JOURNAL OF PHYSIOLOGY AND PHARMACOLOGY 1994, 45, 3, 413—418

M. KRAUSE, I. WOSZCZYCKA-KORCZYŃSKA, E. GRABARCZYK, E. MRUKWA, M. ROTBART-FIEDOR

RESPIRATORY POTENTIALS RECORDED FROM THE HUMAN HINDBRAIN

Department of Physiology, Silesian School of Medicine, Katowice-Ligota, Poland

Using a nasopharyngeal and a neck electrode slow potentials synchronous with respiration were registered. Similar potentials were recorded in a patient with apnoea due to widespread paralysis of the Landry type. The potentials are thought to be of medullary origin.

Key words: *Electromedullogram, respiratory potentials, medullar electrical activity in humans*

There are in the hindbrain, particularly in the medulla, arrays of neurons that generate impulses required for stimulation of the motoneurons of respiratory muscles. There is a wealth of information as to the localization of different parts of this respiratory complex as well as the activity of individual neurons constituting it (1). Less is however known about the integrated electrical activity of the respiratory complex, particularly as far as man is concerned.

For obvious reasons it is not feasible to get at the human respiratory complex and therefore human physiology has to rely on data obtained on animals. However there are substantial differences concerning the said structure between various species. For instance, Gromysz and Karczewski state that cats and monkeys have basically different organization of the respiratory controller (2). For this reason and bearing in mind clinical requirements we made an attempt to record, by means of a noninvasive method electrical respiratory transients generated in the human hindbrain.

MATERIALS AND METHODS

The method applied in this study requires two electrodes. One of them is introduced into the nose and advanced further till it reaches the posterior wall of the pharynx. The other one is attached to the skin of the neck.

The first electrode is manufactured from silver, in the form of a small sphere of 3 mm diameter. It is fastened to a double insulated copper wire rope. The length of the electrode, apart from the connecting cable, is 7 cm. The electrode holds in the nose by itself or is held by the subject.

In the first essays we covered the nasal electrode with lignocaine gel. This procedure was however abandoned, since the subjects not feeling it had troubles with its localization. When itcontacts with the posterior wall of the pharynx some slight irritation may be felt. In order to prevent that, we have shaped the electrode, which initially had the form of a truncated cone (cf. *Fig. 1*), as a sphere void of sharp edges. The localization of the nasopharyngeal electrode is shown on *Fig. 1*.

Fig. 1. Lateral radiograph of the human head showing the localization of the nasopharyngeal electrode used for the registration of respiratory potentials

The idea of a nasal electrode is not new. Already in 1938 Grinker and Serota made use of such an electrode for studies on corticohypothalamic relations in cat and man (3). In 1949 a design of a nasopharyngeal electrode for man was proposed by Mac Lean (4) and a few years later Mavor and Hellen (5) published the results obtained by means of such an electrode. In all the cases, however, classical EEG was registered, because counterelectrodes were placed on the skull.

In our studies the circuit was closed by means of a second electrode applied to the neck. It was placed at the level of and vis-a-vis the nasopharyngeal lead. It consisted of a rectangular silver plate measuring 3 × 5 cm and 0,5 mm in thickness, shaped by bending so as to match the curvature of the neck. Before the application to the alcohol cleaned skin it was covered with electrode electrolyte. The electrode was fastened by means of a rubber band encompassing the head.

The subject was grounded through a third electrode attached to the ear lobe.

Recordings were made with different brands of electroencephalographs, depending on whether they were carried out in the laboratory or at the patient's bed. Three makes of EEG were employed, viz. Bioscript BTS 1 (former GDR), Accutrace 200 EEG Beckman (USA) and EEG 8 S Medicor (Hungary). Routinely 0,53 and 70 Hz filters were used.

Respiratory movements were registered by means of a nasal thermocouple (Bioscript) mounted inside a plastic basket with adjustable diameter. The sensor was inserted into the other nostril and connected by means of a self-made bridge to the ECG channel of the electroencephalograph.

Records similar to the ones displayed in *Fig. 2—5* were obtained on 27 healthy persons (25 men and 2 women), recumbent and fully relaxed. They were medical students who volunteered for the investigation. The only exception, shown in *Fig. 6,* is a record obtained on a patient of the I Neurologic Clinic of the Silesian Medical School, described in the next chapter.

RESULTS

One of the first results obtained is shown in *Fig. 2.* Upon comparing the upper trace representing potential changes with the pneumogram underneath, synchronization between the two events can be easily recognized. The slow

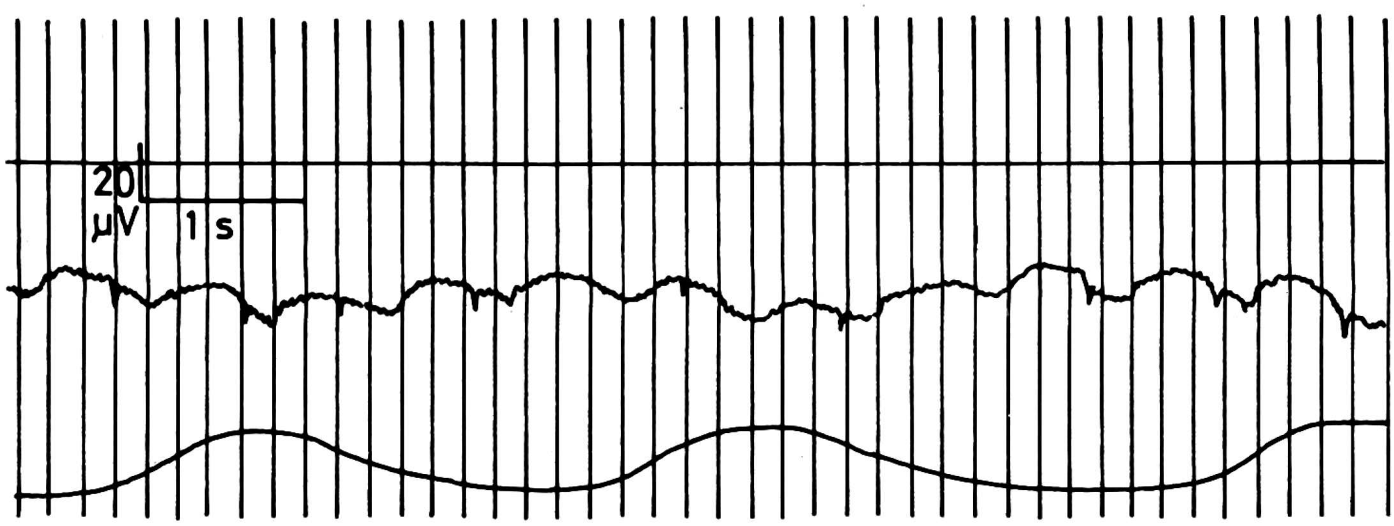

Fig. 2. Record of respiratory potentials (upper curve) and pneumogram (lower curve, inspiration downwards). The small spikes in the upper tracing represent electrocardiogram deflections.

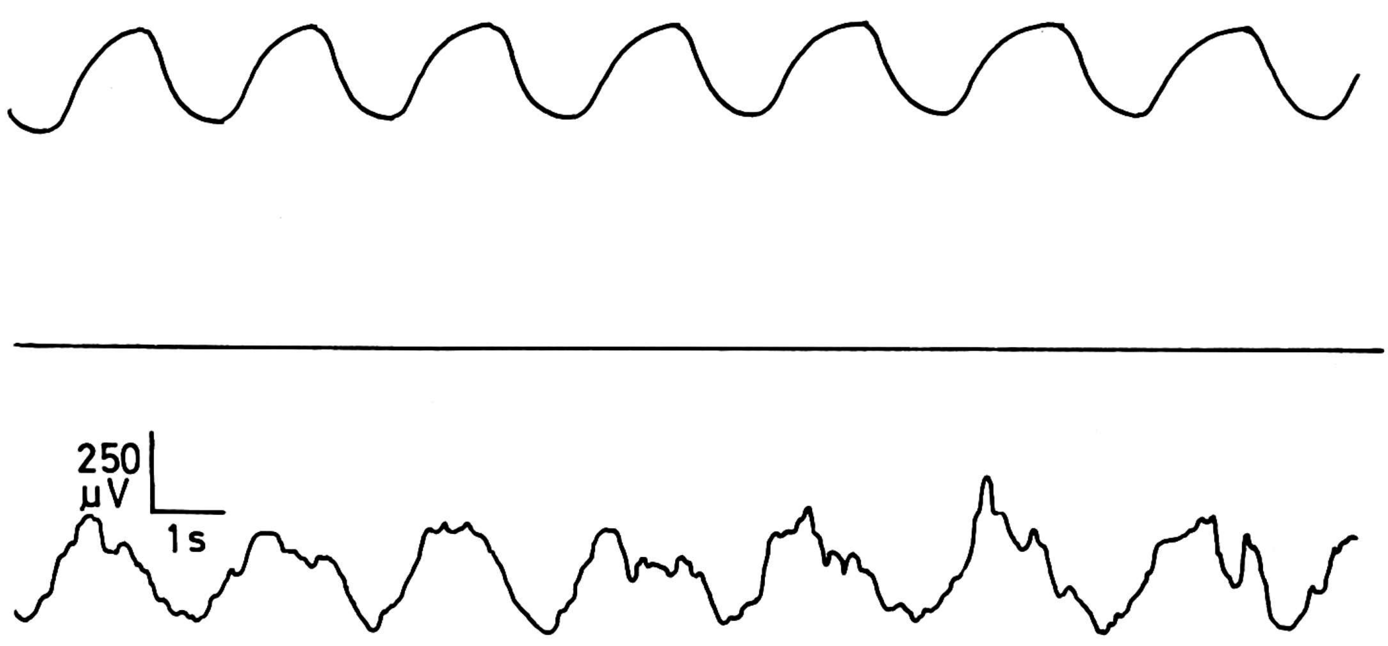

Fig. 3. Pneumogram (upper curve, inspiration upwards) and respiratory potentials (lower curve). Respiratory potentials are synchronous with respiration, the former preceding the latter by about 0,3 s. Note different amplification factor and paper feed speed as compared with record shown in Fig. 2.

wave forms of a frequency of about $19 \cdot min^{-1}$ correspond with respiratory movements. Upon them there are superimposed rapider waves of a 4-fold greater frequency amounting to $76 \cdot min^{-1}$. These second order waves are synchronous with the pulse as indicated by the small ECG deflections.

Fig. 3 shows another record performed at lower amplification and slower paper speed. In such a manner it is easier to observe the synchronization between the slow potentials and the corresponding pneumogram waves. As it may be seen the former precede by about 0,3 s the latter.

In Fig. 4 the behavior of the electrical activity of the medulla at apnoea is shown. As soon as the subject is asked to stop breathing i.e. when cortical inhibition of the respiratory complex sets in, desynchronization of electrical activity ensues and breathing ceases. The conclusion that the recorded events derive their origin in the medulla is based on their close relationship with respiration.

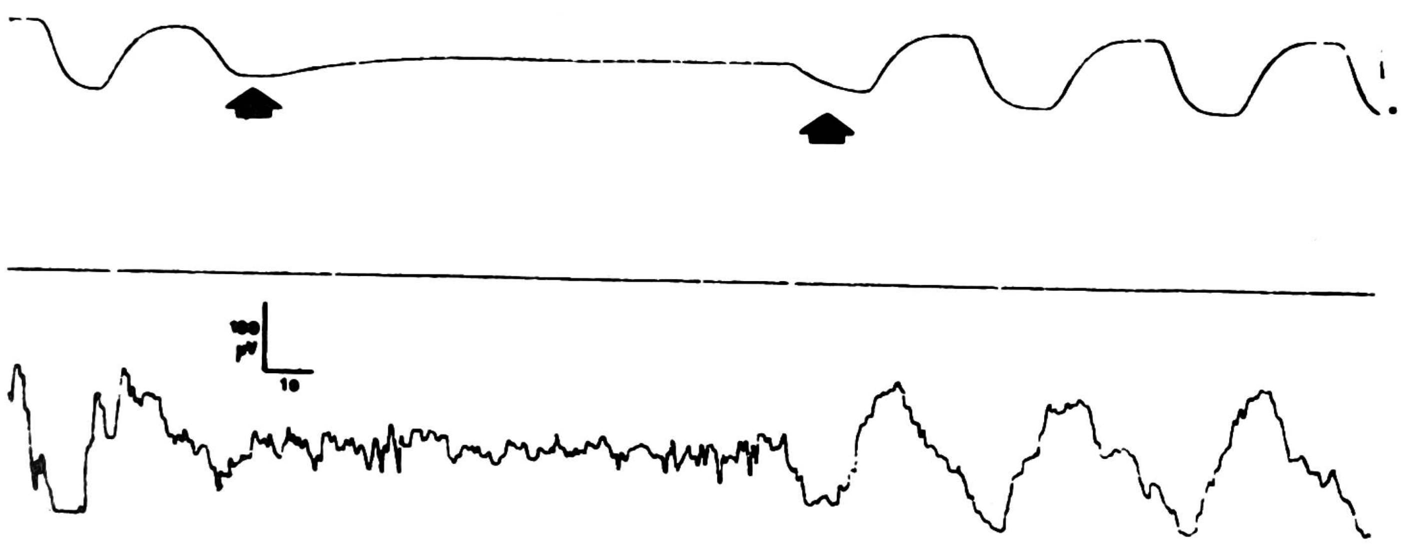

Fig. 4. Pneumogram (upper curve, inspiration upwards) and respiratory potentials (lower curve) during apnoea. Breathing was arrested at the interval indicated by arrows.

Fig. 5 represents another picture of the electrical activity of the medulla. The record was obtained when the subject was asked to swallow. The order was given at the moment indicated by arrow. As soon as the auditory

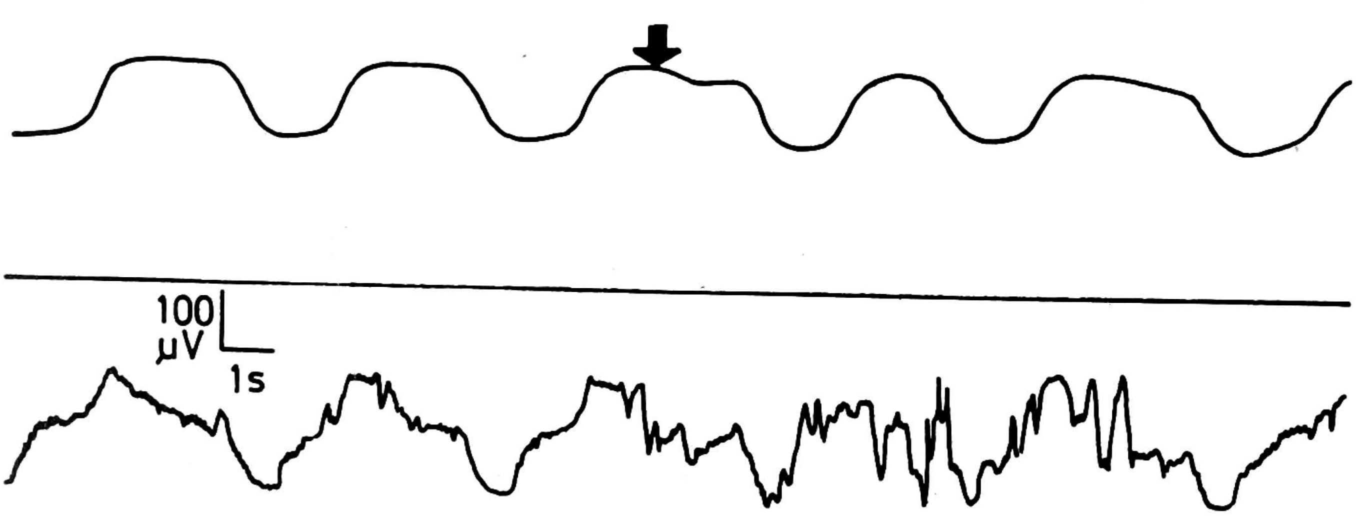

Fig. 5. Pneumogram (uper curve, inspiration upwards) and respiratory potentials (lower curve) during swallowing. At the instant indicated by arrow the subject was asked to swallow. As soon as the information has reached the medulla breathing as well as the recorded potentials became disturbed. At a lag of about 6 s the order was carried out, accompanied by an irregularity in electrical potentials (event marked by inscription).

information reaches the medulla, the regular course of events is disturbed. This reflects itself in the electro- as well as in the pneumogram. The record confirms the observation that swallowing is accompanied by a modification of respiration (6). The swallowing reflex occurs after a delay of about 6 s, at the moment indicated by the inscription.

The tip of the nasopharyngeal electrode is situated in such a place that there is a considerable risk of recording mechanical muscle artifacts. According to v. Euler (7) respiration involves not only the main and accessory "pumping" muscles, but also laryngeal, pharyngeal, tongue and facial muscles, which control the patency of the upper airways and the bronchial smooth muscles. To remove our doubts the electrical activity in question was registered in a patient with widespread paralysis of motoneurons. The patient a female of 28 years, was diagnosed to suffer from: Encephalomyeloradiculoneuritis probabiliter viralis. She was delivered to the clinic due to complete paralysis of all extremities and of respiratory muscles of the progressive Landry type. In *Fig. 6* a record of her medullary activity is shown. The record was performed 24 days before the patient deceased, at a 30 s interval of artificial ventilation arrest.

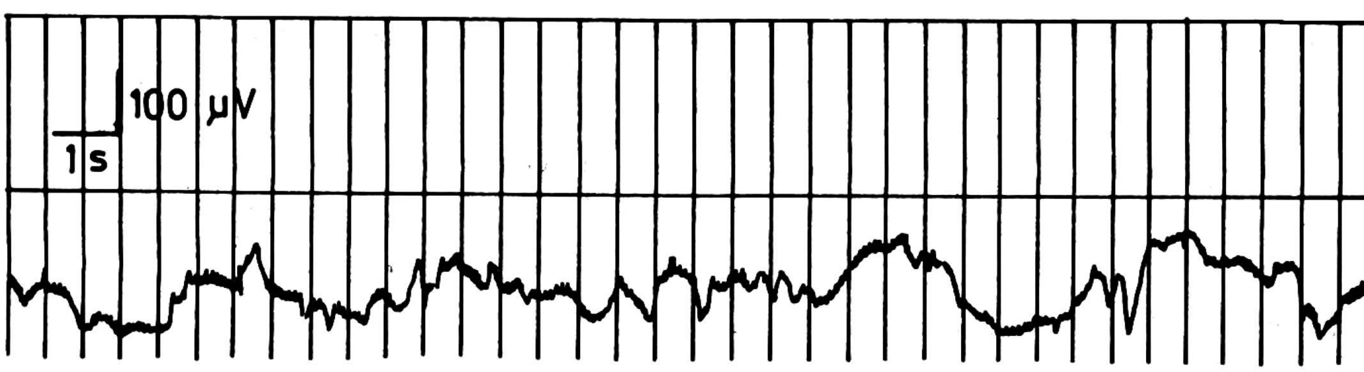

Fig. 6. Respiratory potentials recorded in an unconscious patient with extensive motoneurone paralysis. The potentials were recorded during a 30 s arrest of artificial ventilation.

The record reveals that in these conditions the medulla still exhibits a quasiregular electrical activity of over 100 μV and a frequency of about $20 \cdot \text{min}^{-1}$. It is almost the same frequency as that shown in *Fig. 3*.

DISCUSSION

Physiologists were able long ago to record from the brain stem slow potentials synchronous with respiration. Such potentials were, for instance, registered by Adrian and Buytendijk in 1931 (8). They isolated the brain stem of the goldfish and found that it generated slow rhythmic potential changes which occured pari passu with gill movements. We suppose that the slow potentials in our records represent something analogous, that is to say, they show integrated activity of neurons forming the respiratory controller.

The described respiratory potentials reveal themselves sometimes in the classic EEG, particularly in patients artificially ventilated (9). They are called "respiratory artifacts" because they do not fit into the typical EEG picture. They spoil the picture but they do not deserve the label "artifacts", since they are normal physiological phenomena, only that they originate in a different part of the central nervous system.

We propose for the described records of electrical medullar activity the name electromedullograms (EMedG).

REFERENCES

1. Ezure K. Synaptic connections between medullary respiratory neurons and considerations on the genesis of respiratory rhythm. In Progress in Neurobiology Vol 35, Pergamon Press London 1990; pp. 429—450.
2. Gromysz H, Karczewski WA. Phrenic motoneurone activity in splitbrainstem cats and monkeys. *Resp Physiol* 1985; 50: 51—61.
3. Grinker RR, Serota HM. Studies on corticohypothalamic relations in cat and man. *J Neurophysiol* 1938; 1: 573—589.
4. Mac Lean PD. A new nasopharyngeal lead. *EEG Clin Neurophysiol* 1949; 1: 110—111.
5. Mavor H, Hellen MK. Nasopharyngeal electrode recordings. *Am J EEG Technol* 1964; 4: 43—50.
6. Fleshler B, Hendrix TR, Kramer P, Ingelfinger FJ. Characteristics and similarity of primary and secondary peristalsis. *J Clin Invest* 1959; 38: 110—116.
7. Euler Cv. On the central pattern generator for the basis breathing rhythmicity. *J Appl Neurophysiol* 1983; 55: 1647—1659.
8. Adrian ED, Buytendijk FJJ. Potential changes in the isolated brain stem of the goldfish. *J Physiol* 1931; 71: 121—135.
9. Tyner FS, Knott JR, Brem-Mayer W, Jr. Fundamentals of EEG Technology. Vol. 1, Basic Concepts and Methods Raven Press N. York 1983; p. 296.

Received: January 14, 1994
Accepted: April 13, 1994

Author's address: M. Krause, Department of Physiology, Silesian School of Medicine, ul. Medyków 18, 40-752 Katowice-Ligota, Poland