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ORIGINAL ARTICLE

Neuroimaging in Cerebral Small Vessel Disease

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ABSTRACT

Objective: To determine the role of neuroimaging in cerebral small vessel disease's diagnosis and treatment.
Study Design: Cross-sectional study.
Place and Duration of Study: Department of Neurology, Khairpur Medical College, Khairpur Mir's from 1st January 2022 to 30th September 2022.
Methodology: Seventy five patients were enrolled. The patients were divided in to 5 groups depending on a 5 year interval in their age. The cases of CSVD were included suffering from transient ischemic attack (TIA), lacunar syndromes, stoke with subacute symptoms as cognitive as well as motor disturbances. The age of the patients was >45 years. Clinical examination was conducted through standard procedure and each patient underwent brain magnetic resonance index (MRI) imaging. The neuroimaging features including white matter hyperintensities (WMH), lacunar infarcts (LI), enlarged perivascular spaces (EPVS), microbleeds, lacunae, brain atrophy, and subcortical infarcts. Binswanger's disease, as well as leukoaraiosis, lacunar strokes and cerebral microbleeds (CMBs) were also observed. The MRI used 3.0 MRI system, using 32-channel head coils.The regions scoring was done through Kippss or Dacies score, as well as through MTA-scale, Koedam score, and GCA-scale, ranging within 0-3 points
Results: There are more cases of females suffering from CSVD than males, however only in year 70 there was an equal incidence within gender. There was a significance association of CSVD markers with age wherein the WMH has a significant increase in trend with the ascending of year interval. Fazekas scale was applied quantify amount of the white matter T2-hyperintense-lesions which are accredited to CSVD. It was observed that presence of SVD markers in various age stratification showed highest incidence of MTA scale, Koedam score, Kippss/Dacies score and 3 markers numbers The WMH, CMBs, LI and EPVS were observed highest in the age group of 61-65 years while BA was observed highest in 66-70 years of age
Conclusion: Neuroimaging techniques prove beneficial in exact and timely diagnosis of cerebral small vessel disease. Increasing age has higher risk of CSVD presented through increase incidence in CSVD markers.
Keywords: White matter, Cognitive, Recurrence, Mortality, Etiology

INTRODUCTION

Cerebral small vessel disease (CSVD) is a group of various diseases that affects vascular system including arterioles, arteries, capillaries of brain and small venules that leads to cognitive, clinical and imaging manifestations. These vessels are extremely important for the optimal maintenance of brain functioning and white matter networks. It has low mortality risk but recurrence chances are very high. Recurrent lacunar infarction, stroke, white matter lesions and cognitive impairment are the main clinical manifestations in CSVD patients.[1,2] It is more common among elder people causing psychiatric, cognitive, physical disabilities, diabetes mellitus, hypertension, atherosclerosis and is the main contributing agent of dementia in older people.[3-5]

Exact etiology of cerebral small vessel disease is still unknown, thus cure and treatment are still a matter of debate for many neuroscientists. It is often mislead due to overlapping symptoms and late diagnosis further aggravate the disease condition. Stroke resulting due to CSVD are considered to be associated with cardioembolic stroke and atherothromoembolic stoke. Similarly, cognitive impairment are often overshadowed and misinterpret by Alzheimer' disease. There are many reasons for not knowing the exact cause of this important problem. Small vessel is difficult to investigate and in-vivo studies are difficult to perform. Early diagnosis through MRI has low sensitivity for the detection of microstructural lost in white matter. This problem can be overcome with the use of CT-scan and diffusion tension imaging (DTI).[6-9]

Diffusion tension imaging has various advantages over other diagnostic techniques. It provides mean diffusivity, fractional anisotropy and provides accurate measurement of diffusion of water in white matter. This all combine to form a better diagnostic approach for the directionality of water diffusion. Another method can also be employed for better therapeutic intervention and diagnostic approach. Functional magnetic resonance imaging (fMRI) also prove helpful in determining the functional connectivity between brain regions.[10,11] Primary objective of the present study is the investigation of several neuroimaging techniques for the evaluation of better diagnostic approach for CSVD detection. Associated risk factors are also taken into consideration that causes long and short term structural and functional damage in white matter of brain.

MATERIALS AND METHODS

This cross sectional study was performed at Department of Neurology, Khairpur Medical College, Khairpur Mir's from 1st January 2022 to 30th September 2022 and 75 patients were enrolled. The sample size was generated through WHO sample size calculator where 80% power of test and 95% CI were considered with an increased risk of 6.5% above the age of 45 years. The patients were divided in to 5 groups depending on a 5 year interval in their age. The cases of CSVD were included suffering from transient ischemic attack (TIA), lacunar syndromes, stoke with subacute symptoms as cognitive as well as motor disturbances. The age of the patients was >45 years. Exclusion criteria consisted of severe medical illness, neurological diseases as hydrocephalus, cerebrovascular malformations, brain tumors, dysfunctions of liver or kidney, craniocerebral operation or non-cooperative to neuropsychological testing. Each patient or their attendant submitted a signed informed consent of participation prior their enrollment in the study. Complete demographic, clinical history and recent complaints were correlated with symptoms of the patients and clinical diagnosis was apprehended. The diagnosis was further confirmed through the neuroimaging techniques. Clinical examination was conducted through standard procedure and each patient underwent brain magnetic resonance index (MRI) imaging. The neuroimaging features including white

matter hyperintensities (WMH), lacunar infarcts (LI), enlarged perivascular spaces (EPVS), microbleeds, lacunae, brain atrophy, and subcortical infarcts. Binswanger's disease, as well as leukoaraiosis, lacunar strokes and cerebral microbleeds (CMBs) were also observed. TheMRI used 3.0 MRI system, using 32-channel head coils. The scan sequence was

T1-weighted fast field echo, repetition time (TR) =6.4ms
echo time (TE) =3.0ms,
Field of vision (FOV)=240mm×240mm×180mm,
Reconstruction voxel = 1.1×1.1×1.1,
Reconstruction matrix = 384×384,
Slice thickness = 1.2 mm; DWI, TR = 2462ms, TE = 63ms
FOV = 230mm×230mm×143mm
30 minutes MRI scan regimen

MRI images gained were transferred to Intelli Space Portal. The MRI images presented hyper-intensified lesion on T 2 weighed radiological images and hypointense-lesion on FLAIR-weighted image. Other investigations as CMB, EPVS lesions and BA imageswere observed. The regions scoring was done through Kippss or Dacies score, as well as through MTA-scale, Koedam score, and GCA-scale, ranging within 0-3 points where 0 corresponded to a region of normal volume, 1 corresponded to a region of mild ventricular enlargement and 2 corresponded to a region with loss in volume of moderate ventricular enlargement, whereas 3 corresponded to a region as "knife blade" having severe ventricular enlargement and atrophy. A superficial score ≥2 points was represented in patients with BA having mild degenerative features. Neuropsychological Assessment was performed post neuroimaging. Data was analyzed by SPSS volume 26.0. Tools for analysis comprised of chi square where p value <0.001 was considered significant.

RESULTS

This study presented more cases of females suffering from CSVD than males, however only in year 70 there was an equal incidence within gender. There was a significance association of CSVD markers with age wherein the WMH has a significant increase in trend with the ascending of year interval. The EPVS and BA also had an increase in trend with the 5 year increase in age interval (p value 0.002 and <0.001 respectively) [Table 1].

Table 1: Age, gender and baseline features of patients

Features	5 year interval in age (N=75)					P value
	45-50 (N=12)	51-55 (N=19)	56-60 (N=14)	61-65 (N=20)	66-70 (N=10)	
Males	4 (33.3%)	8 (42.1%)	6 (42.8%)	8 (40%)	5 (50%)	0.282
Females	8 (66.6%)	11 (57.8%)	8 (57.1%)	12 (60%)	5 (50%)	
Age (years)	42.76±1.53	48.33±1.55	53.24±1.45	57.53±1.45	63.31±1.44	<0.001
Lin	1 (8.3%)	--	1 (7.1%)	1 (5%)	1 (10%)	0.011
WMHSn	8 (66.6%)	13 (68.4%)	11 (78.5%)	19 (95%)	9 (90%)	0.002
Fazekas 1 (1~5)	3 (25%)	4 (21%)	3 (21.4%)	3 (15%)	1 (10%)	
Fazekas 1 (6~12)	2 (16.6%)	4 (21%)	1 (7.1%)	3 (15%)	1 (10%)	
Fazekas 1 (13~26)	1 (8.3%)	2 (10.5%)	3 (21.4%)	5 (25%)	1(10%)	
Fazekas 1 (>26)	1 (8.3%)	2 (10.5%)	2 (14.2%)	3 (15%)	2 (20%)	
Fazekas 2	--	2 (10.5%)	2 (14.2%)	3 (15%)	2 (20%)	
Fazekas 3	--	--	--	--	1 (10%)	
EPVSs	7 (58.3%)	12 (63.1%)	11 (78.5%)	16 (80%)	8 (80%)	0.002
1–3	2 (16.6%)	5 (26.3%)	3 (21.4%)	4 (20%)	1 (10%)	
4–6	2 (16.6%)	3 (15.7%)	2 (14.2%)	3 (15%)	1 (105)	
7–13	1 (8.3%)	2 (10.5%)	3 (21.4%)	2 (10%)	2 (20%)	
>13	--	1(5.2%)	1 (7.1%)	5 (25%)	2 (205)	
CMB	--	3(15.7%)	2 (14.2%)	3 (15%)	1 (10%)	0.618
BA	4 (33.3%)	7 (36.8%)	6 (42.8%)	11(55%)	6 (6%)	<0.001

Table 2: Association of CSVD Markers and Age Strata through neuroimaging

Features	5 year interval in age (N=75)					P value
	45-50 (N=12)	51-55 (N=19)	56-60 (N=14)	61-65 (N=20)	66-70 (N=10)	
GCA-scale (complete brain)	2 (16.6%)	6 (31.5%)	5 (35.7%)	4 (20%)	6 (60%)	
MTA-scale (temporal lobe, & hippocampus)	2 (16.6%)	5 (26.3%)	5 (35.7%)	9 (45%)	5 (505)	
Koedam score (parietal lobe)	2 (25%)	5 (26.3%)	5(35.7%)	9 (45%)	5(50%)	
Kippss/Dacies score (frontal, temporal lobes)	3 (25%)	5 (26.3%)	5 (35.7%)	10 (50%)	6 (60%)	
1 marker- number	3 (25%)	5 (26.3%)	2 (14.2%)	2 (10%)	--	0.815
2 marker- number	3 (25%)	6 (31.5%)	5 (35.7%)	5 (25%)	1 (10%)	0.497
3 markers- number	2 (16.6%)	5(26.3%)	5 (35.75)	10 (50%)	4 (405)	0.018
4 markers- number	--	--	1 (7.14%)	1 (5%)	1 (10%)	0.033
5 markers-number	--	--	--	--	--	0.100

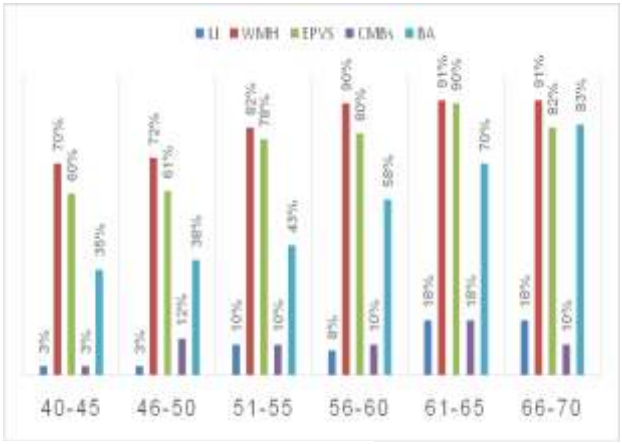

Fig. 1: Association of Age with CSVD markers

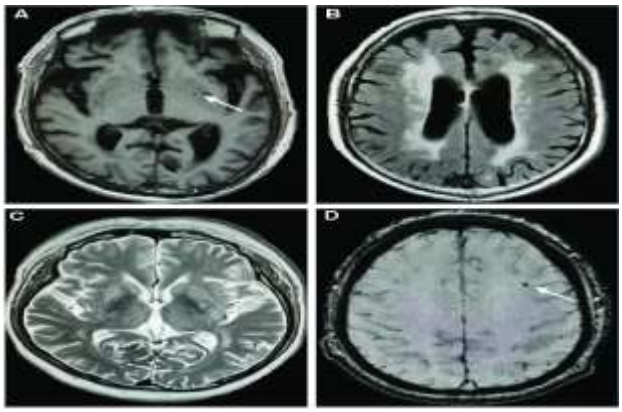

Fig. 2: A: LI, B: WMH, C: Enlarged perivascular spaces, D: Cerebral Microbleeds

Fazekas scale was applied quantify amount of the white matter T2-hyperintense-lesions which are accredited to CSVD. It was observed that presence of SVD markers in various age stratification showed highest incidence of MTA scale, Koedam score, Kippss/Dacies score and 3 markers numbers with increase in age groups specially between ages >60 years (Table 2).

The WMH, CMBs, LI and EPVS were observed highest in the age group of 61-65 years while BA was observed highest in 66-70 years of age (Fig. 1). The MRI images presented LI on T1 weighted images while WMH was observed through severe periventricular-white-matter hyperintensities. Within the basal ganglia enlarged perivascular-spaces were observed through T2 neuroimaging. Cerebral microbleeds were presented in the frontal lobes which were observed through susceptibility-weighted imaging (Fig. 2).

DISCUSSION

Cerebral small vessel disease is now considered a general term used to describe the syndrome of neuroimaging, cognitive and clinical findings. This is raised due to impairment of vascular system including cerebral arterioles, venules and capillaries which cause destructive damage in deep grey and white matter of the brain. Various studies have investigated the consequences and causes of functional changes in white matter by employing several neuroimaging techniques.[12-14] The present study was designed to investigate the role of different neuroimaging techniques that can be prove beneficial in exact and timely diagnosis of CSVD.

The white matter lesions that can be observed through conventional MRI are significantly associated with vascular risk factors and its association are also found with motor and cognitive declination.[15-17] There is still paucity of data on cerebral small vessel disease, parkinsonism and incidence of dementia in relevance with changes in white matter. In present study, various risk factors: clinical, neuroimaging, are studied by establishing a well-defined protocol for finding better results. Those tests are applied which have wide acceptance from other studies as well and are considered highly sensitive and specific with structural brain changes.

Furthermore, balance assessment; motor, cognitive and structural changes were documented according to the international accepted protocols. Functional magnetic resonance imaging and diffusion tension imaging protocols proved to be promising diagnostic methods for the estimation of structural changes in white matter. Similar findings have been reported by various other studies[18-20]

CONCLUSION

Neuroimaging techniques prove beneficial in exact and timely diagnosis of cerebral small vessel disease. Increasing Age has higher risk of CSVD with enhanced incidence of WMH, LI, CMBs and BA markers. Older patients have higher chances of cognitive and motor impairment.

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