

Contribution of Doppler Ultrasound of the Supra-Aortic and Transcranial Trunks in the Lesion Diagnosis of Ischemic Stroke at the Dogta-Lafiè Reference Hospital in Lomé (HDL) and the Kara University Hospital

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Abstract

Objective: Describe the contribution of Doppler ultrasonography of the cervical and encephalic arteries in the lesion diagnosis of ischemic strokes. **Materials and Methods:** This was a prospective descriptive and analytical study carried out from August 2022 to August 2024 (2 years) in the Doppler ultrasound room in the cardiology departments of Dogta-Lafiè Hospital in Lomé and Kara University Hospital. All patients who underwent Doppler ultrasonography of the cervical and encephalic arteries for ischemic stroke during the study period were included. **Results:** We selected 110 Doppler ultrasound scans for ischemic stroke. The mean age was 62.1 ± 12.6 years. The M/F sex ratio was 1.4. Cardiovascular risk factors included hypertension (40%), dyslipidemia (42.8%), diabetes (14.5%) and a history of ischemic stroke (09.1%). Doppler ultrasonography was normal in 22 patients, and significant lesions were present in 88 patients (80%). Significant stenoses were found in 60 patients (55%) and occlusions in 28 (25%). These lesions were intracranial (40.9%), extracranial (59.1%), or mixed (19.3%). Significant stenoses and occlusions involved the carotid system in 78.6% and the vertebrobasilar system in 21.4%. In the cervical region, bulbar carotid and post-bulbar stenoses accounted for 61.5%. In the encephalic region, stenoses of the middle and posterior cerebral arteries

accounted for 61.1% and 30.5% of lesions respectively. Transcranial Doppler ultrasound revealed 23.9% (21 patients) of intracranial lesions in patients with normal Doppler at the cervical level. Diabetes increases the likelihood of stenosing lesions, while hypertension favours occlusive lesions. **Conclusion:** arterial lesions in ischemic stroke are intracranial, and extracranial, hence the need to couple transcranial Doppler with Doppler ultrasound of cervical vessels.

Keywords

Ischemic Stroke, Doppler Ultrasound, Supraaortic Arteries, Transcranial, Togo

1. Introduction

Stroke affects more than 16 million people every year, and is responsible for around 5.7 million deaths worldwide [1]. Stroke is the second leading cause of death and the third leading cause of disability worldwide [2]. In sub-Saharan Africa, stroke is the leading cause of hospitalization in neurology departments, with hospitalization rates ranging from 43.5% to 49.4%, and ischemic strokes are the most frequent [3] [4]. This is a medical emergency requiring rapid diagnosis of the lesion and its etiology, with a view to appropriate management. Among the many paraclinical tools available to explore this ischemic stroke, Doppler ultrasonography is a painless, non-invasive, non-irradiating, inexpensive, reproducible examination that can be performed at the patient's bedside [5] [6].

Doppler ultrasonography (DUS) of the cervical and encephalic arteries is a vital examination in our resource-limited countries, where MRI, angio-MRI and even CT scans are not widely available and inaccessible to patients. The main aim of this study was to describe the contribution of Doppler ultrasonography of the cervical and encephalic arteries to the diagnosis of stroke lesions. The specific objectives were to describe the sociodemographic characteristics of the patients, to describe the vascular lesions encountered in ischemic stroke on Doppler ultrasound of the cervical and encephalic arteries, to contrast the lesions of the cervical and encephalic arteries, and to investigate the statistical relationships between cardiovascular risk factors and lesions on Doppler ultrasound of the cervical and encephalic arteries.

2. Methods and Equipment

The Doppler ultrasound rooms in the cardiology departments of Dogta-Lafiè Hospital in Lomé and Kara University Hospital provided the setting for our study. This was a prospective study with descriptive and analytical aims.

Data collection took place from August 2022 to August 2024 (2 years). We included in our study all patients with ischemic stroke who had undergone Doppler ultrasound of the cervical and encephalic arteries in these health facilities. Stroke should be confirmed on cerebral CT. Patients referred for stroke in whom we did

not have a reliable acoustic window on transcranial Doppler were not included in this study. Patients and accompanying persons were invited to complete a questionnaire to supplement the clinical information. A team of two interviewers (one in Lomé and one in Kara) was responsible for data collection. Medical confidentiality and patient anonymity were respected. All data were initially collected on a pre-established, standardized survey form and subsequently entered into the Epi Info 7 software.

Data were analyzed using Microsoft's EXCEL 2016 office spreadsheet program and Rstudio software version 4.1.0. We performed a descriptive and then an analytical analysis. The statistical test used was Pearson's Chi-square test. The significance threshold was set at 0.05. Qualitative variables were presented in terms of their respective numbers and frequencies, while quantitative variables were presented in terms of mean, standard deviation and extremes.

For each patient in our study, the following parameters were recorded: socio-demographic data (age, sex); cardiovascular risk factors (diabetes, hypertension, smoking, dyslipidemia, previous stroke); results of echo-Doppler of the cervical and encephalic arteries; lipid profile (total cholesterol, HDL-cholesterol, HDL-cholesterol and triglycerides). We were interested in significant stenoses and occlusions. We selected significant stenoses greater than 50%. We used the NASCET criteria for bulbous stenoses and velocity ratios for other stenoses [7].

Occlusions were defined by two-dimensional visualization of total obstruction of the artery, associated with upstream "thrust" flow, and absence of pulsed and color Doppler flow in the artery [8].

3. Results

3.1. Socio-Demographic Data

During the study period, 110 patients were selected according to our inclusion criteria in the study centers. Of the 110 patients, 51 were from CHU-Kara (46.4%) and 59 from Hôpital Dogta-Lafîè (53.6%). The age of the patients included in our study ranged from 28 to 85 years, with an average of 62.1 ± 12.6 years. The most common age group was 55 to 65 (39.5%). The sex ratio M/F was 1.4.

3.2. Cardiovascular Risk Factors

Forty-nine (40.9%) patients had at least one major cardiovascular risk factor. In isolation, hypertension was present in 44 patients (40%) and diabetes in eight (14.5%). Thirty-eight (34.5%) patients had elevated total cholesterol levels (above 2 g/L), including 81.8% with LDL-cholesterol levels above 1.5 g/L. Eight patients (21.5%) had low HDL cholesterol (<0.35 g/L). Eighteen patients (16.4%) had a history of ischemic stroke. There were no smoking patients in our series. Thirty-four (30.9%) patients had at least two major cardiovascular risk factors.

3.3. Ultrasound Data

Vascular lesions on Doppler ultrasonography of the cervical and encephalic arteries

were present in 88 patients, or 80% of ischemic stroke cases. Significant stenoses were found in 60 patients (55%) and occlusions in 28 patients (25%) on all echodopplers. The lesions were tight stenoses (80.9%) and occlusions (19.1%) on atheromatous plaques or post-dissection. **Figure 1** and **Figure 2** show examples, on the one hand of carotid stenosis by atheromatous plaque and on the other hand an occlusion by thrombus on a carotid dissection.

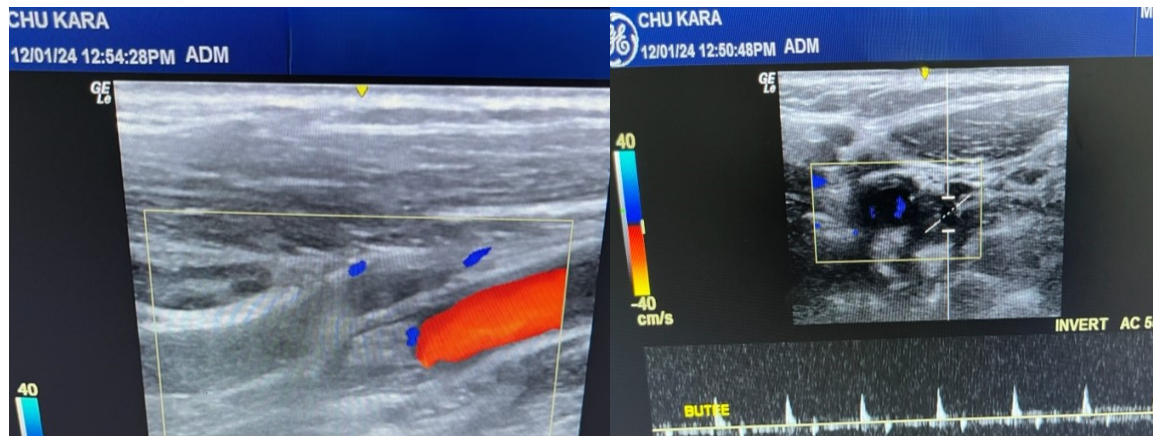


Figure 1. Dissection of the left internal carotid artery with occlusive thrombus in a patient at Kara University Hospital.

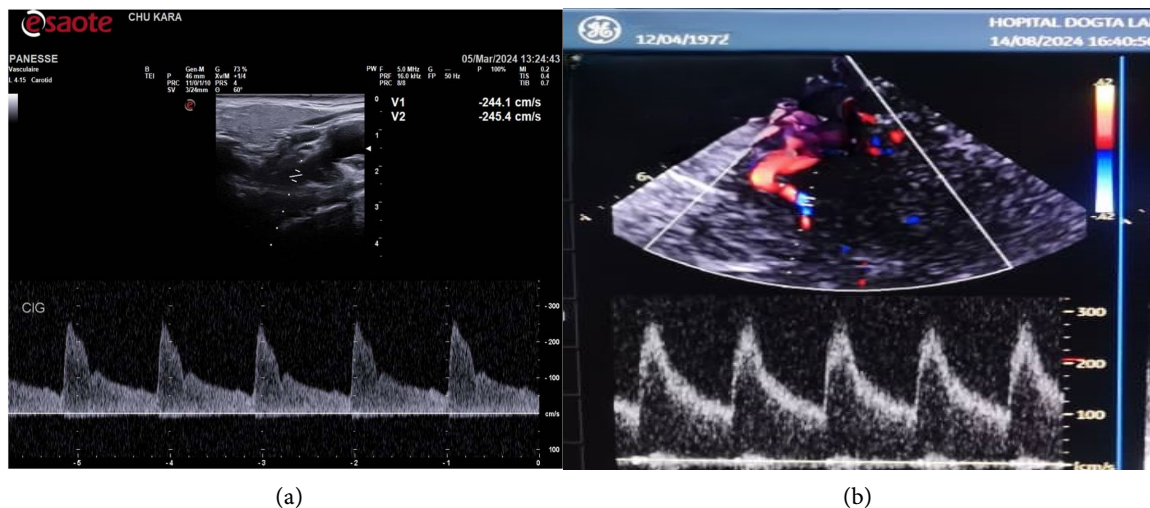


Figure 2. (a) Stenosis of the left internal carotid artery on bulbar plaque at CHU Kara; (b) Tight stenosis of the right middle cerebral artery in a patient at Dogta-Lafiè Hospital.

3.4. Lesion Laterality, Arterial Axes Affected and Lesion Types on Doppler Ultrasound

Ultrasound lesions were right (35%), left (23%) and bilateral (42%). In isolation, lesions were located cervically in 52 patients (59.1%), intracranially in 36 patients (40.9%) and both cervically and intracranially in 18%. The carotid bulb accounted for 38.7% of lesion sites and the middle cerebral arteries for 26.1% (**Table 1**). Significant stenoses and occlusions involved the carotid system in 78.6% and the vertebral-basilar system in 21.4%. In the cervical region, bulbar carotid and post-

bulbar stenoses accounted for 61.5%. In the encephalic region, stenoses of the middle and posterior cerebral arteries accounted for 61.1% and 30.5% of lesions respectively (Table 2). In this study, hypertension was significantly associated with the occurrence of occlusion. There was also a significant association between diabetes, dyslipidemia and the occurrence of stenosis (Table 3).

Table 1. Distribution of patients according to lesion location.

	Number	%
Cervical stage	52	59.1
Carotid bulb	34	38.7
Carotid post-bulbar	8	9.1
Common carotid	4	4.5
Vertebral arteries	6	6.8
Encephalic	36	40.9
ACM	23	26.1
ACP	11	12.5
Vertebrals + TB	02	2.3

ACM Middle cerebral arteries ACP Posterior cerebral arteries TB Basial trunk.

Table 2. Distribution of patients according to significant lesions on Doppler ultrasound of the supra-aortic and transcranial trunks.

	Number	%
Cervical stage		
Bulbar carotid and post-bulbar stenosis	32	61.5
Bulbar and post-bulbar occlusions	09	17.3
Common carotid artery stenosis	04	07.7
Vertebral artery stenosis	07	13.5
Encephalic stage		
ACM stenosis	22	61.1
ACP stenosis	11	30.5
Basilar trunk stenosis	03	08.4
Cervical + encephalic layer	17	19.3
Normal cervical stage and encephalic lesions present	21	23.9

ACM Middle cerebral arteries ACP Posterior cerebral arteries.

Table 3. Distribution of patients according to echodoppler lesions and risk factors.

	OCCLUSION		
	n (N = 28)	n/N	p-value
Hypertension	18	64.3	0.032
Diabetes	6	21.4	0.074

Continued

HypercholesterolemiaTotale	12	42.8	0.0423
HyperLDL	4	14.3	0.064
Antecedent of ischemic stroke	4	14.3	0.068
STENOSIS			
	n (N = 28)	n/N	p-value
HTA	26	43.3	0.052
Diabetes	10	16.7	0.001
HypercholesterolemiaTotale	28	46.7	0.0041
HyperLDL	18	30.0	0.0029
Antecedent of ischemic stroke	6	10	0.0960

4. Discussion

Stroke patients should be rapidly evaluated with tests exploring extracranial and intracranial circulation. The choice of tests reflects the vascular imaging resources and expertise available in the institution. Other medical conditions, such as the presence of a pacemaker or renal failure, also influence the choice of tests. Cost-effectiveness studies have shown that Doppler ultrasonography of the cervical and encephalic arteries is the test of choice for selecting patients requiring endarterectomy [6]. Despite the widespread availability of non-invasive vascular imaging, patients are often under-investigated [5]. The low level of lesion investigation of AVCI in Togo is due partly to the limited availability of the necessary material and human resources, and partly to the poor socio-economic conditions of the population [9].

4.1. Socio-Demographic Data

Ischemic stroke in our study involved patients with an average age of 62.1 ± 12.6 years. This average age is similar to that reported in 2015 by Belo in Togo 2015 (60.3 ± 12.8 years) [3] and Mboup in Senegal (63.4 ± 15.8 years) [10]. In developed countries, on the other hand, DALYs occur 10 years later with a mean age of 73.7 ± 2 years and 73 years [11].

This disparity seems to be linked to the higher life expectancy in industrialized countries, on the one hand, and the early detection of cardiovascular risk factors and their early and appropriate management, on the other.

In our study, men predominated, with a sex ratio M/F of 1.4. Belo and Goeh-Akoue in Lomé [3] [12], Baldé [13] in Conakry 2018 had made the same observation. We can note that ischemic strokes affect men more than women on the African continent.

The ischemic stroke is favored by certain cardiovascular risk factors. The four predominant cardiovascular risk factors in our study were arterial hypertension (40%), dyslipidemia (34.5%), diabetes (14.5%) and a history of stroke (9.1%). Belo in 2015 in a study in Lomé reported hypertension as the main risk factor (86.6%),

followed by total hypercholesterolemia (54.3%) and diabetes in 10.8% of cases [3]. Similar findings have been reported in Guinea and Morocco [13] [14]. A history of ischemic stroke was found in 9.1% of patients, as in Morocco 9.2% [14] and Guinea [13], confirming that a history of ischemic stroke constitutes a high risk of ischemic stroke recurrence. The absence of a precise lesion search for ischemic stroke, as well as the lack of adequate management of these lesions, would be sources of ischemic stroke recurrence.

4.2. Ultrasound Data

Doppler ultrasonography of the cervical and encephalic arteries in our patients revealed vascular lesions in 80% of cases. The carotid system was three times more affected in this study. According to Rénou, lesions of the supra-aortic trunks involved the carotid territory in eight out of two cases, compared with the vertebro-basilar territory [15]. The anatomy of the bulbar portion of the carotid artery may explain this peculiarity.

In our study, transcranial Doppler ultrasound revealed lesions, whereas Doppler ultrasound of the cervical vessels was normal in 21 patients (23.9% of cases). These results show the importance of coupling transcranial Doppler with Doppler ultrasound of the cervical arteries in the etiological diagnosis of AVCI. In addition, the effects of lesions in the cervical arteries are also felt in the brain, and it is essential to assess their importance both for initial treatment and for follow-up.

It is also essential to assess the completeness of the polygon of Willis, and the quality of bypass conduits such as the anterior and posterior communicantes in the event of significant stenosis or upstream occlusion. Today, Doppler ultrasonography of the cervical arteries without transcranial Doppler at the encephalic level is inconceivable. Moreover, Purroy reported that a patient with moderate to severe intracranial or extracranial stenosis on Doppler ultrasonography of the cervical vessels had a threefold increased risk of ischemic stroke [16]. Doppler ultrasonography of the supra-aortic trunks (TSA) of the cervical and encephalic arteries could thus be used not only as a means of exploring the etiology and lesions of ischemic stroke, but also as a means of monitoring patients with risk factors for ischemic stroke, and as a prognostic tool for patients who have already suffered a ischemic stroke. For our part, the essential thing would be to detect these plaques, monitor them, especially in high-risk patients, and offer them endoluminal or surgical treatment before a genuine ischemic stroke occurs. This decision can only be taken with the help of hemodynamic data on lesions and, above all, on downstream intracranial lesions. Hence, once again, the need to couple transcranial Doppler with Doppler ultrasound of the cervical arteries.

4.3. Relationship between Cardiovascular Risk Factors and Supra-Aortic Trunk Doppler Lesions

In our study, hypertension, dyslipidemia and diabetes were associated with the existence of vascular lesions on Doppler ultrasound. Debette *et al.* in 2011 reported

an association between hypertension and the presence of vascular lesions in patients with ischemic stroke (odds ratio = 1.67; 95% confidence interval = 1.32 to 2.1; $p < 0.0001$) [17]. An association between hypertension and the occurrence of occlusive dissection was demonstrated in this study. Similarly, an association between diabetes and the occurrence of stenosis was demonstrated, with $p = 0.009$. Other authors such as Goeh-Akue, Baldé and Belo have made similar findings [11] [13] [18]. There is every reason to believe that diabetes is more conducive to stenoses, while hypertension is more likely to cause occlusions. Dyslipidemia has been associated with both stenosis and occlusion. This shows how often it is necessary to be aggressive in terms of diet and medication for dyslipidemia, while following and respecting recommendations for patients according to their risk level.

Follow-up of patients at high cardiovascular risk should therefore systematically include supra aortic trunk Doppler ultrasonography. The frequency of Doppler ultrasonography of supraaortic trunk may be quarterly, semi-annually or annually, depending on the level of risk and, above all, on the results of the first supra aortic ultrasonography.

5. Conclusion

Ischemic stroke is a major public health issue in Africa, affecting a younger, male population. Doppler ultrasonography of the cervical and encephalic arteries is an important tool in the search for lesions in ischemic stroke, and represents the first-line examination that is painless, reproducible, non-invasive and least expensive. Ultrasound lesions predominate in the carotid system. The main lesions found in our study were stenosing atherosclerotic plaques and occlusions. These lesions are intra- or extra-cranial, justifying the interest of transcranial Doppler and the need to combine it with echodoppler of the cervical vessels in the lesion diagnosis of ischemic strokes. Risk factors for ischemic stroke with significant lesions of the supra-aortic and intracranial trunks were dominated by hypertension, diabetes, dyslipidemia and a history of ischemic stroke. Diabetes increased the probability of stenosing lesions, while hypertension favoured occlusive lesions. Dyslipidemia promotes both stenosis and occlusion. Prevention of ischemic stroke in at-risk patients requires good control of cardiovascular risk factors and systematic screening, as well as regular follow-up with Doppler ultrasound of the cervical and encephalic arteries.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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