FH = focal hypoattenuation; AUC = area under the curve; SE = standard error. Since the sensitivity values of HMCA and LIR are equal, they have the same ROC curve.

were 64.3, 82.1 and 64.3% (44.1–81.4, 63.1–93.9, 44.1–81.4, respectively). There was good agreement beyond chance between the EPs based on the diagnostic accuracy for early ischemic changes ($\kappa = 0.37$; 0.21–0.53).

Discussion

The main finding of this study was that although early CT changes of ischemia may be present within 3 h of stroke symptom onset, agreement among EPs in recognizing them was moderate at best. These results are consistent with previous studies that have shown that nonradiologists and others without specific expertise in stroke, or even physicians experienced in stroke, may miss subtle changes or hemorrhage on CT [10–12]. Even among neuroradiologists with expertise in evaluating diagnostic studies of acute stroke patients, interobserver agreement that was based on a 78% prevalence of early CT changes was reported as moderate, with a κ statistic of 0.53 [5].

Both the observed and reported moderate accuracy in identifying early ischemic changes could be due to the fact that CT does not detect blood degradation products such as hemosiderin and equally cannot identify patients with old brain hemorrhages [11].

Equally, calcification of the basal ganglia can occasionally be mistaken for deep intraparenchymal hemorrhage by EPs. Space-occupying lesions may also mimic ischemic stroke on CT.

Our finding that EPs could not identify early ischemic changes in CT scans either in the presence or absence of hemorrhage could indicate a lack of necessary skill for such interpretations. Hence these EPs will need specialized training to interpret CT scans with sufficient sensitivity to determine whether or not thrombolytics can be administered safely [11].

Interobserver agreement is not entirely explainable on the basis of experience and expertise because among the stroke specialists who were principal investigators in the NINDS rt-PA Stroke Trial and who each had several years' experience reading CT scans in hyperacute stroke patients, interobserver agreement was only fair [10]. Sensitivity for the identification of early signs of stroke is variable. The more apparent acute infarctions were identified by most physicians; however, even the best performers failed to identify a third of the more subtle acute infarctions.

Multiple studies following NINDS have shown an increased risk of ICH, poor neurologic outcomes, and death in patients with early ischemic changes on head CT [14, 15]. Ischemic changes are relative contraindications to rt-PA administration, and their presence may suggest that more than 3 h have elapsed from symptom onset, in which case systemic rt-PA may be contraindicated. In addition, the Food and Drug Administration, American Heart Association, and American Academy of Neurology specifically discourage administering i.v. rt-PA if early signs of major infarction are present, because of increased risk of ICH [16]. The greater the extent of ischemic changes on CT, the higher the risk of bleeding, as demonstrated in the ECASS-II [15]. In this setting, the most important job of the EPs in interpreting the CT is to rule out the presence of hemorrhage. Second, in the presence of significant unilateral neurologic abnormalities, hyperdense MCA sign should be sought. Third, early changes in CT should be identified, again using the patients' clinical symptoms to direct us to the likely abnormal side of the brain. These early changes may imply either an earlier time of onset than suggested by the history or a massive stroke in progress.

The present study has several limitations. The optimal period for interpreting CT scans was not measured. However, our study was not designed to specifically address this issue. Other limitations of our study include the small number of interpreted CT scans, the relatively large confidence intervals and three EPs were not enough to clearly identify the performance in the Emergency Department. The performance of EPs was not compared with the control films based on the fact that EPs were blinded.

Conclusion

Our findings showed that EP performance in interpreting changes on CTs of patients with AIS was moderate and therefore recommend that they should be trained specifically on this topic after completing residency training for emergency medicine.

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