Animal model of transdiaphragmatic phrenic pacing through cervical approach

Françoise Le Pimpec-Barthes*

Department of Thoracic Surgery, Assistance Publique-Hôpitaux de Paris, Georges Pompidou European Hospital, Paris Descartes University, Paris, France

* Corresponding author. Department of Thoracic Surgery, Georges Pompidou European Hospital, 20 rue Leblanc, 75908 Paris, France.
Tel: +33-1-56093459; fax: +33-1-56093380; e-mail: francoise.lepimpec-barthes@egp.aphp.fr (F. Le Pimpec-Barthes).

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The objective of phrenic pacing is to improve the quality of life of ventilator-dependent patients with diaphragm paralysis while restoring a natural negative pressure breathing with their own diaphragm. Weaning from the mechanical ventilator obtained by this technique improves the patient’s independence and allows a more physiological and comfortable breathing as well as an improved sense of smell and speech [1]. Since the first success of phrenic nerve pacing through a direct bilateral cervical approach reported by Glenn et al. in 1972 [2], allowing a total support of ventilation in a tetraplegic patient, the improvements of this concept have concerned the site of implantation and the surgical approach. The objectives were to obtain a safe, effective and minimally invasive technique for this orphan procedure concerning few patients in the world. First, implantation was done into the pleural cavity to avoid the breaking risk of electrodes at the cervical level and to obtain a complete nerve stimulation. Classical thoracotomy was then replaced by a video-assisted mini-thoracotomy approach (VATS), which has proven to be a safe procedure [3]. In this technique by VATS, quadripolar electrodes are implanted around the phrenic nerve with low electric thresholds (1 or 2 mA) without nerve tiredness and excellent long-term results. The implantation of bipolar electrodes by video thoracoscopy (VT) alone or with robotic assistance [4] was reported in short series always requiring nervous dissection. Still with this mini-invasive surgery strategy, the idea of indirect nerve stimulation without any nerve dissection, using a simple hook wire electrode placed into the diaphragmatic muscle, was then proposed mainly in tetraplegic patients after complete studies on the animal model [5]. In this abdominal approach by the standard laparoscopic technique, not requiring respiratory exclusion, a first mapping procedure is needed to identify the motor points of each hemidiaphragm before the insertion of the two stainless steel intramuscular electrodes [6]. This basic surgical technique, much easier than the reference technique by direct nervous stimulation, only consists in simply introducing the electrode inside the diaphragm muscle. The crucial point is to identify the accurate site of implantation. Results in human series were superposable to those observed with the reference technique by a thoracic approach. Safety of this technique allowed its utilization in childhood or adolescence [7] and trials in patients with amyotrophic lateral sclerosis. The application of Natural Orifice Transluminal Endoscopic Surgery (NOTES) was also evaluated in the animal model to assess the feasibility of transgastric mapping and the implantation of a percutaneous electrode [8].

In this issue of the Journal, Assouad et al., from Paris [9], report an animal study analysing the feasibility to perform diaphragm pacing through the transcervical mediastinal approach. After general anaesthesia and selective bronchial intubation performed in nine ewes, the supra sternal cervical approach was done to introduce a flexible endoscope into each pleural cavity. Introduction of each muscular electrode was done directly via transpleural access through the intercostal space. This study shows the feasibility of implanting muscular electrodes near the entrance points of the phrenic nerves into each hemidiaphragm with the help of a transthoracic chest tube to identify the phrenic nerve ending in 12 of 18 hemidiaphragms (67%). Safety of the technique was obtained after short training. Immediate efficiency...
endoscope by cervical incision through the mediastinum, in described by Assouad
investments. Also increase the number of patients, and thus, industrial
patients in an intensive care unit, in order to avoid diaphragmatic
possibility to propose this stimulation for difficult-to-wean
approach. The absence of a more sophisticated device is directly
linked to the fact that the indications of diaphragmatic stimulation
are rare, as it remains an orphan surgical procedure. In the
termediastinal cervical approach to implant intramuscular electrodes. The main interest of this transpleural approach is to avoid a diaphragm motor point mapping because of the direct visualisation of the whole intrathoracic phrenic
nerve. Diaphragm pacing through the transpleural approach represents a simplification of the technique and a complementary
approach in the case of a contraindication of the laparoscopic
approach. The emergent concept of cervical incision for
thoracic endoscopic surgery (CITES) is interesting as the whole
procedure is performed through the unique cervical approach
[10] and no ventilatory exclusion is required. Is the application of
the CITES concept suitable for diaphragm pacing and is it an
innovative research way better than the existing standard procedure? In this model, the cervical approach was only used to introduce the flexible endoscope because the electrode and the chest tube are introduced through the direct lateral thoracic incision. Real simplification of the technique would have been to introduce the endoscope through a direct transthoracic approach like in the classical VT, which allows a perfect visualisation of the phrenic nerve. The intradiaphragmatic stimulation device, made up of a hook wire and an electric wire linked through a transparietal approach to the generator, looked very unsophisticated and this may have been an obstacle to the development of its implantation through a direct thoracic approach. The absence of a more sophisticated device is directly linked to the fact that the indications of diaphragmatic stimulation are rare, as it remains an orphan surgical procedure. In the future, the device will be miniaturized and more flexible, its automation will improve. But it can only develop, once the number of patients concerned by this technique increases. The possibility to propose this stimulation for difficult-to-wean patients in an intensive care unit, in order to avoid diaphragmatic amyotrophy during the period of assisted ventilation [8], may also increase the number of patients, and thus, industrial investments.

To conclude, while the technical prowess in this animal model described by Assouad et al. [9] can be praised, introducing an
doscope by cervical incision through the mediastinum, in
order to visualize the phrenic nerve ending, may seem more
invasive than a direct approach through an intercostal space. That
is quite a challenge and time will tell whether it is an interesting
research method in this very special indication. In fact, to date,
the main indication of phrenic and diaphragm pacing remains
high tetraplegia associated with the loss of respiratory function
requiring definitive tracheostomy, which, of course, represents a
strict contraindication for any cervical approach.

REFERENCES