The Effectiveness of GABA Agonist in Decreasing Expression of NR2B Subunit of N-Methyl-D-Aspartate (NMDA) Receptor in Neuropathic Mice by Partial Sciatic Nerve Ligation (PSNL) Method

(Efektivitas Agonis GABA terhadap Penurunan Ekspresi Reseptor N-Methyl-D-Aspartate (NMDA) Subunit NR2B pada Mencit Neuropati dengan Metode Partial Sciatic Nerve Ligation (PSNL))

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Abstract: Neuropathy pain is a pain that caused by nerves injury. Nowadays, treatment for neuropathic pain change to drugs that works as GABA agonist and cause re/imbalence between excitatory and inhibitory neurotransmitter in central nervous system (CNS). The present study was designed to investigate the effectiveness of gabapentin and baclofen in decreasing N-Methyl-D-Aspartate (NMDA) receptor NR2B subunit activity in neuropathic pain. Fourty mice were divided into 8 groups i.e sham, negative control, gabapentin (10, 30, 100 nmol) and baclofen (1, 10, 30 nmol). Neuropathic pain was induced by ligation of sciatic nerve with Partial Sciatic Nerve Ligation (PSNL) method). Treatments were administrated intrathecally once a day for seven consecutive days, at a week after induction. On day 15th, mice were sacrificed and the spinal cord were removed quickly. The expression of NMDA receptor NR2B subunit were examined with immunohistochemistry and data were analyzed by one way anova. The result from this research was gabapentin and baclofen administration significantly decrease expression of NMDA receptor NR2B subunit in mice compared to sham group. The higher the dose, the more effective to decrease the number of neuron that express NR2B. The conclusion of this research was gabapentin and baclofen treat neuropatic pain by decreased the number of NMDA receptor NR2B subunit.

Keywords: Neuropathic pain, PSNL, baclofen, gabapentin, spinal cord.

Materials and Method

Materials. Male Balb-C mice (20-25 g) were obtained from Faculty of Pharmacy University of Airlangga Surabaya and maintained in room temperature with 12 h light/dark cycle. They had free access to food and water. Gabapentin and Baclofen were purchased from Sigma. Each of them was dissolved in 1 mL of normal saline. Gabapentin and baclofen was administration as a solution 5 µL by intrathecally.

Methods. Neuropathy induction by ligation. Mice were weighed and divided into 8 groups of each 5 animals: on day 0, each mice in group 1-7 (neuropathy group) will induce neuropathy with PSNL method. Mice were anesthetized with aether and tying 1/3-1/2 of dorsal portion of sciatic nerve on the left lumbar nerve of mice with 8-0 silk. In group 8 (Sham group), the sciatic nerve was exposed without ligation. On day 7-13, each group will receive different treatment one daily: negative control (normal saline), sham (normal saline), gabapentin groups (dose 10, 30 and 100 nmol) and baclofen groups (dose 1, 10 and 30 nmol) by intrathecal. On day 14th, all mice will sacrifice with decapitation and spinal organ of each mice was immediatelly removed. Each spinal cord was fixed in neutral buffer formalin (NBF) 10% for 24 hours.

Application of Drugs. All treatments were dissolved in normal saline. Intrathecal injection were administrated according to Hylden and Wilcox (1980). In brief, mice were restrained the left hand and the injection was performed in the right hand. Drugs were injected 5 µL into the spinal subarachinoid space between L5 and L6 using 30 gauge needle combine to 10 µL Hamilton syringe. The right placement of the drugs administration was demonstrated by a quick flicking motion of the mouse’s tail upon entry of needle.

Immunohistochemistry. Tissue section from 3 mice were used for immunohistochemistry (IHC). Mice were sacrificed with dislocation method and the spinal tissue were removed quickly. The IHC method that was used in this research was labelled-streptavidin biotin II (LSAB II), fixation samples with NBF 10% with paraffin block method and sliced of 3-4 µm. These samples were then routinely processed using immunohistochemistry with mouse NMDA receptor subunit NR2B antibody (1:100).
Statistical Analysis. Data are described as the mean ± SEM. The comparison of the number of cell that express NMDA receptor NR2B subunit between treatment groups were tested by one-way ANOVA followed by Tukey’s HSD. Differences p value of less than 0.05 were considered statistically significant.

RESULTS AND DISCUSSION

In neuropathy model, mice were inducted by PSNL method. According to Bridges, et al(7), PSNL was widely used because this method was analog with human condition. This method caused 60% hyperalgesia and allodynia that was usually seen by increasing the response of animal in noxious stimulus or non noxious stimulus. Neuropathy that was caused by PSNL contributed to neuronal damage, particularly at L4 and L5 of the spinal cord(8).

Figure 1. Immunohistochemistry of dorsal horn of mice with magnification of 40x (A,B), 400x (C,D) and 1000x (E,F). Red arrow show activity of NMDA receptor NR2B subunit.

Based on Figure 1, negative control (neuropathic group) had higher intensity of brown colour than sham group. Chronic pain induction by ligation caused higher intensity of brown colour in the cytoplasm of dorsal horn of mice. Higher intensity of brown colour indicated higher activity of NR2B subunit. According to Guo, et al(9), the increased activity of NR2B subunit was associated with tyrosine phosphorylation that was occurred in chronic pain conditions. Neuropathy causes signal transduction and followed by releasing of inflammatory mediators (such as prostaglandins, bradykinin, histamine and serotonine), results activation of nociceptor(10). This process is followed by pain transmission by Aδ and C nerve fibers from dorsal horn of spinal cord to the brain, then induces release of excitatory neurotransmitter (i.e glutamate and substance P). Glutamate binds non NMDA receptors (i.e AMPA and kainite), whereas substance P binds to NK-1 receptors, causes depolarization. Continuous depolarization causes loss inhibition of Mg$^{2+}$ blockade on NMDA receptor channel, resulting Ca$^{2+}$ influx from extracellular to intracellular. Ion Ca$^{2+}$ binds calcium calmodulin (CaM) and stimulates activation of calcium-stimulated signaling pathways. This process involves two pathways, adenylate cyclase and protein kinase, including calcium-calmodulin dependent protein kinase II (CaMKII) and mitogen-activated protein kinase (MAPK). All of the process increases activation of NMDA receptor by higher expression of NR2B subunit(11,12).

Table 1. Number of cells that express the activity of NR2B subunit on dorsal horn of spinal cord mice with neuropathic pain.

<table>
<thead>
<tr>
<th>Groups</th>
<th>Treatment</th>
<th>Average number of cell (± SEM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sham</td>
<td>Normal saline</td>
<td>11 ± 2$^{a}$</td>
</tr>
<tr>
<td></td>
<td>Normal saline</td>
<td>18 ± 1$^{b}$</td>
</tr>
<tr>
<td></td>
<td>Baclofen 1 nmol</td>
<td>27 ± 3$^{c}$</td>
</tr>
<tr>
<td>Ligation</td>
<td>Baclofen 10 nmol</td>
<td>13 ± 1$^{d}$</td>
</tr>
<tr>
<td></td>
<td>Gabapentin 30 nmol</td>
<td>10 ± 1$^{e}$</td>
</tr>
<tr>
<td></td>
<td>Gabapentin 100 nmol</td>
<td>16 ± 2$^{f}$</td>
</tr>
</tbody>
</table>

Note: Different letter show significantly of average number of cell that express NR2B subunit activity in each treatment with one way anova analysis, followed by tukey HSD (p<0.05).

Influence of gabapentin and baclofen administration to the activity of NR2B subunit in neuropathic pain were analyzed by brown colour as positive marker of NR2B subunit activities. This action was showed at Fig 2 and 3.

Figure 2 dan 3 showed that brown colour intensity decreased by the administration of gabapentin and baclofen. The number of neuron that expressed the activity of NMDA receptor NR2B subunit in dorsal horn was showed at Table 1. Gabapentin and baclofen administration decreased activity of NR2B subunit, that was characterized by decreasing the intensity of brown colour. Higher doses indicates lower activity of NR2B subunit. Neuropathy causes imbalance between inhibitory neurotransmitter (GABA) and excitatory neurotransmitter (Glutamate) and leads to neuronal
Gabapentin and Baclofen decrease the activity of NMDA receptor NR2B subunit in mice with neuropathic pain.

REFERENCES


CONCLUSIONS

Gabapentin and Baclofen decrease the activity of NMDA receptor NR2B subunit in mice with neuropathic pain.


