

Comparative Study on the Effects of Frog Vagus-Sympathetic Nerve Trunk on Cardiac Activity

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Abstract: The role of the vagus nerve and the cardiac sympathetic nerve in the sympathetic trunk of the heart are mutually antagonistic, and can achieve dual control of the heart by sensing different levels of stimulation intensity. This study used frog hearts as experimental materials and used atropine and propranolol to inhibit the vagus nerve and sympathetic nerve, respectively. By comparing the cardiac activity after electrical stimulation with normal conditions, the effects of the two nerves on cardiac activity were observed.

Keywords: Vagus Nerve Trunk; Atropine; Propranolol; Cardiac Activity

1. Overview

This study used frog hearts as experimental materials, aiming to explore the dominance of sympathetic nerve trunks in frog hearts on cardiac activity and the impact of vagus sympathetic nerve trunks on cardiac activity. In the composition of the cardiac nervous system, the cardiac sympathetic nerve trunk is composed of sympathetic and parasympathetic nerves, namely the vagus nerve, with the parasympathetic nerve walking in the vagus nerve[1]. In the normal activity of frog heart, the postganglionic nerve endings of the cardiac sympathetic nervous system innervate the ventricular muscle, atrial muscle, and autonomic tissue, releasing norepinephrine to bind with β receptors on the myocardial cell membrane, activating adenylate cyclase, resulting in increased heart rate, faster conduction velocity at the atrioventricular junction, and enhanced myocardial contractility. After cardiac arrest, nerve fiber endings release acetylcholine (Ach), which binds to M receptors on myocardial cells and inhibits adenylate cyclase activity by suppressing G protein. This mainly slows down heart rate and atrioventricular conduction velocity, and also has a certain inhibitory effect

on the contractility of myocardial and atrial muscles. In this experiment, atropine and propranolol were used separately[2]. The excitatory effect of the cardiac sympathetic nervous system on the heart can be blocked by the β - receptor blocker propranolol, which is commonly used in clinical practice to treat sinus tachycardia. The inhibitory effect of the vagus nerve on the heart can be blocked by the M receptor inhibitor atropine[3].

2. Materials and Methods

2.1 Experimental Supplies

The main experimental subject of this experiment is frogs, and the tools and instruments used include commonly used surgical instruments (including thick scissors, hands)

Surgical scissors, surgical forceps, ophthalmic scissors, ophthalmic forceps, metal probes, glass minute hands, fixed needles, culture dishes, waste tanks, cotton thread, gauze, droppers, Ren's solution, frog plate; The measurement tools used include: physiological signal acquisition system and its supporting software, connecting wire, tension transducer, protective electrode, bracket, double concave clip, frog heart clip. The experimental reagents used are: 1% atropine solution, 1% propranolol solution, and Ren's solution.

2.2 Experimental Steps

2.2.1 Exposure of vagus sympathetic nerve trunk: Take one frog, damage the brain and spinal cord, and fix the dorsal position on the frog board. After cutting open the skin between one side of the mandibular angle and the forelimb, and separating the deep connective tissue, an elongated levator scapula muscle can be seen. Cutting this muscle will reveal a vascular nerve bundle, which includes the vagus nerve from the medulla oblongata and the sympathetic nerve from the fourth sympathetic

ganglion.

2.2.2 Exposure of Heart and Connection Experiment Device: Cut open the sternum handle from the xiphoid process, expose the heart, cut the pericardium, clamp the apex of the heart with a frog heart clip, and connect the physiological signal acquisition system through a tension transducer. Open channel 1 of the physiological signal acquisition system. Choose an appropriate scanning speed and gain to make the heartbeat curve easier to observe, with a reference scanning speed of 800 ms/div, and carefully place the protective electrode on the vagus sympathetic nerve trunk.

2.3.3 Electrical stimulation of vagus sympathetic nerve trunk to observe changes in cardiac activity: Record a normal cardiac curve. Then, low-frequency and low-intensity electrical stimulation is used to distract the sympathetic nerve trunk, and changes in cardiac activity are observed and recorded. Afterwards, use moderate frequency and intensity electrical stimulation to observe and record changes in cardiac activity. Finally, use high-frequency and high-intensity electrical stimulation to observe and record changes in cardiac activity.

2.2.4 After adding atropine, electrically stimulate the vagus sympathetic nerve trunk and observe changes in cardiac activity: add 2-3 drops of 1% atropine solution to the venous sinus and atrium. After 5 minutes, stimulate the nerve trunk with the original stimulation intensity, observe and record the changes in cardiac activity.

2.2.5 After adding propranolol, electrically stimulate the vagus sympathetic nerve trunk and observe changes in cardiac activity: add 2-3 drops of 1% propranolol solution to the venous sinus and atrium. After 5 minutes, stimulate the nerve trunk with the original stimulation intensity, observe and record the changes in cardiac activity.

2.3 Observation Project

- ① Under normal circumstances, stimulate the vagus nerve trunk of frogs with electrical stimulation and record a normal heartbeat curve.
- ② Low frequency and low-intensity electrical stimulation can stimulate the sympathetic nervous system and observe and record changes in cardiac activity.
- ③ Observation and recording of changes in cardiac activity through moderate frequency and

intensity electrical stimulation of the vagus sympathetic nerve trunk.

④ Use high-frequency and high-intensity electrical stimulation to distract the sympathetic nerve trunk, observe and record changes in cardiac activity.

⑤ After adding 1-2 drops of 1% atropine, electrically stimulate the vagus sympathetic nerve trunk and observe and record changes in cardiac activity.

⑥ After adding 1-2 drops of 1% propranolol, electrically stimulate the vagus sympathetic nerve trunk and observe and record changes in cardiac activity.

3. Experimental Results

Through the above experimental steps and observation items, the following heart rate curve can be traced.

3.1 Normal Heartbeat

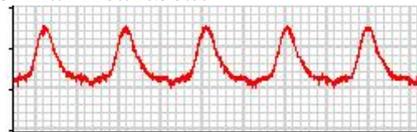


Figure 1. Normal Heartbeat Curve

From Figure 1, it can be observed that there is a certain rhythmicity and intensity of cardiac activity, which can be judged as a normal cardiac curve.

3.2 Low Frequency and Low-Intensity Electrical Stimulation

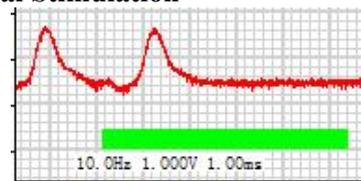


Figure 2. Heartbeat Curves of Low-Frequency and Low-Intensity Electrical Stimulation

From Figure 2, it can be observed that after applying stimulation, the heart only exhibits vagal activity after one heartbeat.

3.3 Medium Frequency and Medium Intensity Electrical Stimulation



Figure 3. Heartbeat Curves of Intermediate Frequency and Medium Intensity Electrical Stimulation

In Figure 3, it can be observed that after applying moderate stimulation, the heart rate intensity begins to decrease, leading to a vagal effect, which gradually increases and returns to normal heart rate, resulting in sympathetic effects.

3.4 High Frequency and High-Intensity Electrical Stimulation

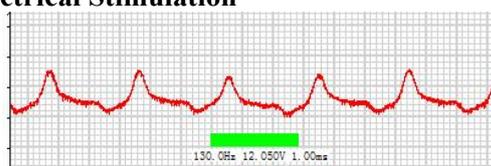


Figure 4. High Frequency and High-Intensity Electrical Stimulation Heartbeat Curve

From Figure 4, it can be observed that the heart rate intensity at the moment of applying high-intensity stimulation gradually increases after the stimulation is applied. Due to the application of stimulation, sympathetic effects appear in cardiac activity, but the effect is not significant.

3.5 Drops of Atropine Followed By Electrical Stimulation

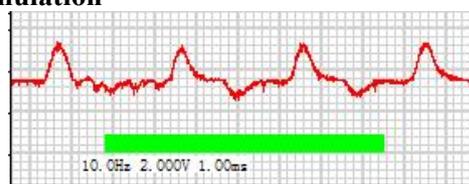


Figure 5. Low Frequency and Low-Intensity Electrical Stimulation of Cardiac Rhythm after Adding Atropine Dropwise

In Figure 5, it can be observed that after the addition of atropine, low-intensity stimulation was applied during myocardial relaxation, causing the myocardium to no longer continue to relax but to maintain its previous state, followed by the restoration of normal heartbeat.

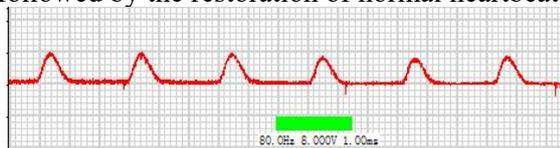


Figure 6. Heartbeat Curve of Moderate Frequency and Intensity Electrical Stimulation after Adding Atropine Dropwise

In Figure 6, it can be observed that after increasing the applied stimulus to medium intensity and frequency, there was no significant increase in frequency or intensity of heartbeat activity, and the frog heart still maintained normal heartbeat activity.

3.6 Electrical Stimulation after Adding Propranolol Dropwise

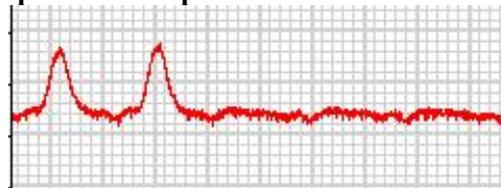


Figure 7. Heartbeat Curve of Moderate Frequency and intensity Electrical Stimulation after Adding Propranolol Dropwise

In Figure 7, it can be observed that after applying stimuli of medium frequency and intensity at the arrow, the heartbeat activity of the frog heart immediately stops and no longer beats, resulting in a sustained vagal effect.

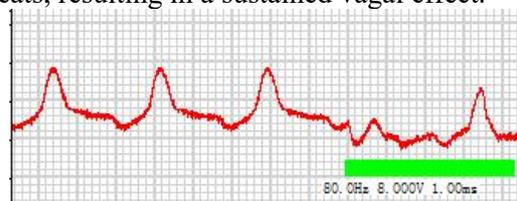


Figure 8. High Frequency and High-Intensity Electrical Stimulation Heartbeat Curve after Adding Propranolol Dropwise

In Figure 8, it can be observed that after the addition of propranolol and the application of high-frequency and high-intensity stimulation, the frog heart rapidly relaxed and showed an inconspicuous vagal effect. However, after the vagal effect, the heartbeat rebounded and a sympathetic effect appeared.

4. Research Conclusions

4.1 Normal Application of Electrical Stimulation

When low-intensity and low-frequency electrical stimulation is applied, frog heartbeats are suppressed and a vagal effect occurs. Because under normal circumstances, the tension and excitability of the vagus nerve are high. When low-frequency and low-intensity electrical stimulation is applied to the vagus sympathetic nerve trunk, it can stimulate the vagus nerve, but due to insufficient intensity, it cannot stimulate the sympathetic nerve. Therefore, after applying low-intensity and low-frequency electrical stimulation, the frog heart exhibits a wandering effect [4].

After applying moderate intensity and frequency electrical stimulation, the frog heart showed a

significant dual effect of first wandering and then sympathetic, where the heartbeat was first suppressed, the myocardium relaxed, and then rapidly tightened, restoring the heartbeat. Due to the fact that under moderate intensity electrical stimulation, the excitability of the vagus nerve is higher than that of the sympathetic nerve, the time and intensity of the effect are also different. The vagus nerve with high excitability will have the effect first, followed by the sympathetic nerve with low excitability, resulting in a dual effect of first vagus and then sympathetic in the frog heart[5].

When high-frequency and high-intensity electrical stimulation is applied, the frog heart is prone to a simple sympathetic effect, as low excitability sympathetic nerves are more likely to respond to high-intensity and high-frequency stimulation. However, in the results of this experiment, the frog heart beat intensity showed a significant decrease compared to before stimulation, and then gradually rebounded. The reason for this situation is that the intensity of electrical stimulation is insufficient, or the activity of frog heart is insufficient, resulting in a response similar to that of applying medium frequency and medium intensity stimulation. But at this time, the vagrancy effect is not obvious, still dominated by sympathetic effects [6].

4.2 Electrical Stimulation after Application of Atropine

When low-frequency and low-intensity electrical stimulation was applied in the experiment, due to the inhibition of the vagus nerve, the intensity of the electrical stimulation could not reach the level required to activate the sympathetic nervous system. Therefore, there was no significant change in the frog's heart beat activity after the stimulation was applied, and it still maintained normal frequency and intensity.

When adjusted to medium frequency and intensity, due to the inhibition of the vagus nerve, there will be an increase in cardiac activity, known as sympathetic effect. However, in the experiment, the heartbeat of the frog heart remained normal and no significant sympathetic effect was observed. It is speculated that it may be because the stimulation was applied during the effective refractory period of the nerve trunk, and the stimulation was not well transmitted.

4.3 Electrical Stimulation after Application of Propranolol

When a medium frequency and medium intensity electrical stimulus is applied to the frog heart, a vagal effect can be observed immediately. However, due to the blockade of the sympathetic nervous system by propranolol, the sympathetic effect cannot be produced, so there will be no double effect when only medium frequency and medium intensity stimuli are applied, and the vagal effect will continue.

When high-frequency and high-intensity electrical stimulation is applied to the frog heart, due to the blockade of the sympathetic nervous system by drugs, only a vagal effect will occur. However, in the experimental results, it was found that after applying high-frequency and high-intensity electrical stimulation, the frog heart showed a similar effect of first vagus and then sympathetic. It is speculated that the reason for this may be due to insufficient dosage of propranolol and longer experimental time. As the drug gradually metabolizes, the inhibitory effect on the sympathetic nervous system gradually weakens. In addition, the stimulation intensity and frequency are high, resulting in less stimulation on the vagus nerve than on the sympathetic nervous system. Therefore, the experimental results show an insignificant vagus effect and gradually increasing cardiac activity.

4.4 Limitations and Improvement Suggestions

The limited number of frogs used in this experiment may affect the final experimental results. Furthermore, before administering propranolol, atropine needs to be washed away using Ringer's solution. However, due to limited time, it cannot be guaranteed that the atropine in the frog heart has been completely metabolized, and a small amount of drug residue may still lead to deviations in experimental results. Therefore, during the experiment, it is necessary to ensure standard operating procedures, avoid damaging the frog heart, and isolate it as soon as possible. During the experiment, Ringer's solution should be added promptly to maintain the activity of the frog heart. Additionally, during the interval between administering the two drugs, more Ringer's solution should be used for rinsing to ensure there is no residual of the previous experimental drug.

In summary, based on the above experimental results and analysis, it can be concluded that in

the vagus nerve and sympathetic nerve trunks of frog hearts, the vagus nerve and sympathetic nerve have an antagonistic effect on each other; Activation of the vagus nerve can weaken cardiac activity, while activation of the sympathetic nerve can enhance cardiac activity; Atropine can inhibit the vagus nerve in the frog heart, causing only sympathetic effects in the frog heart; Propranolol can inhibit the sympathetic nervous system in the frog heart, causing the frog heart to only exhibit vagal effects.

References

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