RESPIRATORY ACTIVITY AND PROPRIOCEPTIVE REFLEXES OF THE ABDOMINAL MUSCLES OF CATS DURING ONTOGENESIS

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In experiments on decerebrate kittens from a few hours to 3 months of age the electromyogram of the oblique and rectus abdominis muscles was recorded during quiet and labored respiration. During quiet breathing the abdominal muscles as a rule were inactive. Under conditions of asphyxia or hypercapnia, expiratory contractions of the abdominal muscles appeared. During stretching of the abdominal muscles, a stretch reflex developed. Proprioceptive reflexes from these muscles participate in the formation of the respiratory activity of the abdominal muscles.

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The results of recent investigations have demonstrated the participation of the abdominal muscles in respiratory activity [3, 6-9]. Proprioceptive impulses were found to be of significance in the regulation of respiratory contractions of the abdominal wall muscles [4, 5].

The problem of participation of the muscles of external respiration in the maintenance of pulmonary ventilation in the early stages of ontogenesis of animals has been examined in very few papers [2, 10]. No information on the respiratory activity of the abdominal muscles is available.

The object of the present investigation was to study the respiratory activity of the muscles of the abdominal press and to examine muscle proprioceptive influences on the respiratory activity of these muscles in young animals.

EXPERIMENTAL METHOD

Experiments were carried out on kittens of ages varying from a few hours to 3 months: under 24 h (4 kittens), 1 day (2), 2 days (3), 3 days (2), 4-7 days (5), 9-24 days (4), and 1-3 months (6 kittens).

All experiments were carried out under decerebrate conditions. Needle electrodes were sutured to the obliquus abdominis muscles (segments IX and X, below the costal arch) and to the rectus abdominis muscle in its upper part. Electrodes were also sutured in the interchondral part of the internal intercostal muscles (in the 1st or 2nd intercostal spaces).

The electromyogram (EMG) of the oblique and rectus muscles of the abdomen and the intercostal muscles was recorded on a dual-beam CRO. Activity was recorded during quiet breathing and during ventilation of the lungs with a gas mixture containing 10% CO_2 (plus O_2) and during breathing from a closed vessel with a capacity of 20 cm^3 (resistance to respiration + asphyxia).

The stretch reflex of the external oblique abdominal muscles was studied. A strip of this muscle attached to ribs 9-11 was isolated. A small bath was formed from flaps of skin and filled with mineral oil. The muscle was stretched by a weight. The EMG of the stretched strip was recorded. As well as stretching the isolated strip, the abdominal muscles were stretched by injection of air into the abdominal cavity. Activity of the rectus and oblique muscles was recorded under these conditions.

EXPERIMENTAL RESULTS AND DISCUSSION

During quiet breathing, the interchondral part of the internal intercostal muscle of decerebrate kittens showed inspiratory activity. The external oblique muscle was inactive in 17 of the 26 experiments. In 5

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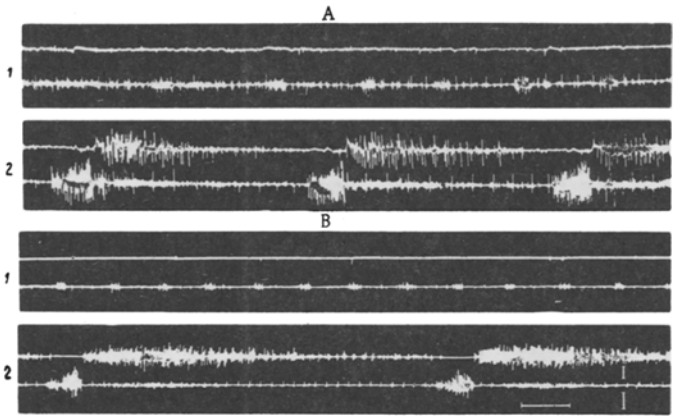

Fig. 1. Activity of abdominal muscles of young kittens during quiet (1) and labored (2) breathing. A) Kitten a few hours old: top curve shows EMG of external oblique abdominal muscle, bottom curve EMG of interchondral part of internal intercostal muscle; B) kitten aged 1 day: top curve shows EMG of rectus abdominis muscle, bottom curve EMG of interchondral part of internal intercostal muscle. Calibration 300 V, time marker 1 sec.

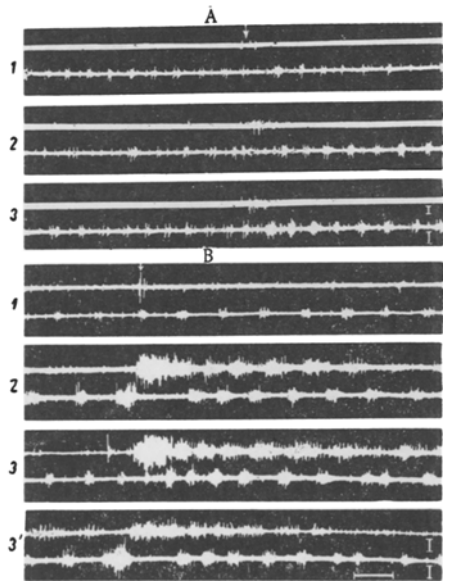

Fig. 2. Stretch reflex of external oblique abdominal muscle of a kitten aged a few hours (A) and 17 days (B). A: 1) Stretching of isolated strip with a threshold load (5 g), 2) with twice the threshold load, 3) 5 times the threshold load; B: 1) stretching of isolated strip by threshold (2.5 g), 2) by twice the threshold load, 3) 4 times the threshold, 3') continuation of 3. Top curve represents EMG of isolated strip of external oblique abdominal muscle, bottom curve EMG of interchondral part of internal intercostal muscles. Arrow indicates stretching of muscle. Calibration 300 V, time marker 1 sec.

experiments expiratory activity of these muscles was detected. In 4 experiments decerebrate rigidity was observed. Activity of this character was found only in animals older than 11 days, and it frequently had respiratory modulations (an increase in activity of the EMG in expiration). In young kittens during quiet breathing, the activity of the oblique muscles thus is essentially indistinguishable from their activity in adult cats [3]. Activity of the rectus abdominis muscle was observed only in kittens older than 11 days, and it was constant and tonic in character.

During an increase in respiratory activity, expiratory contractions of the oblique and rectus abdominal muscles appeared or strengthened. This increase in expiratory activity could be observed in kittens from the moment of birth. Activity of the external intercostal muscles (interchondral part) was always antagonistic relative to activity of the abdominal muscles (Fig. 1).

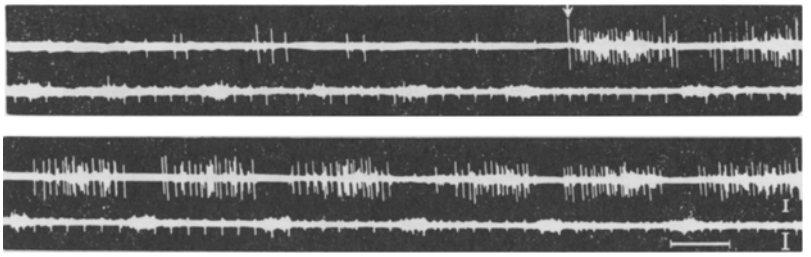

Fig. 3. Increase in respiratory activity of oblique abdominal muscle during stretching (kitten aged 9 days). Bottom segment is continuation of top. Top curve shows EMG of isolated strip of external oblique abdominal muscle, bottom curve EMG of interchondral part of internal intercostal muscle. Arrow denotes stretching of muscle. Calibration 300 μV, time marker 1 sec.

Hence, the reciprocity which was previously demonstrated for adult animals [3], was thus found in newborn animals within a few hours after birth. This finding disagrees with published data [1] indicating that reciprocal inhibition does not appear until 10 days or more after birth.

During sretching of the abdominal muscles a stretch reflex appeared, as has been described for adult animals [4]. Stretching an isolated strip was accompanied by an increase in its electrical activity. In kittens a few hours old a short response of low amplitude was recorded (Fig. 2A). With loads of threshold values (5-10 g), the duration of the reflex was 0.4-0.9 sec, and the amplitude of the EMG 50-300 μV. With an increase in the load stretching the muscle, the duration and amplitude of the reflex were increased. In kittens aged from 1-7 days, the threshold of the stretch reflex was 2.5-5 g. With threshold stretching of the muscle the amplitude of the stretch reflex reached 450 μV and its duration 1.8 sec.

In older kittens, aged from 9-24 days, a stretch reflex could be obtained by a stretching weight of 2-5 g (Fig. 2B). With threshold loads the duration reached 1.5-5.6 sec and the amplitude 550-800 μV.

In animals older than 1 month the threshold values for the stretch reflex were 5-10 g (mean 6 g). During stretching of the muscle by a load 5 times greater than the threshold values, the duration of the stretch reflex was 3-10 min, i.e., close to values observed in adult animals [4]. No inhibition of the stretch reflex of the oblique muscle could be obtained by increasing the force of stretching, just as in adult animals [4]. Stretching the muscle by injecting air into the abdominal cavity evoked a stretch reflex of the oblique and rectus abdominal muscles.

An increase in this activity could be obtained by stretching the muscle against a background of existing expiratory activity. Increased activity during stimulation of the muscle proprioceptors developed particularly clearly in kittens over 8 days old (Fig. 3).

The results demonstrate that in kittens in the earliest stages of postnatal development a stretch reflex of the abdominal muscles is present. Admittedly, this reflex is of low amplitude, high threshold, and low stability. In the course of the first month the amplitude of the reflex response on the EMG increases, the threshold is lowered, and the stability becomes more marked. An important factor in the mechanism of development of a prolonged stretch reflex is the increase with age in the ability of the spindles to discharge repeatedly in response to stretching, in conjunction with the development of the γ-innervation and of the central mechanisms of this reflex [11].

The stretch reflex thus obtained may participate in regulation of the activity of the abdominal press muscles. Just as in adult animals [4], if the abdominal muscles are stretched, respiratory contractions of the abdominal press muscles are stronger than if these muscles are relaxed.

Hence, in the early stages of ontogenesis of the cat, proprioceptive reflexes of the abdominal muscles participate in the mechanism of expiratory contractions of the abdominal press muscles.

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