INFLUENCE OF AFFERENT IMPULSES UPON EFFERENT IMPULSES IN TRANSMEDULLARY REFLEX OF HEART OF TOAD

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This is the report concerning the observation of role of afferent impulses.

With development of the differentiation in animal the neuronal closed circulatory circuits which are called reflex arc are built up in order to adapt to relatively fast or phasic changes in interior or exterior environment under the purpose to maintain the constancy in *milieu interieur*. And the nervous cells group whose name is synapse or transformer is the center of that arc.

In the well-defined brain having complex architecture the point to point type of projection from interior parts of the individual to certain area of central nervous system exists because of maintenance themselves in the alteration of environmental conditions. In other words all points being inside and outside of body are able to converge spatially and temporarily upon the central brain.

Moreover in the personifying it is possible to say that the brain is always informed the conditions of body, and at that time the thing playing a role as messages is afferent impulses.

The present report reveals the relationship of natural stimuli, viz. enteroceptive afferent impulses, to the action of brain received that and may suggest a function of nervous system being observed in the field of Cybernetics.

METHODS

In unanaesthetized toads the nerve to medulla or to heart (vagosympathetic trunks) was exposed by ventral approach. The nerve was placed on silver recording electrodes. The first records from the nerve being intactly like in vivo illustrate the discharges consisted of afferent and efferent impulses in its nerve. Secondary procedure is the recording at the distal end of central part of vagosympathetic trunk cut at about 1.5 cm central from heart and then in this record only efferent

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discharges from medulla can be taken. These discharges probably come from medullary center of heart. Last, the changes of such efferent discharge of oneside by cutting of the nerve of another side are recorded.

The present report discloses the state of efferent impulses which are influenced by afferent impulses, using both vagosympathetic trunks constructing circulatory route from heart to heart via medullary center.

Presumably this observation may be helpful to understand the ground of nervous correlation, i.e. the integrating or regulating action of the center aggregating many synapses and existing between afferent and efferent route will be seen.

Apparently both vagosympathetic trunks run independently in right and left side, but on account of their general organized functions both nerves must be related each other in the synaptic center. The observations on dogs by Scott and Reed (1) suggest the evidence of functional crossing in the medullary reflex centers. Such a priori fiber connection is used in present experiment. The fact like this is used in the pupillary reaction as for instance in the well known co-ordinative innervation of pupils. From this analogy it is clear that afferent impulses of oneside have something to efferent impulses of both sides.

The possibility of mixture of afferent impulses except heart, from respiratory or digestive organs, to impulses mentioned above may be negligible from their nature.

RESULTS AND THEIR INTERPRETATION

Results obtained are the transmedullary efferent manifestation of afferent volleys.

The record in the middle of one vagosympathetic trunk connecting between the medulla and heart is Fig. 1.

Figure 1.

Records of impulses of one vagosympathetic trunk in vivo.

In that figure the composed state of efferent and afferent impulses to heart and to medulla respectively is seen.

Fig. 2 illustrates the efferent impulses at the distal end of central part of a trunk which is cut, and it reveals the function of synaptic cells in medulla.

Figure 2.

These are records which have been selected only efferent impulses by cut of ipsilateral nerve, and hence the recording electrodes are situated at the distal end of central part.

A: only efferent impulses from medulla.

B: with QRS-complex of ECG (biphasic deflection).

This record is that which is omitted only afferent impulses from Fig. 1 and shows regularity in discharging interval. These regular efferent volleys are able to be taken at a little before QRS-complex of electrocardiogram or simultaneously to that (Fig. 2B), i.e. when the ventricle of heart of toad has contracted the efferent volleys are approaching to the heart in very short distance.

The changes of these efferent volleys (Fig. 3) is the final one of a serial observation, when the deafferentation of opposite trunk by severance of afferent fibers has been happened.

Figure 3.

Volleys recorded at the same electrode position as Fig. 2, when the contralateral nerve was cut.

Fig. 3, contrary to Fig. 2, loses the regularity and again reveals the irregularity. The discontinuity of afferent volleys by cut produces an irreversible cessation of efferent rhythmicity. This fact discloses that the regularity of efferent volleys depends upon the action of afferent impulses rather than that within the medulla itself and they, therefore, represent the response of medullary synapses which are a part of a functional cycle running impulses spontaneously.

The initiative mechanism of afferent impulses, especially quantitative relationships of initiation to stimulus, was exactly studied by Adrian, and the impulse of the pressoreceptor of toad's auricle initiated by changes in intracardiac pressure was investigated by Wada (3). The report described here reveals the delicate mechanism of afferent volleys for efferent signalling or the functional significance of the afferent.

The irregularity and complexity of impulses, observed in Fig. 1, are due to the composition of afferent and efferent volleys. And the random of firing shown in Fig. 3 is dependent upon the cellular activity of deafferented medulla. So that it is clear that the regularity of discharge is primarily dependent upon efferent drive due to rhythmical cellular activity of medulla via afferent, and hence this rhythmicity must be maintained by reflex and be adjusted by afferent volleys. Therefore in normal state this arc of reflex can be said as self-regulating circuit rather than self-exciting or self-limiting circuit.

The efferent volleys recorded from vagosympathetic trunk of one side, which concretely relate and manifest the activity of synaptic cells of medullary center, are discharging rhythmically. This may be the reason the cells in medullary center are discharging rhythmically in normal state in vivo. And since this rhythmicity is lost by cutting of another side, namely discontinuity of afferent volleys

in the nerve of another side, it is possible to suppose that the function of medullary center which acts as generator of such rhythmical efferent discharge is centrally kept by the afferent volleys, therefore the rhythmicity in spontaneity is dissociated by deafferentation.

In response of medullary center to afferent volleys the author is able to detect the efferent rhythmical discharge, namely the medullary center behaves with regularity giving always the periodic discharges of efferent impulses only under the condition of existence of natural afferent volleys. And hence the deafferentation is the cause of loss of uniformity of medulla and makes medullary center a simple cellular aggregation. Accordingly the deafferentation establishes the state of dysrhythmical irregular discharge of efferent volleys. It is correct to suppose that the action of whole cells in medullary center, of which efferent discharge is rhythmically, is regulated by natural stimulus called afferent impulses. The mechanism of its regulation is to maintain the automatically rhythmical uniformity or finality.

The representing spontaneous rhythmical oscillation is the product of afferent volleys and is not due to the pace maker action at the neurone of medulla itself.

Summarily in normal state of heart in vivo, periodicity recognized in efferent volleys in innervated nerve is regulated to make the uniformity of whole cells of center by afferent impulses (i.e. self-information of heart itself). It will be apparent that the reflex mechanism which is stimulated by natural stimulus as afferent volleys from heart in normal state plays a role of receiving attitude or responsibility of heart to various changes of conditions. Moreover the periodic efferent volleys are probably the expression of so-called central sympathetic and vagal activity or tone.

In addition it is interesting to note the report made by Suenaga and author (2) on the comparison of electroencephalographical spontaneous activity of medullary center with and without afferent impulses. According to it, the electrical activity of medullary center with afferent volleys from heart is faster in frequency and higher in amplitude than that without afferent volleys.

SUMMARY

This report concerns the effect of afferent volleys from heart on the efferent volleys being the medullary manifestation of medullary center of heart.

The efferent volleys from medulla to heart have the rhythmicity in discharging state.

The rhythmicity in efferent impulses to heart is lost by deafferentiation and hence the author supposes the afferent impulses maintain the periodicity of whole medullary cells which discharge the efferent rhythmical impulses. The importance of central effect of afferent volleys consists in the production of efferent rhythmicity in medulla.

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