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CORRESPONDENCE

Ventilation of denervated transplanted lung at risk for overdistention by reverse triggering and breath stacking: a role for the paradoxical reflex of Head. Comment on *Br J Anaesth* 2022; 129: e1–4

Roberto Santa Cruz[1,2,3,*], Matías Rodriguez[3], Gustavo Scarpa[3] and Romina Fernandez[4]

[1]Laboratory of Physiology, School of Medicine, University of Magallanes, Punta Arenas, Chile, [2]Fundación H. A. Barceló, Instituto Universitario de Ciencias de La Salud, Argentina, [3]Servicio de Terapia Intensiva, Hospital Ramos Mejía, Venezuela and [4]Servicio de Neumonología, Hospital Ramos Mejía, Ciudad Autónoma de Buenos Aires, Buenos Aires, Argentina

*Corresponding author. E-mail: resc.hrrg@gmail.com

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Editor—We read with interest the description of respiratory monitoring performed on a 33-yr-old patient who developed pneumonia after receiving a double lung transplant.[1] The authors describe that the patient experienced reverse triggering and breath stacking during mechanical ventilation. In the case of reverse triggering, the authors describe that according to proposed phenotypes,[2] the patient had mid-cycle reverse triggering, where diaphragmatic contraction begins during passive lung inflation, thus generating a reduction in expiratory flow and air trapping, which can lead to overdistension. In this example, the electrical activity of the diaphragm (EAdi) indicated respiratory entrainment with the presence of reverse triggering.

As was described, entrainment can produce asynchronous breathing patterns, as the insufflation produced by a cycle generated by the ventilator triggers an inspiration from the patient. The pathogenesis involves activation of pulmonary reflexes together with cortical and subcortical influences, and the Hering–Breuer reflex, via the vagus nerve, is believed to play a key role. Notably, the authors were surprised that this patient experienced reverse triggering as a recipient of a double lung transplant with denervated lungs (vagotomy), and they detail several alternative mechanisms that might be involved. We think that another physiological mechanism could explain the presence of reverse triggering: the paradoxical reflex of Head.

Reverse triggering is a form of patient–ventilator asynchrony during which a passive ventilator insufflation triggers an involuntary patient effort, seen as diaphragmatic muscle contractions, that can result in a subsequent ventilator-delivered breath.[3] As described, diaphragmatic contraction occurs in the transition phase from mechanical inspiration to expiration.[3] Subsequently, the phenomenon was described regarding the time of occurrence of reverse triggering within the respiratory cycle.[2]

The physiological mechanisms behind reverse triggering are not fully understood. The Hering–Breuer reflex is thought to be involved, where the flow delivered by the ventilator activates slowly adapting stretch receptors in the upper airway, lungs, and chest wall, which provide a feedback afferent, through the vagus nerve, to the respiratory centre. Entrainment has also been described in patients with bilateral lung transplantation despite resection of vagal afferents.[4] In turn, entrainment can be observed after vagal cooling in animals and in healthy subjects who have undergone lung transplantation. Rapid adapting stretch receptors and vagal C fibres, along with cortical and subcortical influences, also could be responsible for respiratory rhythm entrainment.[3] Reverse triggering can also occur in patients with brain death (with no respiratory drive through the brainstem), in which other receptors could be involved, such as thoracic mechanoreceptors, or other mechanisms could be involved, such as passive chest

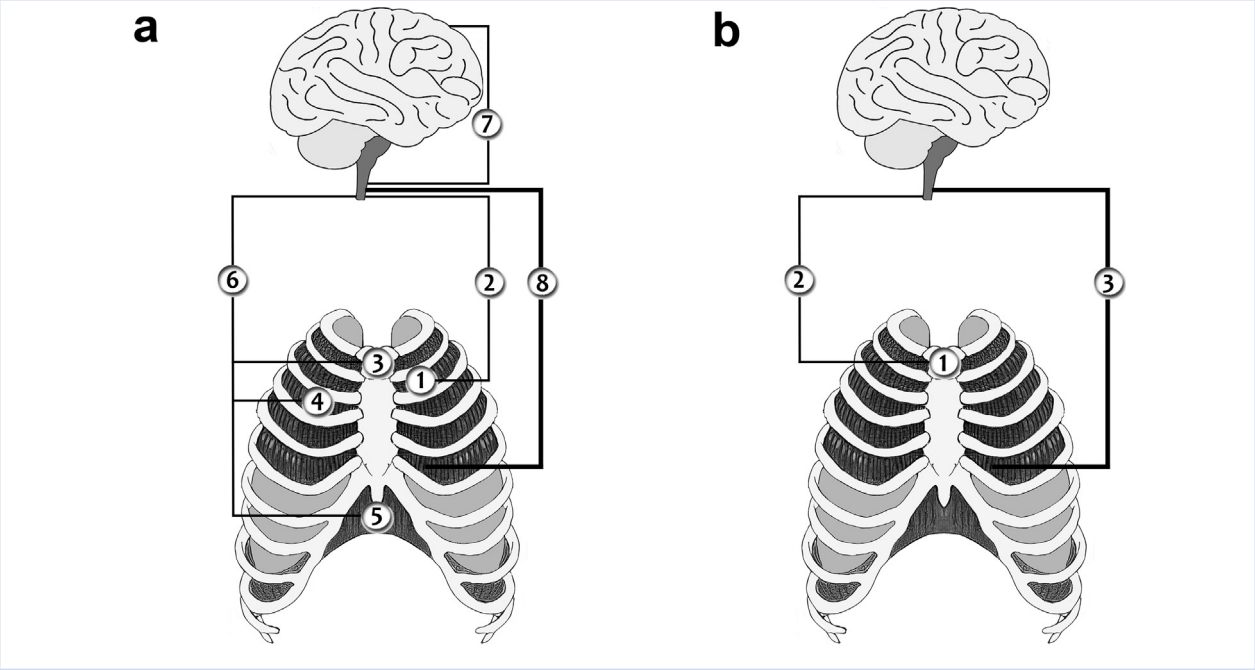

Fig. 1. Probable physiological mechanisms behind reverse triggering. (a) Proposed reflex mechanisms with receptor localisations: (1) slowly adapting stretch receptor, (2) Hering–Breuer reflex, (3) rapid adapting stretch receptor, (4) muscle receptor, (5) receptor in the spinal cord (spinal reflex), (6) probable reflex neural response involved in reverse triggering, (7) influences from higher centres (cortex and subcortex), (8) lung inflation. (b) Probable reflex mechanism via paradoxical reflex of Head: (1) rapid adapting stretch receptor, (2) paradoxical reflex of Head, (3) lung inflation.

movement with the participation of respiratory muscles, chest compression during cardiopulmonary resuscitation, or spinal reflexes[5] (Fig 1a).

In 1889, Henry Head, who worked in Professor Hering's laboratory, described an experiment in rabbits in which the function of the vagus nerves was blocked by cooling to ~0°C. While rewarming the vagus nerves, he noted that in the situation of selective partial vagus nerve block, lung inflation caused additional inspiration instead of the expected apnoea, calling this contraction the paradoxical reflex of Head.[6] In turn, Knowlton and Larrabee[7] showed that a large inflation could trigger this reflex, through the rapid adapting stretch receptors involving the vagus nerves (Fig 1b), whereas small inflations of the lungs produce inhibition of inspiration by activating of slowly adapting stretch receptors (Hering–Breuer inflation reflex).

The paradoxical reflex of Head has been described as important because it produces an increase in functional residual capacity and compliance, and this could play a role in the reopening of partially collapsed airways.[8] It is important to note that this type of additional inspiration, called gasping, has also been described in newborns.[9] Moreover, Greenough and colleagues[10] showed that ventilator inflation could cause a paradoxical inspiratory effort during the first 5 postnatal days and more commonly in the first 24 h of life.

The mechanisms involved in the development of reverse triggering are not currently clear. It could be that there are some common characteristics to both reverse triggering and the paradoxical reflex of Head. In both mechanisms, a diaphragmatic contraction occurs after lung inflation. It has been suggested that vagal feedback is sufficient but not necessary to cause this phenomenon, and entrainment can be observed after vagal cooling in animals and in healthy subjects,[3] a mechanism shown during the description of the reflex of Head. In addition, a consequence of both reverse triggering and the reflex of Head is an increase in lung volume, which was previously seen as a beneficial phenomenon, with an increase in lung compliance. However, in the context of mechanical ventilation it can be associated with overdistension, breath stacking, and lung damage. The paradoxical reflex of Head could be another of the physiological mechanisms involved in reverse triggering, and perhaps could be another explanation for the case presented by Roze and colleagues.[1]

Declaration of interest

The authors have no conflict of interest to declare.

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