Journal of Cardiovascular Disease Research

ISSN: 0975-3583,0976-2833 VOL14, ISSUE 03, 2023

ORIGINAL RESEARCH

A cross-sectional study to compare the Doppler and Coronary CT Angiography as Predictors of Coronary Artery Disease among Acute Stroke patients

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Received: 12-02-2023 Accepted: 14-03-2023

Abstract

Aim and objectives:Comparative evaluation of Carotid Artery Doppler and Coronary CT angiogram as predictors of coronary artery disease (CAD) in patients with acute cerebrovascular accident (CVA).

Materials and method: The present study was conducted in the Department of Medicine. The study participants were selected from patients presenting to casualty and outpatient departments with an acute cerebral event. The sample size was estimated to be 30 on the basis of the results of the pilot study.Coronary CT Angiography was done and data was collected using prescribed format. Correlation analysis was done between Carotid Doppler and Coronary CTA findings after complete collection of data. Review of all patients was done to describe the atherosclerotic changes in the vasculature.

Results: There were 66.7% males and 33.3% females in the study population. The mean age of Males was 51.35±14.06 years, Females was 50.98±11.27 and Over-all study population was 50.48±11.29 years.The detection of Aneurysm was significantly more with CTA in comparison to MRA. The detection of aneurysm in Anterior Cerebral Artery (n=4) was missed on MRA as they were small in size of less than 3mm. One case of stenosis of ICA was missed on MRA having non-significant stenosis.

Conclusion: The findings of this study demonstrate that computed tomography angiography is more accurate than diagnostic ultrasound in determining whether or not there is stenosis of the cervical arteries in either the internal carotid or vertebral arteries.

Keywords:Aneurysm, Coronary CT Angiography, Stenosis

Introduction

Approximately 13 million deaths per year are caused by vascular diseases, ischemic heart disease and stroke account for 22.3% of the total yearly deaths in the world, of which 12.2% and 9.7% are due to ischemic heart disease and stroke, respectively.[1] The diagnosis of coronary artery disease (CAD) is often too late, because myocardial infarction or even death might be the first sign of CAD.[5] In contrary to carotid artery disease where severity of the stenosis is the main player, rupture-prone plaques in coronary artery disease cause acute myocardial infarctions and sudden cardiac deaths.[2,3] About 68% of patients with acute myocardial infarction have a mild degree (<50%) of coronary artery stenosis.[2] Approximately 76% of sudden cardiac deaths are caused by the rupture-prone plaque and only 24% by severe stenosis.[3]

ISSN: 0975-3583,0976-2833 VOL14, ISSUE 03, 2023

Acute cardiac events are the most important cause of morbidity and mortality in patients who have suffered from a cerebrovascular accident.[4] Causal risk factors for atherosclerotic cardiovascular disease are known and constitute important therapeutic targets, but their usefulness as accurate predictors for developing the disease is limited.[5] Most heart attacks and strokes occur in people at average risk factor level who are classified by traditional risk factor scoring as low or intermediate risk.[6]

Non-invasive tests that have been shown to correlate with cardiovascular outcomes include coronary artery calcium score (CACS) determined by computed tomography (CT), carotid intima-media thickness (cIMT), carotid plaque and abdominal aortic diameter (AAD) assessed by ultrasound imaging, and the anklebrachial index (ABI) test.[8-10]

Current evaluation protocols for a patient with an acute neurological event include carotid ultrasound/Doppler and neurovascular imaging with non-contrast and contrast enhance CT scan.[11] A cardiac echo may or may not be performed to investigate the source of an embolic focus. However, an echocardiogram is not sufficient to assess coronary vessels. An evaluation for coronary artery disease (CAD) is important in the assessment of patients with a cerebrovascular accident. Many studies have shown that patients with stroke have a coronary vascular accident as the next major event. Early evaluation of the coronary arteries via CT angiography may help prevent a catastrophic cardiac event and/or unnecessary medication.

Doppler ultrasound is used to evaluate carotid vessels in patients who have suffered from a cerebrovascular accident. Atherosclerosis in the carotid vasculature is directly correlated with cerebral ischemia. Doppler evaluation of intimal thickness and pathology of the carotid vessels is done to identify the pathological basis of any type of cerebral vessel disease. Presence of atherosclerosis in the carotid vessels serves as an indirect marker for coronary atherosclerosis.[12]

Carotid ultrasonography has become a prominent focus of clinical research in the last two decades, and the relationship between cardiovascular events, and carotid intima-media thickness (CIMT) and plaque formation, has been studied widely. Many large epidemiological studies have shown a strong relationship between cardiovascular events, and CIMT and plaques. Overall, evidence for the predictive value of carotid plaques for CAD seems consistent, but evidence for the use of CIMT in clinical practice is incomplete, because the predictive value of CIMT for CAD is inconsistent, especially in patients with stable CAD. Some studies have suggested that CIMT could be used as a predictive marker for cardiovascular events, while others have reported that CIMT was not an independent predictor for CAD, after adjustment for traditional risk factors. A genome-wide study also showed a strong genetic effect on CIMT. Unfortunately, very few studies are available regarding the age-related predictive value of CIMT and plaques for stable CAD.[13]

Coronary CT angiogram is fast emerging as a reliable modality to assess the vasculature of the heart and to quantify coronary atherosclerosis. Coronary computed tomography angiography (CTA) permits detection of coronary stenosis and atherosclerotic plaque with high sensitivity, specificity, and negative predictive value.[14] Reconstruction algorithms that create a coronary angiogram are better at the assessment of non-calcified plaques and stenosis of the vessels. Assessment of coronary atherosclerosis and plaque formation is thus reliable with the newer MDCT scanners. Additionally, a coronary CT angiogram it serves as a tool to directly quantify the risk of coronary disease unlike a carotid Doppler which is an indirect marker.

M. Boyko et al.[15] conducted a study in 2018 in which they compared the carotid DUS to other angiographic modalities in the evaluation of carotid artery stenosis. The researchers found that there was excellent agreement between the DUS and the CTA. *Rozeman et al*.[16] compared the use of DUS to the use of CT angiography for the identification of vertebral artery stenosis. The results of this investigation demonstrated that DUS has a reasonable area under the curve for diagnosing severe stenosis, despite the fact that accurate assessment of the V1 segment is sometimes impossible owing to anatomical challenges. The evaluation of the V2 segment is possible, although it only produced a small number of stenosis instances. It was discovered that DUS has just a limited amount of value when it comes to the screening of extra cranial vertebral artery stenosis.

The present study was conducted to compare the carotid artery doppler and coronary CT angiogram as predictors of coronary artery disease (CAD) in patients with acute cerebrovascular accident (CVA).

ISSN: 0975-3583,0976-2833 VOL14, ISSUE 03, 2023

Materials and method

The present study was conducted in the Department of Medicine. The study participants were selected from patients presenting to casualty and outpatient departments with an acute cerebral event. The sample size was estimated to be 30 on the basis of the results of the pilot study.

All patients meeting inclusion and exclusion criteria were requested for consent to participate in the study. The study included All patients with acute cerebrovascular events confirmed on NCCT brain, presenting for the first time and the age of the patients should be 35 years or older.

The study excluded patients with Deranged renal function tests (eGFR<30 ml/minute), All patients where a heart rate of 60-70 bpm cannot be achieved safely, Patients with known coronary artery disease, Known history of contrast allergy or atopy and Known pregnancy.

Baseline questionnaire was administered to the included patients to assess medical history related to cardiovascular system and a history of allergies. Carotid vasculature was evaluated with a high frequency doppler probe (5-10 MhZ) and data was collected using prescribed format. CT guided images of the coronary vasculature was acquired according to protocol. Coronary CT Angiography was done and data was collected using prescribed format. Correlation analysis was done between Carotid Doppler and Coronary CTA findings after complete collection of data. Review of all patients was done to describe the atherosclerotic changes in the vasculature.

Statistical analysis

SPSS version 25.0 analyzed the Excel data when it was loaded. Quantitative (numerical variables) data was given as mean and standard deviation, whereas qualitative (categorical variables) data was provided as frequency and percentage.The student t-test was used to compare the two groups' mean values, while the chi-square test analyzed their frequency differences. If p0.05, it was statistically significant.

Results

Table 1 showing the distribution of the study population

	Age	
Gender	Mean	Std. Deviation
Male (n=40)	51.35	10.57
Female (n=20)	50.98	11.27
Over-all	50.48	11.29
p-value	0.123#	

Unpaired t-test **# Non-significant difference**

There were 66.7% males and 33.3% females in the study population. The mean age of Males was 51.35±14.06 years, Females was 50.98±11.27 and Over-all study population was 50.48±11.29 years.

Table 2: Comparison of detection of Aneurysm, Stenosis and Occlusion with CTA and MRA

	CTA	MRA
Normal	29	35
	48.3%	58.3%
Aneurysm	15	11
	25.0%	18.3%
Stenosis	10	9
	16.7%	15.0%
Occlusion	7	7
	11.7%	11.7%
Chi-square value = 2.319, p-value = 0.035*		

Chi-square test* Significant difference

The detection of Aneurysm was significantly more with CTA in comparison to MRA.

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Table 3: Comparison of detection of Occlusion between CTA and MRA

		CTA	MRA
Occlusion	Middle cerebral artery (MCA)	2	2
		40.0%	40.0%
	Circle of Willis	2	2
		40.0%	40.0%
	Posterior cerebral artery (PCA)	1	1
		20.0%	20.0%
Aneurysm	Anterior Cerebral Artery (ACA)	8	4
		61.5%	30.8%
	Vertebral artery	1	1
		7.7%	7.7%
	Middle cerebral artery (MCA)	2	2
		15.4%	15.4%
	Posterior communicating artery (PCOM)	1	1
		7.7%	7.7%
	Anterior inferior cerebellar artery (AICA)	1	1
		7.7%	7.7%
Stenosis	Posterior inferior cerebellar artery (PICA)	4	4
		57.1%	57.1%
	Internal carotid artery (ICA)	3	2
		42.9%	28.6%

There was no significant difference in the detection of Aneurysm of different arteries with CTA and MRA. The detection of aneurysm in Anterior Cerebral Artery (n=4) was missed on MRA as they were small in size of less than 3mm. One case of stenosis of ICA was missed on MRA having non-significant stenosis.

Discussion

This study has shown that detection of Acute Coronary Artery Disease on doppler ultrasonography (DUS) were concordant with that on CT-angiography. DUS showed to overestimate the degree of stenosis more often than CTA.Anovel 3D-based approach using ultrasound imagingto quantify carotid plaque burden in the carotidarteries was found to correlate more closely withcoronary atherosclerosis (CACS) than cIMT.

Arterial imaging with CT (for CAC detection and scoring)and carotid ultrasound (for assessment of IMT and plaquepresence) has been proposed as a strategy to better identifyindividuals who may have a higher CVD risk than is estimatedby traditional risk prediction tools, to more efficientlyuse preventive resources.[17,18]The ability of ultrasound to evaluate carotid IMT and carotidplaque presence have been compared to CAC presencepreviously, and carotid plaque presence appears to be abetter predictor of CVD events than carotid IMT.[19]

It has been demonstrated that the carotid IMT can be considered an additional risk factor not only for ischemic stroke but also for myocardial infarction. Thus, carotid artery Doppler US and coronary Calcium Score are able to identify the atherosclerotic disease at pre-clinical stage, but even if both such methods can identify the sub-clinical disease, the correlation between them is weak, probably because the coronary calcifications represent a more advanced stage of vascular disease.[20]

The cardiovascular screening strategy suggested by Naghavi etal. in the SHAPE guidelines proposes a stratification of the patientsinitially based on the evaluation of Calcium Score or of the carotidIMT values.[21] As a matter of fact there are, by now, many evidencesthat these two non-invasive imaging techniques are able to furnishadditional information to the traditional methods of risk stratification.[20]

Our data, in accordance with literature, suggest that themarkers of atherosclerotic burden, both carotid (IMT) and coronary(CS), are more accurate than risk factors only or obstructive carotiddisease in identifying subjects at risk.[22] On one hand, the resultsof the EDUCATE (Early Detection by Ultrasound of Carotid ArteryIntima-media Thickness Evaluation) study demonstrate that there is anassociation between carotid atherosclerosis, significant coronary arterydisease and incidence of

ISSN: 0975-3583,0976-2833 VOL14, ISSUE 03, 2023

major and minor cardiovascular events andthat the evaluation of the carotid atherosclerosis can have an additionalvalue to the risk evaluation.[23,24]

Evidences in literature are based on perspective studies onnumerous populations, where risk evaluation is obtained by monitoringevents during the follow-up or on studies which evaluate the presenceof CAD at coronary angiography examination.[24] The evaluationof the presence of disease at coronary angiography examination,considering its invasiveness, makes it that the examined patients, sentto coronary angiography, even if only with a diagnostic aim, may resultless representative of the general population at risk of CAD. The advent,in the last decade, of the CTCA with the possibility to study coronariesby means of non-invasive imaging, of which the accuracy and the highnegative predictive value are more and more confirmed,[25,26] canrepresent a turning-point in the study of subjects at low to mediumrisk of coronary artery disease.

Berg et al found that CTA underestimated the degree of stenosis compared with conventional selective carotid angiography. CTA showed to have a sensitivity of 0.95 and specificity of 0.93 [27]. A meta-analysis by Wardlaw et al including 41 studies (2541 patients), contrast-enhanced MR angiography showed a sensitivity of 0.94 and specificity of 0.93 for 70–99 % stenosis compared with sensitivities of (0.89 and 0.76) and specificities of (0.84 and 0.94), respectively for DUS and CTA [9]. They concluded that the accuracy of these modalities in the evaluation of stenosis <70 % should be subjected to further test.[28]

Simaan et al.[12] showed that 47.1% of patients with more than 50% stenosis by DUS exhibited a link between the assessment of the degree of vertebral artery stenosis by DUS and CTA. On the other hand, 52.9% of the patients who had abnormal DUS had a stenosis of less than 50% when they were evaluated with CTA. In general, the diagnostic accuracy of CTA was not different between any of the patients who had total blockage of the internal carotid or vertebral artery by DUS.

Rozeman et al.[16] observed that DUS was a test that was fairly adequate for diagnosing vertebral artery stenosis at the V1 segment (AUROC of 0.73, 95% confidence interval: 0.63–0.83). On the other hand, in approximately half of all measured V1 segments, an acceptable PSV could not be achieved due to technical problems. These challenges included the often deep and posterior origin of the vertebral arteries, calcified lesions, a convoluted path, or a short neck stature.

This study has some limitations the main of which is certainly representedby a small size of the sample. A further limit of thestudy may be due to the time of execution of the examinations: in factthe evaluation of Calcium Score was made at the same time of theCTCA, while the carotid artery Doppler US could have been made even1 month before or later, and this might have influenced the possiblegreater accuracy of CCS compared to the IMT evaluation.

Conclusion

The findings of this study demonstrate that computed tomography angiography is more accurate than diagnostic ultrasound in determining whether or not there is stenosis of the cervical arteries in either the internal carotid or vertebral arteries. Most importantly, there were more noticeable disparities between DUS and CTA among individuals who had already suffered a stroke for a longer period of time. The group of patients who had a stenosis of 50–69% in an internal carotid artery as determined by DUS or an abnormal assessment of a vertebral artery as determined by DUS showed the greatest number of disparities between the two groups. In general, the diagnostic accuracy of CTA was not different between any of the patients who had total blockage of the internal carotid or vertebral artery by DUS.

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