Behaviour of human genioglossus single motor units (SMU) discharge properties in quiet breathing, CO_2 and continuous positive airway pressure (CPAP)

J.P. Saboisky,[1] D.J. Eckert,[1] A.S. Jordan,[2] J.A. Trinder,[2] D.P. White[1] and A. Malhotra,[1] [1]Harvard University, Brigham and Women's Hospital, Boston, MA 02115, USA and [2]University of Melbourne, VIC 3010, Australia.

Introduction: The genioglossus is a primary muscle involved in dilating the upper airway. Previous studies recording genioglossal single motor unit discharge activity have reported multiple unit firing patterns (Saboisky *et al.*, 2006). Two of the primary stimuli that contribute to genioglossal control are CO_2 and negative pressure which can modify the behavior of respiratory drive through chemoresponsiveness and mechanoreceptor activation respectively. We therefore studied single motor unit discharge with increased CO_2 and continuous positive airway pressure (CPAP).

Methods: We examined the single motor unit discharge properties of the genioglossus to quantify neural drive during periods of quiet breathing, with elevated end tidal CO_2 (ET_{CO_2}) and with CPAP (2cm H_2O increments until 10cm H_2O) to reduce negative pressure influences on muscle activity. 15 subjects were studied awake lying supine, breathing through a nasal mask. Three fine-wire electrodes were inserted into the genioglossus under ultrasound guidance. Inspiratory flow, tidal volume, mask pressure, and ET_{CO_2} were recorded. We measured onset time, onset and peak firing frequency relative to respiration for 96 single motor units, tracked throughout the eight conditions.

Results: Genioglossus single motor unit activity with increased CO_2, showed a number of consistent changes. First, there was an increase in the discharge rate of inspiratory units (19.1Hz to 21.0Hz $p<0.05$) with activation onset being earlier in the inspiratory cycle (7.5%TI [Inspiratory Time] to -9.1%TI,[before the onset of flow] $p<0.05$), and these units fired for a longer proportion of the respiratory cycle (80.5%TI to 105.7%TI, $p<0.05$). With increases in CO_2, an additional 33.3% of distinguishable single motor units within the selective electrode recoding area were recruited. Nasal CPAP led to a progressive inhibitory response on the number of motor units active. At ~6cm H_2O there were a similar number of motor units active as compared to baseline conditions, with peak frequencies of the inspiratory units returned to near baseline 19.3Hz ($p>0.05$) despite the elevated levels of CO_2. At 10cm H_2O the number of active units was 36.1% less than baseline conditions.

Conclusion: Single motor unit activity is altered in response to chemical and mechanical stimuli; these results have implications for understanding upper airway motor unit rate-coding and recruitment. Inspiratory Phasic and Inspiratory Tonic motor units have earlier pre-activation and increased peak firing frequencies during inspiration in response to CO_2 and this increase in activity is terminated by CPAP.

Saboisky JP, Butler JE, Fogel RB, Taylor JL, Trinder JA, White DP, Gandevia SC. (2006). Tonic and phasic respiratory drives to human genioglossus motoneurons during breathing. *Journal of Neurophysiology* **95**: 2213-2221.