THE CARDIAC COMPONENT OF THE ORIENTING REFLEX AT DIFFERENT AGE PERIODS

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Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 56, No. 7, pp. 15-20, July, 1963
Original article submitted May 27, 1962

Differences in the mechanisms of nervous regulation of cardiac activity at different age periods have been established in our laboratory [1, 2, 6, 7, 8]. The object of the present study was to ascertain if the cardiac component of the orienting reflex varied with age in dogs.

EXPERIMENTAL METHOD

Experiments were conducted on 58 dogs aged from a few days to the adult state. The ECG was recorded (lead 2). The experimental animals were not strapped to the bench but could move about freely on the table in a screened room. From the age at which they could first see, the animals were adapted to the environmental conditions in which the experiments were carried out. The following stimuli were used: tactile (a vibrator fixed to the surface of the abdomen), olfactory (camphor and ammonia vapor), and sound (an electric bell, a hooter, the sound of a falling object, tapping on the window, knocking on the door, the entry of a stranger).

EXPERIMENTAL RESULTS

From the results, the experimental animals could be divided into age groups. The first group included puppies aged up to 5-6 days. These reacted to the tactile and olfactory stimuli; the heart rhythm was not affected by the action of the second stimulus to these animals. The puppies responded to the tactile and olfactory stimulation (camphor) by a quickening of the heart rate (by 10-30 contractions per minute). This reaction was accompanied by a motor component, consisting of a generalized movement and a slight quickening of respiration (by 3-6 per minute). During the action of the olfactory stimulus (camphor), the generalized movement was combined with movement of the head towards the stimulus or away from it, depending on whether or not the puppy was hungry. In some experiments puppies of this age responded to tactile and olfactory stimulation by an increase in the heart rate of 10-20 contractions per minute (Fig. 1a). When the motor component of the reaction, accompanied in some cases by a half-hearted attempt to raise the head, was absent, the cardiac component was absent too. In most cases the puppies responded to stimulation with ammonia vapor by a quickening of the heart rate (from 20 to 50 contractions per minute), which was more marked the greater the accompanying slowing of respiration.

At this early age the well marked bradycardia caused by ammonia vapor was combined with, or even due to, the significant slowing of respiration. The latter, by a reflex mechanism, caused the episodic development of excitation in the vagus nerve center for the heart. The relationship between the changes in the cardiac rhythm and the changes in the respiration rate has been described in a number of communications issuing from this laboratory [3, 5, 9].

After the age of 5-6 days, the puppies responded by a change in the cardiac rhythm also to the action of the sound stimuli. The changes recorded were of two forms. If the motor component of the reaction took the form of a generalized movement and a slight increase in the respiration rate, the heart rate was increased (Fig. 1, b). If the motor component of the reaction consisted of a temporary inhibition of a preexisting generalized and somewhat haphazard movement, and of a slowing of respiration, the heart rate was slowed. The character of the reaction to tactile and olfactory stimulation was the same as at the preceding age (Fig. 1, c). At this age the head movement did not take place towards the source of sound stimulation, and there was no specific manifestation of the motor

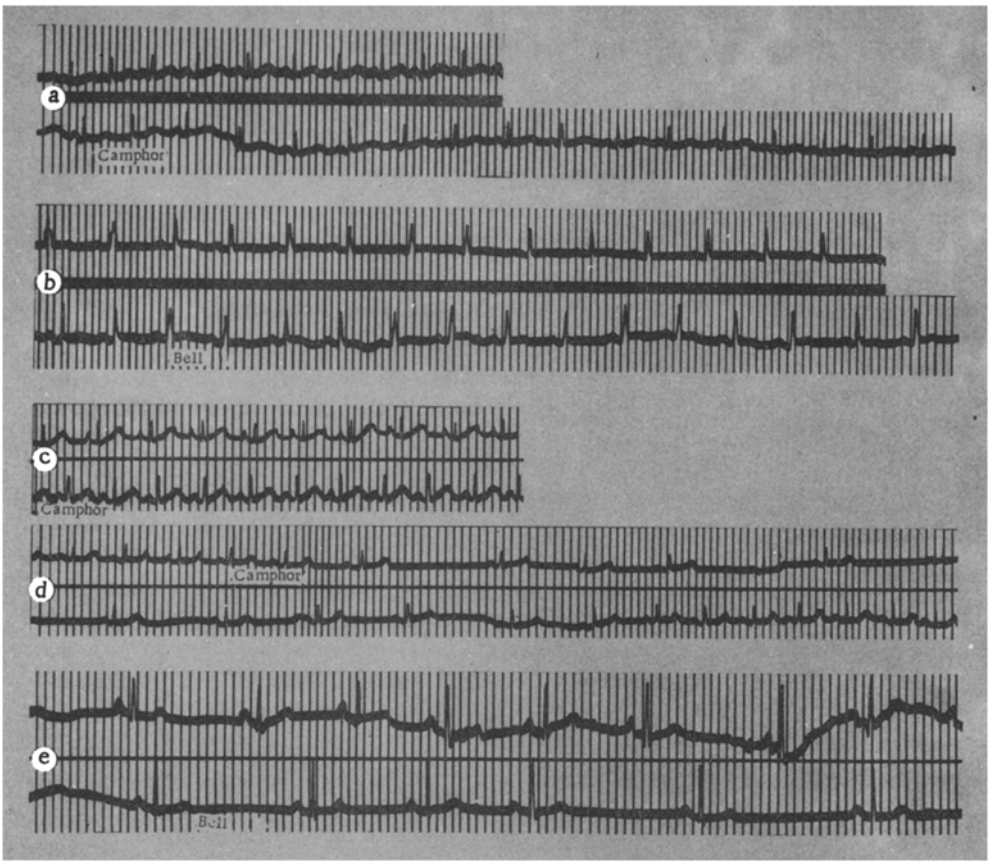

Fig. 1. Changes in the cardiac component of the orienting reflex in healthy puppies of various ages. Electrocardiograms. a) Puppy 3 days old. Olfactory stimulation. Slight bradycardia; b) 9 days old. Sound stimulation. Tachycardia; c) 6 days old. Olfactory stimulation. Tachycardia; d) 42 days old. Olfactory stimulation. Bradycardia subsequently changing to tachycardia. Time marker 1 sec.

component of the orienting reflex, namely, of a turning of the head in the appropriate direction and tuning of the auditory receptor to the source of action of the sound stimulus.

Our parallel observations on the form of the motor component of the orienting reflex in early age periods were in general agreement with those of other workers [12].

Investigations in our laboratory have shown that at this early age the cardiac activity is regulated by a change in the degree of tonic excitation of the sympathetic nerve centers. At this age, the tachycardia and bradycardia arising in response to tactile and olfactory stimuli below 5-6 days old, and in response to a sound stimulus after the 5th-6th day, are due to changes in the tonic excitation in the center for the sympathetic innervation of the heart. After atropinization, these forms of reaction persisted.

Starting from the age of 8-10 days, i.e., from the time of development of sight, coinciding with the possibility of assuming the standing pose by means of the forelimbs, and in particular after the 16th-18th day, when the hindlimbs begin to take part in the standing pose, the puppies first began to display slight signs of vagal tone.

The next group consisted of puppies aged from 16-18 days to 2.5-3 months. At this stage they could correctly identify the source of the olfactory or sound stimulation by turning the head, or even the trunk, towards the stimulus. The cardiac component of the orienting reflex in most experiments took the form of a slight bradycardia. The following variants of the reactions may be observed: 1) bradycardia (a slowing of the heart rate by 10-20 beats per minute) with restoration of the initial rate immediately on withdrawal of the stimulus; 2) an initial brief or more prolonged and marked bradycardia changing to tachycardia (Fig. 1, d); 3) tachycardia from the very beginning. The last variant was observed when the initial heart rate was high (160-180/min). A slight bradycardia sometimes developed when the respiration rate did not change after application of the stimulus. The bradycardic component of the reaction disappeared after atropinization.

The next group consisted of animals aged from 2.5-3 months old up to the adult state. Starting from 2 months, and especially after 3 months of age, the vagal tone became intensified. This was shown by a considerable slowing of the natural rhythm of the heart (to 120-70/min depending on the linear dimensions of the dog), and also by a marked respiratory arrhythmia of the heart. We must draw attention to yet another sign of the transformation of the cardiac activity. Before the age of 16-18 days, i.e., in the period of sympathetic regulation of the cardiac activity, the systolic index had the value of 65-60%, and between the ages of 16-18 days and 2.5-3 months – 55-50%, whereas after the age of 3 months, with strengthening of the vagal tone, its value was 50-45%. Starting from the age of 2.5-3 months, the cardiac component of the orienting reflex took the form of a more marked bradycardia, coupled with intensification of the respiratory arrhythmia of the heart and a lowering of the systolic index to 40% or, in certain cases, to 35%. The bradycardia was always accompanied in these cases by a slowing of respiration (Fig. 1, e). The bradycardic component of the orienting reflex was especially pronounced during the repeated action of the stimulus (2-3 times), before it began to be extinguished.

In one series of experiments the increase in the degree of tonic excitation in the center of vagus innervation of the heart was expressed not only by sinus bradycardia, but also by a transient transverse block, during which only the P wave was recorded, and this was not followed by a ventricular complex. Fleck [13], who investigated the cardiac component of the orienting reflex in 4 adult dogs, found an increase in the heart rate, more marked during the action of a stimulus of low intensity (sound) than in response to a loud sound. Fleck speaks of inhibition of the response to the action of the loud sound. In the present article we cannot discuss the reason for the difference in these descriptions of the cardiac component of the orienting reflex. Unfortunately, Flack does not describe the method he used to record the changes in the cardiac rhythm, but simply presents his numerical results.

What is the mechanism of the bradycardic component of the orienting reflex we have discovered ? We drew attention to the fact that the cardiac component can be detected only if the animal reacts by a specifically motor component of the reaction, shown not merely by a turning of the head, but also by a corresponding change in postural tone.

A special series of experiments was carried out on 6 puppies in which the spinal cord was completely divided between the thoracic and lumbar segments before the age of 20-25 days. These puppies were unable to adopt a standing position with the aid of their hindlimbs, nor could they make corresponding movements in space. Even at the age of 4-5 months, no vagal tone had developed in these puppies, and it was detected only to a very slight degree after the age of 5-6 months. The motor component of the orienting reflex was limited to turning the head. No corresponding change in postural tone was observed under these circumstances. The cardiac component of the reaction consisted only of tachycardia (Fig. 2, a, b). It was not until 6 months had elapsed after operation that the action of the stimulus on the animals with ill-defined vagal tone caused not just a movement of the head, but also attempts to change the postural tone by means of the fore-part of the trunk. In these cases we observed a bradycardic component of the reaction, but without any sign of respiratory arrhythmia of the heart (Fig. 2, c). It was natural to suppose that, starting after the age of 16-18 days and especially after 2.5-3 months, the motor component of the reaction took an important part in the mechanism of the bradycardic component of the orienting reflex.

A special series of experiments was conducted on 6 adult dogs in which the motor component of the reaction was abolished by administration of myorelaxan. This drug was injected in a dose of 0.3-0.6 mg/kg, causing paresis of the skeletal muscles of the fore- and hindlimbs, but not blocking respiration. The ordinary bradycardic component of the orienting reflex was first recorded in these dogs. After the injection of myorelaxan, the rates of respiration and of the heart increased. The motor component of the orienting reflex was limited to turning the head towards the point of action of the stimulus. The postural tone remained unchanged. The cardiac component of the orienting reflex either was absent or was expressed as tachycardia (Fig. 2, d). As the action of myorelaxan came to an end and the ability of the animal to perform the postural-tonic component of the orienting reflex was restored, the bradycardic component of the reaction also appeared.

These results suggest that any indifferent stimulus giving rise to an orienting reflex in the first place produces a motor reaction: a change in the postural muscle tone, movement of the head, and so on. The proprioceptive afferent impulses arising in these circumstances cause corresponding adaptive changes in the activity of the respiratory and cardiovascular systems. In this sense, the bradycardic component of the reaction should evidently be regarded as the expression of a motor-visceral reflex [10, 11]. From the results of the investigations carried out in our laboratory, we can regard the vagal bradycardic component of the orienting reflex as the expression of the anabolic phase of the reaction. According to I. A. Arshavskii [4], this phase of the reaction, providing for the increased potential lability of

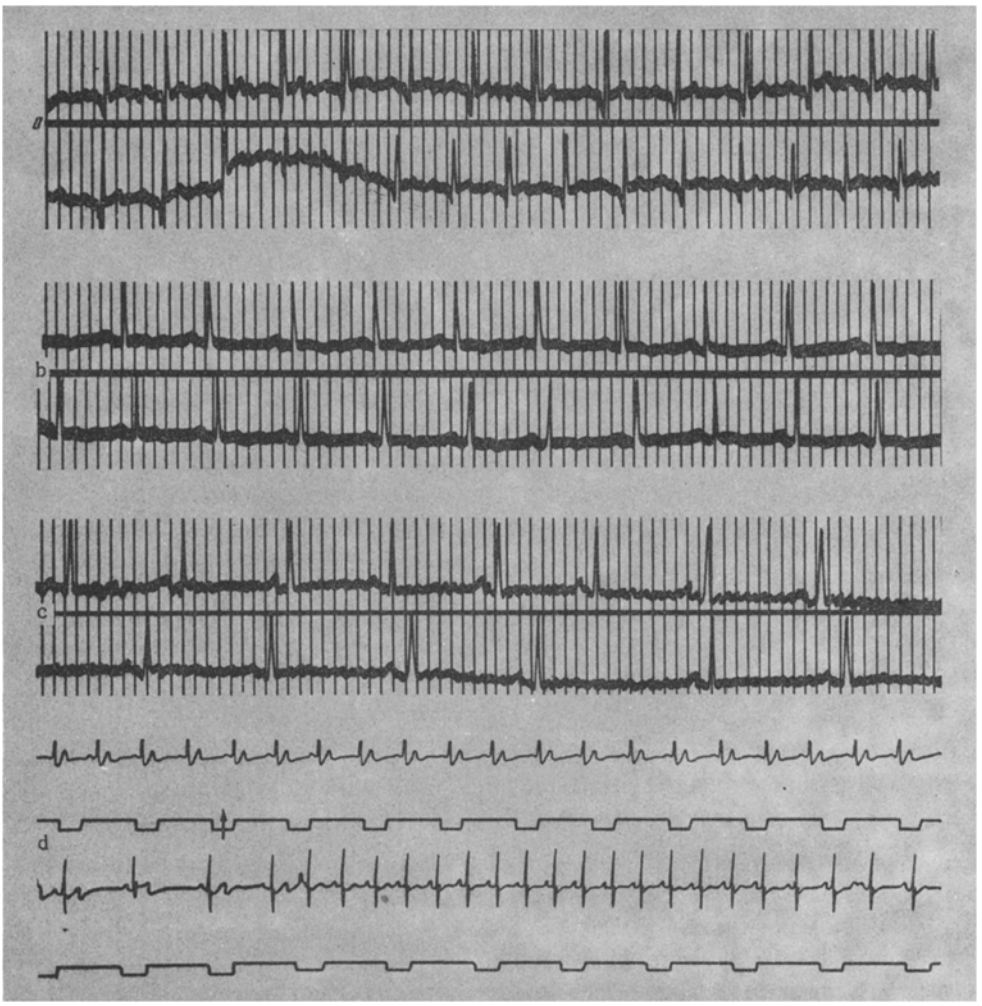

Fig. 2. Changes in the cardiac component of the orienting reflex in spinal puppies of an older age group. Electrocardiograms. a) In a puppy aged 56 days. Sound stimulation. Tachycardia; b) at the age of 6 months. Sound stimulation. Tachycardia; c) at the age of 7 months 12 days. Olfactory stimulation. Bradycardia without respiratory arrhythmia; d) in an adult dog after injection of myorelaxan. Sound stimulation. Tachycardia.

the heart, thereby increases the subsequent working capacity of the organism. This is important should the need arise immediately after the orienting reflex for a behavioral reaction, whether defensive or aggressive.

SUMMARY

The cardiac component of the orienting reflex is manifested by tachycardia in dogs under 16-18 days of age, i.e., at the period of sympathetic control of cardiac activity. From the 16th-18th day of life and especially from the age of 2.5-3 months, i.e., when the vagus tone appears and consolidates, the cardiac component of the orienting reflex is manifested by bradycardia. In the mechanism of effecting the cardiac component of the orienting reflex a considerable role is played by the motor component of the reaction. The cardiac component (bradycardia) of the reaction was absent in a special experimental series in which the possibility of effecting the motor component of the orienting reflex was excluded (experiments on puppies denervated while young and on puppies in which the skeletal muscles of the anterior and posterior extremities were worked by means of a myorelaxant).

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All abbreviations of periodicals in the above bibliography are letter-by-letter transliterations of the abbreviations as given in the original Russian journal. *Some or all of this periodical literature may well be available in English translation.* A complete list of the cover-to-cover English translations appears at the back of this issue.
