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Radiological Imaging for Early Intervention in Stroke: A Scopic Review

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Abstract

Introduction: An event of stroke can be very debilitating if not treated and early intervention is critical. It is one of the leading causes of death and disability in the world. Timely intervention with intravenous thrombolysis (IVT) and mechanical thrombectomy (MT) can save lives with appropriate radiological imaging plays a crucial role. The aim of this study is to discuss the role of radiological imaging in the early detection and management of stroke.

Methods: An electronic search was conducted in PubMed and Medline to identify eligible studies. In the primary screening, titles and abstracts were reviewed to determine the eligibility of the study. Later on, the full texts of eligible articles were retrieved using the university online library. The included studied were subjected to data extraction with two reviewers and the extracted data were reported in data extraction sheets. The data were organized in a qualitative data synthesis without meta-analysis.

Conclusion: Stroke is one of the leading causes of mortality and morbidity in the world. Intravenous thrombolysis (IVT) and mechanical thrombectomy (MT), if done rapidly, many lives can be saved. Various radiological imaging is required to detect an episode of stroke and assess whether a patient qualifies for these interventions. Unenhanced CT is the most basic and easily available scan for detecting stroke and differentiating it from hemorrhage. CT angiography and CT perfusion provide a more detailed view of the vasculature and several perfusion parameters, which further helps in assessing the severity of stroke. Finally, various images of MRI can be used to assess structural changes in the brain parenchyma, but their availability and duration of the scan limit their use.

Keywords: Stroke, brain infarct, brain ischemia, penumbra, CT perfusion, CT angiography.

Introduction

A stroke is a sudden break in blood supply to the brain tissue, which can result from mild neurological symptoms to death. Loss of blood supply is due to clots occluding the arteries or rupturing them; in either case, lack of oxygen supply to brain cells leads to their death. Globally, stroke is the second leading cause of both fatality and the disability it brings to the survivors [1]. Common causes leading to stroke are tobacco smoking, excessive alcohol consumption, myocardial infarction, and arterial disorders in men. Factors specifically related to women are pregnancy, such as preeclampsia, contraceptive use, and hormonal therapy [2]. Time is of extreme importance when dealing with a stroke. Intravenous thrombolysis (IVT) and mechanical thrombectomy (MT) are two common interventions to reopen the occluded blood vessel, and they need to be done fast. Thus it becomes imperative to identify a patient who may benefit from IVT or MT via imaging studies. In the case of IVT, imaging should exclude intracranial hemorrhage. Imaging must also be used to detect intra-arterial thrombus and arterial architecture. Moreover, advanced imaging may be needed to identify volume salvageable and non-salvageable brain tissue [3].

The brain is supplied by two internal carotid arteries anteriorly and two vertebral arteries posteriorly, forming a network of blood vessels intercommunicating in a circle known as the circle of Willis. The commonest form of stroke is ischemic, where occlusion of these arterial vessels leads to loss of oxygen supply to the brain. Hemorrhagic stroke is caused by bleeding and leakage of blood from vessels leading to diminished oxygen supply [4]. Ischemic strokes amount to up to 85% of stroke fatalities. In ischemic stroke, there is a progressive build-up of atherosclerotic plaque or embolization thrombi from another place. Either case leads to the narrowing of a blood vessel supplying the brain and causing necrosis. At the cellular level, there is disruption of the plasma membrane, swelling of organelles, and leakage of cellular matter into extracellular space, which leads to functional loss of neurons. At the tissue level, there is inflammation, infiltration of leukocytes, acidosis, and impairment of the blood-brain barrier [5]. Hemorrhagic stroke amount to 10 -15 % of stroke fatalities. In this, the vessel ruptures, and blood amasses around the brain tissue. Hemorrhagic stroke can be intracerebral and subarachnoid hemorrhage types. Intracerebral hemorrhages are caused due to high blood pressure, disruption of vessel walls, and excessive intake of anticoagulants and thrombolytic agents. Subarachnoid hemorrhages are caused due to head trauma or vessel aneurysm leading to blood accumulation in the subarachnoid spaces [6].

Methods

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Results and discussion

The reason behind quick intervention following stroke is based on the three-compartment model of brain tissue. The innermost zone represents the non-salvageable area where even prompt treatment is less like to help. The middle zone (aka penumbra) is salvageable if rapid reperfusion of tissue is done, and the out zone is likely to survive even without intervention [3]. Intravenous thrombolysis with alteplase (tissue plasminogen activator) is used as the first line of treatment in many stroke cases, provided it is started within 3 hrs of the stroke episode. IVT can pose certain risks of intracranial hemorrhage, which is where imaging comes into play. For IVT, minimum imaging of CT/MRI is a must to exclude cases of hemorrhage and stroke mimics such as brain tumors (gliomas, meningiomas, and adenomas) and metabolic disorders (such as hypoglycemia, hypercalcemia, hyponatremia, uremia, hepatic encephalopathy, hyperthyroidism, thyroid storm) [7]. Occlusion of large vessels such as basilar or carotid terminus isn't responsive to intravenous thrombolysis, and such a large occlusion can only be mechanically removed. Mechanical thrombectomy is where a catheter is inserted via the groin into a major artery and is carried all the way up to the blood clot. The catheter then passes a stent and retrieves the clot mechanically, and reperfuses the brain tissue. CT angiography is utilized to identify large occluded vessels supplying the brain as well as locate the catheter during the procedure for proper placement and removal of a blood clot [8].

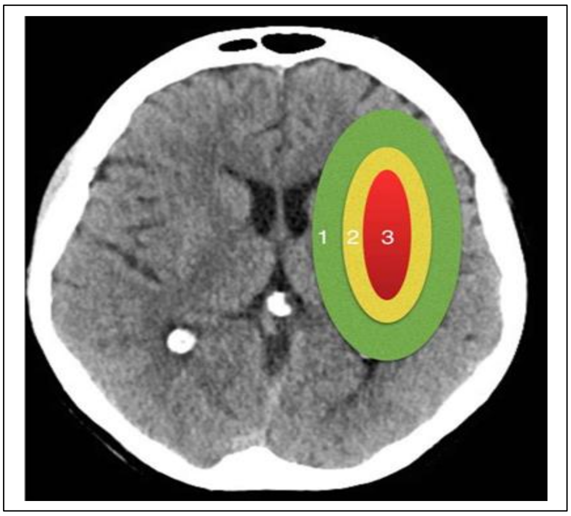

Figure (1): Compartment model. Zone 1 (outer): likely to survive, Zone 2 (middle): salvageable if intervened, Zone 3 (inner): non-viable.

Unenhanced CT

A plain CT scan is the easiest and quickest form of imaging in acute infarct cases. Mature and embolized thrombus appears denser than free-flowing blood on a CT, and therefore, high-density foci will be visible as a dot in cases of embolized thrombi [3]. Due to an increase in water content in the brain parenchyma by edema after acute infarction, there is a reduction in attenuation of grey matter. Edema also results in focal sulcal effacement in the brain tissue. Other signs are loss of differentiation of cortex from underlying white matter and basal ganglia from the adjacent capsule. Unenhanced CT plays a major role in ruling out cases of brain hemorrhage, which contraindicate the use of IVT [3].

CT angiography (CTA) utilizes an injectable contrast agent to better visualize arteries and their collateral supply to the brain. It demonstrates the presence, location, and size of the embolic thrombus occluding the supplying artery. The sensitivity of identifying occlusive thrombus and stenosis of the large intracranial and extracranial vessel is 95-99%. CTA involves acquiring images from the aorta to the circle of Willis, which may provide clues to the cause of ischemia and better guide the interventional neuroradiologist [10].

CT Perfusion (CTP)

CTP imaging is specifically used to obtain certain perfusion parameters, also known as perfusion blood-volume mapping. The parameters include cerebral blood volume (CBV): the volume of blood per unit of brain tissue, cerebral blood flow (CBF): the volume of blood flow per unit of brain tissue per minute, and mean transit time (MTT): defined as the time difference between the arterial inflow and venous outflow [11]. Brain tissue perfusion is evaluated based on the principle of CBF = CBV/MTT. Clinical application of CTP is based on the hypothesis that penumbra has raised MTT, moderately reduced CBF, but normal or raised CBV due to autoregulation, whereas infarcted tissue displays very reduced CBF and CBV and raised MTT. Based on these parameters, a color-coded map of brain parenchyma can be generated using computer software where areas of penumbra and infarct can easily be identified [11].

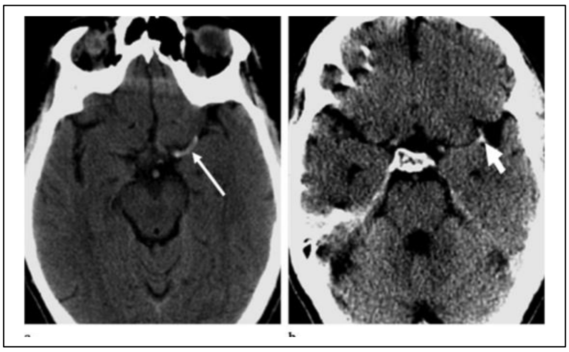

Figure: Axial unenhanced CT images in A: a proximal segment of the left MCA B: a distal segment of the left MCA.

MRI

Magnetic resonant imaging can perform a thorough assessment of brain parenchyma by conventional MR imaging, MR angiography, and diffusion- and perfusion-weighted MR imaging techniques. MRI can be significantly better than CT scan, particularly in diffusion-weighted MR in displaying the infarct core. The advantages offered by MRI are often shadowed by disadvantages of availability and duration of the imaging as time is very crucial in such scenarios [3].

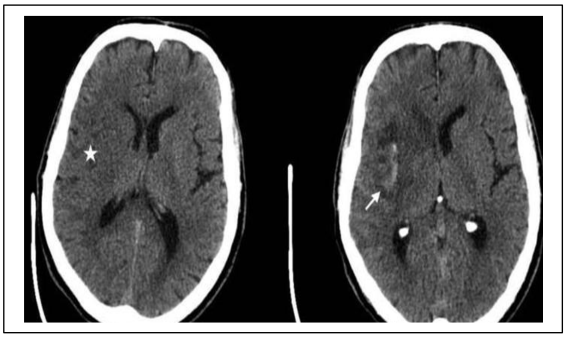

Figure: Right: Demonstrates a right MCA territory infarct with loss of differentiation of the caudate and lentiform nuclei; Left: Demonstrates hemorrhagic transformation of the right MCA territory infarct, a complication of large area infarction.

Conclusions

Stroke is one of the leading causes of mortality and morbidity in the world. Intravenous thrombolysis (IVT) and mechanical thrombectomy (MT), if done rapidly, many lives can be saved. To detect an episode of stroke and assess whether a patient qualifies for these interventions, various radiological imaging is required. Unenhanced CT is the most basic and easily available scan for detecting stroke and differentiating it from hemorrhage. CT angiography and CT perfusion provide a more detailed view of the vasculature and several perfusion parameters, which further helps in assessing the severity of stroke. Finally, various images of MRI can be used to assess structural changes in the brain parenchyma, but the availability and duration of scans limit their use.

Conflict of interests

The authors declared no conflict of interests.

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