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Research Article

Imaging Based Detection of Acute Ischemic Stroke Via Multidetector Computed Tomography

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ABSTRACT

BACKGROUND: The current study was designed to capture comprehensive imaging of acute ischemic stroke (AIS) using multidetector computed tomography (MDCT). The study also evaluated the accessibility and potential use of computed tomography angiography (CTA) and sought to determine stroke subtypes in patients with AIS.

METHODS: The presence of ischemic lesions was detected by the MDCT, transesophageal echocardiography (TEE), and non-contrast flat detector computed tomography (FDCT). The study selected the AIS patients with hyperacute stroke for less than 6 hours from July 2021 to August 2022. The CTA of cervical arteries was performed in order to determine stroke subtypes.

RESULTS: The MDCT-based detection of ischemic lesions in 110 studied ischemic stroke patients showed 34% had extensive intracranial artery damage, 86% detected a partial territorial infarct, while 52% patients had detected artery-to-artery embolization. These percentages of detected ischemic lesions overlapped in all studied AIS patients. The findings showed significant susceptible plaques and arterial stenosis.

CONCLUSION: The findings of the study clearly indicated that AIS patients admitted within less than 6 hours of a hyperacute stroke showed multiple types of ischemic lesions. The findings also concluded that the MDCT technique is highly useful for the detection of multiple patterns of brain infarction and for the determination of the causative mechanisms in patients with acute ischemic stroke.

1. INTRODUCTION

The etiology for the classification of ischemic stroke and its subtypes still remains fully defined (Alawneh et al., 2020; Qawasmeh et al., 2020). The advances in computed tomography technology enhanced the possibility of their use in clinics to investigate complicated patients with ischemic stroke (Ginat & Gupta, 2014; "StatPearls," 2023). The multidetector computed tomography angiography (MDCTA) was utilized to increase the sensitivity and reliability of acute stroke detection (Ibad et al., 2023; Linh et al., 2022). The causes of embolic stroke for prognosis and diagnosis in patients with acute ischemic stroke were previously investigated (Arora et al., 2022; Kim et al., 2019; Wong et al., 2020). These studies identified several limitations of the diagnostic process of TEE and included in the restriction where the nature of the diagnostic process was semi-invasive (Kim et al., 2019).

In contrast, the utilization of MDCT has several advantages, as it performs scanning in a shorter scan time with more accuracy (Arora et al., 2022; Kim et al., 2019; Wong et al., 2020). Furthermore, the studies also reported that the non-contrast flat detector CT (FDCT) was used to detect the post-interventional complications, but the technique still has several limitations when compared with the effectiveness of MDCT (Petroulia et al., 2023). In addition, several other studies also assessed the FDCT efficacy for the detection of ischemic lesions, and they compared the imaging with MDCT and reported that MDCT is more reliable and accurate for the detection of ischemic lesions (Maier et al., 2018; Yan et al., 2020). Studies also investigated the cause of embolic stroke by MDCT, which considered it a significant diagnostic step in managing patients with acute ischemic stroke, mostly when the embolic mechanisms were investigated (Ntaios et al., 2021; Yan et al., 2020). The importance of TEE in highlighting the extracardiac and intracardiac embolic damages was well reported (Chu & Wang, 2018) but several other studies pointed out a number of flaws in TEE's diagnostic process, including the fact that the diagnostic procedure is semi-invasive due to the presence of a blind spot (Kim et al., 2019) and is also not perfect in evaluating the aortic arch and may not be available to a large number of patients due to its limited access in remote regions across the globe (Ashworth & Greenhalgh, 2020; Kim et al., 2019; Poppe et al., 2023). Furthermore, the management of acute stroke patients with TEE imaging failed because of the meager cooperation aligned with severe neurological problems(Ashworth & Greenhalgh, 2020; Poppe et al., 2023) . Therefore, there is a need for less invasive and accurate assessment of embolic sources with proper diagnostic tools and procedures. The advantages of the cardiac MDCT include the availability of the diagnostic tool for 24 hours in almost all settings. The operator and patient dependency were minimized with the short scan time and a significant and better view of the ascending aorta. However, the research considered a few research types comparing the diagnostic efficacy of cardiac MDCT with that of TEE in many elective diagnostic settings and subacute stroke patients (Jones & Odisio, 2020). It is reported that the MDCT was not validated in acute stroke patients, and the investigation pertaining to the diagnosis was hindered by a lack of cooperation (Kim et al., 2019). The study's objective was to compare the plausibility, feasibility, and yield of cardiac MDCT with that of TEE in acute stroke patients(Kim et al., 2019) . Other studies reported that the patients could be triaged for better management using imaging techniques beyond the CT scan. The essential issues that imaging should address were published (Meijer et al., 2023). In view of these, this study was designed to identify and assess the concise imaging of acute ischemic stroke on multidetector CT and to characterize the patient population on the basis of MDCT detection of ischemic lesions in patients with acute ischemic stroke.

2. MATERIALS AND METHODS

This study was designed to evaluate patients with acute ischemic stroke (AIS) using the MDCT as described previously (Ko et al., 2010; Ledezma & Wintermark, 2009) with slight modifications. The study protocol used in this research was approved by the Institutional Review Board and the local ethics committee (IRB approval # 20-09-05). The study selected the AIS patients with hyperacute stroke for less than 6 hours from July 2021 to August 2022. The 110 adult patients (males: 57; females: 53) with a mean (±SD) age of 46.6 (±4.9) years who suffered from symptoms of the acute ischemic stroke consistent with the MCA's acute ischemia and had previously undergone CTA were eligible for inclusion in the study. The patients excluded from the study were those with intravenous iodine contrast administration, those who refused to participate, and patients whose final diagnosis was posterior circulation stroke. The examinations were conducted with previously reported protocols with the mean dose of ion radiation and intravenous iodine contrast in MDCT. The inclusion of non-contrast computed tomography and cervical and intracranial MDCT in the examination required up to 5 minutes. The data were processed with available software on a workstation. Two neuroradiologists who had vascular imaging experience were individually assessed for the CTA examination in the emergency room. The abnormalities of the vascular sort associated with the coexisting stroke were distinguished based on the imaging features. This study provided the visibility of the plaque on the CTA with categories based on the stenosis grade type and kind of plaque. The study also tested the morphologies of the plaque with subjective investigation with consensus and the measurement of the densities with the ROI. All of the information was entered into a database with Excel 2011. The data was then entered into IBM, SPSS Statistics Software (version 22.0). The Chi-Square ($\chi 2$) test was used to compare the variables between patients with brain infarctions and the patients devoid of any brain infarctions. The P-value less than 0.05 was considered statistically significant.

3. RESULTS

The recruited subjects (n = 110) were retrospectively analyzed in this study. The patients were divided into two groups on the basis of stroke and non-stroke incidences. A report of the anterior circulation stroke in 50 out of 110 patients (stroke group) was analyzed with imaging. Whereas 60 patients out of 110 had no evidence of brain ischemia (non-stroke group). The cervical MDCTA (multidetector CT angiography) results were detected in 18 patients who were included in the stroke group. In the non-stroke group, relevant and irrelevant stenosis were found in the cervical arteries in 17 and 15 patients, respectively. As shown in Figure 1 of a scan of a 56 years old man presented within 60 minutes of left hemiplegia. Similar findings of the stenosis were discovered in 4 patients as they were distinguished from the non-stroke group, while 20 patients in this group had average results on the MDCTA. Whereas, 32 patients were detected with only non-relevant stenosis.

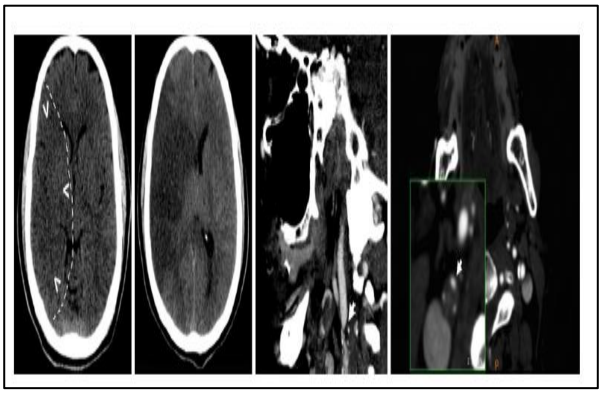

Figure 1: Scan of a 56-years-old man who presented within 60 minutes of left hemiplegia.

The presence of plaques may not cause sufficient barriers (obstruction), but they might cause cerebral infractions in accordance with their characteristics. The examination of the patients with non-relevant stenosis revealed 10 patients in the stroke group having susceptible plaques. Similar to that, 10 patients in the non-stroke group reported with vulnerable plaques. The patients included in the stroke group number 50. Out of them, 7 patients had average/normal extracranial and intracranial vessels. The images were aligned with intracranial large-artery disease (ILAD) in a total of 7 patients, while12 had cervical carotid atherosclerosis and 10 had consistent ILAD and extracranial atherosclerosis. Whereas, the 14 patients were diagnosed with atherothrombosis or cardioembolic with thrombi in the intracranial system. These similar details were diagnosed in a scan of an 80-years-old woman, as shown in Figure 2.

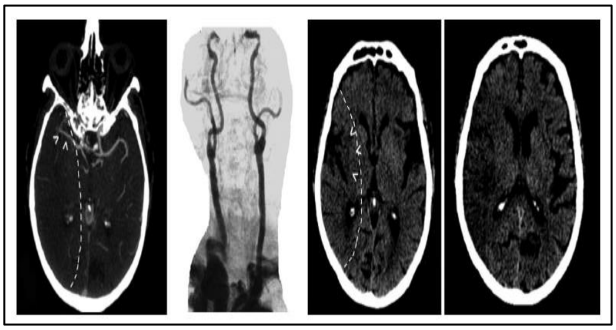

Figure 2. Scan of an 80-years-old woman who presented within 120 minutes of the onset of left hemiplegia

4. DISCUSSION

This study was performed on patients with acute ischemic stroke who were admitted in less than 6 hours after their hyperacute stroke and whose ischemic lesions were detected using the MDCT imaging technique. The MDCT imaging showed multiple types of ischemic lesions. The findings of this study also strongly suggested that the MDCT technique is highly useful for the detection of multiple patterns of brain infarction in patients with acute ischemic stroke. The feasibility of cardiac MDCT in patients with a possible embolic stroke was considered an essential tool for patient diagnosis (Orakzai et al., 2006).

The importance of MDCT over other imaging techniques is that it is fast to detect and easily manage ischemic lesions at multiple sites (Adler et al., 2018). In recent times, several features of MDCT were proved to be more efficient as compared with other imaging techniques, including non-contract FDCT, as MDCT provides high quality images in the supratentorial region, which are highly useful for the diagnosis of massive hemorrhages (Belen et al., 2022; Levy & Palacio, 2022; Zhang et al., 2023).

In view of these, the present study was performed in order to diagnose patients with ischemic stroke abnormalities at different stages by MDCT. The 110 patients were recruited and divided into two groups on the basis of onset of stroke incidences. Anterior circulation stroke was observed in 50 patients out of a total of 110, whereas 60 patients showed no evidence of brain ischemia, and were considered a non-stroke group. The cervical MDCTA was used for cardiac abnormalities in 18 patients who were included in the stroke group. In the non-stroke group, relevant and nonrelevant stenosis were found in the cervical arteries in 17 and 15 patients, respectively. These characterizations of patients were made on the basis of the high sensitivity and accuracy of MDCT imaging techniques, which have several advantages over the other imaging techniques (Adler et al., 2018; Belen et al., 2022; Garvey & Hanlon, 2002; Levy & Palacio, 2022; Zhang et al., 2023). Several studies compared the MDCT with other imaging techniques, including FDCT, after neurointerventional procedures, and the outcomes of the diagnosis revealed that MDCT had a higher susceptibility than FDCT or other techniques to detect intracerebral hemorrhage in patients with ischemic abnormalities (Maier et al., 2018). These studies provided evidence for the feasible and reliable diagnosis of ischemic changes by MDCT over FDCT in acute stroke patients (Belen et al., 2022; Maier et al., 2018).

Furthermore, Pacheco et al. considered new and vital advances in MDCT and formed their opinion on the feasibility of clinical applications of MDCT (Pacheco et al., 2015). In this study, the stenosis was discovered in 4 patients, and these were significantly distinguished from the patients in the group with no stroke history. Whereas, 32 patients were detected with only non-relevant stenosis. The presence of plaques may not cause sufficient obstruction, but they might cause cerebral infractions as aligned with their characteristics. Moreover, 10 patients were examined for non-relevant stenosis, and another 10 patients showed signs of plaque. Similar to that, 10 patients in the non-stroke group reported having vulnerable plaques. All these cardiac abnormalities were detected by MDCT, which is an essential diagnostic tool as it improved the sensitivity and reliability of the acute stroke (Pacheco et al., 2015). The diagnostic tool is non-invasive and appropriate for assessing carotid artery disease in the context of hyperacute ischemic stroke, and included in the specificity was the detection of atherosclerosis inclusion in extra and intracranial vessels. It was reported in several studies that MDCTA findings and diagnostic outcomes are closely aligned with those of digital angiography for the detection of the degree of stenosis. Therefore, it was suggested that the sensitivity of MDCTA could play an important role in the detection of angiography, and the technique also reduces the risk of the appearance of side effects. In this study, 7 patients showed an average/normal extracranial and intracranial vessels, and the images were aligned with intracranial large-artery disease (ILAD) in these 7 patients, whereas 12 patients showed cervical carotid atherosclerosis and 10 had consistent ILAD and extracranial atherosclerosis. These detections in the present study were well supported by previous studies that demonstrated a degree of cervical artery abnormalities (Garvey & Hanlon, 2002; Pacheco et al., 2015). Furthermore, this study confirmed that MDCT was also able to detect relevant stenosis on cervical carotid arteries, and mostly in patients with brain infarcts, As the 14 patients were diagnosed in this study with atherothrombosis and cardioembolic with thrombi in the intracranial system, these detections clearly showed the sensitivity and accuracy of MDCT. These findings have also been well supported by the other studies (Ledezma

& Wintermark, 2009; Mnyusiwalla et al., 2009). The findings from this study also well described the fact that extensive artery atherosclerosis was considered the significant and primary stroke subtype in the selected patient population, as it included almost 50% of the cases. The results revealed a higher prevalence of carotid atherosclerosis disease as a reason for stroke than previously stated.

The study's benefits included the employment of advanced CT techniques that are safe and have minimum invasiveness. These results have also been supported by other studies, which pointed out the usefulness of MDCT for the detection of an etiologic examination in patients with ischemic strokes (Tong et al., 2014). The data obtained from this study clearly point out that the ischemic stroke patients have benefited from the addition of MDCT to the imaging protocol as it is a reliable, fast, and less invasive tool for early detection of the basic etiologic factors. This study has few limitations, and the most obvious limitation was the moderate sample size and the fact that all patient data were collected from a single hospital. It would be better if the study should be performed on patients from various hospitals.

5. CONCLUSION AND RECOMMENDATIONS

The findings of the studies clearly indicated that AIS patients admitted with less than 6 hours of hyperacute stroke showed multiple types of ischemic lesions. The findings also concluded that the MDCT was fast, reliable, and effective in stroke detection, especially under emergency conditions. The MDCT technique is highly useful for the detection of multiple patterns of brain infarction and for the determination of the causative mechanisms in patients with acute ischemic stroke.

AVAILABILITY OF DATA AND MATERIALS

The data sets used in this study are available with corresponding author and will be provided on a reasonable request.

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This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

CONSENT

Written consents were taken from all studied subjects.

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