Arrhythmias Produced by Cerebral Stimulation

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Changes in heart rate and various arrhythmias are induced by the stimulation of certain areas of the brain in dog. The cerebral map of arrhythmia in dog was made. Stimuli of midline, medial and anterior thalamic nuclei provoked arrhythmias, which are observed clinically in the patients with thalamic injury.

Cardiac arrhythmias are induced by the excitation of the brain, such as emotional stress, cerebral hemorrhage, trauma, electroshock and so on. Levy (1912) first studied the extrasystoles due to the stimulation of a certain area of the brain in cats. Since then many investigators, such as Beattie, Allen, Dikshit, Korth, Shinozaki, Purpura and Weinberg have studied on the arrhythmias and the changes in heart rate by the injection of drugs into the cerebral ventricles. However, the brain map and the mechanism of cardiac arrhythmias are not yet clarified.

In this article, the brain map of cardiac arrhythmias in dog is described and the role of neurohumoral factors in the mechanism of arrhythmia is discussed.

METHOD

The experiments were carried out in 132 dogs anesthetized with morphine chloride 6 mg/kg body weight or combination of morphine chloride 1 to 3 mg/kg and chloralose 50 to 70 mg/kg. Bipolar concentric stimulation electrode was inserted into the brain by means of stereotaxic instrument. The sites of the electrode tip were determined by histological examination after each experiment. The electrical stimuli were rectangular voltage pulses of 1 msec. duration, 100 cycles per second frequency and 1 to 6 volts voltage. Each stimulation was given for 15 to 30 seconds. Electrocardiogram was taken on the standard limb leads I and III and the intra-atrial lead. The arterial blood pressure and the respiratory movement of the thorax were also recorded.

RESULTS

I. Cerebral Map of Arrhythmia in Dog

Cerebral Cortex:

In general, arrhythmia was provoked not frequently by the stimulation of cerebral cortex. Sinus tachycardia was noticed by the stimulation of gyrus Sylvii ant., polus temporalis, orbital surface, gyrus cinguli, hypocampi and amygdala. Premature beats, particularly atrial premature beats, appeared by the stimulation of gyrus cinguli, polus temporalis and lateral nuclei of amygdala. Ventricular extrasystole of short coupling appeared from polus temporalis and amygdala (Fig. 1).

Diencephalon:

1. Hypothalamus and Preoptic Area

Changes in heart rate:

Tachycardia was frequently provoked by the median and posterior nuclei of the hypothalamus. On the other hand, bradycardia was observed on stimulation of the preoptic area, anterior and middle hypothalamus.

Arrhythmias:

Various arrhythmias, such as atrial extrasystole, atrial fibrillation, nodal extrasystole, ventricular extrasystole, ventricular tachycardia and fibrillation, were observed by the stimulation of hypothalamus and preoptic area. Frequently, the atrial extrasystole and fibrillation...
occurred on stimulation of the posterior and median part of hypothalamus (Fig. 2).

2. Thalamus

Tachycardia was observed on stimulation of midline and medial nuclei group of thalamus, however, bradycardia was rarely recorded from midline nuclei group. Many kinds of arrhythmias such as supraventricular and ventricular premature beats or escape and atrioventricular block were also obtained from the above mentioned nuclei. These ventricular extrasystoles were divided into two types according to their coupling period. Ventricular premature beats of shorter coupling occurred by the stimulation of the nuclei of midline and medial nuclei group. These of longer coupling were seen on stimulation of the anterior nuclei as well as the midline and medial. Ventral and lateral nuclei rarely exhibited atrial extrasystoles (Fig. 2).

_Blood Pressure  Heart Rate  Arrhythmias_

Fig. 2a. Diencephalon (rostral part)
Frontal sections of the diencephalon of the dog, mapping the stimulated sites. Symbols are as follows.

A: Blood pressure
- □ marked rise (more than 80% to the control level)
- ○ moderate rise (40-79%)
- ● no change or slight rise
- ■ fall

B: Heart rate
- □ marked tachycardia (more than 100%)
- ○ moderate tachycardia (50-99%)
- ● no change or slight rise
- ■ bradycardia

C: Arrhythmia
- F atrial fibrillation
- A atrial extrasystole
- N nodal extrasystole
- ○ ventricular extrasystole of B-type
- □ ventricular extrasystole of A-type
- ● no arrhythmia

**Mesencephalon:**

Tachycardia was observed on stimulation of the central gray, reticular formation and the posterior commissure near gray matter. In-frequently, bradycardia was obtained by the stimulation of basal and segmental portion of the midbrain. Many kinds of arrhythmias such as premature beats, atrial and ventricular fibrillation and atrio-ventricular block were observed (Fig. 3).

**Medulla:**

Inhibition of heart rate was common in medullary stimulation. Stimulation of vagal nuclei—nucleus ambiguus, nucleus dorsalis n. vagi and nucleus tractus solitarii—produced cardiac inhibition accompanied by blood pressure elevation, which was often associated with various arrhythmias such as nodal and ventricular extrasystoles or escapes, ectopic tachycardia and atrial fibrillation. However, on stimulation of nucleus dorsalis n. vagi, cardio-accelerating responses were seen in some cases. Stimulation of lateral reticular formation usually caused cardio-inhibitory and pressor effects (Fig. 4).

II. Some Properties of Ventricular Extrasystoles provoked by Cerebral Stimulation

The ventricular extrasystoles which occur by the stimulation of the brain have some characteristics. There are two types of extrasystoles: that is, A-type of short coupling (usually 0.20 to 0.30 sec.) and B-type of long coupling (usually more than 0.30 sec.).

The A-type appears in the early stage of stimulation, while the B-type appears in the late stage or shortly after the end of stimulation. The B-type occurs frequently as ventricular tachycardia and is usually accompanied with blood pressure elevation. The A-type appears independently of the pressure change and sometimes as bigeminy or trigeminy. The chief cause of A-type may be of nervous origin.

The shape of QRS-complex in these two types of extrasystoles can be classified into four types according to the direction of the
Fig. 4. Medulla
Mappings of the stimulated sites at which changes in heart beats were obtained. Symbols are as follows.

Changes in heart rate
- Tachycardia
- No change
- Bradycardia

Types of arrhythmia
- Ventricular extrasystole
- Ectopic tachycardia
- F Atrial fibrillation
- Bl A-V block
- N Nodal rhythm
- S Sinus arrest

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<thead>
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<th>II</th>
<th>III</th>
<th>IV</th>
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<td>8</td>
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<tr>
<td>B</td>
<td>0</td>
<td>4</td>
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main ventricular deflection. Table I shows the details. The A-type mostly belongs to the type-I and the B-type to the type-IV. The type-I has its ectopic focus in the basal portion of right ventricle and the type-IV in the apical portion of left ventricle (Table I).

It is therefore presumed that the A-type may be provoked by the direct nervous effect from the brain to the right ventricle, while the B-type may be originated from the left ventricle which is loaded with the rise in blood pressure. Besides, the B-type may be precipitated by the reflectory vagal inhibition accompanying the rise in blood pressure and by the humoral factors such as catecholamines from the adrenal gland.

The localization of the stimulated area in the brain stem differs in each type of ventricular premature beat. That is, the A-type concentrates in the median parts of the brain stem and the B-type scatters in relatively widespread regions, stimulation of which caused a marked elevation of blood pressure.

III. Catecholamine and Vagus Nerve in the Mechanism of Cerebral Arrhythmias
1. Catecholamine

The catecholamine, particularly epinephrine, in the blood increases remarkably by the electrical stimulation of the brain stem (hypothalamus, midline nuclei group of thalamus, central gray matter of midbrain), accompanying elevation of blood pressure, tachycardia and arrhythmia. After the ligation of the bilateral suprarenal veins, the rise in blood pressure is seen solely during the stimulation of the brain and the arrhythmia, particularly the B-type of ventricular extrasystole, is rarely observed. The elevated blood pressure returns to the original level as soon as the stimulation ceases (Fig. 5).

The more frequently the cerebral ventricular extrasystole occurs, the more the blood catecholamine increases and the blood pressure rises. On the other hand, arrhythmia is observed after the electrical stimulation of the major splanchnic nerve or intravenous administration of epinephrine.

Therefore, the endocrine factors, such as catecholamine, are considered to play some role.
ARRHYTHMIAS PRODUCED BY CEREBRAL STIMULATION

in the mechanism of cerebral arrhythmias.

2. Vagus Nerve

After bilateral cervical vagotomy, only the sinus tachycardia was recorded by the stimulation of the brain stem and the marked bradycardia was no more observed. The ventricular premature beat occurred very rarely. However, when the peripheral vagus was stimulated in addition to the brain stem, various arrhythmias such as ventricular extrasystole and ventricular tachycardia, accompanied by sinus suppression, appeared again easily and earlier (Fig. 6).

Therefore, the vagus nerve may also play some role in the production of cerebral arrhythmias and changes in heart rate.

CONCLUSION AND SUMMARY

(1) Changes in heart rate and various kinds of arrhythmias are provoked by the stimulation of certain areas of the brain in dogs. The cerebral map of arrhythmias in dog was made.

(2) The ventricular premature beats provoked by the electrical stimulation of the brain show particular patterns. The premature beats are classified into two types according to their length of coupling. The one is of short coupling and the other is of long coupling. The long coupled one (B-type) appears in the late stage of electrical stimulation or shortly after the cessation of stimulation and is associated with a marked elevation of blood pressure. It exhibits the pattern of left ventricular origin. The short coupled one (A-type), on the other hand, appears even in the initial stage of stimulation independently of the rise in blood pressure, mostly exhibiting the pattern of right ventricular origin.

(3) The cerebral arrhythmias are provoked chiefly by the neural mechanism. However, the humoral factors such as catecholamine as well as pressor-reflectory and vagal nerve mechanism may also play a role in producing cerebral arrhythmias.

(4) The stimulation of the thalamic nuclei, particularly the midline, the medial and the anterior nuclei groups, provoked various arrhythmias, which are observed clinically in the patients with thalamic injury.

REFERENCES

Stimulation of Central Gray Vagal Stimulation

Cav. I
II

15° 20°

Fig. 6.

Arrhythmia produced by the stimulation of central gray matter and right peripheral vagus nerve after bilateral vagotomy.


