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Original Research Article

CORRELATION OF SERUM VITAMIN B12 WITH VISUAL EVOKED POTENTIAL AND BRAINSTEM EVOKED RESPONSE AUDIOMETRY IN CHRONIC KIDNEY DISEASE PATIENTS ON MAINTENANCE HEMODIALYSIS AND NONHEMODIALYSIS

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ABSTRACT

Background: In chronic kidney disease, neurological complications include stroke, cognitive impairment and dementia. **Objective:** To determine the correlation between serum vitamin B12 with VEP and BERA in CKD patients on maintenance hemodiaysis and nonhemodialysis.

Materials and Methods: The study participants of age 18 to 65 yrs were divided into two groups according to GFR (glomerular filtration rate) staging as per KDIGO. Group A consist of 41patients with CKD stage 2 to5 nonhemodialysis and Group B consist of 41 patients with CKD stage 5D on maintenance hemodialysis. The serum levels of urea, creatinine, eGFR and vitamin B12 were measured. The CNS dysfunction were assessed by VEP and BERA.

Results: There was S.vitamin B12 levels of Group A were found to be statistically highly significant than that of Group B(hemodialysis).On comparing the VEP parameters of right eye P100-N145 amplitude of nonhemodialysis group was found statistically significant and for left eye, P100 and N75 latency were found statistically significant of hemodialysis group. On comparing left and right ear BERA parameters, only wave-II latency(ms) of right ear showed statistically significant difference. Among nonhemodialysis cases, S.urea and eGFR showed statistically significant correlation with wave-III (left ear) and wave -II(Rt ear) respectively. Among hemodialysis cases, S. creatinine, S. urea and eGFR showed statistically significant correlation with wave-I, II, III and IV right ear and wave-I of left ear.

Conclusion: Managing these blood parameters and developing therapeutic strategies that target their regulation could potentially delay the onset of CNS complications in individuals with CKD.

Keywords: Vitamin B12, chronic kidney disease, VEP , BERA, hemodialysis

INTRODUCTION

Chronic kidney disease (CKD) is characterized by the presence of kidney damage or an estimated glomerular filtration rate (eGFR) of less than 60 mL/min/1.73 m², persisting for 3 months or more, irrespective of the cause[1] .Approximately 8- 16% of the global population is impacted by CKD. 17.2% of the adult population in India had evidence of CKD[2,3,4] .

In CKD, neurological manifestation can be divided into chronic or acute presentation. Chronic manifestation include stroke, cognitive impairment and dementia and acute manifestation include encephalopathy and delirium[5] .

Visual evoked potential (VEP) and Brainstem Evoked Response Audiometry (BERA)have been reported to represent a useful test in early diagnosis of CNS involvement in CKD patients. VEP measure the electrical signal (amplitude and latencies) generated at the visual cortex in response to visual stimulation[6]. BERA are recorded from the ear and vertex in response to a brief auditory stimulation to assess neural functions along the ascending auditory pathway, from cochlea to inferior colliculus[7].

Vitamin B12 is an essential water soluble vitamin[8].Vitamin B12 is an essential coenzyme for the conversion of methylmalonyl-coA into succinyl coA, which is a basic requirement for myelin synthesis. Myelin is required for neuronal protection as well as normal transmission of impulses in the nerves. In the low serum level of vitamin B12, methymalonyl coA convert into methyl malonic acid(MMA). This methyl malonic acid (MMA) form abnormal fatty acids, which leads to abnormal myelination or demyelination[9].

The aim of the study was, examined individuals VEP and BERA and investigate how renal failure and hemodialysis affect the visual pathway and auditory pathway. Since VEP and BERA are easy, affordable, and non-invasive tests that may be used to show the advantages of fluid evacuation and identify subclinical CNS impairment in CRF patients before clinical symptoms manifest.

MATERIALS AND METHODS

This study was a cross-sectional study was carried out on 82 adult CKD patients in Department of Physiology, RMLIMS, Lucknow. Ethical clearance was obtained from the RMLIMS Institutional Ethics Committee (IEC No.07/23). All patients of age 18 to 65yrs were recruited from the hemodialysis unit of Department of Nephrology. The inclusion criteria of the CKD patients according to GFR, Kidney disease improving global outcome(KDIGO):

Group A:41 Patients with chronic kidney disease [CKD] stage 2 to5 nonhemodialysis.

Group B: 41 patients with CKD stage 5D on maintenance hemodialysis more than 3 months.

Patients excluded were those who had congenital hearing loss, middle ear disease, history of continuous exposure of noise which leads to hearing loss or use of hearing aids, CNS disease such as altered sensorium hospitalized ESRD patients with multiple organ failure, cerebrovascular accident, psychiatric illness.

Informed consent were taken from all the study participants. The blood parameters were recorded from OPD file of patients. Estimation of serum vitamin B12 done by Liquid chromatography tandem mass spectrometry in Department of Biochemistry, Dr. RMLIMS, Lucknow. Opthalmological examination, tuning fork tests and pure tone audiometry were reviewed before starting the test.

Visual Evoked potential(VEP) and Brainstem Evoked Response Audiometry (BERA) were measured by using Neuro- MEP .NET (Neurosoftware version 4.4.9.0) in the Department of Physiology at Dr. RMLIMS, Lucknow.

At the end of the study, the data were expressed as mean±standard deviation (SD). All statistical analysis were carried out using SPSS version 23.0. Chi-square test was used to compare the proportional differences between the groups, student ‘t test’ was applied to compare difference in mean values and Pearson’s correlation was used for correlation of two or more continuous variable. ‘p’ value<0.05 was considered as statistically significant.

RESULTS

Out of 82 patients enrolled in the study 41 (50.0%) were males and rest 41 (50.0%) were females. In Group A (nonhemodialysis) 53.7% of patients were female and rest 46.3% were males while in Group B (hemodialysis) 46.3% patients were female and rest 53.7% were males.

Table 1: Comparison of Blood Profile Parameters of two study groups

SN	Parameters	Group A (Nonhemodialysis) (n=41)	Group B (Hemodialysis) (n=41)	‘t’	‘p’
		Mean± SD	Mean± SD		
1-	Hemoglobin (g/dl)	10.07±1.36	9.84±1.79	0.670	0.505
2-	S. urea (mg/dl)	71.37±30.52	84.91±19.31	-2.400	*0.019
3-	S.creatinine (mg/dl)	3.74±1.37	8.19±2.28	-10.688	**<0.001
4-	S.sodium (meq/L)	137.29±3.73	136.61±3.73	0.829	0.410
5-	S.potassium (meq/L)	4.57±0.76	4.53±0.80	0.263	0.793
6-	S. calcium (mg/dl)	7.57±1.58	7.40±1.41	0.512	0.610
7-	S. uric acid (mg/dl)	6.47±1.11	6.23±0.95	1.048	0.298
8-	S.phosphate (mg/dl)	4.53±1.01	4.51±1.03	0.093	0.926
9-	S. SGOT/AST (U/L)	21.00±8.75	21.49±7.15	-0.277	0.782
10-	S. SGPT/ALT (U/L)	21.49±7.78	18.90±5.32	1.760	0.082±
11-	S. Alkaline phosphatase (U/L)	92.29±57.37	111.95±102.31	-1.073	0.286
12-	Vitamin B12 (pg/ml)	852.14±47.30	94.06±14.03	98.390	**<0.001

Analyzed by unpaired t-test, SD: Standard deviation

*P value <0.05 were considered to be statistically significant. ** P value <0.01 were considered to be statistically highly significant S.creatinine of Group B (hemodialysis) patients were statistically highly significant than that of Group A (nonhemodilysis), S. Urea was statistically significant for Group B (hemodialysis).

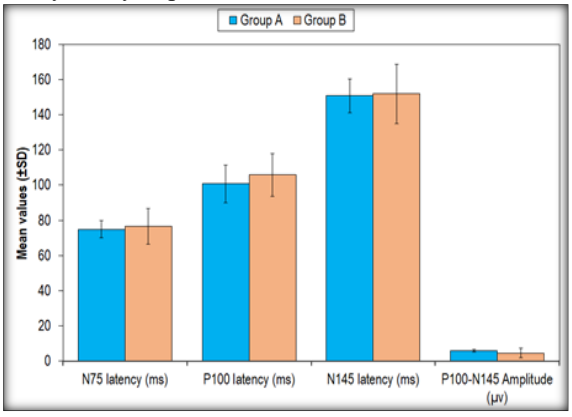
Vitamin B12 levels of Group A (nonhemodilysis) were found to be statistically highly significant than that of Group B(hemodialysis).

Rest of the laboratory parameters did not show any statistical significant difference.

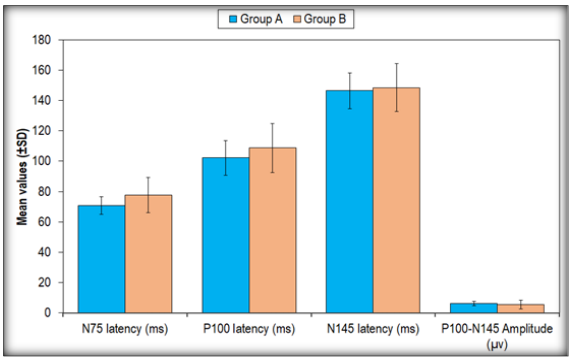
Table 2: Comparison of Visual Evoked Potential (VEP) Parameters for Right and Left Eye of two study groups

SN	Parameters	Group A (Nonhemodialysis) (Right Eye) (n=41)	Group B (Hemodialysis) (Right Eye) (n=41)	't'	'p'	Group A (Nonhemodialysis) (Left Eye) (n=41)	Group B (Hemodialysis) (Left Eye) (n=41)	't'	'p'
		Mean ±SD	Mean ±SD			Mean ±SD	Mean ±SD		
1	N75 latency(ms)	74.89 ± 4.83	76.57 ± 10.32	-0.944	0.348	70.66 ±5.80	77.70 ±11.53	-3.493	**0.001
2	P100 latency(ms)	100.79 ±10.73	105.79 ±12.16	-1.973	0.052	102.20 ±11.35	108.79± 16.12	-2.138	*0.036
3	N145 latency (ms)	150.76 ± 9.52	151.92 ± 16.84	-0.386	0.7	146.51 ±11.77	148.44 ±15.68	-0.629	0.531
4	P100-N145 Amplitude(µv)	5.75 ± 0.71	4.56 ± 2.84	2.598	*0.011	6.08 ±1.45	5.37 ± 2.88	1.402	0.165

Analyzed by unpaired 't' test, SD: Standard Deviation



Graph 1: Comparison of Visual Evoked Potential (VEP) Parameters for Right Eye of two study groups

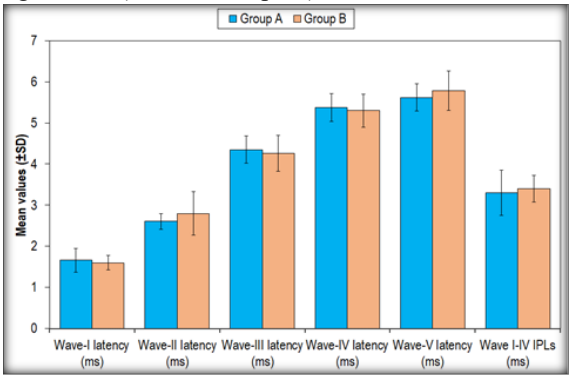


Graph 2: Comparison of Visual Evoked Potential (VEP) Parameters for Left Eye of two study groups

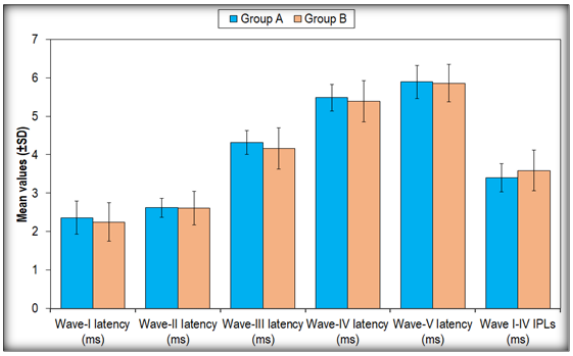
*P value <0.05 was considered to be statistically significant. ** P value <0.01 was considered to be statistically highly significant. For Right eye Group B(hemodialysis) patients had higher latency (N75, P100 and N145) as compared to Group A (nonhemodialysis) patients but the differences were not found to be statistically significant. P100-N145 Amplitude of Group A (nonhemodialysis) was found to be statistically significant than that of Group B (hemodialysis) (Table 2, Graph 1).

On comparing the Left eye VEP parameters of above two study groups it was observed that Group B (hemodialysis) patients had statistically significantly higher N75 latency and P100 latency as compared to that of Group A(nonhemodialysis) (Table 2; Graph 2).

Though Group B (hemodialysis) patients had higher N145 latency as compared that of Group A(nonhemodialysis) yet this difference was not found to be statistically significant. P100-N145 amplitude of Group A (nonhemodialysis) was found to be higher than that of Group B (hemodialysis) but this difference was not found to be statistically significant (Table 2, Graph 2).



Graph 3: Comparison of Brainstem Evoked Response Audiometry (BERA) Parameters for Right Ear of two study groups



Graph 4: Comparison of Brainstem Evoked Response Audiometry (BERA) Parameters for Left Ear of two study group

*P value <0.05 was considered to be statistically significant. On comparing the Right ear Brainstem Evoked Response Audiometry (BERA) parameters (Wave I, II, III, IV, V and Wave I-IV IPLs) of above two study groups only Wave II latency (ms) showed statistically significant difference. Wave II latency of Group B(hemodialysis) patients was statistically significant higher than that of Group A(nonhemodialysis) (Table 3 ,Graph3).

On comparing the Left Ear BERA parameters of above two study groups, all the BERA parameters of above two study groups were comparable.(Table 3, Graph 4)

Table 3: Comparison of Brainstem Evoked Response Audiometry (BERA) Parameters for Right and Left Ear of two study groups

SN	Parameters	Group A (Nonhemodialysis) (Right Ear) (n=41)	Group B (Hemodialysis) (Right Ear) (n=41)	't'	'p'	Group A (Nonhemodialysis) (Left Ear) (n=41)	Group B (Hemodialysis) (Left Ear) (n=41)	't'	'p'
		Mean ±SD	Mean ±SD			Mean ±SD	Mean ±SD		
1	Wave-I latency(ms)	1.66 ±0.29	1.60 ±0.18	1.143	0.257	2.36± 0.43	2.25 ±0.50	1.039	0.302
2	Wave-II latency(ms)	2.61± 0.19	2.80± 0.53	-2.166	*0.033	2.62 ±0.25	2.61± 0.44	0.177	0.86
3	Wave-III latency(ms)	4.35 ±0.33	4.26 ±0.44	1.039	0.302	4.31 ±0.31	4.16 ±0.54	1.55	0.125
4	Wave-IV latency(ms)	5.37 ±0.34	5.30 ±0.40	0.892	0.375	5.48 ±0.35	5.39 ±0.54	0.938	0.351
5	Wave-V latency(ms)	5.62 ±0.33	5.78 ±0.48	-1.765	0.081	5.89 ±0.43	5.86 ±0.49	0.315	0.753
6	Wave I-IV IPLs(ms)	3.30 ±0.55	3.40 ±0.32	-0.937	0.351	3.40 ±0.36	3.59 ±0.53	-1.895	0.062

Analyzed by unpaired 't test, SD: Standard Deviation

Table 4A: Pearson's Correlation of Laboratory, VEP and BERA Parameters (Group A: Non-hemodialysis)

Blood Profile Parameters		Visual Evoked Potential(VEP) Parameters								Brainstem Evoked Response Audiometry(BERA) Parameters									
		Right eye				Left eye				Right ear						Left ear			
		N75 (ms)	P100 (ms)	N145 (ms)	P100-N145 (µv)	N75 (ms)	P100 (ms)	N145 (ms)	P100-N145 (µv)	Wave-I (ms)	Wave-II (ms)	Wave-III (ms)	Wave-IV (ms)	Wave-V (ms)	IPL I-IV (ms)	Wave-I (ms)	Wave-II (ms)	Wave-III (ms)	Wave-IV (ms)	Wave-V (ms)	IPL I-IV (ms)
S.creatinine (mg/dl)	'r'	0.072	0.400	0.252	-0.206	-0.017	0.463	0.284	-0.043	-0.184	-0.089	0.283	0.213	-0.154	0.012	-0.043	-0.112	0.083	0.005	-0.041	-0.071
	'p'	0.654	*0.010	0.112	0.196	0.914	**0.002	0.072	0.792	0.249	0.581	0.073	0.180	0.336	0.940	0.790	0.486	0.605	0.973	0.800	0.657
S. urea (mg/dl)	'r'	-0.116	0.260	0.029	-0.040	0.100	-0.016	0.126	-0.041	-0.206	-0.089	0.070	0.045	-0.033	0.190	-0.132	0.097	0.325	0.011	-0.247	0.108
	'p'	0.470	0.100	0.856	0.805	0.534	0.923	0.434	0.798	0.195	0.578	0.665	0.781	0.837	0.235	0.412	0.545	*0.038	0.945	0.119	0.502
eGFR (ml/min/1.73 m^2)	'r'	-0.120	-0.510	-0.049	0.270	0.090	-0.273	-0.151	0.060	0.008	0.356	-0.108	-0.165	0.192	0.105	-0.027	-0.067	-0.290	0.141	0.055	0.011
	'p'	0.456	**0.001	0.762	0.088	0.574	0.084	0.347	0.709	0.963	*0.023	0.503	0.302	0.230	0.515	0.867	0.676	0.066	0.379	0.733	0.946
Vit B12 (pg/ml)	'r'	-0.034	-0.191	0.023	-0.015	-0.178	-0.116	-0.089	-0.040	-0.184	-0.089	0.283	0.213	-0.154	0.012	-0.043	-0.112	0.083	0.005	-0.041	-0.071
	'p'	0.831	0.231	0.889	0.924	0.266	0.471	0.582	0.803	0.249	0.581	0.073	0.180	0.336	0.940	0.790	0.486	0.605	0.973	0.800	0.657

P value were calculated by using pearson's correlation. 'r' was correlation coefficient. *Correlation were statistically significant at the <0.05 level(2-tailed). ** Correlation were statistically highly significant at the <0.01 level (2-tailed).

Among CKD cases nonhemodialysis, S. creatinine showed statistically significant correlation with P100 (Right & Left eye). S. urea showed statistically significant correlation with Wave-III (Left ear). eGFR showed statistically highly significant correlation with P100 (Rt eye), Wave-II (Right ear) (Table 4A)

Table 4B: Person's Correlation of Laboratory, VEP and BERA Parameters (Group B: Hemodialysis)

		Visual Evoked Potential(VEP) Parameters								Brainstem Evoked Response Audiometry(BERA) Parameters											
		Right eye				Left eye				Right ear						Left ear					
Blood Profile Parameters		N75 (ms)	P100 (ms)	N145 (ms)	P100-N145 (µv)	N75 (ms)	P100 (ms)	N145 (ms)	P100-N145 (µv)	Wave-I (ms)	Wave-II (ms)	Wave-III (ms)	Wave-IV (ms)	Wave-V (ms)	IPLI-IV (ms)	Wave-I (ms)	Wave-II (ms)	Wave-III (ms)	Wave-IV (ms)	Wave-V (ms)	IPLI-IV (ms)
S.creatinine (mg/dl)	'r'	0.009	0.108	-0.182	-0.090	0.004	-0.022	-0.098	0.080	0.395	0.152	-0.145	-0.271	-0.190	0.109	-0.160	0.218	0.089	-0.289	0.038	0.167
	'p'	0.957	0.500	0.256	0.577	0.981	0.893	0.540	0.617	*0.011	0.342	0.366	0.086	0.234	0.498	0.316	0.170	0.582	0.067	0.814	0.297
S. urea (mg/dl)	'r'	0.293	0.086	-0.067	0.021	0.351	-0.137	-0.008	-0.013	-0.060	0.017	-0.316	-0.024	0.119	0.066	-0.390	0.059	-0.079	-0.019	0.073	0.032
	'p'	0.063	0.593	0.676	0.896	*0.024	0.393	0.958	0.937	0.710	0.917	*0.044	0.882	0.460	0.683	*0.012	0.716	0.624	0.906	0.649	0.845
eGFR (ml/min/1.73 m^2)	'r'	-0.034	-0.079	0.035	0.105	-0.013	0.031	0.024	0.036	-0.298	-0.339	-0.073	0.426	-0.280	0.169	0.069	-0.071	0.142	0.145	0.089	-0.205
	'p'	0.831	0.624	0.829	0.512	0.934	0.850	0.882	0.824	0.058	*0.030	0.651	**0.006	0.076	0.291	0.670	0.660	0.378	0.367	0.580	0.198
Vit B12 (pg/m)	'r'	0.079	0.167	0.025	-0.174	0.175	0.144	0.026	0.130	0.395	0.152	-0.145	-0.271	-0.190	0.109	-0.160	0.218	0.089	-0.289	0.038	0.167
	'p'	0.622	0.296	0.875	0.276	0.275	0.369	0.871	0.416	0.011	0.342	0.366	0.086	0.234	0.498	0.316	0.170	0.582	0.067	0.814	0.297

P value were calculated by using pearson's correlation. 'r' was correlation coefficient. *Correlation were statistically significant at the <0.05 level(2-tailed).

** Correlation were statistically highly significant at the <0.01 level(2-tailed).

Among CKD cases on maintenance hemodialysis, S. creatinine showed statistically significant correlation with wave-I (Right ear). S. urea showed statistically significant correlation with N75 (Rt eye), Wave-III (Right ear) and Wave-I (Left ear). eGFR showed statistically significant correlation with Wave-II & statistically highly significant correlation with Wave-IV (Rt ear). Vitamin B12 did not show any statistically significant correlation with any of the VEP and BERA parameters (Table 4B).

DISCUSSION

In chronic kidney disease (CKD) the neurological complications are very common, which include stroke, cognitive impairment and encephalopathy. Many neurological complications do not fully respond to current therapy modalities, even with ongoing therapeutic advancements. According to researches on neuropathy in end stage renal disease (ESRD), 70–100% of patients still suffer from neuropathic symptoms, even attaining the dialysis adequacy goals[10].

On comparison of VEP parameters for the right eye of both the groups, we found that hemodialysis patients had prolonged latencies (ms) of N75, P100, and N145 as compared to nonhemodialysis patients, but these latencies were not statistically significant. The amplitude of P100-N145 (µv) of nonhemodialysis was found to be statistically

significant high as compared to hemodialysis. On comparison of VEP parameters for the left eye of both the groups, we found that hemodialysis patients had statistically significant prolonged latencies (ms) of N75 and P100 as compared to nonhemodialysis patients, but N145 latency was not statistically significant. While the amplitude of P100-N145 (μv) of nonhemodialysis was found to be high as compared to hemodialysis, but it was not statistically significant.

Prolonged latencies and decreased amplitudes observed in hemodialysis patients indicate the extent of neurological impairment and provide quantitative data on the severity of renal insufficiency. The difference in pupillary diameter of two eyes, and asymmetric neurological involvement in visual pathway due to pre-existing eye condition in one eye could contribute to different VEP results for both the eyes. These findings align with the study conducted by Sokol S et al[11],found significant difference in P100 latency in two eyes.

The results were partly consistant with H.K. Agrawal et al[12] ,which investigated visual evoked potentials in 50 healthy controls and 100 chronic kidney disease (CKD) patients.

On comparison of BERA parameters for the right ear of both the groups, found that hemodialysis patients had prolonged wave- II, wave-V latencies (ms), and interpeak latency (ms) I-IV as compared to nonhemodialysis patients, but wave-V latency (ms) and interpeak latency (ms) I-IV were not statistically significant, also found only wave –II latency were statistically significant for right ear of hemodialysis patients.

On comparison for left ear, found that only interpeak latency of wave I-IV had prolonged value in hemodialysis patients as compared to nonhemodialysis patients, but it was not statistically significant. The difference in absolute and interpeak latencies for both the ears could be due to damage to the inner hair cells within cochlea, middle ear disease and auditory nerve affected at one ear.

These findings were partly in accordance with Rossini et al[13] ,who measured BERA in 28 patients of chronic renal failure. They found that in symptomatic peripheral neuropathy patients prolonged I-II IPLs while I-V and III-V IPLs were prolonged in patients without neuropathic symptoms.

On comparison of vitamin B12 in both the groups, observed that there was low serum levels of vitamin B12 in hemodialysis patients as compared to nonhemodialysis patients which was statistically significant. Similar findings seen in Saifan C. et al[4] ,Amini M et[15] ,Iqbal N. et al[16],Billion S. et al[17],and Pastore A. et al[18].A systematic review done by Amini M et who studied on end stage renal disease patients with Vitamin B12 deficiency found and reported the effect of vitamin B12 supplementation in these patients.

In present study, dialysis patients had low levels of vitamin B12 due to their often inadequate dietary intake because meals that have high concentrations of vitamin B12 also had high concentration of electrolytes which might be harmful to dialysis patients, therefore they should only eat foods that were low in vitamin B12. Also vitamin B12 is a common middle-sized chemical compound that may be removed using modern high-flux dialyzers[18]. Deficiency of vitamin B12 in hemodialysis patients can lead to neuropathy which manifest as tingling, numbness and weakness in the hands and feet. Increased risk of cardiovascular disease, anemia are the other complications of vitamin B12 deficiency[19].

In present study found the correlation of VEP of nonhemodialysis patients with s. creatinine and eGFR were statistically significant for P100 latency for both the eyes, P100 latency of right eye respectively. The correlation of BERA of nonhemodialysis patients with s. urea, eGFR were statistically significant for wave-III latency of left ear and wave-II latency of right respectively.

The correlation of visual evoked potential (VEP) of hemodialysis patients with s. urea was statistically significant for N75 latency for left eye. The correlation of BERA of hemodialysis patients with s. creatinine, s. urea and eGFR were statistically significant for wave-I latency for right ear, wave –I and wave-II latency for both the ear and wave-II, wave-IV latency of right ear respectively.

An association were found between VEP and BERA results with biochemical parameters which means duration of disease, accumulated toxins and dialysis itself significantly impacted optic and auditory pathway. Therefore, VEP and BERA could be considered a routine screening tool to detect early subclinical CNS involvement.

These finding were partly consistant with H.K. Agrawal et al[12],who found correlation between latencies of P100 and N145 with blood urea and serum creatinine, but not with N75 in chronic kidney disease patients and also found correlations of wave-I , wave-III and interpeak latencies III-V , I-V with blood urea levels. However , only wave-III and interpeak latencyIII-V were found correlated with serum creatinine values.

However, some previous researches were not in accordance with our study, Lewis et al[20],Kuba et al[21] and Hamel et al[22] observed that, there was no association existed between visual evoked potential results and blood profile parameters.

With increasing the stages of CKD, eGFR get reduced, but the levels of creatinine and urea in blood increased due to loss of function of kidneys, these toxins get accumulated in brain tissues and causes CNS dysfunctions. In present study, the correlation of these toxins with VEP and BERA parameters were found. Means as s. creatinine and s.urea levels get increased the absolute latencies of VEP (P100, N75, N145) could be prolonged, amplitude (P100-N145) could be decreased, and also absolute latencies and interpeak latencies of BERA also increased.

In present study, found blood levels of vitamin B12 were low in hemodialysis patients, but there was no statistically significant correlation found between

serum levels of vitamin B12 with VEP and BERA parameters.

Limitations:

There was no control group in the study. Future studies with a control group will help to better analyze the role of BERA as an intervention. A relatively smaller number of participants were enrolled, so the results cannot be generalized to the entire population. The absence of any intervention to treat the neurological dysfunction which early diagnosed by BERA in CKD patients.

CONCLUSION

Recent findings highlight a statistically significant correlation between BERA and various blood parameters in patients with CKD. In nonhemodialysis patients, these correlations were observed with urea and eGFR. Conversely, in hemodialysis patients, the relationships were noted between BERA, serum creatinine, eGFR and urea levels. These associations suggest that changes in these specific blood parameters may contribute to CNS involvement in CKD patients. Therefore, managing these blood parameters and developing therapeutic strategies that target their regulation could potentially delay the onset of CNS complications in individuals with CKD.

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