Original Article

Dose-dependent Modulation of Pentylenetetrazol-induced Seizure Activity by Histamine and Receptor Antagonists in Wistar Rats

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ABSTRACT

Background: Epileptic activity often involves key brain structures, like the hippocampus and amygdala, while histamine plays a crucial role in regulating neuronal excitability.

Objectives: The primary objective of this research was to investigate how different doses of histamine influence seizure frequency and the potential therapeutic effects of histamine in conjunction with chlorpheniramine and ranitidine.

Methods: Forty-eight Wistar rats (280–320 g) were divided into several groups, including control, histamine (2, 4, and 8 µg/kg), chlorpheniramine, ranitidine, and combinations of histamine with these drugs. The rats were anesthetized with ketamine-xylazine (70–7 mg/kg), and precise injections of 0.5 µL of each drug were delivered into the amygdala using a Hamilton syringe. Brain activity was recorded before and after administering pentylenetetrazol (PTZ) (80 mg/kg, i.p.) to induce seizures, followed by monitoring convulsive activity. Diazepam (10 mg/kg, i.p.) was then given to suppress the seizures.

Results: Histamine significantly reduced seizure frequency in a dose-dependent manner, and chlorpheniramine and ranitidine exhibited similar effects, both alone and in combination with histamine. Notably, although seizure frequency varied among groups, the amplitude of convulsive activity remained unchanged.

Conclusion: The findings provide deeper insight into the role of histamine in seizure modulation and suggest potential therapeutic implications for epilepsy treatment.

Keywords: Neurotransmitter, Histamine, Hippocampus, Amygdala, Epilepsy

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Introduction

Epilepsy is a neurological disorder that affects millions of people worldwide, defined by the recurrence of unprovoked seizures due to abnormal patterns of brain activity (Stafstrom & Carmant, 2015). While many factors contribute to seizure generation, the limbic system, especially the hippocampus and amygdala, has been a central focus in understanding how seizures emerge and spread. The hippocampus plays a fundamental role in learning and memory (Lisman et al., 2017), while the basolateral amygdala (BLA) is crucial for processing emotional and aversive stimuli (Aroniadou-Anderjaska et al., 2008). The dynamic interactions between these two regions influence how emotional experiences affect memory and, under pathological conditions, how they might contribute to seizure vulnerability (Provensi et al., 2020).

One less understood player in this system is histamine, a neurotransmitter with diverse effects in the brain. Histamine acts through four receptor subtypes—H1, H2, H3, and H4—each with distinct distributions and functions (Parsons & Ganellin, 2006). The H1 receptor, typically linked to excitatory activity, might intuitively be thought to raise seizure risk. Yet, paradoxically, some studies suggest that blocking this receptor using antagonists, like chlorpheniramine could reduce seizure susceptibility (Vohora et al., 2004; Bousquet et al., 2008). This contradiction suggests a more complex relationship between histaminergic signaling and seizure activity than previously appreciated.

Compared to H1 receptors, the role of H2 receptors in the brain is less well defined. These receptors are primarily known for regulating acid secretion in the stomach, and their presence in the brain—and particularly their function in seizure modulation—is not thoroughly studied (Murialdo et al., 1990). Some early evidence points to a possible central effect of H2 antagonists, such as ranitidine (Privou et al., 1998), but their influence on brain excitability is still not well characterized. Taken together, the interplay between histamine signaling, its receptor subtypes, and limbic brain structures opens a compelling avenue for exploration—particularly when it comes to seizure modulation. Field action potentials (FAPs), which reflect the collective electrical response of neurons, provide an excellent window into how drugs affect neuronal activity in real-time (Buzsáki et al., 2012).

In this study, we explored how histamine, chlorpheniramine (an H1 antagonist), and ranitidine (an H2 antagonist), individually and in combination, affect hippocampal field potentials in anesthetized rats. By monitoring these signals, we hope to shed light on how histamine receptor signaling shapes brain excitability and what implications this might have for understanding and potentially treating seizure disorders.

Materials and Methods

This study was conducted on 48 adult male Wistar rats, weighing 280–320 g, and aged 10–12 weeks. The animals were housed in groups of three per cage under standard laboratory conditions (22±2 ˚C temperature, 50–60% humidity, 12-hour light/dark cycle), with ad libitum access to food and water. According to the report of the Ethics Committee of the University of Tabriz, this research project was conducted based on the ethical principles and national standards of medical research in Iran.

The animals were randomly assigned to eight groups (n = 6 per group):

1. Control (normal saline, 0.5 µL/site of injection),

2. Histamine (2, 4, or 8 µg/kg),

3. Chlorpheniramine (8 µg/kg),

4. Ranitidine (8 µg/kg),

5. Histamine (8 µg/kg) + Chlorpheniramine (8 µg/kg),

6. Histamine (8 µg/kg) + Ranitidine (8 µg/kg).

The dose selections were based on prior studies that evaluated histaminergic modulation in rodent seizure models (Vohora et al., 2004; Privou et al., 1998). Drug formulations were obtained from local pharmaceutical manufacturers:

- Histamine dihydrochloride (≥99% TLC, ATR-MED, Tehran, Iran),

- Ranitidine injection (50 mg/2 mL, Kimidaru, Tehran, Iran),

- Chlorpheniramine maleate (10 mg/mL, Darupakhsh, Tehran, Iran).

Animals were anesthetized with ketamine (70 mg/kg) and xylazine (7 mg/kg) intraperitoneally. Anesthesia depth was verified by the absence of the pedal reflex. The head was shaved, disinfected with povidone-iodine, and secured in a stereotaxic apparatus. A midline scalp

incision (1.5–2 cm) was made to expose the skull, and stereotaxic coordinates were determined using the Paxinos and Watson rat brain atlas (7th edition). Coordinates were referenced from the bregma, and the injection site for the BLA nucleus was AP: +0.24 mm, ML: ±5.0 mm, DV: −0.85 mm; the recording site in the CA1 region of the hippocampus was AP: −2.7 mm, ML: ±1.4 mm, DV: −3.0 mm.

Drug administration was performed via a Hamilton syringe (0.5 µL/site over 1 minute). After one minute, the needle was slowly withdrawn, and a bipolar tungsten recording electrode was implanted at the CA1 site. Baseline field activity was recorded for 10 minutes using the eLab acquisition system and eTrace software (Sciencebeam, Tehran, Iran).

To induce epileptiform activity, pentylenetetrazol (PTZ) was administered intraperitoneally at a dose of 80 mg/kg. Seizure-like activity was monitored and recorded for 10 minutes post-injection. At the end of the observation period, diazepam (10 mg/kg, i.p.) was administered to terminate convulsive activity (Panahi et al., 2023) (Table 1).

All treatments, recordings, and data analyses were conducted under blinded conditions. Animals were randomly allocated to groups using a computerized randomization tool, and investigators responsible for recording and analyzing data were unaware of treatment assignments.

Sample size was determined based on previous pilot data and power calculations (α=0.05, power=0.8), which indicated that a minimum of 6 animals per group would be sufficient to detect significant changes in hippocampal field potentials following treatment.

Statistical analysis

Statistical analysis was conducted using a one-way analysis of variance (ANOVA) to assess the differences among the experimental groups. Subsequently, Tukey's post-hoc test was applied to identify specific group differences where applicable. A $P<0.05$ was considered statistically significant, indicating meaningful differences between the groups under investigation.

Results

The administration of histamine into the basolateral nucleus of the amygdala resulted in a significant decrease in the frequency of convulsive activities compared to the placebo. This reduction was found to be dose-dependent, suggesting that higher histamine doses were associated with a more pronounced decrease in activity frequency. Interestingly, when chlorpheniramine and ranitidine, histamine's antagonists, were administered, there was a significant reduction in the frequency of FAPs in the hippocampus compared to the placebo group. Additionally, pretreatment with chlorpheniramine and ranitidine followed by histamine administration also led to a significant decrease in convulsive activity frequency. Importantly, the amplitude of convulsive activities in all the studied groups did not exhibit any significant changes. This suggests that the interventions primarily impacted activity frequency, with no significant changes observed in their intensity across all studied groups (Figures 1 and 2).

Table 1. Timeline of experimental procedures

Step	Time (min)	Procedure
0	1	Anesthesia with ketamine (70 mg/kg) and xylazine (7 mg/kg)
1	1	Injection of drug (e.g. histamine, chlorpheniramine, ranitidine) via a Hamilton syringe
2	2	Withdrawal of injection needle
3	3	Implantation of bipolar tungsten recording electrode at CA1 site
4	10	Baseline recording of field activity (10 minutes)
5	1	Administration of PTZ (80 mg/kg, i.p.) to induce seizures
6	10	Monitoring and recording seizure-like activity (10 minutes)
7	10	Administration of diazepam (10 mg/kg, i.p.) to terminate convulsive activity

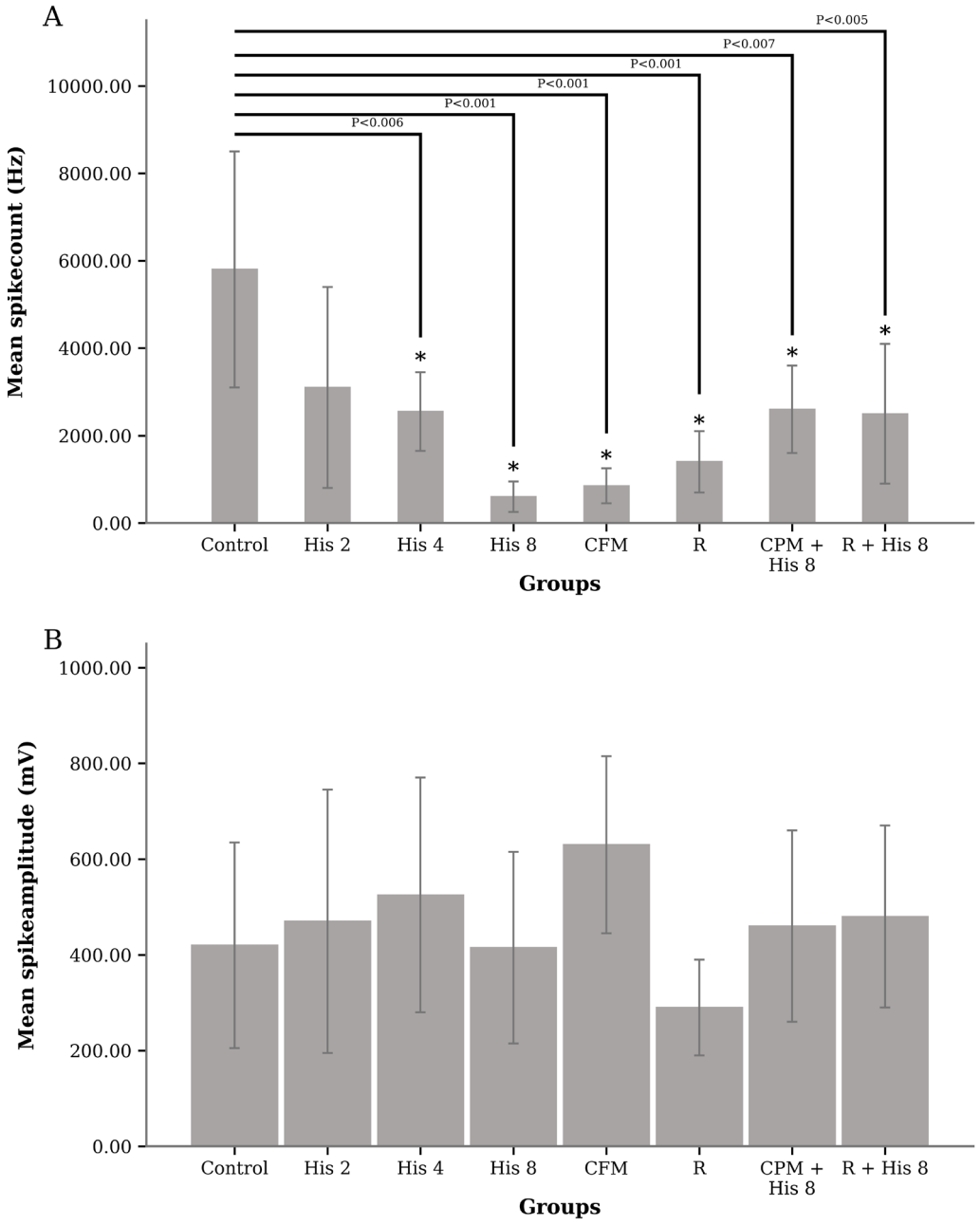

Figure 1. Spike count (A) and amplitude (B) in control (saline), His (2, 4, 8 µg/kg), CPM (8 µg/kg), R (8 µg/kg), CPM+His 8, and R+His 8 groups

*P<0.05 vs control.

Note: Data are presented as Mean±SEM.

Discussion

This study explored how histamine, chlorpheniramine, ranitidine, and their combinations affect spike frequency and activity amplitudes in neuronal networks, with a particular focus on the hippocampus and amygdala. The results indicated that histamine had dose-dependent effects on spike reduction. Additionally, significant decreases in spike numbers were observed when chlorpheniramine and ranitidine were used either individually or in combination with histamine. Importantly, the amplitudes of neuronal activities remained stable across all experimental groups and showed no significant deviation from the control group.

One of the central findings of this study is the dose-dependent effect of histamine on spike reduction, as increasing doses of 2, 4, and 8 µg led to progressively

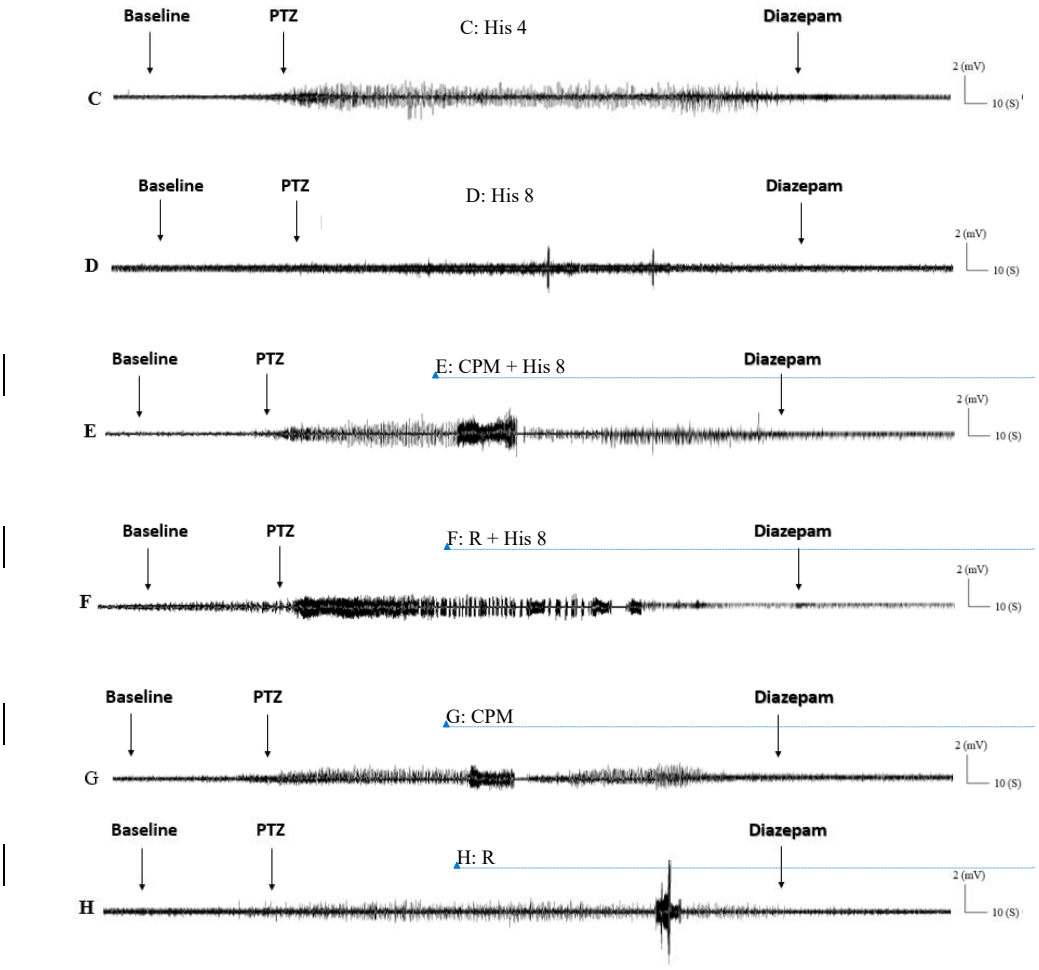

Figure 2. LFP traces from hippopotamus CA1 in control (A), His 2, 4, 8 µg/kg (B–D), CPM+His 8 (E), R+His 8 (F), CPM (G), and R (H) groups

Note: Baseline (anesthesia), PTZ (80 mg/kg), and diazepam (10 mg/kg) are shown as references.

greater decreases in spike activity. This suggests that histamine has an inhibitory influence on neuronal spiking activity, with higher doses producing more pronounced effects. Similar to histamine, both chlorpheniramine and ranitidine, when administered individually at 8 µg, demonstrated a significant reduction in the number of spikes compared to the control group. These findings suggest that certain antihistamines may directly modulate neuronal excitability, inhibiting action potential generation or propagation through mechanisms that are independent of their conventional H1 receptor antagonist activity. Furthermore, the combination of chlorpheniramine and ranitidine with histamine at 8 µg also reduced the number of spikes compared to the control group. Investigating the precise mechanisms underlying these interactions could provide valuable insights into the complex regulatory networks governing spike activity.

Despite the observed differences in spike frequency, the amplitude of recorded neuronal responses remained consistent across all experimental groups. These findings suggest that although the substances affected spike frequency, they did not modify the overall structure or amplitude of the neuronal responses.

Recent studies have provided compelling evidence for the multifaceted role of histamine in modulating neuronal activity and its potential relevance to seizure regulation (Haas et al., 2008). Comprehensive reviews have described the actions of histamine across H1, H2, and H3 receptors, highlighting its involvement in synaptic plasticity, sleep-wake cycles, and excitatory-inhibitory balance in the brain. Particularly, H3 receptors function as autoreceptors that regulate histamine and glutamate release, thereby influencing excitability thresholds (Bhowmik et al., 2012). Furthermore, H3 receptor activation has been shown to enhance cognition, apparently facilitating mem-

ory consolidation while dampening excessive neuronal firing (Bhowmik et al., 2012) In addition, it has been demonstrated that H3 receptor antagonists possess anticonvulsant properties in animal models, and that these effects may stem from modulation of glutamatergic transmission and oxidative stress pathways. Additionally, Yang et al. explored cross-talk between histamine and glutamate receptors, indicating that histamine signaling may influence seizure susceptibility by altering excitatory neurotransmission (Yang et al., 2022). These findings collectively reinforce the idea that histamine does not exert merely a proconvulsant or anticonvulsant role, but rather acts as a context-dependent neuromodulator whose impact varies with receptor subtype, dose, and neural circuitry.

A compelling area of investigation is the potential link between histamine and seizures, which remains elusive due to the complex roles of histamine receptors in various tissues (Panula et al., 2015). Research has indicated that histamine H3 receptors, in particular, play a role in modulating neurotransmitter release, including the release of excitatory neurotransmitters, like glutamate. The activation of H3 receptors could potentially reduce seizures by inhibiting glutamate release (Mahmood, 2016). While some investigations have pointed toward histamine having anticonvulsant properties, it is crucial to acknowledge that this realm of study lacks solid grounding and requires further investigation to comprehend the intricate relationship between histamine and seizures.

Animal studies have ventured into this arena, examining the effects of histamine or histamine receptor agonists (substances that activate histamine receptors) on seizure activity. However, these studies have yielded mixed results, with some indicating possible anticonvulsant effects and others revealing no significant impact (Beheshti & Wesal, 2022). While there is growing interest in understanding the role of histamine in epilepsy and seizures, this curiosity has not yet translated into established clinical treatments. Currently, the primary approach for managing seizures involves anticonvulsant medications that target specific mechanisms related to epilepsy. The interaction between histamine and seizures appears to be multifaceted, shaped by individual genetic predisposition and the specific type and underlying cause of epilepsy (Beheshti & Wesal, 2022).

Some research has suggested that histamine, particularly through the activation of H1 and H2 receptors, might play a protective role against seizures. It is believed to regulate neurotransmitter release and inhibit excessive excitatory activity in the brain (Hu & Chen, 2012). However, other studies have indicated proconvulsant (seizure-promoting) effects, depending on various factors. It is worth noting that histamine is generally not associated with proconvulsant properties (Svob Strac et al., 2016). Instead, it tends to have more complex and context-dependent effects on the nervous system. Its role in seizures is not well-established, and histamine is often considered to have a modulatory role in neurotransmission, influencing various processes in the brain, such as wakefulness, appetite regulation, and immune responses (Khouma et al., 2023).

It is important to emphasize that the majority of medications used to treat epilepsy and seizures do not target histamine receptors but instead focus on other neurotransmitter systems and mechanisms involved in seizure control (Löscher et al., 2020). Some promising research has explored the potential use of histamine receptor antagonists, drugs that block histamine receptors, as adjunctive therapy for specific forms of epilepsy. For instance, certain H1 receptor antagonists (commonly known as antihistamines), like cetirizine and diphenhydramine, have shown potential antiepileptic properties or the ability to enhance the effectiveness of traditional antiepileptic drugs (Hu & Chen, 2012). These drugs may influence the excitatory neurotransmitter glutamate, contributing to reduced seizure activity. Additionally, histamine H2 receptor antagonists, such as ranitidine (Bramhall & Levine, 1988) and famotidine (Świąder & Czuczwar, 2014), typically used to reduce stomach acid production in conditions, like acid reflux and ulcers, have antiepileptic effects. However, the precise mechanism behind these potential benefits remains unclear but may involve the modulation of neurotransmitter systems. It is important to underscore that histamine receptor antagonists are primarily associated with their use in treating allergies, gastric acid regulation, and other conditions (Thangam et al., 2018). The research exploring their potential antiepileptic properties or enhancement of traditional antiepileptic medications does not suggest that these drugs induce or promote epileptic seizures. It is vital to differentiate between the potential therapeutic effects of these drugs in managing seizures and their primary pharmacological actions. This area of research is ongoing and has not yet become a standard treatment approach for epilepsy.

Investigating the underlying mechanisms responsible for the observed effects, particularly the interactions between histamine and antihistamines, is crucial for understanding how these substances modulate neuronal activity. The significant reductions in action potential frequency observed in this study may hold implications for conditions characterized by abnormal neuronal activity, such as epilepsy or certain neuropathic pain syndromes. Further research is needed to explore the clinical potential of these findings.

Conclusion

This study found that histamine reduced neuronal spike activity in a dose-dependent manner—higher doses led to a greater reduction. These results point to a potentially protective role for histamine, particularly through H1 and H2 receptors. Still, other studies have reported varying outcomes depending on specific conditions, which underscores the complexity of histamine's role in the nervous system and highlights the need for a more detailed understanding. Our findings also raise the possibility that histamine receptor antagonists could be explored as supplementary treatments for disorders involving abnormal neuronal activity, such as epilepsy. However, further research is crucial to clarify the underlying mechanisms and fully understand the clinical relevance of these interactions

Ethical Considerations

Compliance with ethical guidelines

This study was approved by the Research Ethics Committee of the University of Tabriz, Tabriz, Iran (Code: IR.TABRIZU.REC.1402.023).

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Authors' contributions

Conceptualization and methodology: Yousef Panahi and Emad Khalilzadeh; Experiments: Haghgouei. Tannaz Haghgouei and Soodeh Tavakoli; Data analysis: Yousef Panahi; Writing and final approval: All authors.

Conflict of interest

The authors declared no conflict of interest.

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References

Aroniadou-Anderjaska, V., Fritsch, B., Qashu, F., & Braga, M. F. M. (2008). Pathology and pathophysiology of the amygdala in epileptogenesis and epilepsy. *Epilepsy Research, 78*(2-3), 102-116. [DOI:10.1016/j.eplepsyres.2007.11.011] [PMID]

Beheshti, S., & Wesal, M. W. (2022). Anticonvulsant activity of the histamine H3 receptor inverse agonist pitolisant in an electrical kindling model of epilepsy. *Neuroscience Letters, 782*, 136685. [DOI:10.1016/j.neulet.2022.136685] [PMID]

Bhowmik, M., Khanam, R., & Vohora, D. (2012). Histamine H3 receptor antagonists in relation to epilepsy and neurodegeneration: A systemic consideration of recent progress and perspectives. *British Journal of Pharmacology, 167*(7), 1398-1414. [DOI:10.1111/j.1476-5381.2012.02093.x] [PMID]

Bousquet, J., Khaltaev, N., Cruz, A. A., Denburg, J., Fokkens, W. J., & Togias, A., et al. (2008). Allergic rhinitis and its impact on asthma (ARIA) 2008 update (in collaboration with the world health organization, GA(2)LEN and AllerGen). *Allergy, 63* (Suppl 86), 8–160. [DOI:10.1111/j.1398-9995.2007.01620.x] [PMID]

Bramhall, D., & Levine, M. (1988). Possible interaction of ranitidine with phenytoin. *Drug Intelligence & Clinical Pharmacy, 22*(12), 979-980. [DOI:10.1177/106002808802201210] [PMID]

Buzsáki, G., Anastassiou, C. A., & Koch, C. (2012). The origin of extracellular fields and currents--EEG, ECoG, LFP and spikes. *Nature Reviews. Neuroscience, 13*(6), 407-420. [DOI:10.1038/nrn3241] [PMID]

Haas, H. L., Sergeeva, O. A., & Selbach, O. (2008). Histamine in the nervous system. *Physiological Reviews, 88*(3), 1183–1241. [DOI:10.1152/physrev.00043.2007] [PMID]

Hu, W. W., & Chen, Z. (2012). Role of histamine and its receptors in cerebral ischemia. *ACS Chemical Neuroscience, 3*(4), 238-247. [DOI:10.1021/cn200126p] [PMID]

Khouma, A., Moeini, M. M., Plamondon, J., Richard, D., Caron, A., & Michael, N. J. (2023). Histaminergic regulation of food intake. *Frontiers in Endocrinology, 14*, 1202089. [DOI:10.3389/fendo.2023.1202089] [PMID]

Lisman, J., Buzsáki, G., Eichenbaum, H., Nadel, L., Ranganath, C., & Redish, A. D. (2017). Viewpoints: How the hippocampus contributes to memory, navigation and cognition. *Nature Neuroscience, 20*(11), 1434-1447. [DOI:10.1038/nn.4661] [PMID]

Löscher, W., Potschka, H., Sisodiya, S. M., & Vezzani, A. (2020). Drug resistance in epilepsy: Clinical impact, potential mechanisms, and new innovative treatment options. *Pharmacological Reviews, 72*(3), 606-638. [DOI:10.1124/pr.120.019539] [PMID]

Mahmood, D. (2016). Histamine H(3) receptors and its antagonism as a novel mechanism for antipsychotic effect: A current preclinical & clinical perspective. *International Journal of Health Sciences, 10*(4), 564-575. [DOI:10.12816/0048906] [PMID]

Murialdo, G., Piovano, P. L., Costelli, P., Fonzi, S., Barberis, A., & Ghia, M. (1990). Seizures during concomitant treatment with theophylline and ranitidine: A case report. *Annali Italiani Di Medicina Interna : Organo Ufficiale Della Societa Italiana Di Medicina Interna, 5*(4 Pt 1), 413. [PMID]

Panahi, Y., Fathi, E., & Shafiian, M. A. (2023). The link between seizures and prolactin: a study on the effects of anticonvulsant medications on hyperprolactinemia in rats. *Epilepsy Research, 196,* 107206. [DOI:10.1016/j.eplepsyres.2023.107206] [PMID]

Panula, P., Chazot, P. L., Cowart, M., Gutzmer, R., Leurs, R., & Liu, W. L. S., et al. (2015). International union of basic and clinical pharmacology. XCVIII. Histamine Receptors. *Pharmacological Reviews, 67*(3), 601-655. [DOI:10.1124/pr.114.010249] [PMID]

Parsons, M. E., & Ganellin, C. R. (2006). Histamine and its receptors. *British Journal of Pharmacology, 147*(Suppl 1), S127-135. [DOI:10.1038/sj.bjp.0706440] [PMID]

Privou, C., Knoche, A., Hasenöhrl, R. U., & Huston, J. P. (1998). The H1- and H2-histamine blockers chlorpheniramine and ranitidine applied to the nucleus basalis magnocellularis region modulate anxiety and reinforcement related processes. *Neuropharmacology, 37*(8), 1019-1032. [DOI:10.1016/s0028-3908(98)00087-2] [PMID]

Provensi, G., Passani, M. B., Costa, A., Izquierdo, I., & Blandina, P. (2020). Neuronal histamine and the memory of emotionally salient events. *British Journal of Pharmacology, 177*(3), 557-569. [DOI:10.1111/bph.14476] [PMID]

Stafstrom, C. E., & Carmant, L. (2015). Seizures and epilepsy: An overview for neuroscientists. *Cold Spring Harbor Perspectives in Medicine, 5*(6), a022426. [DOI:10.1101/cshperspect.a022426] [PMID]

Svob Strac, D., Pivac, N., Smolders, I. J., Fogel, W. A., De Deurwaerdere, P., & Di Giovanni, G. (2016). Monoaminergic mechanisms in epilepsy may offer innovative therapeutic opportunity for monoaminergic multi-target drugs. *Frontiers in Neuroscience, 10*, 492. [DOI:10.3389/fnins.2016.00492]

Świąder, M. J., & Czuczwar, S. J. (2014). Interaction of famotidine, an H2 histamine receptor antagonist, with conventional antiepileptic drugs in mice. *Pharmacological Reports: PR, 66*(3), 485–491. [DOI:10.1016/j.pharep.2013.11.006] [PMID]

Thangam, E. B., Jemima, E. A., Singh, H., Baig, M. S., Khan, M., & Mathias, C. B., et al. (2018). The Role of Histamine and Histamine Receptors in Mast Cell-Mediated Allergy and Inflammation: The Hunt for New Therapeutic Targets. *Frontiers in Immunology, 9*, 1873. [DOI:10.3389/fimmu.2018.01873] [PMID]

Vohora, D., Pal, S. N., & Pillai, K. K. (2004). Histamine as an anticonvulsant inhibitory neurotransmitter. *Current Neuropharmacology, 2*(4), 419-425. [DOI:10.2174/1570159043359459]

Yang, L., Wang, Y., & Chen, Z. (2022). Central histaminergic signalling, neural excitability and epilepsy. *British Journal of Pharmacology, 179*(1), 3-22. [DOI:10.1111/bph.15692] [PMID]