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The Protective Effects of Vitamin B_{12} on Pentylenetetrazole-Induced Seizures in Rats

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Abstract

Objective: Epilepsy is defined as a short-lived paroxysmal disorder of the brain functions observed in seizures by sudden, abnormal and hypersynchronous discharges of a group of neurons in the central nervous system. Vitamin B_{12} derivatives are complex organometallic cofactors used by a limited number of enzymes. B_{12} vitamins are involved in many cellular functions, both glial and neuronal, in the central and peripheral nervous system. The aim of this study was investigate to effects of vitamin B12 on pentylenetetrazole-induced seizures in rats.

Methods: In our study, 18 240-280gr male Wistar albino rats were used. Animals were divided into three groups: control (n=6), 50μg/kg vitamin B_{12} (n=6) and 100μg/kg vitamin B_{12} (n=6). Serum physiologic to first group and other two groups were administered for seven days at the indicated doses of vitamin B_{12} intraperitoneally. On the seventh day, pentylenetetrazole (PTZ) was intraperitoneally injected at 70mg/kg 45 minutes after drug administration. The animals were observed for 30 min. Stages were determined according to the Racine seizure scale and the first myoclonic jerk time (FMJ) was recorded in seconds. After the procedure, brain tissues were removed of animals. After routine histological follow-up, serial sections from brain tissues were stained with toluidine blue. The hippocampal CA1, CA2 and dentate gyrus regions were evaluated histopathologically. The data analyses were performed with SPSS Version 21.0 for Windows and were evaluated using a one-way analysis of variance (ANOVA).

Results: The results of epileptic behavior were evaluated according to Racine convulsion scale, the difference between the control and 50μg vitamin B_{12} group was statistically significant ($p<0.01$). The first myoclonic jerk time was considered, the difference between the control and 50μg vitamin B_{12} was statistically significant ($p<0.001$). When the groups were evaluated histopathologically, it was statistically significant that 50μg B_{12} treatment reduced neuronal damage in CA1, CA2 and dentate gyrus regions ($p<0.05$).

Conclusion: This study suggests that vitamin B_{12} therapy may reduce epileptic seizures and post-seizure neuronal damage.

Abbreviations: PTZ: Pentylene Tetrazole; FMJ: First Myoclonic Jerk; AEDs: Antiepileptic Drugs; RCS: Racine's Convulsion Scale; CA: Cornu Ammonis; DG: Dentate Gyrus; SEM: Standard Error of Mean

Keywords: Epilepsy; Pentylenetetrazole; Vitamin B_{12}

Introduction

Epilepsy is the one of most common and critical neurological disorder that affects millions of people worldwide [1]. This neurological disorder is defined the repeated occurrence of bursts of electrical activity (seizures) in specific brain areas such as limbic system and cerebral cortex [2]. Various antiepileptic drugs (AEDs) are widely used both long-term combined therapy and mono therapy in epilepsy. Drug resistant (i.e., pharmacoresistant or medically intractable) epilepsy is defined as failure to achieve seizure control despite adequate trials of antiepileptic drug (AED) therapy [3] and approximately one-third of epileptic patients do not respond efficiently to present AEDs [4]. Many available AEDs may also cause toxicity [5]. Therefore, more influential and safer new therapeutics are necessary.

Vitamin B12 is needed for the development and initial myelination of the central nervous system as well as for the maintenance of its normal function [6]. Promoting neurite growth, neuroregeneration and antinociception properties

of vitamin B_{12} were studied in several animal models related to neuronal diseases [7,8]. Neurological problems arise from vitamin B_{12} deficiency have wide spectrum, from asymptomatic to life-threat pancytopenia or myelopathy. It was also implicated that vitamin B_{12} is a risk factor in the etiology of ischemic vascular events and in the course of many degenerative diseases, particularly Alzheimer's disease [9,10]. In addition, vitamin B_{12} deficiency has been shown to cause epileptic seizures [11,12]. Although there are enhancement evidences indicating neuroprotective effect of vitamin B_{12}, the effect of vitamin B_{12} on the antiepileptic effect has not been clearly demonstrated. This study was designed to investigate the effect of vitamin B_{12} on pentylenetetrazole-induced seizures and to demonstrate the neuroprotective effect of vitamin B_{12} on neuronal damage after pentylentetrazol administration.

Materials and Methods

Experimental animals

The present study was performed in Cumhuriyet University Animal Laboratory after approval of Local Ethics Committee. Healthy adult male, weighing 230-250 g, Wistar albino (n=18) were used. All animals were fed by a standard laboratory diet and they could drink water whenever they requested. Rats were capable of normal activity in the cages, 22 ± 2°C, humidity (50-70%) and 12 hours of night/day. All animals were kept under observation for a few days before the study to decide if they are healthy or not.

Drug administration

Vitamin B12 and pentylentetrazol were dissolved in physiological saline. The drugs were purchased from Sigma-Aldrich Co., St Louis, MO, USA. Solutions were freshly prepared on the days of the experiments.

Experimental procedure

Eighteen rats were divided randomly into three groups for behavioral and histological assessments. Group1 was given saline intraperitoneally (i.p.), group2 50µg/kg vitamin B_{12} i.p. and group3 100µg/kg vitamin B_{12} i.p. for 7 days. The seventh day, pentylentetrazol (PTZ) (70 mg/kg, i.p.) was injected 45 min after last vitamin B_{12} injection to induce seizures. Racine's Convulsion Scale (RCS) were used to evaluate the seizures stages as follows: 0 = no convulsion; 1 = twitching of vibrissae and pinnae; 2 = motor arrest with more pronounced twitching; 3 = motor arrest with generalized myoclonic jerks; 4 = tonic-clonic seizure while the animal remained on its feed; 5 = tonic-clonic seizure with loss of the righting reflex; and 6 = lethal seizure. Rats were observed for both to evaluate Racine's Convulsion Scale (RCS) and to record first myoclonic jerk(FMJ) onset times which coincide inception stage3 [13]. The observation period for PTZ-induced seizures was limited to 30 min in duration [14]. Two hours after, the animals were terminated using the decapitation method and brain tissues were removed.

Histopathological evaluation

Formalin-fixed brain sections (5µm) were stained with toluidine blue stain to quantify the number of dark neurons. All sections were examined and photographed with Olympus C-5050 digital camera at Olympus BX51 microscope. In hippocampal CA1, CA2 (Cornu Ammonis) and DG (Dentate gyrus) regions, dark neurons and survival neurons were counted in six sections per studied animal (n=3 for each group) by an image analysis system (Image- Pro Express 1.4.5, Media Cybernetics, Inc. USA). The numbers of dark neurons were given as percentage (toluidine blue stained neurons*100/survival neuron). The observers blinded to the study groups accomplished all histological assessments.

Statistical analysis

The results were expressed as a mean ± standard error of mean (SEM). The data analyses were performed with SPSS Version 21.0 for Windows. The RCS score, FMJ time and dark neurons were evaluated using a one-way analysis of variance (ANOVA). A posthoc Tukey test was utilized to identify the differences between the experimental groups, and a value of $p < 0.05$ was accepted as statistically significant.

Results

Evaluation of groups in terms of RCS and FMJ Onset Times

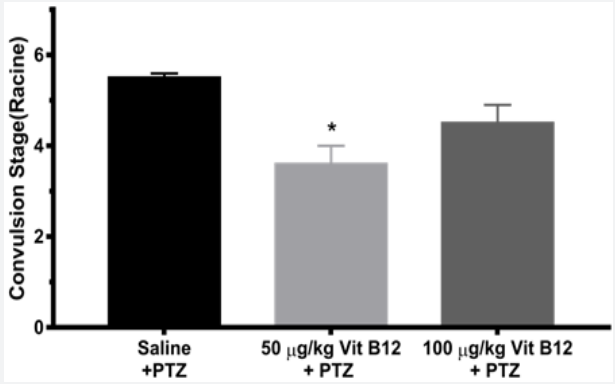

Figure 1: Racine Convulsion Scale. Data are presented as mean ± SEM .*p < 0.01, 50µg/kg vitamin B12 group + PTZ group compared with saline + PTZ.

When the Racine scores were calculated between the groups, there were statistically significant differences between the saline (5.5 ± 0.2) and 50µg/kg vitamin B_{12} (3.6± 0.4)($p < 0.01$). However there were no statistically significant differences between the saline (5.5 ± 0.2) and the 100µg/kg vitamin B_{12} (4.5 ± 0.4) group than in the saline ($p > 0.05$). In addition, there were no differences between the 50µg/kg vitamin B_{12} and 100µg/kg vitamin B_{12} ($p > 0.05$) (Figure 1). There were statistically significant differences ($p < 0.001$) between saline (83.3 ± 9.9 s) and 50µg/kg vitamin B_{12} (176.6 ± 16.7 s) groups in terms of FMJ onset times. There were no statistically significant differences between 100µg/kg vitamin B_{12} (109.3± 11.2) and saline in terms of FMJ onset times

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(p>0.05). In addition, there were differences between 50µg/kg vitamin B_{12} and 100µg/kg vitamin B_{12} statistically (p<0.01) (Table 1).

Table 1: Fist myoclonic jerck (FMJ) onset time as seconds(s). Data were expressed as mean ± SEM.

FMJ onset time (s)	Groups
83,0 ± 9,9	PTZ (70mg/kg) and saline (group 1)
176,6 ± 16,7*#	PTZ (70mg/kg) and 50µg/kg vitamin B_{12} (group 2)
109,3 ± 11,2	PTZ (70mg/kg) and 100µg/kg vitamin B_{12} (group 3)

Evaluation of groups in terms of dark neurons

Dark neurons were identified by the neuronal shrinkage, cytoplasmic esoinophilia, nuclear pyknosis, and surrounding spongiosis in total hippocampal formation (Figure 2A,2E,2I) and CA1 (Figure 2B,2F,2J), CA2 (Figures 2C,2G,2K) and DG (Figures 2D,2H,2L) hippocampal regions' formation. Administration of Vitamin B12 at the dose of 50µg/kg significantly prevented production of dark neurons due to PTZ induced seizures in CA1, CA2 and DG regions of hippocampus (p< 0.05) (Figures 3A-3C). However there was no significant difference between at the dose of of 100µg/kg vitamin B_{12} and PTZ group in CA1, CA2 and DG regions of hippocampus in point of dark neurons (p>0,05) (Figures 3A-3C). In addition, there was no significant difference between at the dose of 50µg/kg and at the dose of 100 µg/kg vitamin B_{12} in CA1, CA2 and DG regions of hippocampus in point of dark neurons (p>0,05).

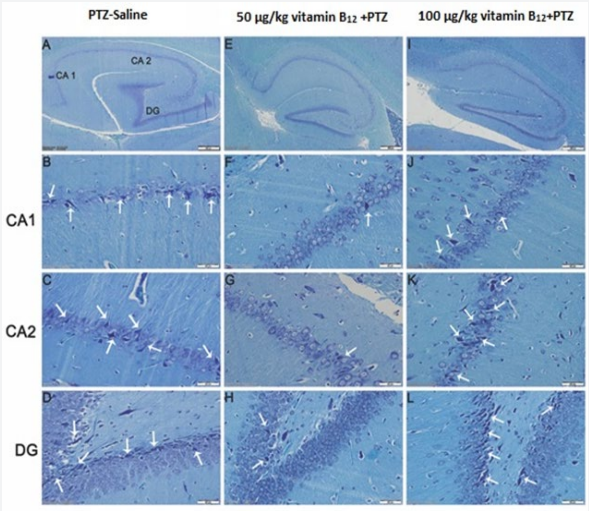

Figure 2: Sections of the rat coronal hippocampus with toluidine blue staining. Basophilic (dark) neurons (white arrow) distributed between normal pyramidal neurons in the hippocampal CA1region; (B) PTZ group, (F) 50µg/kg vitamin B12 group, (J) 100µg/kg vitamin B12 group. Basophilic (dark) neurons distributed in the hippocampal CA2 region, (C) PTZ group, (G) 50µg/kg vitamin B12 group, (K) 100µg/kg vitamin B12 group. In the hippocampal DG (dentate gyrus) region, (D) PTZ group, (H) 50µg/kg vitamin B12 group, (L) 100µg/kg vitamin B12 group. General hippocampal images of groups A, E and I.

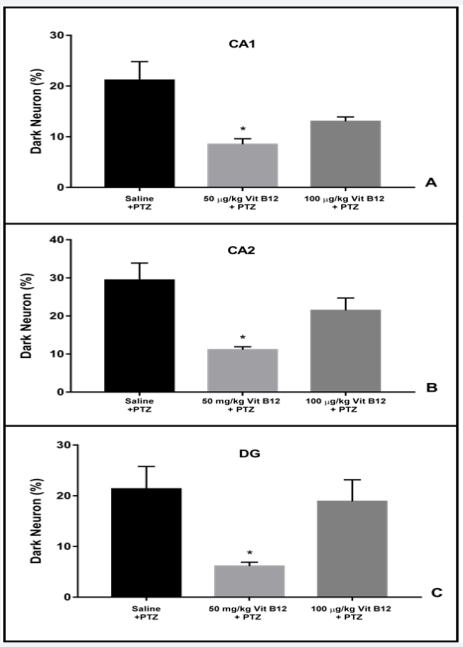

Figure 3: Comparison of dark neuron numbers per area in CA1(A), CA2(B), DG(C) areas between groups. Data are presented as mean ± SEM . *P <0.05 in comparison with control group.

Discussion

In the present study, on the one hand subchronic administration of vitamin B_{12} significantly decreased RC and also increased FMJ. Vitamins have been considered important patterns in controlling certain types of seizures or even preventing adverse effects of AEDs [15,16]. There are various studies indicating an association between vitamin B12 deficiency and EEG abnormalities in epilepsy [17,18]. In addition, there are increasing evidences indicate neuroprotective effects of vitamin B_{12} in peripheral and central nervous systems. In the previous studies, researchers evaluated the neuroprotective actions of vitamin B_{12}, in rats with sciatic and corneal nerves crush injury models [19,20]. In addition, a study indicated that vitamin B_{12} has anti-apoptotic effect on peripheral neuron injury by increasing Bax protein and reducing Bcl-2 protein [21]. Furthermore, studies have shown that vitamin B_{12} is able to protect cortical neurons and retinal cell cultures against glutamate cytotoxicity [22]. Also vitamin B_{12} show antiepileptic activity in penicillin-induced model via GABAA receptor system [23]. On the other hand, neuroprotection is very important as a promising therapy for preventing and treating epilepsy [24]. These findings show possibility potential of vitamin B_{12} in the treatment epilepsy. However, the potential use of vitamin B_{12} in the treatment of epilepsy is not enough yet.

On the other hand, these findings show possibility potential of vitamin B_{12} in the treatment epilepsy. However, the potential use of vitamin B_{12} in the treatment of epilepsy is not enough yet. In present study showed that after PTZ-induced seizures

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damaged to hippocampals neurons of the rats were prevented by vitamin B_{12}. Dark neurons, previously were considered as histological artifacts in neuro surgical biopsies [25] but later, they were seen after brain trauma [26].

Dark neurons have basophilic appearance and morphological changes and might be seen after hypoglycemia, ischemia, stress and epilepsy [27,28]. Epilepsy has also been introduced as an important cause of dark neuron production [29]. The results of present study showed that PTZ-induced seizures were resulted in dark neuron production in the hippocampal regions which were confirmed by various studies [30,31]. Several studies have also confirmed hippocampal damages created by seizures [32,33]. The results of present study were consistent with previous studies in which it was shown that PTZ-induced seizures were followed by production of dark neurons in the brain tissues.

Conclusion

The results of the present study showed that vitamin B_{12} decreased epileptic seizures as well as preventing neural damage after PTZ- induced seizure in rats. These results support the beneficial effect vitamin B_{12} on the nervous system. Further studies are required for determining the protective effect and mechanism of vitamin B_{12}.

Financial Disclosure

No funding agency had any part in this study.

Conflict of Interest

The authors declare no competing interests.

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