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Doppler sonographic assessment of carotid arteries in Sudanese stroke patients

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Abstract:

BACKGROUND: Hypertension, diabetes, and smoking were considered to be associated with several public health problems.

OBJECTIVE: the study aims to explore the hemodynamic of carotid arteries in association with hypertension, diabetes, and smoking in Sudanese stroke patients.

MATERIALS AND METHODS: In a quantitative descriptive study, fifty patients with stroke were scanned by B-mode and Doppler sonography. Carotid arteries were investigated with a 7-MHz linear transducer by a standard carotid sonography protocol.

RESULTS: The average Doppler resistive index (RI) was 0.71 ± 0.084 and intima-media thickness was 1.39 ± 0.78 mm. The end diastolic velocities (EDVs) and peak systolic velocities (PSVs) of common carotid arteries were significantly changed in smokers and hypertensive ($P < 0.05$). The elevation of RI in right and left CCAs were significantly correlated with smokers ($P = 0.017$ and 0.010 respectively). Hemorrhagic stroke was most prevalent in hypertensive rather than diabetic and smokers. The carotid hemodynamics changed significantly in hypertensive and smokers more than diabetics.

CONCLUSION: EDV and PSV were significantly correlated with hypertension and tobacco smoking rather than diabetes. Hypertension, diabetes, and smoking have an association with stroke and hand significant effect on carotid artery hemodynamic and atherosclerotic disease. The Doppler RIs were significantly correlated with smokers. Patients with risk factors of stroke should be scanned with Doppler sonography as early as possible.

Keywords:

Assessment, carotid arteries, Doppler, sonographic, stroke, Sudanese patients

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Introduction

Cerebral stroke is a major health problem and represents a significant source of mortality and morbidity in many countries. It is the second cause of death in the world.[1] Hypertension, diabetes mellitus, atherosclerosis, and smoking were the most common risk factors. In previous studies, hypertension was the most prevalent risk factor of stroke and it is associated with plaque formation and contributes to plaque growth.[2] On the other hand, diabetes mellitus is a prominent risk factor for the first stroke in patients with ischemic stroke.[3,4] Previous studies reported that diabetes mellitus was an independent factor of recurrent stroke in the previous population-based study and accounts for 9.1% of recurrent strokes.[5-7]

In the current literature, smoking is a significant factor for ischemic stroke and risk of stroke was about twice as high for passive smokers than for nonsmokers.[8,9] Furthermore, atherosclerosis is considered a contributor factor of ischemic stroke in patients with Type 2 diabetes mellitus.

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Lee *et al*.[10] assessed intima-media thickness (IMT) of the common carotid arteries (CCAs) as a vascular risk factor in patients with ischemic stroke and they found that CCA-IMT was significantly higher in patients with diabetes and acute ischemic stroke more than in patients with diabetes who were stroke-free. In the current study, these risk factors were interfering with each other.

Doppler ultrasonography is nowadays widely used to assess carotid arteries for evaluating blood flow velocity in a cardiac cycle. Doppler parameters such as pulsatility index (PI),[11,12] resistive index (RI),[12,13] and systolic-diastolic ratio[14] were used to evaluate and classify obstructive changes and occlusive diseases of the carotids. Several studies evaluated hemodynamics of the carotid artery about smoking, diabetes, and hypertension. In smokers, the IMT significantly increased as the duration of smoking increased.[15] Diabetes and hypertension also have an apparent effect on IMT. Al-Aubin *et al*. evaluated the effect of hypertension on IMT of carotid arteries in Type 2 diabetic patients and concluded that diabetes and hypertension increase the IMT of carotid arteries independently.[16] The objective of this study was to assess the hemodynamic (RI, end diastolic velocity [EDV], and IMT of CCA and internal carotid arteries in stroke patients) and their relation to the risk factors; hypertension, diabetes, and smoking. Doppler sonography of carotid arteries was important since it provides accurate diagnosis of vascular abnormalities and stenosis which were critical to identify patients who need surgical intervention. The importance of this study is to provide clinicians with informative data on hemodynamic of carotid arteries and their relation with risk factors that help in diagnosis and management of stroke. However, to our knowledge, there were few published data regarding the Doppler assessment of carotid arteries in Sudanese stroke patients. However, we found most of the present studies evaluating the carotid arteries in diabetics.

Materials and Methods

This was a descriptive cross-sectional study conducted in Khartoum State from February 2016 to August 2016. We examined fifty Sudanese patients who were clinically diagnosed with stroke. They were admitted to Khartoum Teaching Hospital for treatment and follow-up and then referred to the Ultrasound Department to examine the carotid arteries. A detailed clinical history and thorough physical examination were maintained and written on the patients' records. Hypertension, diabetes mellitus, and smoking were documented. The exclusion criteria included patients with systematic diseases such as head injuries, cancer, congestive heart failure, myocardial infarction, and chronic renal diseases. Demographic data such as clinical history, age, gender, and smoking were collected from records of the admitted patients. Informed consent was taken from the participants.

The patients were examined with computerized tomography and magnetic before Doppler sonography and the findings were documented. Duplex Doppler sonography was done using GE and Mindray US machines with 7 MHz array transducers. The carotid arteries were scanned following the standard carotid sonography protocol. The patients were examined in supine and semi-supine position with the head slightly rotated to the opposite site. Both carotid arteries were scanned were scanned with gray-scale sonography to measure the IMT. Spectral Doppler scanning was performed to assess the RI, EDV of the CCA and Internal carotid arteries (ICAs). The velocity of blood flow was measured in the mid-CCA and proximal ICA with Doppler angle of 60°. RI values <0.70 were considered high. We compared RI values of the current study to RIs taken from Sudanese adults.[17]

Statistical analysis

Statistical analyses performed using a computing software; a Statistical Package for Social Sciences (Version 16, SPSS, Chicago, Illinois, USA). Test of normality was done to check homogeneity of continuous variables (age, RI, EDV). Data were presented in mean ± standard deviation for descriptive statistics. Spearman's correlation was applied to find correlation of hypertension and diabetes with EDV of left CCA (LCCA) and right CCA (RCCA). Student's *t*-test was used to compare mean values of RI, IMT, and EDV normal values in the previous studies conducted in Sudanese. $P < 0.05$ was considered statistically significant.

Results

Among the fifty patients, 31 patients (62%) were males and 19 (38%) were females. Of the fifty patients studied, 43 (86%) patients had ischemic stroke and 7 (14%) patients had hemorrhagic stroke. Mean age of the participants was 74 ± 13 years. Frequency of stenosis is summarized as shown in Table 1. Table 2 summarizes the average value of RI in carotid arteries RI in the participants. The highest value of RI observed in LCCA (0.74 ± 0.084) than the RCCA (0.72 ± 0.096). Table 3 summarizes the measurements of carotid IMT. The measurements were 1.11 ± 0.40 mm and 1.17 ± 0.50 mm for right and left CCAs, respectively. And measurement of left and right ICAs were 0.96±0.33 and 1.07±0.53 mm respectively. They were significantly higher standard published value in Sudanese (07 mm), $P = 0.00$. The measurement of IMT of right and left ICA were 0.70 ± 0.090 mm and 0.70 ± 0.080 mm, respectively, and they were significantly high ($P = 0.00$). Table 4 shows correlations of hypertensive, diabetic, and smokers with

CCA EDV in the participants. Hypertension and smoking had a negative correlation with EDV of LCCA, R^2= –0.28 and 0.56, respectively. Hypertension and smoking caused a significant decrease of EDV of carotid arteries, P = 0.04 and 0.00, respectively. However, the impact of smoking is high. Table 5 summarizes correlations of peak systolic velocity (PSV) in carotid arteries with tobacco smoking, hypertension, and diabetes. Significant negative correlations were found between PSV and hypertension and smoking (P = 0.003 and 0.00, respectively). However, no significant correlation of PSV with diabetes mellitus (P = 0.577). In Table 6, we observed that the RI is significantly correlated with tobacco smoking (P = 0.017). In general, these findings indicate that hypertension and smoking have more significant effect on carotid hemodynamic than diabetes.

The regions of the stroke are demonstrated in table 7. A 60% of the stroke affects the temporoparietal region of

Table 1: Characteristics of the study variables

Characteristics	Frequency (%)
Age (years), mean±SD	74.1±13.43
Male	31 (62)
Female	19 (38)
Type of stroke	
Ischemic	43 (86)
Hemorrhagic	7 (14)
Stenosis in right CCA	6 (12)
Stenosis in left CCA	4 (8)
Stenosis in internal right ICA	6 (12)
Stenosis in left ICA	7 (14)

SD: Standard deviation, CCA:Common carotid arteries, ICAs: Internal carotid arteries

Table 2: The mean values of resistive index, end diastolic velocities, and peak systolic velocities of carotid arteries in the participants

Parameters	Right	Left
RI CCA	0.72±0.096	0.73±0.084
RI ICA	0.70±0.090	0.70±0.080
EDV CCA (cm/s)	20.92±7.93	20.88±7.77
EDV ICA (cm/s)	16.92±03.68	17.44±3.79
PSV CCA (cm/s)	67.47	68.32
PSV ICA (cm/s)	58.32	51.24

RI: Resistive index, EDVs: End diastolic velocities, PSVs: Peak systolic velocities, CCAs: Common carotid arteries, ICAs: Internal carotid arteries

Table 3: Measurements of intima-media thickness of common and internal carotid arteries in stroke patients

Parameters	Right (mm)	Left (mm)
IMT CCA	1.11±0.40	1.17±0.50
IMT ICA	0.96±0.33	1.07±0.53

IMT: Intima-media thickness, CCAs: Common carotid arteries, ICAs: Internal carotid arteries

Table 4: Correlations of hypertension, diabetes, and smoking with end diastolic velocities of common carotid arteries in stroke patients

Risk factors	EDV right CCA	EDV left CCA
Hypertensive		
Correlation	–0.280	–0.234
P	0.049	0.102
Diabetic		
Correlation	–0.024	–0.172
P	0.870	0.233
Smokers		
Correlation	–0.585	–0.345
P	0.00	0.014

EDVs: End diastolic velocities, CCAs: Common carotid arteries

Table 5: Correlations of hypertension, diabetes, and smoking with peak systolic velocities of common carotid arteries in stroke patients

Risk factors	PSV right CCA	PSV left CCA
Hypertensive		
Correlation	–0.413**	–0.358*
P	0.003	0.011
Diabetic		
Correlation	–0.081	–0.246
P	0.577	0.085
Smokers		
Correlation	–0.517**	–0.336*
P	0.00	0.017

PSVs: Peak systolic velocities, CCAs: Common carotid arteries. **Correlation is significant at the 0.01 level (2-tailed), *Correlation is significant at the 0.05 level (2-tailed)

Table 6: Correlations of hypertension, diabetes, and smoking with resistive index in stroke patients

Risk factors	RI right CCA	RI left CCA
Hypertensive		
Correlation	–0.049	–0.005
P	0.733	0.974
Diabetic		
Correlation	–0.088	–0.114
P	0.545	0.432
Smokers		
Correlation	0.335*	0.361*
P	0.017	0.010

RI: Resistive index, CCAs: Common carotid arteries. *Correlation is significant at the 0.05 level (2-tailed)

Table 7: Distribution of regions of stroke in the brain

Brain regions	Frequency (%)
Temporoparietal	30 (60.0)
Temporal	4 (8.0)
Parietal	3 (6.0)
Thalamic	7 (14.0)
Capsuler	3 (6.0)
Other	3 (6.0)
Total	50 (100.0)

the brain, 14% in the thalamic region. The other regions were less frequent. The types of stroke (ischemic and hemorrhagic) were compared to hypertension, diabetes, and smoking as shown in Figures 1-3. It was observed that hemorrhagic stroke mainly occurred in hypertensive rather than diabetic and smokers. Figure 4 and figure 5 were sonograms of patients with stroke demonstrating Doppler analysis of left ICA and left CCA respectively.

Discussion

Ultrasonography has been widely used for evaluation of cerebrovascular diseases. For carotid arteries, ultrasound is the initial diagnostic modality as it is safe, accurate, and relatively inexpensive, can be obtained at the bedside, and accurately depicts vascular abnormalities and complications. The study highlighted the role of Doppler sonography in ischemic and hemorrhagic stroke. However, the association of hemodynamics of carotid arteries in Sudanese stroke patients with diabetes, hypertension, and smoking was not clearly studied. Therefore, we have measured the RI and IMT of the carotid arteries, beside EDV and PSV of CCA and ICA in stroke Sudanese patients and to evaluate their association with diabetes, hypertension, and smoking.

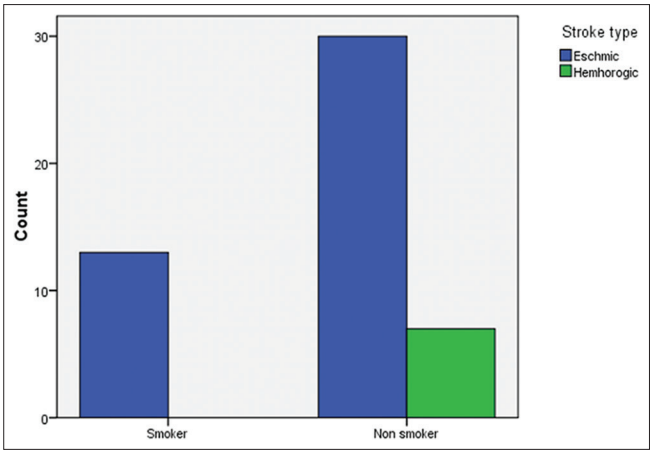

Figure 1: Graph comparing ischemic and hemorrhagic stroke in smokers and nonsmokers

Our data regarding the mean EDV flow velocities in the carotid arteries are consistent with previously published results.[18] However, the RI was significantly increased when compared to the normal values in Sudanese adults.[19] In a previous study, there was a clear correlation between elevated RI and atherosclerosis and clinical outcome.[20] These findings supported that RI is an important hemodynamic parameter and a predictive marker of stroke.

In the study, we observed significant correlation of PSV in the carotid arteries with hypertension and tobacco smoking. This finding agreed with Haq *et al*., who reported a significant correlation of PSV with hypertension.[21] In general, both EDV and PSV were significantly associated with hypertensive and tobacco smokers more than diabetics. This supported that hypertension and smoking were risky more than diabetes mellitus for cerebral stroke. However, Haq *et al*. found that hypertension and diabetes were the most prevalent risk factors for cerebral ischemic stroke.[21]

The study found association of carotid hemodynamics with IMT, diabetes, hypertension, and tobacco use in stroke participants. These data agreed with Sidhartha Das *et al*.,[22] whose results based on sonographic

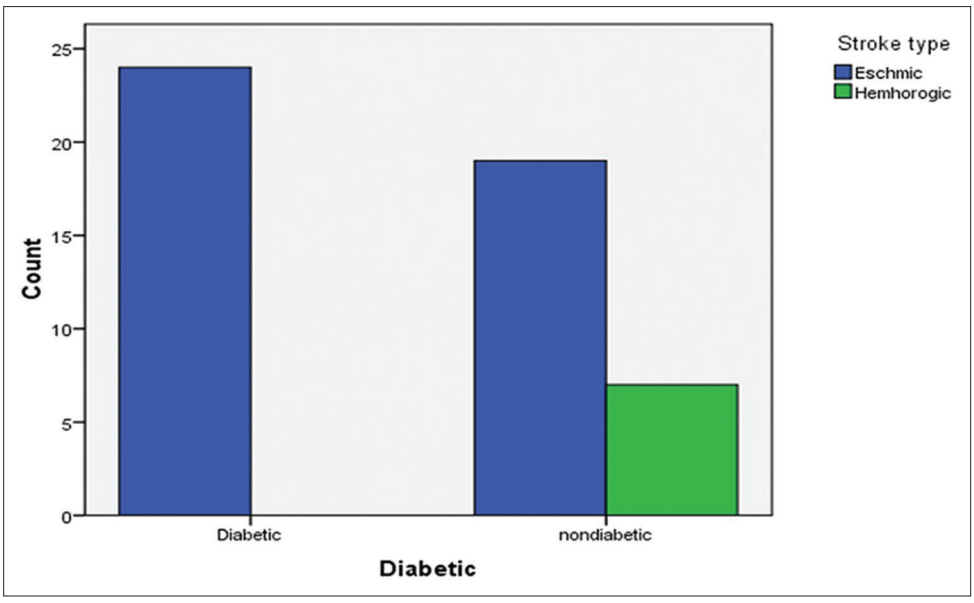

Figure 2: Graph comparing ischemic and hemorrhagic stroke in diabetic and nondiabetic

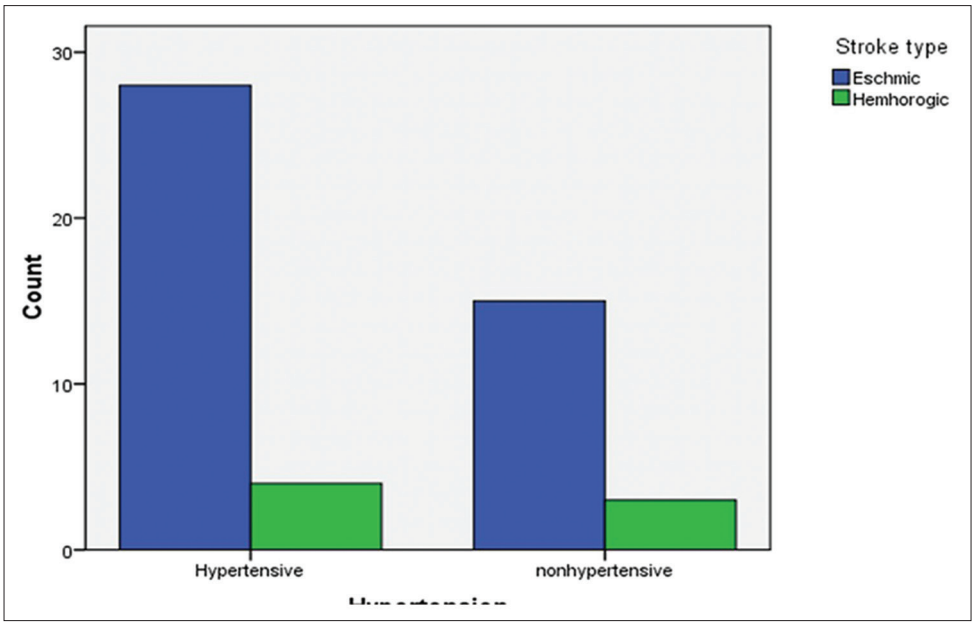

Figure 3: Graph comparing ischemic and hemorrhagic stroke in hypertensive and nonhypertensive

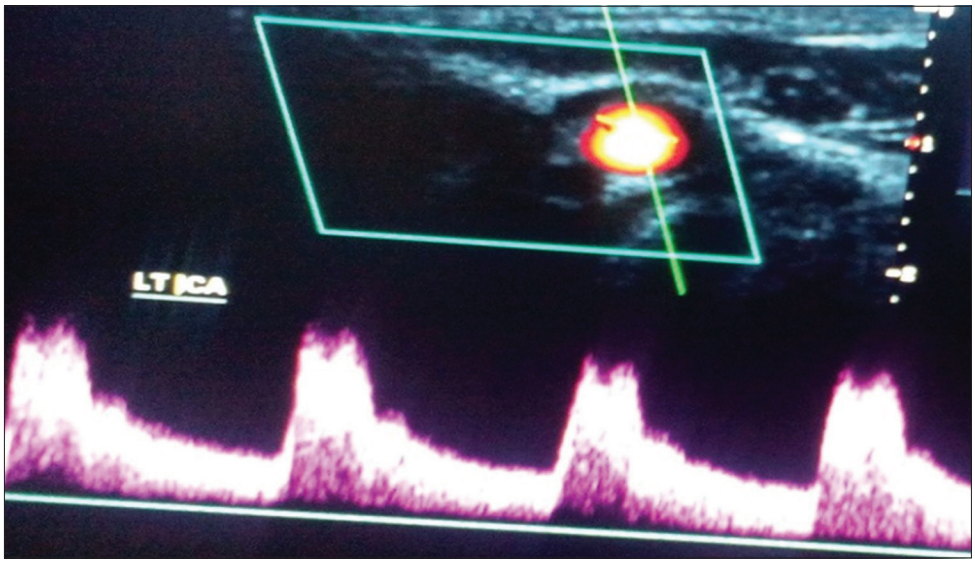

Figure 4: Spectral analysis of the right internal carotid artery of an 80-year-old male with stroke and stenosis of left internal carotid artery

measurements and suggested that there was significant association ($P > 0.05$) between stroke and values of IMT, PI, and RI in diabetics, hypertensive, and smokers. This current study proposed that hypertension was associated with both types of stroke (ischemic and hemorrhagic). The study found RI was positively correlated with smokers more than hypertensive and diabetics.

This study also showed that the EDV of CCA was associated significantly with smoking and hypertension more than diabetic in stroke participants. These findings strongly agree with those of Agunloye *et al*.,[23] which proposed that among hypertensive patients, the CCA diameter and EDV are significantly associated with stroke risk, $P > 0.05$.

Moreover, this current study suggested that the three risk factors (diabetes, hypertension, and smoking) were strongly associated with increased IMT <0.9 mm in the stroke participants. These findings are consistent with Kazmierski.,[24] who studied the sonographic measurements of IMT in carotid arteries for stroke groups. He suggested that wall thickening has a significant association with stroke occurrence and the prominent association was with smoking (63% of the participants) and hypertension (59% of the participants), $P > 0.00$.

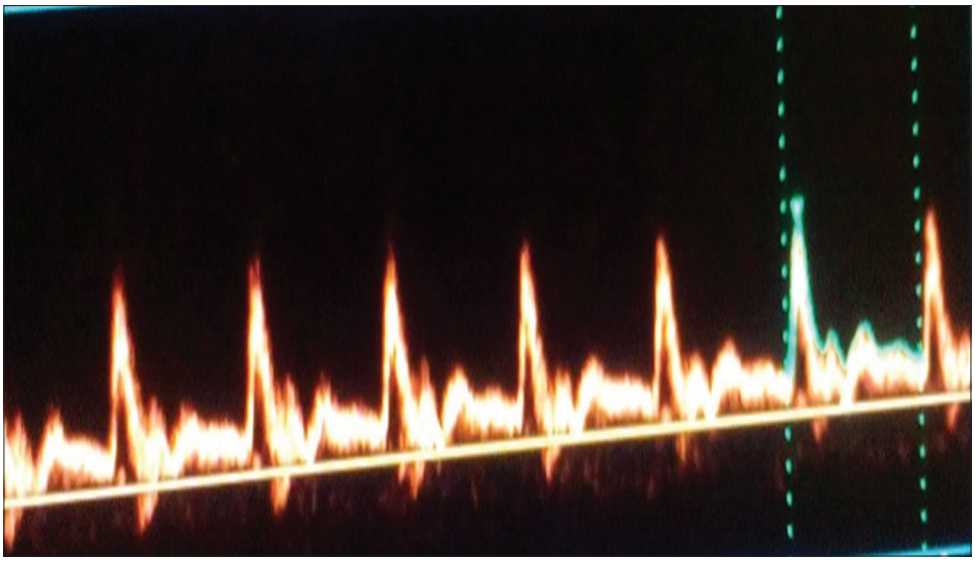

Figure 5: Doppler analysis of left common carotid arteries of an 80-year-old female known diabetic and hypertensive for 20 years having left side capsular small ischemic stroke resistive index = 0.78

Although all findings of this study showed a strong association between diabetes, hypertension, and smoking with stroke, our study faced great limitations. The sample size was small and there were no available reference values of RI, EDV, and IMT in Sudanese adults. Further studies with suitable sample size were recommended to confirm the initial results.

Conclusion

Our findings revealed that RI and IMT were significantly increased in stroke patients. Hypertension, diabetes, and smoking have an association with stroke. They have a significant effect on carotid artery hemodynamics and atherosclerotic disease. Hypertension and smoking were the most prevalent risk factors for cerebral stroke. Indeed, hypertension is mainly associated with hemorrhagic stroke.

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Conflicts of interest
There are no conflicts of interest.

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