ROLE OF COMPUTED TOMOGRAPHY PERFUSION IN EVALUATION OF EARLY ACUTE STROKE-A TWO YEARS STUDY IN RIMS, IMPHAL

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ABSTRACT

OBJECTIVE

Detection of acute strokes along with assessment of size of infarct core and penumbra with computed tomography perfusion (CTP) imaging.

METHOD

Thirty patients with signs and symptoms of acute cerebrovascular accident underwent a plain CT scan (NCCT) followed by CTP and a follow-up NCCT or Diffusion-weighted MRI (DWI) within 7 days from symptom onset.

RESULT

Of the total 29 patients with acute ischaemic stroke confirmed by followup DWI, NCCT correctly detected 18 cases of acute ischaemic infarction (64.28%), whereas CTP could correctly detect 24 cases of acute ischaemic infarction (85.7%). Out of the 24 patients with abnormal perfusion CT studies found during the study period, there were total of 69 aspects areas of perfusion abnormalities with 48 areas of infarct core and 21 areas of perfusion mismatch.

CONCLUSION

CTP is much more sensitive than NCCT in detection of acute stroke and CTP can also detect penumbra area in shorter investigation time as compared to DWI, proving its usefulness in planning for thrombolysis.

KEYWORDS

Aspects, Computed Tomography Perfusion, Stroke, Penumbra.

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INTRODUCTION

Non-Contrast Computed Tomography (NCCT) has been the primary and initial modality utilized for imaging stroke for almost four decade. Advances in reperfusion strategies have made identification of potentially salvageable brain tissue a more practical concern. Advances in CT technology now permits identification of acute and chronic arterial lesions and also the cerebral blood flow deficits. Section-selective dynamic CTP involves the acquisition of sequential CT data from a few sections in a cine mode during an intravenous bolus of iodinated contrast material. Dynamic CTP data can be analyzed according to two distinct mathematical models: the maximal slope model and the central volume principle.[1]

CTP parameters that are commonly calculated by the help of post processing softwares include CBF, CBV and MTT. CBV is defined as the volume of flowing blood for a given volume of brain. MTT is defined as the average amount of time it takes the blood to transit through the given volume of brain.

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CBV is defined as the volume of flowing blood moving through a given volume of brain in a specific amount of time.[2]

In this study we attempted to determine the performance of CTP in detection of early acute strokes as compared with NCCT and also assess its ability in delineating tumor core and penumbra.

AIMS AND OBJECTIVES

1. Detection and delineation of Early Acute Ischemic stroke by Non-Contrast Computed Tomgraphy and Computed Tomography Perfusion.
2. Assessment of size of infarct core and penumbra in Acute Stroke by Computed Tomography Perfusion.

MATERIALS AND METHODS

The study was conducted from October 2013 to September 2015, for a period of two years. Thirty patients who were clinically suspected of having cerebrovascular accident having no intracranial haemorrhage at initial NCCT and presented within 12 hours from symptom onset were included in the studies. Cases with space occupying lesion at initial NCCT, cerebellar or brainstem infarction, infarction outside the perfusion CT coverage area, age of less than 18 years, pregnancy or contraindications for contrast agent administration were not included. All patients or relatives signed an informed consent.

The study was performed by using Philips Brilliance 64 slice CT. and Siemens 1T Harmony. Initially, a whole brain

NCCT was obtained followed by CT perfusion. Non-Jog scans mode was performed. Eight contiguous slices at 5mm thickness for a total of 40mm thickness were obtained with cine scanning for a total of 40 sec.

Dynamic contrast-enhanced CT scans was acquired by injecting 50ml of iodinated contrast medium (350mg/ml) followed by 20ml saline through the antecubital vein using a 20-gauge catheter with an angiographic power injector at the injection rate of 6ml/sec.

The majority of the MCA circulation centered at the basal ganglia was imaged. Post processing was performed on Extend Brilliance Workstation CT perfusion package with regions of interest placed in the anterior cerebral artery for arterial input function and the superior sagittal sinus for venous output function. A manual evaluation of the perfusion scan was performed based on circular Region Of Interest (ROI) placed in brain region of interest. CT perfusion image was interpreted in conjunction with plain CT.

Later by one week from onset of system, a follow-up imaging with MRI/NCCT for detection and confirmation of the extent of final infarct area(s) involved.

IMAGE INTERPRETATION

The MCA territory was allotted 10 points according to Alberta Stroke Program Early CT Score (ASPECTS) determined from two standardized axial CT cuts, one at the level of the thalamus and basal ganglion and one adjacent to the most superior margin of the ganglionic structures, such that they were not seen. On these two sections which were by definition non-continuous, a single point was subtracted for an area of early ischemic change such as focal swelling or parenchymal hypoattenuation for each of the defined regions. A normal CT scan received ASPECTS of 10 points. Caudate head; lentiform nucleus; internal capsule; insular ribbon; 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 respectively, approximately 2cm superior to M1, M2 and M3 respectively, rostral to basal ganglia. A score of zero indicated diffuse ischemic involvement throughout the MCA territory.[3]

For CTP, infarct threshold as defined by earlier published literatures were taken as areas of decreased CBF (less than 25ml/100gm/min or less than 30% of normal contralateral CBF) or marked decrease in CBF (<70% of normal contralateral), decrease CBV (Less than 2.5ml/100gm or less than 40% of normal contralateral CBV) with increase in MTT (More than 7 seconds or more than 145% of normal contralateral MTT). Marked reduction in both CBF and CBV areas may be infarcted. Penumbra or salvageable areas showed prolonged MTT with moderately decrease in CBF and a normal or increased CBV or increase in MTT with marked decrease in CBF and moderately reduce in CBV. Mismatch between CBV and CBF or CBV/MTT mismatch, where there is reduction in CBF with maintained CBV and increase in MTT.

For MR imaging, acute infarction showed as areas of low signal or isosignal intensity in T1-WI, high signal intensity in T2-WI and FLAIR with loss of gray-white matter differentiation. Diffusion weighted images showed acute infarction as areas of restricted diffusion seen as high signal intensity in DWI and low signal intensity in ADC. The acute DWI lesion was used to define the acute infarct core.

RESULTS AND OBSERVATIONS

A total of 30 patients with symptoms of acute ischemic stroke were included in the study; 17 males and 13 female patients, with age ranging from 18 yrs to 85 years old. Two patients were excluded from the study, one patient had infarct beyond the area of CTP coverage area (Pontine infarction), one patient showed no evidence of infarction on NCCT, CTP or followup diffusion weighted imaging. Of the 29 patients with acute ischemic stroke confirmed by followup DWI, 4 patients had lacunar infarction (<1.5cms), which were not detected by either by NCCT or CTP. NCCT correctly detect 18 cases of acute ischemic infarction (64.28%) and CTP could correctly detect 24 cases of acute ischemic infarction (85.7%) that were confirmed by followup DWI.

Out of the twenty four patients with abnormal perfusion CT studies found during the study period, there were total of 69 ASPECTS areas of perfusion abnormalities were detected. 48 areas of infarct core, which show marked reduction in CBV with reduced CBF and prolonged MTT were detected. These areas were seen as restricted diffusion on followup DWI. Our result shows that CTP detected an additional of 16 separate areas of infarction as compared to NCCT; 21 ASPECTS areas show perfusion mismatch which were seen as areas of prolonged MTT with moderately or markedly decreased CBF and moderately reduced CBV. On followup DWI, these mismatch areas were seen as infarct areas with high signal intensity in DWI and low signal intensity in apparent diffusion coefficient.

Out of 21 perfusion mismatch areas seen on CTP, 18 areas were confirmed as acute infarction on diffusion weighted imaging and apparent diffusion coefficient. Three of the perfusion mismatch areas were overestimated which are attributed to benign oligaemia.

DISCUSSION

In the present study, NCCT could detect 62.8% of ischemic stroke which correlate with earlier published results.[1,4] Within the first hours after stroke onset, the sensitivity of NCCT to infarction is low and ischemic signs are not readily recognized outside of specialized centers. Ischemic stroke can be seen as early as 6 hours after symptom onset. There is variation in the rate of neuronal loss/neuronal death, which is best explained by differences in the adequacy of the collateral circulation.[5]

In our study CTP could detect 85.7% cases of infarction, which correlate with earlier published literature including Wintermark et al.[1] K Lin et al.[6] Kloska et al.[4] and Meyer TE et al.[7] who had the sensitivity ranging between 75.3–93%. The CTP can efficiently detect more number of acute strokes compared to NCCT. CTP yields diagnostic results within a few minutes and may guide treatment decisions. Delineation of final infarct extent by using ASPECTS were more accurate on CT perfusion than non-contrast CT.

Our study also showed that the CTP imaging well delineates the infarct core and the penumbra which was confirmed by followup imaging. The size of the perfusion infarct core relative to the mismatch (Infarct core-penumbra ratio) are use to determine eligibility for reperfusion therapy in patients with acute stroke and to select patients for either intravenous or intra-arterial thrombolysis during the extended time window.

A mismatch ratio of 0.2 (20%) benefit from acute thrombolysis/recanalization in an extended time window (3–

6 hours), a greater benefit seen for a mismatch ratio of 0.5 (50%). The size of the CTP infarct core with low CBV larger than one-third of the MCA territory is a contraindication to acute reperfusion therapy because of an increased risk of hemorrhagic transformation.[8]

Follow-up studies provide information on the response to thrombolytic therapy.[9] Perfusion CT is easily accessible and feasible, rapid data acquisition and is well tolerated by patients even in the acute phase of stroke.[10]

Limitations: Brain coverage is limited with perfusion CT. Cases with multiple infarctions pose a problem in interpreting CTP administration iodinated contrast material may be contraindicated or risk of toxicity.[9] Small and chronic infarcts may not be detected by CTP. Microvascular changes may potentially be mistaken for regions of acute ischemia.[11] Extracranial and intracranial carotid stenosis may show asymmetry in perfusion. Seizure can pose a diagnostic problem. CTP may show asymmetric perfusion with ictal areas of hyperperfusion.

CONCLUSION

Computed Tomography Perfusion shows increased detection of infarction compared to NCCT. It can also delineate penumbra area in shorter investigation time as compared to DWI. This may be useful while planning for thrombolysis therapy in acute stroke patients.

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Fig. 1a: NCCT showing ill-defined hypodense lesion with effacement of adjacent sulci in left M4-M5 region

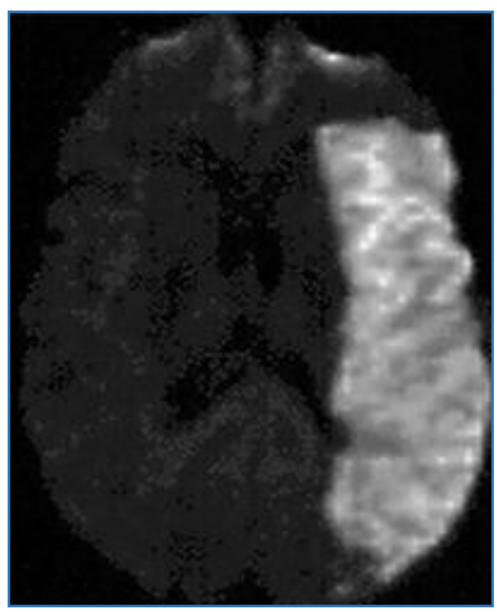

Fig. 1b: Followup diffussion weighted imaging on 5th day showing left hemisphere infarction

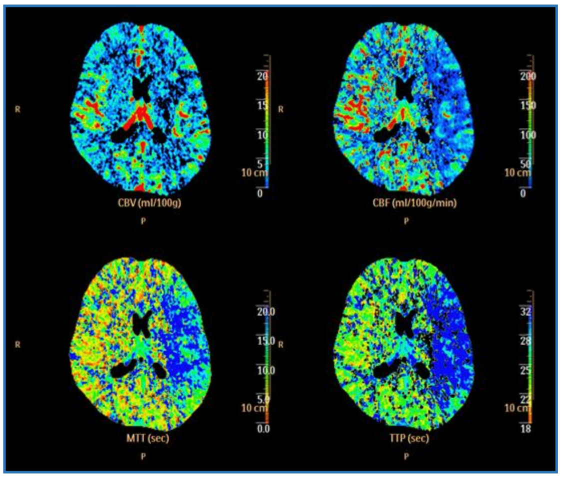

Fig. 1c: Perfusion Imaging showing prolonged MTT with reduced CBF and moderate reduction in CBV

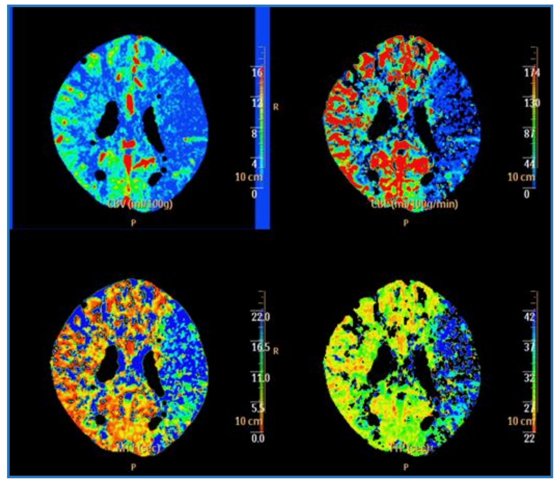

Fig. 2b: CTP showing prolonged MTT with marked reduction of CBV and CBF involoving M4, M5 and M6 area

Fig. 2a: NCCT showing hypodense area in left M5-M6 area with effacement of adjacent sulci