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Differentiating Seizure from Acute Stroke with Clinical-radiological Correlation–a Case Report

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Abstract

Background: Patients who present with acute ischaemic stroke require both accurate and timely diagnosis in order to facilitate prompt treatment. Up to 30% of acute stroke presentations can actually consist of stroke mimics such as seizures or migraine. Recent advances in Artificial Intelligence (AI) have enabled automatic analysis and quantification of both CT angiography and CT perfusion studies. AI analytic programs can assist clinicians in both detecting ischaemic penumbra, as well as recognising atypical perfusion patterns in stroke mimics.

Methodology/Case presentation: A 68-year-old lady with a background of cardiovascular risk factors presented to Emergency as a stroke activation. She exhibited right sided weakness, aphasia and neglect. Urgent computed tomography imaging showed neither evidence of established infarct or haemorrhage, nor any large vessel occlusion. Collateral history revealed a generalized tonic-clonic movements preceding her right-sided weakness, and clinical seizure was diagnosed. Anti-epileptic medications were commenced, and her clinical deficits rapidly improved. The next morning, our patient's right sided neglect and aphasia recurred.

Findings: Repeat CT angiography showed reduced opacification of cortical branches of the left middle cerebral artery. CT perfusion imaging showed areas of mild hypoaemia in the left frontoparietal lobes, quantified by commercially available artificial intelligence processing software as slightly reduced perfusion time of 4 seconds involving only 18 mL of territory. These findings indicated a final diagnosis of post-ictal paresis. Post-ictal Todd's paresis leads to reduced cerebral perfusion *via* metabolic exhaustion and the action of inhibitory interneurons.

Conclusion: This case study demonstrates the utility of CT perfusion studies and AI-analysis in differentiating ischaemic strokes from stroke mimics stroke mimics, facilitating accurate and timely diagnosis in order to streamline management.

Limitations: This case report's unitary sample size allows for only case-restricted conclusions, and does not allow its findings to be generalized to a greater population. Larger studies could correlate its findings on a greater sample size and allow for further analysis and application to patient populations.

Keywords: Stroke • Radiology • CT perfusion • Artificial intelligence • Seizure • Epilepsy

Introduction

Patients who present with acute ischaemic stroke require both accurate and timely diagnosis in order to facilitate prompt treatment. Emergent interventions such as intravenous tissue plasminogen activator and mechanical thrombectomy must be administered within hours of the onset of stroke symptoms to minimize cerebral infarction and consequent disability [1].

However, up to 30% of acute stroke presentations can actually consist of stroke mimics such as seizures or migraine [2]. Urgent radiological investigations are required to differentiate acute ischaemic stroke from stroke mimics [1,2]. Computed Tomography (CT) techniques are frequently the first-line imaging modalities used to aid the diagnosis of patients presenting with stroke symptoms *via* non-contrast CT, CT angiography and CT perfusion [1,2].

Recent advances in Artificial Intelligence (AI) have enabled automatic analysis and quantification of both CT angiography and CT perfusion studies [2,3]. AI programs such as RAPID can assist clinicians in both detecting ischaemic penumbra, as well as recognising atypical perfusion patterns in stroke mimics [2,4]. The following case illustrates the value of CT perfusion and AI-assisted analysis to diagnosis and management of a patient presenting with acute stroke symptoms.

Case Presentation

A 68-year-old lady presented to the Emergency Department of our tertiary hospital late in the evening with acute onset of altered mentation and right sided weakness. She had a background history of poorly controlled diabetes, hypertension, hyperlipidaemia, and peripheral vascular disease. Additionally, she had a history of previous hypertensive haemorrhage in the left thalamus and bilateral striatocapsular lacunar infarcts regions, for which she was asymptomatic and compliant to aspirin. Our patient was conveyed to hospital *via* ambulance, and acute stroke service was activated. On examination, she was aphasic with right sided weakness of NMRC grade power 2/5 and right sided neglect. She was assessed to have a high NIHSS score of 19. As per our hospital protocol, acute stroke activations are imaged with Computed Tomography (CT) of the brain as well as CT angiography; CT perfusion studies are reserved for patients with large vessel occlusion as well as prolonged onset over 6 hours. Urgent CT brain revealed neither evidence established infarct nor haemorrhage, while CT angiography revealed neither large vessel occlusion nor severe flow limitation (Figure 1).

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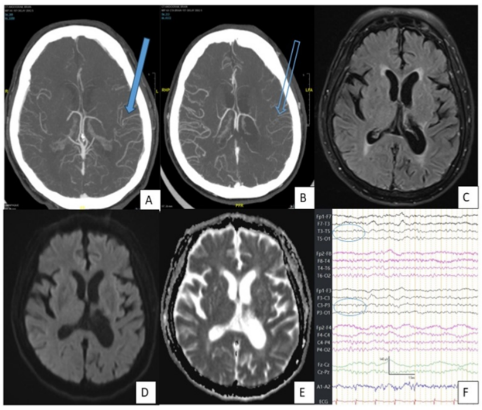

Figure 1. CT angiogram images, (A) 1st CT on arrival in ED showing preserved cerebral flow (solid arrow); (B) 2nd CT angiogram during acute deterioration showing reduced opacification over cortical branches of the left middle cerebral artery (outline arrow); (C) FLAIR sequences of MRI brain showing gliosis of the left thalamus; (D) DWI B1000 and ADC sequences respectively showing no acute infarction; (E) DWI B1000 and ADC sequences respectively showing no acute infarction; (F) EEG showing asymmetrical reduced voltages over the left hemisphere (circles)

Our initial differential diagnosis included acute stroke and seizure. Collateral history from her caregiver revealed that prior to her presentation she had a witnessed generalized tonic-clonic seizure that lasted approximately 15 minutes. Thereafter, she developed right sided weakness and neglect. She was provisionally diagnosed with an acute seizure and subsequent post-ictal paresis. Conservative measures were initiated with intravenous hydration and intravenous levetiracetam. On repeat examination in the emergency department, her gaze was central and there was no jerking of limbs or convulsions. Our patient's right sided weakness and neglect improved, and her NIHSS score improved from 19 to 10. She was admitted to the general ward and scheduled for an electroencephalogram the next day.

During review by the neurology team the next morning, our patient was found to have profound right sided neglect and aphasia. She now displayed a left-sided gaze deviation, with a high NIHSS score of 25. The Neurology team suspected an acute stroke, possibly with large vessel occlusion involving the left hemisphere. Urgent repeat CT angiography was performed which once again fails to demonstrate any obvious occlusion or severe vascular stenosis; nevertheless, there appeared to be a markedly diminished left hemispheric cerebral blood flow compared to the right hemisphere.

We carefully considered our next course of action. Given that the onset of her symptoms was the night before, she was out of the 4.5-hour time window for administration of intravenous tissue plasminogen activator. The only other intervention for an acute ischaemic stroke would be mechanical recanalization; however, CT angiography did not show any large vessel occlusion amenable to endovascular therapy. We decided to proceed with CT perfusion imaging in order to identify any cerebral perfusion mismatch.

Results and Analysis

CT perfusion is a radiology modality that is used in cases of suspected acute ischaemic stroke to assist clinical decision making by differentiating areas of established infarcted tissue (i.e. core) from areas of salvageable ischaemia (i.e. penumbra). Suitable patients with a large penumbra may benefit from endovascular therapy in order to rescue ischaemic tissue before complete infarction occurs. Area of infarcted tissue (i.e. core) appear on CT perfusion as regions with both reductions in cerebral blood flow, and cerebral blood volume. Conversely, areas of salvageable ischaemia (i.e. penumbra) appear as regions with reduced cerebral blood flow, but preserved cerebral blood volume. In our patient, CT perfusion imaging revealed both preserved cerebral blood flow as well as cerebral blood volume; neither core nor penumbra was present, which was highly atypical of an acute ischaemic stroke (Figure 2).

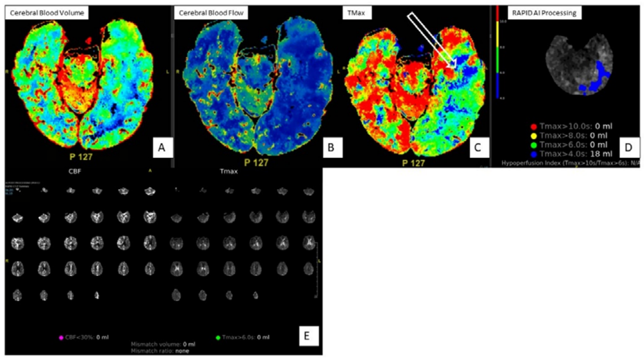

Figure 2. CT perfusion sequences, (A) CBV sequence showing preserved cerebral blood volume, General Electric vendor software; (B) CBF sequence showing preserved cerebral blood flow, General Electric vendor software; (C) T_{max} sequence showing area of reduced flow speeds in left MCA region (white arrow), General Electric vendor software; (D) RAPID AI analysis showing a small region of 18 mL with slightly prolonged flow speed in left MCA region; (E) RAPID AI summary showing neither significant mismatch volume nor mismatch ratio

Our patient did display evidence of reduced Time-to-Maximum (T_{Max}) over the left hemisphere, which reflects delayed blood transit between the proximal large vessels and brain parenchyma. In addition, commercially available artificial intelligence programs such as RAPID AI can assist in quantifying both core and penumbra, as well as the extent of T_{Max} prolongation. RAPID AI analysis showed an absence of mismatch volume routinely used to indicate a significant ischaemic stroke. Further inspection of the specific RAPID AI T_{max} threshold slices showed asymmetrical reduced flow rate of 4 seconds over the left temporal-occipital lobes, involving only 18 mL of territory. Ischaemic stroke was deemed unlikely to be the cause of her deficits given the paucity of significant mismatch volume identified on CT perfusion; an alternative diagnosis that would explain both a witnessed seizure and left hemispheric hypoperfusion was that of post-ictal Todd's paresis following a seizure.

Diagnosis

Taking into consideration our patient's presenting complaint of right sided weakness following a witnessed seizure, as well as our radiological finding of preserved cerebral vasculature with reduced cerebral blood flow over the left cerebral hemisphere, our diagnosis was that of a left hemispheric seizure with resultant right sided Todd's paresis. Her deterioration inpatient following her initial improvement was secondary to a new non-motor epileptic seizure which occurred following admission.

Our patient was transferred to the Neurological High Dependency Unit for close neurological monitoring. A lumbar puncture was performed to exclude encephalitis and showed no evidence of elevated white blood cells or protein. An electroencephalogram showed mild diffuse encephalopathy, and asymmetrical reduced voltages over the left hemisphere. Magnetic resonance imaging was also performed several hours later, which showed evidence of restricted diffusion to suggest a stroke. Our final diagnosis was that of a idiopathic left hemispheric seizure with resultant post-ictal paresis. Our patient continued to improve over the next 2 days, with complete resolution of her acute deficits. She was discharged at her baseline clinical status on anti-epileptic medications.

Discussion

This case report illustrates the applications of CT perfusion techniques in the assessment of a stroke mimic. In this case, our patient was fortunate to have corroborative history of tonic-clonic movements that suggested a convulsive seizure. A CT angiogram done at presentation showed preserved cerebral flow and vasculature. Her resulting right sided paresis and altered mentation was thus correctly diagnosed as post-ictal drowsiness and a right sided Todd's paresis.

Our team grew concerned of a left cortical stroke when she displayed prominent right sided neglect with a left sided gaze deviation on subsequent review. A repeat CT angiogram confirmed patent cerebral vasculature, while showing new interval findings of reduced cerebral vessel arborization over the left hemisphere. Our patient's CT perfusion study findings of elevated mean transit time correlated radiologically with the second CT angiogram finding of reduced cerebral flow.

Up to 4% of strokes can present atypically as seizures [5]. Post-ictal Todd's paresis leads to reduced cerebral perfusion *via* metabolic exhaustion and the action of inhibitory interneurons [6]. These CT perfusion images are classic examples of post ictal changes, which show hypoperfusion if scan is done more than 3 hours of seizure occurrence [5,7,8]. Conversely, if performed during ongoing ictal activity or up to 3 hours following seizure, perfusion studies classically show hyperperfusion due to increased metabolic demands from upregulation of the neurovascular unit and blood-brain barrier disruption during seizures [9,10]. MRI brain was performed and proved the absence of ischaemic changes; our patient gradually recovered from her seizure and returned to previously baseline physical status.

Conclusion

In conclusion, newly available CT perfusion techniques as well as AI-assisted analytic programs are proving to be a valuable addition to the diagnostic toolkit used in patients with acute stroke symptoms. Valuable additional information such as atypical perfusion patterns can allow clinicians to differentiate ischaemic strokes from stroke mimics, allowing us to improve diagnostic accuracy and streamline care.

Limitations and recommendations

This case report is limited by the inclusion of only 1 patient, albeit with more in-depth description of clinical course and radiological findings. The unitary sample size allows for case-restricted conclusions, and does not allow its findings to be generalized to a greater population. Further studies could expand on the potential for using CT perfusion studies with artificial intelligence platform processing to localize seizure foci in patients with epilepsy or seizures, potentially allowing more accurate characterization and targeted imaging or therapeutic procedures over ictal foci.

Acknowledgement

None.

Conflict of Interest

The authors declared no conflict of interest.

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