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NONINVASIVE CLOSED LOOP DIAPHRAGM STIMULATION FOR VENTILATED ICU PATIENTS

E-POSTER VIEWING

James Fitzgerald, PhD[1,2], Conor Keogh, MB ChB[1,2], Francisco Saavedra, PhD[3], Sebastian Dubo, PhD[4], Pablo Aqueveque, PhD[3], Paulina Ortega, PhD[4], Britam Gomez, PhD[3], Enrique Germany, PhD[3], Daniela Pinto, BSc (Hons)[3], Rodrigo Osorio, BSc (Hons)[3], Fancisco Pastene, MSc[3], Adrian Poulton, PhD[1,2], Jonathan Jarvis, PhD[5], Brian Andrews, PhD[1,2]

[1]University of Oxford, Oxford Neural Interfacing, Oxford, United Kingdom, [2]University of Oxford, Nuffield Department Of Surgical Sciences, Oxford, United Kingdom, [3]Universidad de Concepcion, Electrical Engineering Department, Concepcion, Chile, [4]University of Concepcion, Kinesiology, Concepcion, Chile, [5]Liverpool John Moores University, Sport And Exercise Sciences, Liverpool, United Kingdom

Introduction: Many COVID-19 patients need prolonged artificial ventilation. Skeletal muscle wastes rapidly when deprived of neural activation, and in ventilated patients the diaphragm muscle begins to atrophy within 24 hours (ventilator induced diaphragmatic dysfunction, VIDD). This profoundly weakens the diaphragm, complicating the weaning of the patient off the ventilator, and increasing the risk of complications such as bacterial pneumonia. 40% of the total duration of mechanical ventilation in ITU patients is accounted for by the weaning period, after the initial illness has resolved. Prevention of VIDD would therefore both improve individual outcomes, and also release ITU capacity. We aim to prevent VIDD by exercising the diaphragm with electrical stimulation of the nerves that control it. Evidence suggests that muscle wasting can be prevented by quite low levels of exercise (e.g. 200 contractions per day).

Materials / Methods: The diaphragm is activated by the phrenic nerves, formed from branches of the C3-C5 nerve roots in the neck. These nerves may be electrically stimulated in the lower neck. An electrode array is positioned on each side of the neck using surface landmarks. The system automatically determines the best electrode to use in each array. Sensors built into the ventilatory circuit are monitored both to match stimulation to the respiratory cycle and to determine the effects of stimulation.

Results: We have designed and built a prototype system for unsupervised noninvasive phrenic nerve stimulation. The system delivers one contraction every 7 minutes, synchronised to early inspiration so as not to disrupt ventilation. Electrode impedances are measured before each stimulus, and the closed loop system continuously monitors the effects of stimulation on airflow and adjusts stimulation parameters to compensate for changes in coupling, for example due to head movement.

Discussion: This stimulator system overcomes several limitations of existing solutions, namely the resource implications and risk profile of invasive electrodes, and the requirement for supervised operation. While invasive systems are applied selectively for these reasons, routine use of our system can be envisaged. This system was inspired by COVID-19 patients but is not limited to them, and has broad applicability to ventilated intensive care patients in general, for example patients with traumatic brain injury.

Conclusions: Non-invasive stimulation of the phrenic nerves using pressure-free skin surface electrodes is feasible and safe. It offers the potential for prevention of VIDD and thereby faster ventilator weaning and shorter stay on ITU. Clinical trials are planned in 2022.

Learning Objectives: After this presentation delegates should be aware of: 1. Ventilation induced diaphragm dysfunction (VIDD) and its importance in patients having lengthy periods of ventilation, as in many cases of COVID-19. 2. The fact that low levels of activity can maintain the condition of skeletal muscles including the diaphragm muscle 3. The potential for noninvasive stimulation of the phrenic nerves to provide 'diaphragm exercise' and prevent VIDD.

Keywords: phrenic nerve stimulation, diaphragm, ventilation, COVID-19