Original Article

Evaluation of Cerebral Hemodynamics and its Impact on Cognitive Screening Test in SLE Patients

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ABSTRACT

Background: Systemic lupus erythematosus (SLE) is an inflammatory autoimmune disease targets the vascular system resulting in vasculitis, vasculopathy, and premature atherosclerosis. Vascular affection is one of the proposed pathogenic mechanisms for neuropsychiatric lupus. **Objective:** The purpose of this study was to measure the total cerebral blood flow volume (TCBFV) in patients with SLE using Doppler ultrasonography and to determine whether a relationship exists between cerebral perfusion changes with disease activity and cognitive screening tests. **Subjects and Methods:** This study was conducted on twenty-one SLE female patients diagnosed according to the modified American College of Rheumatology revised criteria of SLE. Ten age-matched female volunteers served as the control group. All subjects were assessed using Modified Mini-Mental State as a neuropsychological screening test. Cerebral blood flow was assessed by extra- cranial Doppler ultrasonography to calculate TCBFV. **Results:** TCBFV was lower in patients' than in the control group but not statistically significant. A significant lower CBFV in Left Internal Carotid Artery in patients' group compared to the control group (p 0.05). The cerebral perfusion was significantly lower in patients with active disease (p 0.01). There was no statistically significant difference between patients with neuropsychiatric lupus (NPSLE) compared to Non NPSLE or between patients with antiphospholipid syndrome (APS) and without APS; regarding their TCBV. SLE patients had subcortical pattern of cognitive impairment. **Conclusion:** Using ultrasound for measuring TCBFV cannot detect evident cerebral hypoperfusion. However, lower TCBFV in SLE patients is associated with more disease activity, but not related to the cognitive dysfunction. **[Egypt J Neurol Psychiat Neurosurg. 2013; 50(3): 213-220]**

Key Words: Systemic Lupus Erythematosus, Doppler ultrasonography, Cerebral blood flow volume, cognitive screening test, SLEDAI.

INTRODUCTION

Systemic lupus erythematosus (SLE) is an autoimmune disease affecting the vascular system produces several vascular manifestations, such as, vasculitis, vasculopathy, and premature atherosclerosis[1].

Also Patients with SLE often have cognitive complaints that are not specific to one brain region or cognitive domain, and in the majority of patients' cognitive dysfunction are subclinical[2] which may manifest with impaired social function and work disability[3,4].

Neuropsychiatric systemic lupus erythematosus (NPSLE) is a diagnostically challenging, severe, and life-threatening condition, which is currently lacking a"gold standard."[5].

It has been reported that SLE patients may suffer from regional or general abnormal cortical blood flow[6] even in the absence of neurological symptoms[7]. The quantitative measurement of CBFV is possible by different noninvasive methods such as stable xenon-enhanced CT, single-photon emission CT, positron-emission tomography, and MR imaging technology. These have proved to achieve reliable and accurate measurements of CBFV. All of these techniques, however, are bulky and expensive. Previous in vitro and in vivo studies have demonstrated a close correlation between phase contrast MR imaging and Doppler require ultrasound (US)[8]. Doppler sonography is suggested to be a potentially practical method for the measurement of CBFV in the internal carotid artery (ICA) and vertebral artery (VA) as an estimate for cerebral blood flow[9]. However imaging with sonography has showed an overestimation of BFV, but being applied up till now as it is practically applicable and widely available in comparison with other procedures[10]. This study aimed to measure the TCBFV in patients with SLE using Doppler ultrasonography and to determine whether a relationship exists between cerebral perfusion changes with disease activity and cognitive screening tests.

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SUBJECTS AND METHODS

After approval of the study by the Ethics Committee of the Kasr Al-Aini Hospital, Cairo university and after obtaining informed consent, this comparative cross-sectional study was performed.

Subjects

Twenty-one SLE female patients with mean age of 28.24±8.92 years & duration of illness of 4.48±3.92 years were included in this study and all fulfilled the 1997 American College of Rheumatology (ACR) criteria for SLE[11]. Nine of them manifested with neuropsychiatric Lupus during the course of the disease.

Ten healthy volunteer subjects matched by age, sex and educational level were taken. The patients were recruited from the Rheumatology and Internal medicine departments, Kasr El Aini University Hospital.

Secondary Antiphospholipid syndrome (APS) was diagnosed in ten SLE patients according to the Miyakis et al. criteria[12]. Disease activity was quantified using the SLE Disease Activity Index (SLEDAI)[13].

Methods

All subjects underwent the following

1. Cognitive screening: using The Modified Mini-Mental State (3MS) its maximum score was100 points[14].
2. Extracranial Doppler ultrasonography: were performed at Kasr El Aini neurology department neurovascular ultrasonographic laboratory, by a 7MHZ probe Phillips HDI 5000 ultrasound equipment. CBF volume was determined as the sum of the flow volumes of ICA and the VA of both sides (Figure 1 a and b).

It was calculated as following

Total CBFV (both ICA + Both VA) ml/min= RT CBFV + LT CBFV

Data management and analysis:

Statistical package for social science (SPSS) version 12 was used for data management and analysis. Descriptive analyses were conducted using frequencies and percentage for qualitative variables, and mean and standard deviation for quantitative variables. To test the significance of difference between quantitative variables not normally distributed, Mann Whitney test was used. Chi square test was used to compare qualitative variables. Spearman correlation was performed to study the relation between numerical variable.

RESULTS

Detailed description of patients' demographics and clinical data is shown in Table (1).

Five of our SLE patients (23.8%) have abnormal MRI brain as described in Table (2).

Cerebral Blood Flow Volume

a) Patients versus control (Table 3):

Although Total Cerebral Blood Flow Volume (TCBFV) was lower in patient group than in control group but this is not reaching statistically significant difference. Yet; CBFV is significantly lower in Left ICA in the patients compared to Controls group.

b) Comparison between patients subgroups:

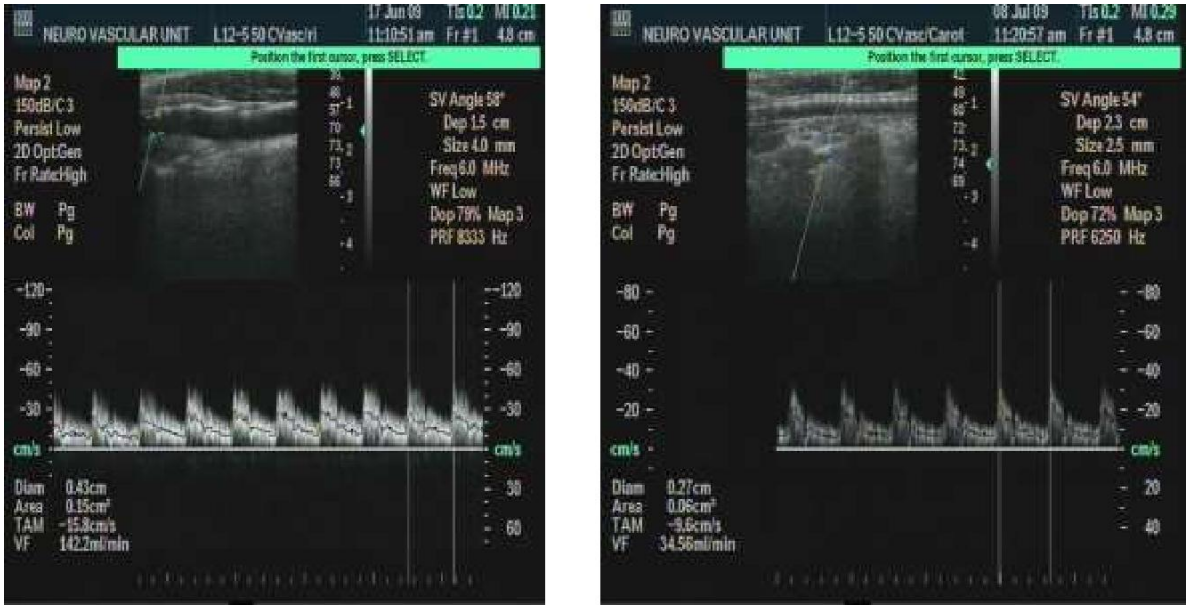
Comparison between TCBFV for patients with NSLE and those without NSLE showed no statistically significant difference (p=0.2). Comparing the TCBFV between SLE patients with APS and those without APS syndrome revealed no statistical significant difference (p=0.14)

Cognitive screening (3Ms) test

It is value ranged from 78 to 100 with mean 86.68±11.39 in SLE patients compared to control group which ranged from 86 to 99 with mean 93.7±1.09. However on comparison of the test sub-items, a statistical significant difference was found between the two groups in many sub-items of the 3MS; as the mental reversal (p=0.03) and repetition (p= 0.04) Table (4) & also the mean value of the 3MS was lower in the patients subgroup with APS (91±6.5) than in the patients without APS (82.8±13.6) but without statistically significant difference. However on comparison of the test sub-items a statistically significant difference was found between the two subgroups in three sub-items of the 3MS; the four-legged animals (p=0.01), repetition (p=0.05), and writing (p=0.03).

Total Cerebral Blood Flow Volume (CBFV) Correlations

In our patient populations we did not detect significant correlation of The TCBFV with age, duration of illness, BMI or blood pressure. Inspite of positive correlation of TCBFV with 3 Ms total score, this correlation did not reach significant value (r=0.33 & p=0.08). There was a statistical significant negative correlation between TCBFV and disease activity score assessed by the SLEDAI. (r=-0.52 & P value=0.01) (Table 5 & Figure 1).



(a) **(b)**

Figure 1. (a) The flow volume measurement in RT ICA & (**b)** in RT VA obtained with B mode Doppler, the vessel diameter was measured & blood-flow volume was calculated (mL/min).

Table 1. Demographic and clinical characteristics of SLE patients.

ITEM	
Age (years) Mean±SD	28.24±8.92
Sex Female/Male	21/0
Body mass index (BMI)	26.32±4.73
Disease duration (years)	4.48±3.92
Clinical Manifestations n(%)	
1- Musculoskeletal	20 (95.2%)
2- Cutaneous	19 (90.4%)
3- Pulmonary	9 (42.8%)
4- Renal	16 (76.1%)
5- Cardiovascular	
a) Hypertension	8 (38%)
b) Raynaud's	4 (19%)
c) DVT	2 (9%)
d) Pericardial effusion	1 (4%)
6- Neurological	9 (42.8%)
a) Stroke	2 (9%)
b) Convulsions	4 (19%)
c) Acute confusional	4 (19%)
d) Transient ischemic attack	1 (4%)
e) Migraine	1 (4%)
Secondary APS (no., %)	10 (47.6%)
SLEDAI	Median=4 (range=0-28)

% percentage, ***CBFV*** Cerebral Blood Flow Volume, ***APS*** Antiphospholipid syndrome, ***SD*** standard deviation

Table 2. Clinical findings in patient subgroups with abnormal MRI Brain.

Patient Number	Clinical Findings	MRI Brain Findings
Patients with APS (n= 4)	Left hemiparesis, dysarthria	Multiple Lacunar Infarctions involving the Right External Capsule, Right Basil ganglia & Periventricular White Matter
	Acute Confusional State	Cortical Brain Involutional Changes
	Generalized Tonic Clonic Convulsions	Bilateral periventricular small white matter lesions
	Left Hemiparesis, Generalized Tonic Clonic Convulsions	Right Subcortical Temproparietal Infarction
Patient without APS (n=1)	Acute Confusional State, Generalized Tonic Clonic Convulsions	Bilateral Parietal Subcortical Small white matter lesions

APS Antiphospholipid syndrome

Table 3. Cerebral Blood Flow Volume in extracranial vessels in study groups.

	Patients (n=21)	Controls (n=10)	P-value
	Mean±SD	Mean±SD	
Rt. ICA (CBFV)	181.39±69.43	149.61±41.56	0.12
Rt. VA (CBFV)	44.82±29.38	52.74±21.12	0.4
Lt. ICA(CBFV)	144.18±67.28	208.47±85.1	0.05*
Lt. VA (CBFV)	45.92±24.4	61.36±29.39	0.17
TCBFV	414.79±117.68	472.17±92.6	0.1

CBFV cerebral blood flow volume, ***ICA*** internal carotid artery, ***Lt*** left, ***Rt*** right, ***TCBFV*** total cerebral blood flow volume, ***VA*** vertebral artery, * Significant at P≤0.05

Table 4. Results of 3MS in study population.

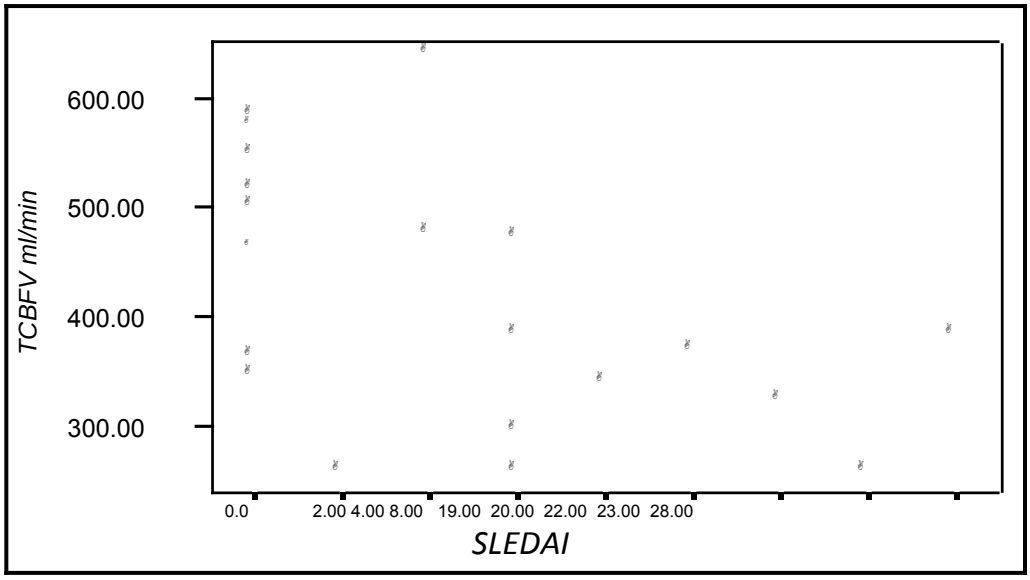
	Patients (n=21)	Controls (n=10)	P-value
	Mean±SD	Mean±SD	
3MS	86.68±11.39	93.7±1.09	0.1
Date & Place of birth	4.7±0.9	5±0	0.11
Registration	3±0	3±0	--
Mental Reversal	6.6±0.7	7±0	0.03*
First recall	8±1.7	8.4±1.1	0.51
Temporal Orientation	14.1±3.1	15±0	0.38
Spatial Orientation	4.6±0.9	5±0	0.07
Naming	5±0	5±0	--
Four-Legged Animals	7.1±2.1	8.2±1.7	0.16
Similarities	2.3±1.7	3±2	0.32
Repetition	4.8±0.4	5±0	0.04*
Read & Obey	2.8±0.4	2.9±0.3	0.72
Writing	4.7±0.7	4.7±1	1.0
Copying Two Pentagons	8.3±2.2	9.2±1.1	0.15
Three-Sage command	3±0	3±0	_
Second Recall	8.1±1.9	8.8±0.4	0.11

* Significant at P≤0.05

Table 5. TCBFV correlation with age, duration and disease severity.

Variable	Regression Coefficient (r)	P-value
Age	-0.20	0.28
SLE duration	0.27	0.26
SLEDA	-0.52	0.01*

SLE systemic lupus erythematosus, ***SLEDAI*** systemic lupus erythematosus disease activity index, * Significant at P≤0.05



SLEDAI Systemic lupus erythematosus disease activity index**, *TCBFV ml/min*** Total cerebral blood flow volume ml/min

Figure 2. Correlation between TCBFV and disease activity index.

DISCUSSION

This study aimed to measure TCBFV and whether a relationship exists between cerebral perfusion changes with disease activity and cognitive screening tests.

In our study, we found that cerebral perfusion in SLE patient was lower compared to the healthy control group but this was not statically significance. Which can be explained by Zardi et al.[15], who demonstrated that vascular changes in SLE patients are time dependent, and are significantly associated with the duration of the disease, which is about 4.48±3.92 years in our population and also our study is a cross sectional study which did not detect changes of the patients'cerebral blood flow over time. It is reasonable to favor longitudinal study to detect the changes of the cerebral blood flow during the patient's disease course over time. Another factor contributing to our result is that we included Patients (42.8%) who manifested with NPSLE during the disease course and not at time of the study, and hence, they were not suffering from recent cerebrovascular disease or lupus cerebritis. However, Left Internal Carotid Artery blood flow volume was significantly lower in SLE patients compared to controls and this agree with Kubinyi et al.[16], who observed that the perfusion defects in his SLE patients were predominantly localized in frontal and temporal lobes of the left hemisphere.

The cerebral perfusion was significantly lower in patients with ongoing disease activity as assessed by SLEDAI, which would suggest that the alteration in blood flow is related to SLE activity; this is in accordance with Falcini et al.[17]. An association between changes in the SPECT and SLE activity was also found[18]. These findings might suggest that the changes in cerebral perfusion may be related to diffuse cerebral as well as inflammatory vasculopathy resulting from the clinical and inflammatory activity of the SLE.

TCBFV did not show significant difference in patients either with NPSLE or with non - NPSLE, the

results can be explained by heterogeneity of causes in the pathogenesis of NPSLE and the different vascular adaptation of cerebral macrocirculation as opposed to cerebral microcirculation may represent possible reasons for the inability of ultrasound to differentiate SLE patients from NPSLE patients.[16]

Antiphospholipid antibodies (aPL) directed predominantly against phospholipid-binding proteins such as glycoprotein I and prothrombin, aPL induce a procoagulant state and are associated with focal manifestations of NPSLE, such as stroke and seizures which possibly due to thrombosis within vessels of minute caliber so we did not found significant changes in TCBFV between SLE patients with APS and those without[19].

In this study, a difference between patients and controls regarding cognitive assessment by measuring total score of 3MS was found but did not reach statistical significance. However, the absence of a significant difference by total score contradicts other studies, pointed out before, and reporting a prevalence of cognitive impairment ranging from 20% to 80%. This could be attributed to the fact that screening tests identify cognitively impaired patients but still have substantial rates of false-negative findings[20]. In this study, analysis of the sub-items of the 3MS showed significant difference; with patients scoring less than controls as regards attention, tested by mental reversal, and language, as tested by repetition of a phrase. The finding of specific defects affecting attention and language is in accordance with other studies confirming a defect in these domains[21,22]. The divergent networks of attention explain its wide affection in most of diffuse vascular pathological conditions and most of subcortical cognitive affection[23].

In 3MS the repetition task involves sentence repetition; in our cases sentence repetition was impaired while short term memory (word recall) was intact; which suggests syntactic and semantic processing defect. Yet further more detailed assessment of short term memory and of non-word repetition tasks were required to verify our findings and help in recognizing pathophysiological basis of repetition affection in our patients[24]. This can be explained by the pattern of cognitive impairment is the same as between our patient subgroups as regard presence of APS or not which agree with Chapman et al.[25], who found that decline in cognitive function, possibly due to thrombosis within vessels of minute caliber which confirmed by our study in which 19% has abnormal MRI brain compared by 4.7% in patients without APS and also there were an evidence of in vitro modulation of neural function raise the alternative possibility of a direct pathogenic effect on neurons.

We could not detect significant association between the cognitive screening dysfunction (subcortical pattern) and the TCBFV measured by Doppler ultrasonography and this agree with Waterloo et al.[26], who proof that no significant association between rCBF by SPECT or neuropsychological measures. Cognitive dysfunction may be related to an inflammatory process in the white matter that leads to cognitive impairment by a process of early myelin injury followed by neuronal loss without significant disturbance in cerebral perfusion and also explained by Omdal et al.[27], who reported an association between anti-glutamate receptor antibodies and cognitive dysfunction which not related to a significant disturbance in cerebral perfusion in SLE patients.

In conclusion, this study suggests that using ultrasound for measuring TCBFV cannot detect evident cerebral hypoperfusion. However, lower TCBFV in SLE patients is associated with more disease activity, and can be beneficial as an early marker of activity in longitudinal follow up, but not related to the subcortical cognitive dysfunction.

[Disclosure: Authors report no conflict of interest]

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الملخص العربى

تقييم ديناميكا الدم الدماغي وأثره على اختبار الفحص المعرفي في مرضى الذئبة الحمراء

الذئبة الحمراء هو أحد أمراض المناعة الذاتية التي تستهدف الأوعية الدموية مما يؤدي إلى التهابات بالأوعية الدموية، اعتلال وعائي، وتصلب الشرايين المبكر.

وكان الغرض من هذه الدراسة هو قياس إجمالي حجم تدفق الدم الدماغي في المرضى الذين يعانون من الذئبة الحمراء باستخدام الموجات فوق الصوتية (دوبلر) لتحديد ما إذا كان وجود علاقة بين التغيرات فى التروية الدماغية مع الحالة الاكلينيكية، والمعملية والفحوصات المعرفية. أجريت هذه الدراسة على واحد وعشرين من المرضى الإناث المصابون بالذئبة الحمراء حيث هؤلاء المرضى شخصوا وفقا للمعايير المنقحة من الكلية الأمريكية لأمراض الروماتيزم وعشرة من الإناث من نفس الفئة العمرية لا يعانون من أية أمراض (كمجموعة الضابطة) للمقارنة. تم تقييم جميع المشاركات فى الدراسة باستخدام اختبار فولستين (المعدل لقياس القدرة العقلية). تم تقييم تدفق الدم الدماغي من قبل خارج الجمجمة بالموجات فوق الصوتية المزدوجة لحساب إجمالي حجم تدفق الدم الدماغي.

أثبت هذا البحث أن إجمالي حجم تدفق الدم الدماغي أقل في مجموعة المرضى مقارنة بالمجموعة الضابطة ولكن لا تصل إلى فروق ذات دلالة إحصائية. ولوحظ وجود انخفاض كبير في حجم تدفق الدم الدماغي للشريان السباتي الداخلي في مجموعة المرضى مقارنة مع المجموعة الضابطة. كانت التروية الدماغية أقل بكثير في المرضى الذين يعانون من الذئبة الحمراء النشطة. لم يكن هناك فروق ذات دلالة إحصائية بين المرضى الذين يعانون من الذئبة الحمراء بأعراض عصبية ونفسية مقارنة بالمرضى الذين يعانون من الذئبة الحمراء بغير أعراض عصبية ونفسية بين المرضى الذين يعانون من متلازمة الفوسفوليبيد ودون متلازمة الفوسفوليبيد؛ فيما يتعلق بإجمالي حجم تدفق الدم الدماغي بهم وكان مرضى الذئبة الحمراء لديهم قصور فى بعض القدرات المعرفية الدالة المسيطرة عليها المناطق تحت القشرية المخية.

إذا باستخدام الموجات فوق الصوتية لقياس حجم تدفق الدم الدماغي لا يمكن الكشف عن نقص انسياب الدم الدماغي بوضوح. ومع ذلك، يرتبط انخفاض حجم تدفق الدم الدماغي في مرضى الذئبة الحمراء أثناء النشاط المرضى، ولكن لا علاقة لضعف القدرات المعرفية للمنطقة تحت القشرة الدماغية.