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Breathing–Swallowing Interaction in Neuromuscular Patients: A Physiological Evaluation

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Rationale:

Malnutrition and aspiration are major problems in patients with neuromuscular disease. Because impaired swallowing contributes to malnutrition, means of improving swallowing are needed.

Objectives:

To investigate interactions between breathing and swallowing in neuromuscular disorders and to evaluate the impact of mechanical ventilation (MV) on swallowing in tracheostomized patients.

Methods:

We studied 10 healthy individuals and 29 patients with neuromuscular disease and chronic respiratory failure (including 19 with tracheostomy). The tracheostomized patients who could breathe spontaneously were recorded during spontaneous breathing (SB) and with MV, in random order.

Measurements and Main Results:

Breathing–swallowing interactions were investigated by chin electromyography and inductive respiratory plethysmography, using three water-bolus sizes (5, 10, and 15 ml) in random order. In contrast to healthy individuals, neuromuscular patients showed piecemeal deglutition with several swallows over several breathing cycles for each bolus. The percentage of swallows followed by expiration was about 50% in the patients compared with nearly 100% in the control subjects. The number of swallows and total swallowing time per bolus correlated significantly to maximal inspiratory pressure. In the 10 tracheostomized patients who were recorded both in SB and MV, the number of swallows and total swallowing time per bolus were significantly reduced during MV compared with SB.

Conclusion:

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Neuromuscular patients showed abnormal breathing– swallowing interactions, which correlated to maximal inspiratory pressure. Moreover, MV improved the swallowing parameters in tracheostomized patients who were able to breathe spontaneously.

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Direct Measurement of Subglottic Air Pressure While Swallowing

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Objective:
The subglottic pressure theory for swallowing asserts that laryngeal mechanoreceptors have a role in the regulation of swallowing function. The primary purpose of this study was to determine if subglottic air pressure is generated during swallowing in a healthy, nontracheostomized person.

Methods:

This pilot investigation used a prospective, repeated-measures design in a single subject. Direct measurement of subglottic air pressure was obtained through percutaneous puncture of the cricothyroid membrane. Swallows were timed with four randomly assigned lung volumes: total lung capacity, tidal volume, functional residual capacity (FRC), and residual volume.

Results:

Lung volumes above FRC generated positive subglottic pressure during the swallow, whereas lung volumes below FRC generated consistently negative subglottic pressures. The degree and polarity of the pressure was directly related to lung volume at the time of the swallow.

Conclusion:

These findings illustrate that during normal swallowing, positive subglottic air pressure is likely present. Previously, subglottic air pressure during swallowing had been measured in tracheostomy patients only. Key Words: Swallowing, deglutition, subglottic air pressure, tracheostomy tube.

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Effect of a tracheostomy speaking valve on breathing–swallowing interaction

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Purpose:

Expiratory flow towards the upper airway after swallowing serves to expel liquid or food particles misdirected towards the trachea during swallowing. However, expiration may not occur consistently after swallowing in tracheostomised patients with an open tracheostomy tube. We investigated the effect of a speaking valve (SV) on breathing-swallowing interactions and on the volume expelled through the upper airway after swallowing.

Methods:

Eight tracheostomised neuromuscular patients who were able to breathe spontaneously were studied with and without an SV. Breathing-swallowing interactions were investigated by chin electromyography, cervical piezoelectric sensor, and nasal and tracheal flow recording. Three water-bolus sizes (5, 10, and 15 mL) were tested in random order.

Results:

Swallowing characteristics and breathing-swallowing synchronisation were not influenced by SV use. However, expiratory flow towards the upper airway after swallowing was negligible without the SV and was restored by adding the SV.

Conclusion:

In tracheostomised patients, protective expiration towards the upper airway after swallowing is restored by the use of an SV.

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Lung Volume During Swallowing: Single Bolus Swallows in Healthy Young Adults

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Purpose:

This study examined the relationship between swallowing and lung volume initiation in healthy adults during single swallows of boluses differing in volume and consistency. Differences in lung volume according to respiratory phase surrounding the swallow were also assessed.

Method:

Nine men and 11 women between the ages of 19 and 28 years served as study participants. Lung volume and respiratory phase data were recorded as each participant completed 5 trials each of 10-mL and 20-mL water boluses by cup, and thin and thick paste boluses by spoon, presented in randomized order.

Results:

Significant differences in lung volume at swallow initiation were found based on bolus consistency but not on bolus volume. No differences were found for lung volume initiation based on the respiratory phase surrounding the swallow or for the respiratory pattern based on bolus volume or consistency.

Conclusion:

Findings of this study extend the existing knowledge base regarding the interaction of the swallow and respiratory systems by identifying targeted lung volumes at swallow initiation. In addition to other swallow-related biomechanical events and respiratory phase relationships surrounding a swallow, the lung volume at swallow initiation may be an important consideration when investigating swallow physiology and physiopathy.

Journal of Applied Physiology 95: 2211–2217, 2003.

Lung volume effects on pharyngeal swallowing physiology

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Abstract:

The experiment was a prospective, repeated-measures design intended to determine how the variation of lung volume affects specific measures of swallowing physiology. Swallows were recorded in 28 healthy subjects, who ranged in age from 21 to 40 yr (mean age of 29 yr), by using simultaneous videofluoroscopy, bipolar intramuscular electromyography, and respiratory inductance plethysmography. Each subject swallowed three standardized pudding-like consistency boluses at three randomized lung volumes: total lung capacity, functional residual capacity, and residual volume. The results showed that pharyngeal activity duration of deglutition for swallows produced at residual volume was significantly longer than those occurring at total lung capacity or at functional residual capacity. No significant differences were found for bolus transit time or intramuscular electromyography of the superior constrictor. The results of this experiment lend support to the hypothesis that the respiratory system may have a regulatory function related to swallowing and that positive subglottic air pressure may be important for swallowing integrity. Eventually, new treatment paradigms for oropharyngeal dysphagia that are based on respiratory physiology may be developed.

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Lung Volume Measured During Sequential Swallowing in Healthy Young Adults

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Purpose:

Outcomes from studying the coordinative relationship between respiratory and swallow subsystems are inconsistent for sequential swallows, and the lung volume at the initiation of sequential swallowing remains undefined. The first goal of this study was to quantify the lung volume at initiation of sequential swallowing ingestion cycles and to identify the respiratory pattern(s) surrounding each sequential swallow ingestion cycle. The second goal was to compare these results with existing data for single swallows.

Method:

Twenty healthy young adults served as participants, 9 males and 11 females, between 19 and 28 years of age (*M* = 22 years of age). Participants completed 2 trials each of 100 mL of water self-delivered by cup and by straw. Calibrated respiratory inductance plethysmography, surface electromyography, and a contact throat microphone were used to detect respiratory parameters, identify swallow-related muscle contraction, and identify swallowing sounds, respectively.

Results:

Significantly higher lung volume initiation for trials delivered by straw and more variable respiratory patterns surrounding cup and straw sequential swallowing ingestion cycles existed compared with single swallows.

Conclusions:

Results show that as the physiologic demands of swallowing deviate from single, small bolus swallows, the integration of the swallowing and respiratory systems change. This may reflect obligate differences in airway protection strategy and prolonged competition for respiratory resources.

Perspectives on Swallowing and Swallowing Disorders (Dysphagia) March 2009 vol. 18 no. 1 13-18

Subglottic Air Pressure and Swallowing

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Abstract:

The existence of positive subglottic air pressure at the time of the swallow was first demonstrated in patients with indwelling tracheostomy tubes. Deglutitive subglottic air pressure has also been measured in non-tracheostomized persons. Several investigations that compared the occlusion status of tracheostomy tubes (open vs. closed) have found relationships between swallowing physiology and tube status. Similar findings were reported when healthy individuals swallowed at various lung volumes. As such, there is emerging evidence for the role of subglottic air pressure in swallowing motor control. Clinically, subglottic pressures in relation to breathing and swallowing coordination, pulmonary function, and lung-thoracic unit recoil forces may need to be considered when working with both tracheostomized and non-tracheostomized patients.

The Annals of otology, rhinology, and laryngology 1996 Apr;105(4):253-8.

Subglottic air pressure: a key component of swallowing efficiency

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Abstract:

The relationship between tracheostomy and swallowing dysfunction has been long recognized. Often this dysfunction is manifested by aspiration, for which a number of etiologic factors may be responsible. Disruption of glottic closure has been previously demonstrated in association with the presence of an indwelling tracheostomy tube. The plugging or removal of the tracheostomy tube, or the use of an expiratory air valve, has been demonstrated to decrease aspiration and improve swallowing function. Measurement of subglottic pressure through an indwelling tracheostomy tube during swallowing demonstrated pressure peaks occurring concomitant with swallowing and laryngeal elevation. This presentation will review the evidence supporting the role of subglottic pressure rise in swallowing efficiency. Current investigational activity will be reviewed, and new areas for study will be suggested.

Dysphagia (2008) 23:136–145

The Coordination of Breathing and Swallowing in Parkinson's Disease

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Abstract:

Multiple investigations have determined that healthy adults swallow most often during exhalation and that exhalation regularly follows the swallow, even when a swallow occurs during inhalation. We hypothesized that persons with idiopathic Parkinson's disease would demonstrate impaired breathing and swallowing coordination during spontaneous eating. Twenty-five healthy volunteers and 25 Parkinson's disease patients spontaneously swallowed calibrated pudding and cookie portions while simultaneous nasal airflow and respiratory inductance plethysmography were used to track spontaneous breathing. Surface EMG was used to record the timing of each swallow within the respiratory cycle. When compared to the healthy control group, those with Parkinson's disease swallowed significantly more often during inhalation and at low tidal volumes. The Parkinson's participants also exhibited significantly more postswallow inhalation for both consistencies. Only the healthy subjects exhibited significantly longer deglutitive apnea when swallows that occurred during inhalation were compared with those that occurred during exhalation. The high incidence of oropharyngeal dysphagia and risk of aspiration pneumonia found in Parkinson's disease patients may be partially attributable to impaired coordination of breathing and swallowing.

Perspectives on Swallowing and Swallowing Disorders (Dysphagia) March 2009 vol. 18 no. 1 34-40

The Interaction of Pulmonary Physiology and Swallowing: A Juggling Act for the Physician and Speech-Language Pathologist

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Abstract:

Patients who are dependent upon tracheostomy and/or ventilator use present a particular challenge to health-care providers. The interaction of pulmonary physiology and deglutition is complex, as illustrated in the course of patients who are in the weaning process. Speech language pathologists (SLPs) should work closely with their physician colleagues to understand the influence of multiple medical co-morbidities on intervention. In traditional medicine, the clinician's objective is to connect a patient's many symptoms and complaints to a single disease entity. However, in caring for the ventilator dependent geriatric population, a symptom such as dysphagia typically results from the interplay of various, multi-organ symptoms, and conditions. This article strives to demonstrate the "juggling act" that the physician and SLP must balance between the patient's current medical condition, pulmonary dysfunction, and disordered swallowing. Clinical case studies illustrate the benefit of swallowing intervention on quality of life. While the care of patients with tracheostomy and ventilator dependence requires a team approach, with respiratory therapy and nursing vital members, this article emphasizes the roles of the SLP and physician.