Analysis of GABRB3 Protein Level After Administration of Valerian Extract (Valeriana officinalis) in BALB/c mice

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ABSTRACT

Background: Valeriana officinalis is most commonly used as traditional medicine. Valerenic acid is the primary component of Valerian officinalis which inhibits the catabolism of enzyme induced breakdown of gamma amino butyric acid (GABA) in the brain, resulting in sedation. The aim of this study is to determine the level of GABRB3 protein, as part of major inhibitory neurotransmitter in the brain, after administration of Valerian extracts in BALB/c mice. Material and Methods: This is an experimental study using animal model with post test-only controlled group design. Twenty healthy adult male BALB/c mice were randomly divided into four groups, negative control group (Aquadest), positive control group (Diazepam 0.025 mg/10 g), first treatment group (Valerian extract 2.5 mg/10 g) and second treatment group (Valerian extract 5 mg/10 g). The drugs were administered via gastric gavage for seven consecutive days. The blood was drawn from each mice on the first day (before treatment) and on the seventh day of experiment (2 hours after treatment). The blood sample was examined by enzyme-linked immunosorbent assay (ELISA) to determine the GABRB3 protein level. Results: GABRB3 protein level in BALB/c mice after administration of Valerian extract was increased significantly in both treatment group (p <0.0001). The highest increment in protein levels was found in the first treatment group with an increase of 2.988 μmol/L, compared with the second treatment group with an increase of 2.146 μmol/L. Conclusion: GABRB3 protein level in BALB/c mice were increased after administration of Valerian extract. Administration of higher dose does not yield in higher GABRB3 protein level nor sedative effect.

Key words: Valerian extract, Diazepam, GABRB3 protein, BALB/c mice.

INTRODUCTION

Valerian, also known as Setwall, Valerianaceae family. It is an herbaceous plant from Europe and Asian, present in almost all countries. The Valerian’s root is often used as herbal medicine. Valeriana officinalis is most commonly used as traditional medicine for 2000 years. Since 16th century until now, Valerian extract has anxiolytic, hypnotic, tranquilizing, and sleep inducing effects that have been demonstrated in both animal studies and clinical trials. Valerian contains volatile oil (menoterpene bornyl acetate, sesqui terpenes, valerinic acid), valepotriates, hidroxypyreno sinol, alkaloid (act iminid, catinidin, valerianin, valerin), and glutamine. Glutamine cross the blood brain barrier which will then be converted into GABA inside GABA-ergic neurons. The primary component of Valerian officinalis is Valerenic acid with hydroxyl and acetone group derivatives, which inhibits catabolism enzyme induced breakdown of gamma amino butyric acid (GABA) in the brain resulting in sedation.1,16

Gamma aminobutyric acid receptors are the target of Valerian extract.Gamma aminobutyric acid is a major inhibitory neurotransmitter that works in the central nervous system. GABA has an important role to reduce the excitation of neurons by inhibiting the transmission of nerve impulses in the brain and also plays a role in the regulation of muscle tone. GABA has two types of receptors located in post synapse neurons, GABA_A receptors and GABA_B receptors. GABA_A is a pentametric protein consisting of different subunits. The effects of Valerian to induce sleep are associated with GABA_A receptors. GABA_A receptors are important targets for hypnotic-sedative components, general anesthesia, mechanism of benzodiazepine and barbiturates drugs. GABA_A receptors are expressed in anatomical regions that involve sleep. The component of Valerian extract has an influence on the GABA_A receptor (gamma-aminobutyric acid subtype A). Valerian influences the presynaptic component of GABA-ergic neurons that affect the release of GABA synaptomals. In addition, Valerian also inhibits GABA reuptake and inhibits GABA catalbolism by inhibiting the enzyme GABA transaminase.1,16

The mechanism of action of Valerian is similar to Benzodiazepine. Benzodiazepines bind to GABA_A receptor Gamma subunit (Figure 1). Valerian and Benzodiazepine works on the same GABA receptor but binds to a different subunit, Valerian binds to Beta subunit (Figure 2). Both of them cause the movement of chloride into the neuron when neurotransmitter GABA binds to GABA_A receptor which generates a chloride inlet current, which induces a hyperpolarization of the cell membrane and therefore inhibits nerve impulse conduction, so
excitatory postsynaptic potentials (EPSPs) make neuron less responsive to stimulation that can suppress central nerve system. Valerian has been shown to reduce metabolism of GABA, thus GABA can last longer. Diazepam has been proved to works on GABA receptor. In this study Diazepam was administered in the positive control group. Diazepam is a GABA agonist that binds specifically to Benzoazepine receptor of GABA which result in inhibition of central nervous system activity.17-23 The aim of this study is to determine the level of GABRB3 protein, as part of major inhibitory neurotransmitter in the central nervous system, after administration of Valerian extracts in BALB/c mice.

MATERIAL AND METHODS

This is an experimental study using 20 healthy adult males BALB/c mice, 8-weeks-old, and weighted approximately 25-35 g (Figure 3). Mice that died or pregnant were dropped out of the study. Mice were obtained from the maintenance and development unit of the experimental animal laboratory of Molecular Biology Faculty of Medicine, Hasanuddin University, Makassar, Indonesia. All experimental protocols employed in this study were approved by the Medical Research Ethics Committee of Hasanuddin University Makassar, Indonesia (903/H4.8.4.5.31/PP36-KOMTEK/2017). BALB/c mice were also used in our reference study regarding the use of Valerian extract.31,32 Valerian extract used in this study was Blackmores Valerian Forte, a standardized herbal pill equivalent to 2 gr (2000 mg) of Valeriana officinalis’ dry root or rhizome. The extract was diluted with Aquadest to 2 mg/0.1 ml solution. The drugs were administered via gastric gavage with 1 ml syringe (Figure 4).

The mice were adapted for one week in a room with room temperature of 25 °C, 12-hour cycle of light and dark, and were given prophylactic food and drink. Before drug administration, all mice were fasted for 3 hours. The mice were divided into 4 groups, as follows: negative control group with Aquadest 5 ml; control positive group with Diazepam 0.025 mg/10 g; first treatment group with Valerian extract 2.5 mg/10 g; second treatment group with Valerian extract 5 mg/10 g. In this study, the dose of Valerian extract was adjusted from the human daily dose of 20 mg/kg and 40 mg/kg. The maximum tolerated dose in human are 81.2 mg/kg according to Kakehashi (2014), and 51 mg/kg according to Al Majeed (2006). Food and Drugs Administration (FDA) regulated the doses from human to mice by multiplying 12.3 as a conversion factor, which led to the final dose of 2.5 mg/10 g and 5 mg/10 g as a meticulous doses for mice on the average weight of 20 grams. Meanwhile, the dose of Diazepam was adjusted from human daily dose of 0.2 mg/kg, multiplied by 12.3 as a conversion factor, which led to the final dose of 2.5 mg/kg or 0.025 mg/10 g.27,28 The blood was drawn from each mice on the first day (before treatment) and on the seventh day of experiment (2 hours after treatment), as showed as in figure 5. The blood sample was examined by enzyme-linked immunosorbent assay (ELISA) Reader 270 (Biomeriux, France) to determine the GABRB3 protein level.

The data were analyzed using SPSS software version 20. The data were tested with Shapiro-Wilks test. The statistical analysis technique using ANOVA test was used to compare numerical difference in each group. Paired T-test and Independent T-test was used to compare the GABRB3 protein level of each group, before and after experiment. P value <0.05 was considered significant.

RESULTS

Table 1 showed the comparison of GABRB3 protein levels between before and after treatment from all group using statistical analysis Paired T-test. There was a significant increment of GABRB3 protein level from 2.366 μmol/L before treatment to 3.118 μmol/L after treatment (p <0.0001).
Table 2 showed the comparison of GABRB3 protein levels between before and after treatment from each group using Paired T-test statistical analysis. In the negative control group, there was an increment of protein level from 2.048 µmol/L before treatment to 2.299 µmol/L after treatment, although not significant (p = 0.341). In the positive control group, there was an almost significant increment of protein level from 1.869 µmol/L before treatment to 2.849 µmol/L after treatment (p = 0.067). In the first treatment group (Valerian 2.5 mg/10 g), there was a significant increment of protein level (p <0.0001) from 2.371 µmol/L before treatment to 5.359 µmol/L after treatment. In the second treatment group (Valerian 5 mg/10 g), there was also a significant increment of protein level (p <0.0001) from 2.102 µmol/L before treatment to 4.248 µmol/L after treatment.

Statistical analysis using ANOVA test in the four groups (Table 3) showed that the average value of GABRB3 protein levels before treatment did not show a significant difference between each group (p= 0.67), while the contrary was found after treatment (p <0.0001).

Table 4 and 5 showed the comparison of GABRB3 protein levels between two groups. There were no significant differences (p >0.05) in GABRB3 protein level before treatment. However, there were significant differences in GABRB3 protein level between two groups after treatment (p <0.05), as shown in Table 5. Among the comparison between 2 groups, the most significant differences in GABRB3 protein levels was found between the negative control group (Aquadest) and first treatment group (Valerian 2.5 mg/10 g), between the negative control group (Aquadest) and second treatment group (Valerian 5 mg/10 gr), and between the positive control group (Diazepam) and first treatment group (Valerian 2.5 mg/10 g) with p value <0.0001.

**DISCUSSION**

The majority of the world’s population still uses natural herbal medicines, and Valerian is one of the herbal medicines that is often used. The Valerian cellular target is the GABA A receptor (sub-unit β3) which is linked to the GABRB3 gene to cause sedation effects. The aim of this study is to evaluate the connection between Valerian extract and increment of GABRB3 protein level to induce sedation effect.
According to the American Society of Anesthesiologists, sedation is a condition of decreased awareness to the surrounding environment as well as a reaction to external stimuli. 28,33,34

In this study the GABRB3 protein level in each mice was analyzed two times. The first blood sample was drawn from each mice on the first day, precisely before drug administration. The second blood sample was drawn from each mice on the seventh day of experiment, precisely 2 hours after drug administration. The blood sample was examined by enzyme-linked immunosorbent assay (ELISA) to determine the GABRB3 protein level.

The GABRB3 protein levels in the negative control group (Aquadest 5 ml) showed no significant differences with p value of 0.341, from level of 2.048 µmol/L before treatment to level of 2.299 µmol/L after treatment. The GABRB3 protein levels in the positive control group (Diazepam 0.025 mg/10 g) showed an almost significant increment with p value of 0.067, from level of 1.869 µmol/L before treatment to level of 2.849 µmol/L after treatment. Although the protein level increment was not significant, the p value obtained is close 0.05. This fact is due to the lack of subjects in each group (5 mice) and it is expected that increasing the number of subjects will produce a more significant differences.

The GABRB3 protein levels in first treatment group (Valerian 2.5 mg/10 g) showed a significant increment with p value of <0.0001, from level of 2.371 µmol/L before treatment to level of 5.359 µmol/L after treatment. The GABRB3 protein levels in second treatment group (Valerian 5 mg/10 g) showed no significant increment from level of 2.102 µmol/L before treatment to level of 4.248 µmol/L after treatment.

Table 3: Comparison Between GABRB3 Protein Level Before and After Treatment of Four Groups

| No | Variable | N | Mean (µmol/L) | SD | Median | P value | F value |
|----|----------|---|---------------|----|--------|---------|--------|
| 1. | GABRB3 Protein Level Before Treatment | | | | | | |
| 1 | Aquadest 5 ml | 5 | 2.048 | 0.409 | 1.933 | | |
| 2 | Diazepam 0.025 mg/10 g | 5 | 1.869 | 0.817 | 2.284 | 0.582 | 0.67 |
| 3 | Valerian 2.5 mg/10 g | 5 | 2.371 | 0.317 | 2.421 | | |
| 4 | Valerian 5 mg/10 g | 5 | 2.102 | 0.588 | 2.379 | | |
| 2. | GABRB3 Protein Level After Treatment | | | | | | |
| 1 | Aquadest 5 ml | 5 | 2.299 | 0.209 | 2.364 | | |
| 2 | Diazepam 0.025 mg/10 g | 5 | 2.849 | 0.152 | 2.783 | <0.0001 | 61.49 |
| 3 | Valerian 2.5 mg/10 g | 5 | 5.359 | 0.1 | 5.377 | | |
| 4 | Valerian 5 mg/10 g | 5 | 4.248 | 0.738 | 4.527 | | |

Data were analyzed with ANOVA test, P-value of <0.05 was considered significant.

Table 4: Comparison of GABRB3 Protein Level Before Treatment Between Two Groups

| No | Variable (n=5) | Mean (µmol/L) | SD | Min | Max | Median | P value |
|----|----------------|---------------|----|-----|-----|--------|---------|
| 1. | Aquadest 5 ml | 2.048 | 0.409 | 1.579 | 2.493 | 2.364 | 0.674 |
| 2. | Diazepam 0.025 mg/10 g | 1.869 | 0.817 | 0.947 | 2.623 | 2.284 | |
| 3. | Aquadest 5 ml | 2.048 | 0.409 | 1.579 | 2.493 | 2.364 | 0.201 |
| 4. | Valerian 2.5 mg/10 g | 2.371 | 0.317 | 1.846 | 2.646 | 2.421 | |
| 5. | Valerian 5 mg/10 g | 2.048 | 0.409 | 1.579 | 2.493 | 2.364 | 0.868 |
| 6. | Valerian 5 mg/10 g | 2.102 | 0.588 | 1.088 | 2.508 | 2.379 | |

Data were analyzed with Independent t-test, P-value of <0.05 was considered significant.

Table 5: Comparison of GABRB3 Protein Levels After Treatment Between Two Groups

| No | Variable (n=5) | Mean (µmol/L) | SD | Min | Max | Median | P value |
|----|----------------|---------------|----|-----|-----|--------|---------|
| 1. | Aquadest 5 ml | 2.299 | 0.209 | 2.025 | 2.554 | 2.364 | 0.001 |
| 2. | Diazepam 0.025 mg/10 g | 2.849 | 0.152 | 2.710 | 3.045 | 2.783 | |
| 3. | Aquadest 5 ml | 2.299 | 0.209 | 2.025 | 2.554 | 2.364 | <0.0001 |
| 4. | Valerian 2.5 mg/10 g | 5.359 | 0.100 | 5.198 | 5.468 | 5.377 | |
| 5. | Valerian 5 mg/10 g | 2.299 | 0.209 | 2.025 | 2.554 | 2.364 | <0.0001 |
| 6. | Valerian 5 mg/10 g | 4.248 | 0.738 | 3.19 | 4.973 | 4.527 | |

Data were analyzed with Independent t-test, P-value of <0.05 was considered significant.
5 mg/10 g) showed a significant increment with a p value of <0.0001, from level of 2.102 μmol/L before treatment to level of 4.248 μmol/L after treatment. The results showed a significant increment of GABRB3 protein levels after administration of Valerian extracts. Thus, this study proved that Valerian extracts are associated with changes in GABRB3 protein levels, as a gene that encodes the GABA\(_A\) receptor beta subunit.

The GABRB3 protein levels after treatment in the four groups showed a significant difference. The protein in the negative control group (Aquadest) was seen to have the lowest level, then followed by a positive control group (Diazepam). The highest GABRB3 protein levels after treatment were obtained in the first treatment group (Valerian 2.5 mg/10 g) and followed by the second treatment group (Valerian 5 mg/10 g). The fact showed that the increment of GABRB3 protein level in the first treatment group, with lower dose of Valerian, have resulted in higher increment level compared to the second treatment group, with higher dose of Valerian. Therefore, we can conclude that by increasing the dose of Valerian extract, does not increase the GABRB3 protein level.

This study support by Kniffin (2016), that GABRB3 is a heteromeric gene that encodes the GABA\(_A\) receptor \(\beta_3\)-subunit. The GABRB3 is a member of the GABA\(_A\) receptor family gene which has a heterometric structure of pentameric ion channel ligand channels where it works from GABA.26 GABA has an important role to reduce the excitation of neurons by inhibiting the transmission of nerve impulses in the brain. Khom et al. and meta-analysis studies by Bent et al. Khom et al (2016) related to the effect of valeric acid on the GABA\(_A\) receptor \(\beta_3\) subunit. Valerenic acid inhibits catalysis enzyme induced breakdown of gamma amino butyric acid (GABA) in the brain resulting in sedation.27,28 The result also consistent with study from Miftakhul (2009) which Valerian extract can cause sedative effect on BALB/c mice (p <0.001) and consistent with Al Majeed (2006) which Valerian liquid which Valerian extract can cause sedative effect on BALB/c mice (825).  

This study has several limitations. First, there are various available formulation of Valerian extract without a clear standard of processing method. Second, this study was not performing a staining of brain slice to determining the GABRB3 protein level through immunohistochemistry tests. Third, this study was not conduct behavioral experiment and needed to better explain the observed processes and mechanisms, responsible for the development sedative effect use beam walking assay and chimney test. More definitive studies to determine the correlation between GABRB3 protein level and sedation effect are needed.

**CONCLUSION**

Valerian extract is bound to the GABA\(_A\) receptor subunit-\(\beta_3\) to induce sedation effect and the GABRB3 protein levels was increased after administration of Valerian Extract in BALB/c mice. Increasing dose of Valerian extract does not increase the GABRB3 protein level that associated to the sedative effect.

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**CONFLICTS OF INTEREST**

The authors declare there is no conflict of interest.

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