

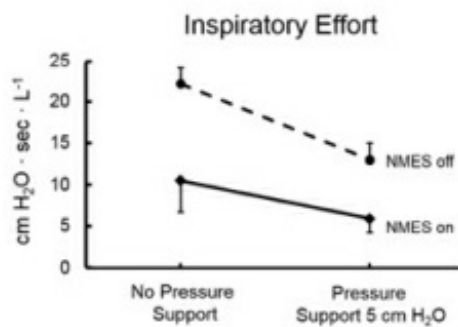
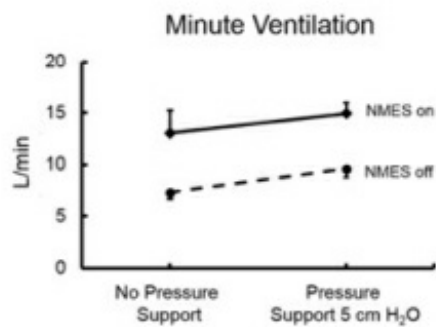
Application of Neuromuscular Electrical Stimulation of the Abdominal Wall Muscles in Combination with Pressure Support Ventilation to Assist Respiration

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Rationale: We recently reported that it is possible to provide inspiratory assistance through the use of transcutaneous neuromuscular electrical stimulation of abdominal muscles in healthy subjects who breathe spontaneously (McLachlan AJRCCM 191:A2681). Whether stimulations on expiration can provide inspiratory assistance during pressure support ventilation is unknown.

Aim: To investigate the effect of combining neuromuscular electrical stimulation of the abdominal wall muscles with pressure support ventilation on minute ventilation and inspiratory effort.

Methods: Six healthy subjects were studied while semi-recumbent. Two minutes of breathing without stimulation followed by two minutes of breathing with stimulation were measured under two conditions: breathing while not connected to the ventilator (unsupported breathing) and breathing while connected to the ventilator set at pressure support of 5 cm H₂O. Flow, gastric pressure and esophageal pressure were recorded throughout the experiment. Intensity of electrical current was set at 90% of maximum tolerable current: 53 ± 3.8 mA (mean $\pm$ standard error). Data was analyzed using a two factor repeated measures ANOVA with the presence of stimulation and presence of pressure support specified as within subject effects. **Results:** All subjects tolerated neuromuscular stimulation without difficulty. In all instances, stimulation was successfully delivered during exhalation. Minute ventilation and inspiratory effort (pressure time product of the diaphragm per liter of minute ventilation) during the experiment are shown in the figure. As expected, breathing with stimulation, compared to breathing without stimulation, increased minute ventilation ($p < 0.01$) and reduced inspiratory effort ($p < 0.01$). A similar effect on minute ventilation ($p = 0.04$) and inspiratory effort ($p = 0.03$) was found when breathing with pressure support compared to unsupported breathing. The increases in minute ventilation elicited by neuromuscular stimulation while subjects were concurrently on pressure support and when they were not on pressure support were similar ($p = 0.84$). Likewise, the decreases in inspiratory effort elicited by neuromuscular stimulation while subjects were concurrently on pressure support and when they were not on pressure support were similar ($p = 0.30$). These results suggest that the effects of the two adjuncts to respiration were additive. **Conclusions:** In healthy subjects, inspiratory assistance provided by neuromuscular stimulation of the abdominal-wall muscles and by pressure support are additive. Support: Veterans Administration Research Service, Liberate Medical LLC, National Science Foundation



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