BIO-ELEKTRA 92

Respiratory Applications of Magnetic Stimulation

Thomas Similowski, *MD*

Laboratoire de Physio-Pathologie Respiratoire, Service de Pneumologie & Réanimation
Groupe Hospitalier Pitié-Salpêtrière, 47-83 Bd de l'Hôpital,
75651 Paris Cedex 13, France

Abstract **. A. Provoking a bilateral contraction of the diaphragm is a useful way to obtain information about the intrinsic contractile properties of the diaphragm, main agonist of inspiration. This is currently done using transcutaneous electrical stimulation of the phrenic nerves in the neck. The relative painfulness of this procedure limits its use. Magnetic stimulation, applied at the cervical level, stimulates both phrenic nerves, therefore giving non invasively access to the same diaphragm information.**

B. The control of breathing is classically considered an automatic phenomenom, depending on brainstem mechanisms. However, cortical projections to the diaphragm exist and allow temporary disruptions of the automatic control. Cortical magnetic stimulation is a simple way to obtain valuable data about the localization of these projections, and their function in the control of breathing.

I. INTRODUCTION

Magnetic stimulation allows activation of peripheral and central nervous structures. Compared to electrical stimulation, it has the advantages of being non invasive, safe, and painless. It has proven extremely useful in the field of neurophysiology, and is considered a promising tool for clinical investigation.

The purpose of this paper is to summarize the current and potential interests of magnetic stimulation in the respiratory field.

II. BILATERAL PHRENIC STIMULATION

1) Introduction: The diaphragm is the main agonist of inspiration, and, as opposed to other skeletal muscles, has to contract permanently to maintain life. Assessing its function under various circumstances have long been a concern of respiratory physiologists. Bilateral phrenic-nerve stimulation produces uniform contractions of the entire diaphragm (twitches) independent of any voluntary contribution and isolated from other respiratory muscles contraction. Therefore, in addition to phrenic nerve conduction time [1], it provides valuable information about the intrinsic contractile properties of the diaphragm [2]. Up to now, because supramaximal stimulation of the phrenic nerve at its motor point in the neck is painful, the use of this technique in conscious man has been limited to laboratory studies. Given it provides comparable results, magnetic stimulation could allow an easier use of phrenic stimulation, e.g. for routine respiratory testing of patients.

2) Method and results: Cervical magnetic stimulation using a large circular coil positioned at the center back of the neck has proven capable of stimulating both phrenic nerves with a single stimulus [3]. Surface recordings of diaphragm electromyogram showed action potentials of shape and amplitude comparable to those observed with electrical stimulation, and illustrated the capability of magnetic stimulation to supramaximally activate phrenic nerves. Phrenic latencies (6.5 ± 0.4 ms) were not different with magnetic or electrical stimulation. The diaphragm mechanical output induced by cervical magnetic stimulation was studied, as is classical, using the measurement of pressure developed across the diaphragm (transdiaphragmatic pressure). Typical twitches were produced, comparable in amplitude to those obtained with electrical stimulation.

3) Discussion: Electrical phrenic stimulation is specially interesting with respect to assessment of diaphragm function because it provokes a pure diaphragm contraction. This is not the case with cervical magnetic stimulation, which co-activates the diaphragm and neck muscles. This could make the interpretation of magnetic stimulation data complex and therefore less useful. Furthermore, the exact site of neural activation responsible for the cervical magnetic stimulation induced diaphragm contraction is not clear. Although it is likely to be peripheral in nature (phrenic nerves or, more probably, cervical roots), it could also be central (cervical spinal cord). In order to clarify these points, we have studied the pattern of changes of "magnetic" phrenic conduction time and transdiaphragmatic twitch pressure during inspiratory efforts (twitch occlusion principle : stimulations are superimposed upon voluntary efforts of graded intensity)[unpublished]. In six normal volunteers, we have observed that 1) phrenic latency did not vary with the intensity of the underlying diaphragm contraction ; in the case of activation of a central nervous structure such as the

0-7803-0785-2/92$03.00 ©IEEE

ce. 4

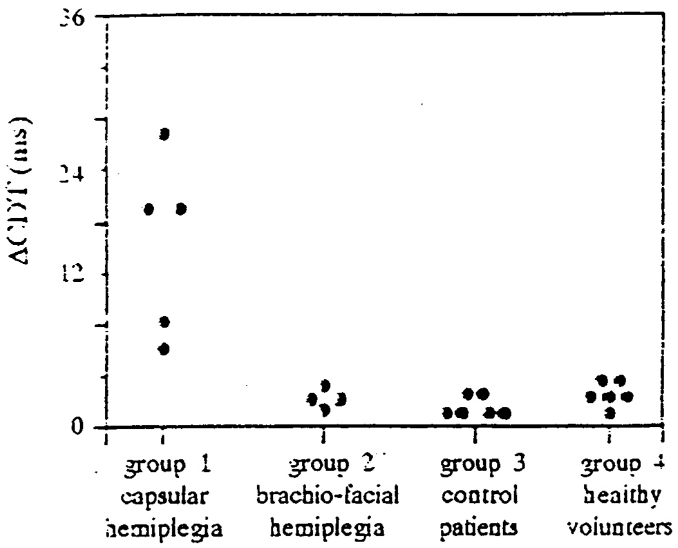

Fig.2. Difference between the right and left cortico-diaphragmatic conduction time (ΔCDT) in 4 categories of subjects. Only in patients with complete interruption of the pyramidal tract (group 1) did a significant difference exist.

CO_2 rebreathing. It is classically presumed that the respiratory response to CO_2 inhalation, hypoxia, or metabolic acidosis is devoid of any volitional contribution. If facilitation is predominantly a cortical phenomenom, Murphy et al. observation imply that there is a cortical (behavioral ?) component in some aspects of the control of breathing.

REFERENCES

[1] J. Newson-Davis," Phrenic nerve conduction in man", *J. Neurol. Neurosurg. Psychiatr.* , vol 30, pp 420-426, 1967.

[2] F. Bellemare, and B. Bigland-Ritchie, "Assessment of human diaphragmatic strength and activation using phrenic nerve stimulation", *Respir. Physiol* ., vol 58, pp 263-277, 1984.

[3] T. Similowski, B. Fleury, S. Launois, H.P. Cathala, P. Bouche, and J.P. Derenne, "Cervical Magnetic Stimulation : a new and painless method for bilateral phrenic nerve stimulation in conscious man", *J. Appl. Physiol* , vol 67, pp 1311-1318, 1989.

[4] S.C. Gandevia, and J.C. Rothwell, "Activation of the human diaphragm from the motor cortex", *J. Physiol. (Lon)* , vol 384, pp 109-118.

[5] T. Similowski, M. Catala, B. Orcel, J.C. Willer, and J.P. Derenne, "Unilaterlaity of the motor cortical representation of the human diaphragm", *J. Physiol. (Lon)* , vol 438, 37P, 1991.

[6] K. Murphy, A. Mier, L. Adams, and A. Guz, "Putative cortical involvement in the ventilatory response to inhaled CO2 in conscious man", *J. Physiol. (Lon)* , vol 420, pp 1-18, 1990.