EFFECT OF CARBAMAZEPINE ON THE SPONTANEOUS BEATING OF ISOLATED GUINEA PIG ATRIA

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ABSTRACT

Carbamazepine, a drug effective in pain, seizure, and affective disorders, was studied for its effects and toxicity on spontaneously beating isolated guinea pig atria. Carbamazepine (20-30 μg/mL) has a negative chronotropic effect on atria, without any significant effect on contractile force. The most significant effect (12.5%) was seen with 30 μg/mL of carbamazepine on atria. With higher doses (>30 μg/mL) carbamazepine produced toxic effects which resulted in atrial standstill. Pretreatment of atria with theophylline (5-50 μg/mL) prevented the negative chronotropic effect of carbamazepine (30 μg/mL). Three dose ratios of carbamazepine (1.33, 2, 2.33) in the presence of three different doses of theophylline (30, 50 and 60 μg/mL) were obtained. These results suggest that the negative chronotropic effect of carbamazepine and its toxicity may be due to its action as an agonist on adenosine A1 receptors and as an antagonist on A2 receptors of the atria. Moreover, using adenosine antagonists such as theophylline may overcome the toxic effect of carbamazepine on the heart. This may explain the reason for the interaction between carbamazepine and theophylline in clinical settings.


Keywords: Carbamazepine, isolated atria, theophylline, adenosine receptors.

INTRODUCTION

Carbamazepine is a tricyclic anticonvulsant drug. Its most pronounced clinical effect is in seizure disorders, paroxysmal pain syndromes and treatment of manic-depressive disorders. Carbamazepine is also effective in terminating digital-induced ventricular tachyarrhythmias. Carbamazepine blocks sodium channels at therapeutic concentrations and inhibits high-frequency repetitive firing in neurons in culture. It has also been shown that carbamazepine in therapeutic doses can interact with adenosine receptors. It has been suggested that the anticonvulsant properties of carbamazepine may be partially explained by an influence of this drug on adenosine receptors.

been shown that carbamazepine interacts competitively with adenosine-binding sites in the brain. It has been claimed that carbamazepine binds to A1 receptors completely and to A2 receptors partially at therapeutic levels. Derivatives may act as agonists of A1 receptors and antagonists of A2 receptors. Moreover, methylxanthines have stimulant and convulsant properties due to their action as antagonists on both A1 and A2 receptors. It has been shown that theophylline completely reverses the anticonvulsant action of carbamazepine. Carbamazepine also increases the severity of heart block caused by adenosine.

Adenosine receptors are G-protein coupled receptors and are divided into four subtypes, including A1, A2, A3, and A4, based on agonist actions of adenosine. A1 and A2 receptors are antagonized by xanthines, whereas A3 and A4 receptor are not. Stimulation of A1 recep-
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Effectors have been associated with inhibition of adenyl cyclase, and activation of K+ currents as well as activation of phospholipase C in some circumstances, and ion channel regulation. A2 receptors stimulate adenyl cyclase activity. Activation of A3 receptors also causes the release of inflammatory mediators such as histamine from mast cells. The physiologic role of A4 receptors remains unclear. Adenosine has negative chronotropic and dromotropic effects in patients with paroxysmal supraventricular tachycardia. These effects of adenosine would be mediated by A1 receptor subtypes. By acting on both the sinoatrial and atrioventricular nodes, adenosine causes bradycardia and heart block. Adenosine analogues have inhibitory effects in guinea pigs atria.

Theophylline is a nonselective adenosine receptor antagonist. Theophylline and carbamazepine reduce the efficacy of each other when they are co-administered.

The aim of the present study was to determine the effects of carbamazepine on isolated heart, to find a way to prevent the toxic effects of carbamazepine on the heart and to explore the interactions between carbamazepine and theophylline.

MATERIAL AND METHODS

Experimental protocol

Guinea pigs (300-700g) of either sexes were killed by a sharp blow to the back of the neck. The hearts were excised and placed in cool oxygenated Ringer Locke solution of the following composition (gram per liter): NaCl, 9; KCl, 0.42; CaCl2, 0.12; NaHCO3, 0.5; and glucose, 1. The atria were dissected and isolated from other tissues. The preparation was then mounted in a 20-mL organ bath which contained Ringer Locke solution, gassed with a mixture of 95% oxygen and 5% CO2 and maintained at a constant temperature of 36-37°C. A resting tension of 1g was applied and kept constant by readjustment during the equilibration period. The mechanical activity was recorded isometrically by means of a Grass 701E polygraph. The preparation were allowed to equilibrate 30 minutes before the use of drugs. The organ bath solution was changed every 15 minutes during the equilibration period. Each time the volume of drug solution was added to the organ bath was 0.1 mL.

The effective dose of carbamazepine (30 μg/mL) was added. The effective dose of carbamazepine in the presence of theophylline (30 μg/mL) shifted from 30 μg/mL to 40 μg/mL and the dose ratio was 1.33. The toxic dose of carbamazepine in the presence of theophylline (30 μg/mL) shifted from 40 μg/mL to 50 μg/mL (Fig. 4). Then the atria were pretreated with theophylline (50 μg/mL) and after the incubation period, different concentrations of carbamazepine (25-
Theophylline dose (µg/ml) were added. The effective dose of carbamazepine in the presence of theophylline (50 µg/mL) shifted from 30 µg/mL to 60 µg/mL and the dose ratio was 2. The toxic dose of carbamazepine in the presence of theophylline (50 µg/mL) shifted from 40 µg/mL to 70 µg/mL (Fig. 4). Finally, the atria were pretreated with theophylline (60 µg/mL) and after the incubation period, different concentrations of carbamazepine (40-80 µg/mL) were added. The effective dose of carbamazepine in the presence of theophylline (60 µg/mL) shifted from 30 µg/mL to 70 µg/mL and the dose ratio was 2.33. The toxic dose of carbamazepine in the presence of theophylline (60 µg/mL) shifted from 40 µg/mL to 80 µg/mL (Fig. 4).

**DISCUSSION**

It has been shown that the anticonvulsant properties of carbamazepine may be partially explained by an influence of this drug on adenosine receptors. It has been claimed that carbamazepine interacts competitively with adenosine-binding sites in the brain. It has also been shown that theophylline completely reverses the anticonvulsant action of carbamazepine. It has been suggested that carbamazepine acts as an agonist on A1 receptors and an antagonist on A2 receptors. In this study carbamazepine had a negative chronotropic effect on spontaneously beating isolated guinea pig atria. This is similar to the adenosine effect. Pretreatment of atria with theophylline (5-50 µg/mL), an unselective antagonist of adenosine receptors, prevented the negative chronotropic effect of carbamazepine. The negative chronotropic and dromotropic effects of adenosine are mediated by A1 receptor subtypes. Stimulation of A1 receptors causes inhibition of adenylyl cyclase and enhances potassium conductance which both lead to suppression of automaticity of the sinus node. Stimulation of A2 receptors activates adenylyl cyclase. Thus the antagonism effect on A2 receptors may lead to further inhibition of adenylyl cyclase which favors more suppression of the sinus node. The results may suggest that carbamazepine produces its negative chronotropic effect by acting as an agonist on A1 receptors and an antagonist on A2 receptors of isolated guinea pig atria. It is also suggested that theophylline, an unselective adenos-
The results also showed that carbamazepine may have interaction with adenosine and intensify the toxic effects of adenosine when they are co-administered.

REFERENCES

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