ON THE BEHAVIOR OF THE RESPIRATORY MUSCLES IN THE GASPING

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When the brain stem is transected at the level of the region situated just caudally to the striae acusticae, the gasping appears. This abnormal breathing is apparently different from the normal in its behavior and consists of abrupt inspiration and expiration. It may be considered that the gasps are an attribute of the gasping center which is capable of discharging autochthonously and rhythmically only when it is released from the control of the normal respiratory center located in the striae acusticae. As to how the respiratory muscles behave in the gasping the detailed studies have not been performed. Consequently a study was performed by means of an electromyographic technique in order to obtain further informations about the behavior of the respiratory muscles in the gasping. And from the results of the experiments we referred also to the mechanism of the alternation of the activity of the inspiratory and expiratory muscles.

METHOD

As experimental animals dogs were used. The animals were anesthetized with 3 mg. of morphine and 0.8 g. of urethane per kilo body weight. The details of the method of decerebration as well as of transection of the brain stem were previously reported (1). As the representatives of the inspiratory and expiratory muscles the intercartilaginous and the thoracic transversal muscles were chosen respectively, the former being exposed in the 4th or 5th interchondral space and the latter lying close to the former dorsally being exposed by the removal of the former. The activity of these muscles was recorded by means of the electromyographic technique which was similar to that described in the previous paper (2).

RESULTS

When the brain stem was transected at the level of the region just caudal to the striae acusticae, the normal breathings were instantaneously abolished and in turn there appeared the gasps with a slower and irregular rhythm than before the transection. The gasps were apparently characterized in that they consisted of an abrupt inspiration and expiration. In the electromyograms of
the inspiratory (M. intercartilagineus) as well as of the expiratory muscles (M. transversus thoracis) we unexpectedly perceived a remarkable phenomenon which was especially conspicuous when the gasps occurred with a relatively long time intervals: The expiratory muscles usually discharged continuously between in the interval gasps. When a gasp occurred, the inspiratory muscles discharged abruptly with great frequency, accurately synchronizing with each other, while the expiratory stopped to discharge almost completely. As soon as the inspiratory muscles ceased to discharge, the expiratory discharged in turn again, being at first active and then subsiding gradually. Such a phenomenon seen in the expiratory muscles might be called the post-inhibitory rebound. The rebound phenomenon could also be observed even when the expiratory muscles did not apparently discharge. In addition it is noteworthy that the duration of the inspiratory volley in gasps was far shorter than that in the normal breathing and that the pattern of the inspiratory discharge is of a type d'emblée in the gasp, whereas that is usually of a type of gradual increase in the normal. The examples were shown in fig. 1 in which the facts described above could be clearly seen.

![Electromyograms of the inspiratory and expiratory muscles in a gasp.](image)

The brain stem was transected at the region just caudal to the striae acusticae. Tracings: from above downwards, pneumogram, electromyograms of the intercartilaginous (inspiratory) and the thoracic transversal muscles (expiratory). Time marks 1/12 sec. In A the expiratory muscles discharged continuously between each gasp, while they did not in B.

From the results described above it can be said that the expiratory neurons involving in the gasping center have a character of discharging continuously, the thorax being consequently continuously narrowed, though slight in degree, while the inspiratory have a character producing periodically a burst of
impulses, inhibiting the activity of the former. With the decrease in the activity of the latter, the former are conversely not only released from the inhibition but also become transitorily more active, exerting an inhibiting influence upon the latter. It may be considered that in the normal breathing the mechanism to which the alternation of the activity of the inspiratory and expiratory neurons is due, is essentially the same as in the gasp. The differences are, however, observed between both types of breathings: In the normal condition the expiratory neurons are usually active so weakly that a considerable number of neurons does not discharge and the rhythm and the pattern of the inspiratory volley are different from those of the gasp.

In the normal breathing the expiratory neuron usually discharges with a pattern in which the discharges rapidly augment and decrease, showing a similar course to that seen in the rebound phenomenon described above, while the inspiratory neuron generally discharges with a pattern which consists of crescent, constant and decrescent stages, characteristic of a volley produced in the pace setting nerve cells of the normal respiratory center. It would be said in addition that the activity of the expiratory neurons is so weak that it exerts only a negligible inhibitory effect upon that of the inspiratory. Fig. 2 shows the typical patterns of the inspiratory as well as of the expiratory discharges both of which were led from the normal respiratory centers situated at about the level of the striae acusticae of decerebrated dog.

Without artificial ventilations, the gasping animals fell sooner or later in asphyxia. In such a stage the aspect of gasps changed: the expiratory discharges were inhibited only transitorily at the beginning of the inspiratory discharges and soon afterward appeared again with a frequency greater than before, resulting in an inhibition of the inspiratory discharges to some degree (fig. 3A). In the later stage of the experiment both inspiratory and expiratory muscles occasionally discharged almost at the same time (fig. 3B). In addition,
we observed that the inspiratory and expiratory muscles discharged almost simultaneously just before death of the dog nondecerebrated, as shown in fig. 3C.

![Figure 3. Electromyograms detected from the inspiratory and expiratory muscles in a gasp in the later stage of the transection experiment.](image)

Each picture shows that the reciprocal character of the activity of the inspiratory and expiratory muscles was broken down. Tracings: from above downwards, pneumogram, electromyograms of the intercartilaginous (inspiratory) and the thoracic transversal muscles (expiratory). Time marks 1/12 sec. A and B: led from the respiratory muscles of the animal of which brain stem was transected at the region situated at the level of the lower border of the striae acusticae. C: led from the respiratory muscles of the nondecerebrated dog just before death.

In these asphyxiating animals an unknown mechanism which is supposed to be related to the elicitation of the inhibitory phenomena described above may be broken down, and on the other hand the inspiratory discharges may excite the expiratory neurons to produce the discharges.

CONCLUSIONS

(1) In the gaspings which were produced by transecting the brain stem of dogs at the level of the region situated just caudally to the striae acusticae
the behavior of the intercartilaginous (inspiratory) and the thoracic transversal (expiratory) muscles were electromyographically studied.

(2) The expiratory muscles usually discharged continuously in the intervals between gasps.

(3) The gasp was produced by the outbreak of the inspiratory discharges resulting in the complete inhibition of the expiratory discharges. When the inspiratory discharges had ceased, the expiratory were not only released from the inhibition but also transitorily increased (rebound).

(4) With the lapse of time the ability of the inspiratory neurons to suppress the expiratory discharges became gradually incomplete, until at last both inspiratory and expiratory discharges were almost simultaneously produced.

(5) Some suggestions were postulated with regard to the mechanism of the alternation of the activity of the inspiratory and expiratory neurons.

REFERENCES