

Reliability of Persian Early Computed Tomography Score in Patients with Brain Infarction

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Abstract

Background: The one-third middle cerebral artery (1/3 MCA) method and Alberta Stroke Program Early Computed Tomography Score (ASPECTS) were used to detect significant early ischemic changes on brain computed tomography (CT) of patients with acute stroke. We designed the Persian Early CT Score (PECTS) and compared it with the above systems.

Methods: The tomograms were chosen from the stroke data bank of Ghaem Hospital, Mashhad, in 2008. The inclusion criteria were the presence of MCA territory infarction and performance of CT within 6 hours after stroke onset. Axial CTs were performed on a third-generation CT scanner (Siemens, ARTX, Germany). Section thickness above posterior fossa was 10 mm (130 kV, 150 mAs). Films were made at window level 35 HU. The brain CTs were scored by four independent radiologists based on the ASPECTS, 1/3 MCA method, and PECTS. The readers were blinded to the clinical information except the symptom side. Cochran Q and Kappa tests were used for statistical analysis.

Results: Twenty four CT scans with sufficient quality were available. The difference in distribution of dichotomized ≤ 7 and > 7 ASPECT scores between the four raters was significant; $Q=13.071$, $df=3$, $P=0.04$. The difference in distribution of dichotomized $>1/3$ and $\leq 1/3$ MCA territory involvement between 4 raters was also significant; $Q=13.5$, $df=3$, $P=0.004$. Distribution of dichotomized <6 and ≥ 6 scores based on PECTS system between the four raters was not different; $Q=6.349$, $df=3$, $P=0.096$.

Conclusion: PECTS method was more reliable than ASPECTS and 1/3 MCA methods in detecting major early ischemic changes in stroke patients who were candidates for thrombolysis therapy.

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Keywords • Computed tomography • cerebral infarction • thrombolysis

Introduction

While the use of tissue plasminogen activator (rTPA) in certain stroke patients is endorsed by International Stroke Guidelines, one concern with the use of this treatment is the risk of precipitating parenchymal hematoma

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with mass effect.¹ In strokes of middle cerebral artery (MCA) territory, involvement of greater than one third of the territory by ischemic tissue increases the risk of intracerebral hemorrhage.² The relationship between the extent of ischemia and thrombolysis-related hemorrhage has been investigated in several recent studies.^{1,2,3} Since early signs of major MCA territory involvement considered as an exclusion criteria in thrombolysis therapy, physicians must be able to reliably identify the scans with this finding.³ However, estimation of ischemic tissue extent is hampered by modest inter-observer agreement among experts, with reported k-values of 0.39-0.64.⁴ Additionally, it appears that while clinicians adequately rate very small and large infarcts, classifying moderately large infarcts appears to concern many clinicians.⁴ The Alberta Stroke Program Early CT Score (ASPECTS) system and one third middle cerebral artery (1/3 MCA) method were used for estimation of large MCA territory infarcts that are ineligible to receive thrombolysis using tPA. The ASPECTS and 1/3 MCA method are semiquantitative for localization and estimation of ischemic tissue volume within MCA territory. These methods improve detection of early ischemic changes in CT scans. We developed Persian Early CT Score (PECTS) as an alternative to the above systems to enhance the inter-observer agreement among experts. This article compares inter-observer agreement among four radiologists between ASPECTS, PECTS and 1/3 MCA methods in patients with hyper acute brain infarction.

Patients and Methods

This cross-sectional study was conducted in ischemic stroke patients admitted to Ghaem Hospital, Mashhad, northeast Iran, during January to May 2008. The tomograms were chosen from Ghaem Stroke Data Bank. The inclusion criteria were the presence of MCA territory infarction and availability of electronic and hardcopies of CT scans performed within 6 hours after stroke onset. Patients were excluded if infarction outside the MCA territory was present on the tomogram. Uncertain time of stroke onset and poor scan quality were considered as the other exclusion criteria. Tomograms of stroke patients with lacunar syndrome were also excluded. The Human Research Ethics Committee of Ghaem Hospital approved the present study. Axial CT was performed by a third-generation CT scanner (Siemens, ARTX, Germany) oriented along the supraorbital meatal line. Section thickness was 5 mm in the posterior fossa (130 kV, 150mAs) and 10 mm superiorly (130 kV, 150 mAs). The

films were made at window level 35 HU. All patients' details were removed from the films. Early signs of ischemia were defined as hypo attenuation, loss of the gray-white boundary (which is due to radiographic hypo attenuation of the gray matter) and focal brain swelling⁵. The later was defined as any focal narrowing of the cerebrospinal-fluid space due to compression by adjacent brain structures such as effacement of the cortical sulci or ventricular compression.⁵ Only new areas of ischemia were scored. Determination of >1/3 MCA versus ≤1/3 MCA territory involvement performed by the Alteplase Thrombolysis for Acute Non-interventional Therapy in Ischemic Stroke (ATLANTIS)/CT summit criteria.^{6,7} The ATLANTIS criteria define >1/3 MCA territory as substantial involvement of ≥2 areas of the following 4 areas: frontal, parietal, temporal, or both basal ganglia and insula.^{8,9} The ASPECTS system is an alternative method to the ATLANTIS: >1/3 MCA method.^{8,9} The former differs from the later in that the entire MCA territory is summarized by 10 regions of interest on two axial CT slices which involve basal ganglionic and supraganglionic structures (figure 1).^{8,9} One point is deduced for partial or total involvement by ischemic tissue in any of the 10 designated regions.^{8,9} An ASPECT score of ≤7 was associated with an increased risk of symptomatic hemorrhage following intravenous rTPA therapy.^{8,9} A normal CT scan has an ASPECTS value of 10 points. The PECTS system was designed by a stroke neurologist and approved by scientific committee of Khorasan Associations of Neurologists and Radiologists. The PECTS is calculated from two standard axial cuts, one at the level of the thalamus and basal ganglia, and one just rostral to the ganglionic structures. For PECTS, the territory of MCA is allotted 8 points. PECTS is assessed by systematically scoring each of 7 regions (M1-M7) on the CT scan. The evaluated cortical regions M1 to M6 are the same as ASPECTS system (figure 1). The M7 region includes subcortical structures (internal capsule, lentiform nucleus, external capsule, insular ribbon) and insular cortex. The caudate head is not included in PECTS because it has dual blood supply from the MCA and anterior cerebral artery. One point is deduced for partial or total involvement by ischemic tissue in any of the M1 through M6 designated regions and two points is deduced in partial or total M7 region involvement. A score of 8 implies no evidence of new early signs of ischemia in the MCA territory. A progressively lower score indicates more extensive ischemic changes. A validation study was conducted for detection of inter-observer agreement in estimating volume of MCA stroke

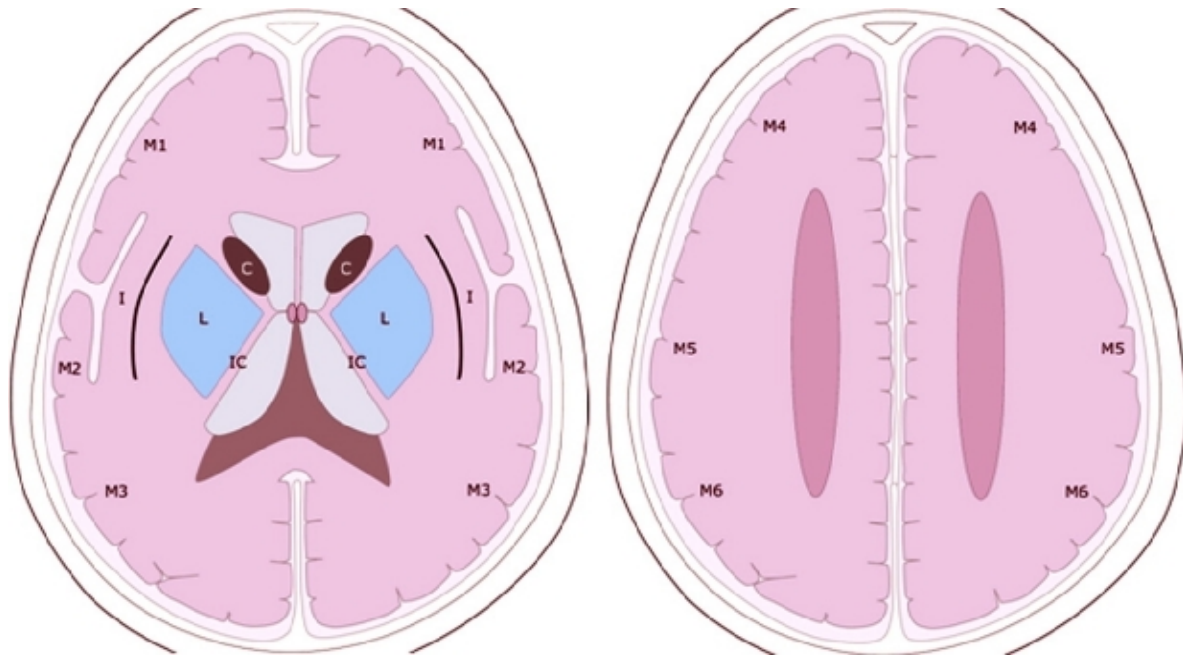


Figure 1: ASPECTS and PECTS templates.

C=caudate; L=lentiform; IC=internal capsule; I=insular ribbon;

MCA= middle cerebral artery; M1=anterior MCA cortex; M2=MCA cortex lateral to insular ribbon; M3=posterior MCA cortex; M4, M5, and M6 are anterior, lateral and posterior MCA territories immediately superior to M1, M2 and M3, rostral to basal ganglia.

based on the three methods. Four experienced academic radiologists independently evaluated the tomograms based on the ASPECTS, 1/3 MCA method, and PECTS at separate sessions. The radiologists were provided a brief training that included a set of written guidelines based on pertinent published articles.⁶⁻⁹ Five separate tomograms (two with extensive early ischemic changes) were viewed to the radiologists as example.¹⁰ Rating for each method was performed 2 weeks apart.¹⁰ Training on the use of each method was provided prior to each reading. The radiologists were blinded to all clinical information except the side of symptom. All images were reviewed on film. The PECTS and ASPECTS templates were provided to the readers. PECT and ASPECT scores were dichotomized at <6 or ≥ 6 and at >7 or ≤ 7 respectively.^{8,9} Determination of $>1/3$ MCA versus $\leq 1/3$ MCA territory involvement performed by the worksheet derived from the ATLANTIS/CT summit criteria.⁷ Cochrane Q test and Kappa test were used for statistical analysis to compare the readers' agreement for quantification of early CT ischemic changes

based on the three mentioned methods.

Results

Fifty tomograms were available while 16 scans were excluded due to inadequate quality or uncertainty about the stroke onset. Ten patients had brain infarction outside the MCA territory and were excluded. Twenty-four patients (15 males) with the mean age 61.8 ± 8.5 years with infarctions in the MCA territory were studied. Twenty-four scans were examined by four raters yielding a total of 96 patient-scan examinations. Table 1 represents the inter-rater agreement of major MCA territory infarction based on the reading methods.

Four radiologists agreed on dichotomized ≤ 7 and >7 scores based on the ASPECTS method of 4 (16.6%) and 4 (16.6%) patients respectively. A total of 33.3% of the patients had whole raters' agreement based on the ASPECTS method. The difference in distribution of dichotomized ≤ 7 and >7 ASPECT score between the four raters was significant; $Q=13.071$, $df=3$, $P=0.04$. Four radiologists

Table 1: Inter-raters agreement of major MCA territory infarction based on the reading methods in 24 patients.

Radiologist	ASPECTS ≤ 7 Number of scans	PECTS <6 Number of scans	ATLANTIS: $>1/3$ MCA Number of scans
Rater 1	16	9	16
Rater 2	13	14	22
Rater 3	15	11	22
Rater 4	6	15	24

agreed on >1/3 MCA territory involvement based on the ATLANTIS method in 15 patients (62.5%). However, no patient achieved total agreement of the four raters on ≤1/3 MCA territory involvement based on the ATLANTIS criteria. The difference in distribution of dichotomized >1/3 and ≤1/3 MCA territory involvement based on the ATLANTIS criteria between the four raters was significant; $Q=13.5$, $df=3$, $P=0.004$.

Four radiologists agreed on dichotomized <6 and ≥6 scores based on the PECTS method in 4 patients (16.6%) and 7 patients (29.2%) respectively. 45.8% of the patients had whole raters' agreement based on the PECTS method. The difference in distribution of dichotomized <6 and ≥6 scores based on PECTS method between the four raters was not significant; $Q=6.349$, $df=3$, $P=0.096$.

Ninety-six patient-scan examinations by the four raters were analyzed for number of patients considered as eligible for thrombolysis based on the three methods. 87.5%, 52.1% and 51.1% of the 96 patient-scan examinations were ineligible to rTPA therapy based on the ATLANTIS, ASPECTS and PECTS methods respectively. The difference in distribution of patients ineligible for thrombolysis was significant when ASPECTS and PECTS methods were compared with ATLANTIS: >1/3 MCA method; $k=0.354$, $P<0.001$ and $k=0.365$, $P<0.001$ respectively. Distribution of patients ineligible for thrombolysis was not significantly different comparing the ASPECTS and PECTS methods with each other; $k=0.010$, $P=0.885$.

Discussion

The European co-operative Acute Stroke Study trial identified importance of early ischemic changes as a trend to increased mortality with rTPA treatment of patients with early ischemic changes visible in greater than one third of MCA territory.¹¹ These stroke patients were treated up to 6 hours after the symptom onset.¹¹ Although intravenous thrombolysis with rTPA within 3 hours post event is approved, intra-arterial rTPA therapy extends therapeutic time window up to 6 hours. Thus, inter-observer reliability studies usually assess inter-rater agreement in brain CT obtained up to 6 hours after symptom onset.⁸⁻¹¹ While magnetic resonance imaging (MRI), especially diffusion and perfusion weighted images are highly sensitive for detection of early ischemic changes within 3 to 6 hours windows,⁴ CT is the routine imaging modality in candidates of rTPA therapy worldwide.¹²

Inter-observer agreement study based on MRI is costly and was one of the limitations of our study.

ASPECTS and PECTS were devised to provide a systematic approach of assessing and improving reliability of early ischemic changes in regions of the MCA territory. These systems provide a reliable semiquantitative, localization weighted estimation of ischemic tissue volume within the MCA territory.^{4,13} ASPECTS is a predictor for both functional outcome and symptomatic hemorrhage in patients treated by rTPA thrombolysis.¹⁴ In an individual with ASPECTS value of 7 or less, the risk of symptomatic intracerebral hemorrhage with rTPA is 14 times more than a patients with a score greater than 7.^{14,15} Inter-rater agreement of >1/3 MCA between three neuroradiologists has been reported 72% to 86%.^{16,17} The ASPECTS has shown higher inter-rater agreement than 1/3 MCA rule in some studies,^{13,15} while similar reliability studies have demonstrated reverse results.^{10,18}

The results of the present study revealed that reliability of PECTS is more than ASPECTS and 1/3 MCA methods. A significant difference in distribution of stroke patients ineligible to rTPA therapy was found by the four radiologists based on 1/3 MCA and ASPECTS methods, while this difference was not significant based on the PECTS system. Ninety-six scan-patient examinations in our study group revealed non-significant difference in distribution of patients ineligible for rTPA thrombolysis comparing the ASPECTS and PECTS systems. These findings confirm that PECTS is an alternative to ASPECTS system with higher reliability.

Brain CT is the routine imaging study in hyper acute phase of stroke for candidates of thrombolysis therapy and some of the contraindications of this therapy such as intracerebral hemorrhage and extensive early ischemic changes are investigated routinely based on CT images.^{12,19} The PECTS was developed to offer the reliability and utility of a standard CT examination with a reproducible grading system to assess early ischemic changes in the MCA territory. In our pilot study, this CT scoring system has shown to be simple, reliable and identifies stroke patients unlikely to make an independent recovery, despite thrombolytic treatment. However reliability of PECTS should be re-evaluated in further studies with larger sample size and by other specialties including neurologists and stroke fellows.

Conflict of Interest: None declared

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