Abstract

Objectives: Based upon our Laboratory’s newly confirmed motor pathway for glottic closure, we measured the glottic closing force (GCF) during isolated stimulation of the external branch of the superior laryngeal nerve (eSLN) in the porcine model. Glottic closure is one of the primary mechanisms for prevention of aspiration during deglutition.

Methods: The recurrent laryngeal nerve (RLN) and eSLN were identified bilaterally in four porcine necks. Subsequently, we proceeded to bilaterally stimulate the distal ends of representative nerves in a staged manner using bipolar platinum-iridium electrodes. GCF was measured using a pressure transducer placed anteriorly between the vocal cords with direct visualization and repeated 6 times. The RLN mediated GCF was measured first, followed by isolated eSLN mediated GCF, followed by transsection of the RLN and then repeat measurement of the eSLN GCF. Ultimately the cricothyroid (CT) muscle attachment was released as well and the GCF was measured once again.

Results: The measured GCF during isolated eSLN stimulation before and after RLN transaction is approximately 89% of the RLN mediated GCF in each animal. The GCF after CT release is approximately 84% of the RLN perceived GCF in each animal. Transsection of the RLN did not alter the eSLN observed GCF.

Conclusions: The GCF obtained during isolated eSLN stimulation is adequate for delivery of an appropriate laryngeal protective response and may be considered a target motor nerve for augmenting GCF in selected rehab settings.

Methods and Materials

Four Yorkshire pigs, weighing approximately 40 kg each, were used in the study. Inhalational anesthesia was maintained at a level of 1 MAC throughout. No long-term muscle relaxants were used. A tracheotomy was performed and the RLNs and eSLNs were exposed bilaterally. A pharyngotomy was then performed to visualize the vocal cords and gain exposure of the thyroarytenoid (TA) muscles. Bipolar 200-mA platinum-iridium stimulating electrodes were then used to stimulate the nerves of interest. A neurax EMG machine (XLTEK, Oakville, Canada) was used to provide electrical stimuli starting at 0.1mA and increasing by 0.1mA until adequate responses were noted. To measure glottic closing force (GCF) a catheter pressure transducer (SPC-330, Micro-Tip, Millar, Houston TX) was placed with its pressure-sensitive tip in the mid-portion of the glottis. This transducer was connected to a DC amplifier that displayed the waveform on an oscilloscope. Trials were repeated six times to ensure reproducibility. There were four sequential experimental protocols as follows:

Step 1: Stimulate bilateral RLNs → measure GCF
Step 2: Stimulate bilateral eSLNs → measure GCF
Step 3: Transect RLN bilaterally → stimulate eSLN bilaterally → measure GCF
Step 4: Transect cricothyroid muscle attachment → stimulate eSLN → measure GCF

Results

Stimulation of the RLNs as well as the eSLNs each led to TA muscle contraction and a measurable GCF. The GCF from bilateral RLN stimulation alone measured 660 ± 140 mmHg. The GCF from bilateral eSLN stimulation alone measured 580 ± 138 mmHg. After transecting the RLNs, the eSLN-mediated GCF was 586 ± 118 mmHg. This persisted even after transecting the CT muscle insertion, thus eliminating the possibility of a stretch response.

Stepwise Experimental Progression

- Stimulate bilateral RLN
- Measure GCF
- Stimulate bilateral eSLN
- Measure GCF
- Transect bilateral RLN then stimulate bilateral eSLN
- Measure GCF
- Transect CT muscle attachment, stimulate bilateral eSLN
- Measure GCF

Discussion

Perhaps the most important mechanism of airway protection in mammals is reflex adduction of the vocal cords. Classically, the RLN has been thought of as the main efferent mediator of this reflex, allowing for contraction of the TA muscles and an adequate glottic closing force for airway protection.

Our study demonstrates that the eSLN can serve as the main effector branch leading to TA contraction in the porcine model. The GCF from eSLN-mediated contraction was approximately 84% of the GCF achieved when the RLN was directly stimulated. This occurred even after transection of the RLN and CT muscle attachments; the former preventing an afferent contribution from the SLN to the RLN, and the latter ensuring that the glottic closure was not due to a stretch response from CT muscle contraction.

Conclusions

The external branch of the superior laryngeal nerve plays a significant role as an efferent mediator of thyroarytenoid muscle contraction in the porcine model.

The glottic closing force attained from eSLN stimulation is able to approach the RLN-mediated glottic closing force.

The eSLN is a suitable target nerve in order to augment a weakened or ineffective glottic closure response.