

**Critical Review:**  
**Evidence of the Association between Laryngopharyngeal Sensory Deficits and Risk of Aspiration**

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This critical review examines the association between laryngopharyngeal (LP) sensory deficits (as determined by laryngopharyngeal sensory testing (LPST)) and risk of aspiration. Study designs include: prospective exploratory research. Overall, the literature provides evidence that LP sensory deficits and pharyngeal motor deficits are closely related and are associated with an increased risk of aspiration. Although impaired sensation alone did not appear to increase risk of aspiration for puree consistencies, it was found to significantly increase risk of aspiration of thin liquids.

***Introduction***

Dysphagia is defined as “any abnormality in swallowing physiology or biomechanics of the oral, pharyngeal and/or oesophageal areas that may be due to developmental or acquired etiologies” (CASLPO, 2000, p.23 ). It can produce aspiration, which is the “entry of foreign material into the airway beyond the vocal folds” (CASLPO, 2000, p.23). This aspirate can potentially accumulate and produce an infection in the lungs known as pneumonia.

Currently methods to assess these risks go beyond the conventional bedside swallowing examination, and include approaches such as the ‘gold standard’ Modified Barium Swallow (MBS) and more recently, the use of Fiberoptic/Flexible Endoscopic Evaluation of Swallowing (FEES).

Traditionally, deficits in the motor control of the larynx and pharynx have been considered to be the cause of dysphagia and aspiration (Aviv et al., 1996). However, sensory disturbances in this area would also be anticipated to negatively affect both voluntary laryngopharyngeal protective mechanisms as well as laryngeal reflexes (Aviv et al., 1996).

Currently, the use of laryngopharyngeal sensory testing (LPST) has allowed professionals to more accurately and quantitatively describe the sensory aspects of the swallow (Thompson, 2003). This type of testing involves the observation of the laryngeal adductor response (LAR) during endoscopic administration of discrete air pulses to the hypopharyngeal mucosa, in order to objectively determine sensory thresholds (Aviv et al., 2002).

This testing can be achieved by using FEESST, or fiberoptic endoscopic evaluation of swallowing with sensory testing, which involves the established endoscopic procedure to assess swallowing, but also determines the LP sensory discrimination thresholds (Aviv et al., 1998).

The LAR is a reflex controlled by the brainstem which protects the airway by briefly closing the true vocal folds (Aviv et al., 2002). It does not require conscious control by the patient and thus is “ideal for pediatric patients who cannot provide a subjective response or [those] who lack the cognitive functional ability to cooperate” (Thompson, 2003, p.167). An impaired LAR may represent an incapability to perceive secretions and food in the laryngopharynx, and may hinder the initiation of laryngeal-protective reflexes, subsequently allowing these materials to move into the esophagus and/or the tracheobronchial tree (Thompson, 2003 & Aviv et al., 1998).

Presently, common practice during bedside assessment is to elicit the gag reflex as a gross measure of laryngopharyngeal sensation, yet this does not test the internal branch of the superior laryngeal nerve (10<sup>th</sup> cranial nerve) which provides sensory information from the laryngopharynx, and instead demonstrates afferent activity of the 9<sup>th</sup> cranial nerve (Aviv et al., 1997).

While MBS and FEES are the current methods of assessing swallowing function, they only visualize the motor aspects of the swallow and fail to directly examine the sensory component of LP functioning (Aviv et al., 1996). As outlined by CASLPO, “inappropriate assessment or management of patients afflicted with dysphagia can cause physical and/or mental harm including, but not limited to increasing the risk of aspiration, [and] increasing the risk of suffering from the complications of aspiration” (CASLPO, 2000, p.3). This begs the question, whether speech-language pathologists are sufficiently assessing sensory deficits in the laryngopharynx.

***Objectives***

The primary objective of this paper is to critically evaluate existing literature regarding the

association between LP sensory deficits and risk of aspiration. The secondary objective is to propose evidence-based practice recommendations about the use of LP sensory thresholds as part of the swallowing assessment and management protocol.

### ***Methods***

#### **Search Strategy**

Computerized databases, including PubMed and CINAHL were searched using the following search strategy:

(laryngopharyngeal sensory (deficits OR testing) AND (aspiration)).

The search was limited to articles written in English.

#### **Selection Criteria**

Studies selected for inclusion in this critical review paper were required to investigate the relationship between LP sensory deficits (as determined by LPST) and risk of aspiration.

#### **Data Collection**

Results of the literature search yielded five articles meeting the above criteria, all of which were prospective exploratory research studies.

### ***Results***

The study by Perlman et al. (2004) describes prospective exploratory research looking at 204 consecutive patients with dysphagia in which the relationship between varying levels of laryngopharyngeal sensory deficits, motor deficits, and the risk of aspiration of pureed foods was examined. FEESST was utilized to observe the outcome of the presence or absence of aspiration. The LAR was used to determine the level of LP sensory deficit and pharyngeal squeeze was employed to determine the presence of motor deficits. Results were analyzed using the t-test and confirmed with the Fisher's Exact test. The authors reported a significant difference in the presence of aspiration for normal and moderate sensory loss in patients with normal versus impaired pharyngeal squeeze ( $P < 0.001$ ). No significant difference was found for the severe sensory loss group. Regardless of pharyngeal motor function, no significant difference in aspiration was found as the sensory deficit increases. The researchers found that patients with impaired pharyngeal squeeze with different levels of sensory deficits are at significantly greater risk for aspiration of pureed food. They concluded that aspiration of pureed foods may depend more on pharyngeal motor function than on sensation.

The study by Setzen et al. (2003) describes prospective exploratory research looking at 204 consecutive patients with dysphagia in which the relationship between varying levels of laryngopharyngeal sensory deficits, motor deficits, and the risk of aspiration of thin liquids were examined. The outcome of aspiration was observed by the use of FEESST. The LAR was used to determine level of LP sensory deficit and pharyngeal squeeze was employed to determine the presence of motor deficits. Results were analyzed using the t-test and confirmed with unspecified nonparametric test(s). The researchers reported that patients with severe LP sensory and pharyngeal motor deficits are at an exceptionally high risk of aspiration of thin liquids (100%). Moderate sensory deficits only significantly influenced the prevalence of aspiration when concomitant with pharyngeal motor deficits.

The study by Aviv et al. (2002) describes prospective exploratory research looking at 350 consecutive patients with dysphagia in which the relationship between intact versus absent LAR and the presence or absence of pharyngeal motor deficits was examined in regards to the prevalence of laryngeal penetration and aspiration. The relationship between pharyngeal motor weakness and LP sensory deficits was also investigated. FEESST was utilized to observe the outcome of the presence or absence of penetration and aspiration. The LAR was used to identify patients with normal ( $<4$  mm Hg of air pulse pressure to elicit the reflex) and severe sensory deficits ( $>6.0$  mm Hg). Pharyngeal squeeze was employed to determine the presence or absence of motor deficits. Results were analyzed using the Pearson  $\chi^2$ . The researchers reported that the prevalence of penetration and aspiration was significantly higher in the absent LAR/impaired contraction group than in the normal sensation/impaired contraction group. They concluded that patients with absent LAR and impaired pharyngeal squeeze are at greater risk for laryngeal penetration and aspiration compared to patients with intact LAR and intact pharyngeal squeeze.

The study by Setzen et al. (2001) describes prospective exploratory research looking at 40 patients with dysphagia in which the relationship between intact versus absent LAR and the presence or absence of pharyngeal motor deficits was examined in regards to the prevalence of laryngeal penetration and aspiration. The relationship between pharyngeal motor weakness and LP sensory deficits was also explored. FEESST was utilized to observe the outcome of the presence or absence of penetration and aspiration. The LAR was utilized to identify patients with normal and severe sensory deficits.

Pharyngeal squeeze was used to determine the presence or absence of motor deficits. Results were analyzed using the Fisher's Exact test. The authors reported a significant difference in the incidence of aspiration and pharyngeal muscular weakness between the severe sensory deficit and normal sensation groups. They concluded that there is a strong association between pharyngeal motor function deficits and LP sensory deficits.

The final study by Link et al. (2000) describes prospective exploratory research looking at 108 pediatric patients with varying etiologies in which the feasibility of FEESST in the pediatric population was examined. Additionally, this study assessed whether the sensory testing results correlated with aspiration during a feeding assessment or correlated with a history of pneumonia, neurologic disorder, or gastroesophageal reflux. The LAR was used to determine the level of LP sensory deficit. Results were analyzed using a variety of statistical analyses including a paired t-test, Mann-Whitney U test, ANOVA, Bonferroni-Dunn correction, and chi-square analysis. The researchers reported that FEESST was found to be feasible and correlative in the pediatric population. Reduced LP sensation was significantly correlated with laryngeal penetration and aspiration during a feeding assessment. As well, such deficits correlated with a history of pneumonia, neurologic disease, and gastroesophageal reflux.

### *Discussion*

#### **Subject Selection and Sample Size**

In all studies, no explanation of sample size was given and neither sample size nor power calculations were included. Therefore, adequacy of the number of participants should be questioned as having a potential impact on the detection and strength of significant results (potential Type II error).

The first two studies (Perlman et al., 2004; Setzen et al., 2003) identified an additional limitation of their sample size which required them to combine severe and absent sensory deficits into a single group. This too is questionable as differences may exist between the two groups which could be lost or could have an effect on the outcomes observed. Setzen et al. (2003) questioned the results for their moderate group also due to sample size limitations, as the distribution of participants among groups was not even. Designation to a given sensation group was based on the LP threshold of the 'best performing side', potentially skewing the data. No test comparing the two sides to determine if there was a significant difference was completed, which would have strengthened the internal validity of these studies.

Overall, the studies lacked control for various confounds including age, sex, and size matching of groups, and included participants with a variety of underlying etiologies (Perlman et al., 2004; Setzen et al., 2003, Aviv et al., 2002; Link et al., 2000). These variables may have impacted the detection or strength of significant results. Only Setzen et al. (2001) size and sex matched their groups; however sample size was much smaller in this study (n=40).

Studies by Perlman et al. (2004) and Setzen et al. (2003) used the same participants (n=204), limiting the ability to generalize their findings. Specification of their inclusion criteria was also limited, identifying participants only as patients with dysphagia taken consecutively from an otolaryngologist's office.

In order to be included in studies by Aviv et al. (2002) and Setzen et al. (2001) patients had either normal laryngopharyngeal (LP) sensation (intact LAR) or severe sensory deficits (absent LAR). The neglect by both sets of researchers to include various levels of sensory deficits in the study is somewhat questionable as this information may provide a better picture of the overall implications of such deficits. By looking at the extreme opposing ends of the spectrum, significant results may more easily be obtained; however the ability to generalize these findings to other patients may not be appropriate, and therefore limits the external validity of these studies. Furthermore, the definition of a severe sensory deficit as having an absent LAR is not typical and may present a potential confound in comparing results with other research. In addition, the inclusion criteria for Aviv et al. (2002) involved a referral from a physician for FEESST. This may represent a potential bias, in which patients with unclear or silent LP sensory deficits could be unintentionally excluded.

Determination of the diagnosis of dysphagia and type of dysphagia were not outlined by any of the researchers. As dysphagia is sometimes defined as the occurrence of aspiration, this represents another potential confound which was present in all studies.

#### **Methodology**

The methodologies of these studies were clearly outlined for both sensory testing and motor evaluation, allowing for easy reproducibility; however, details of actual feeding procedures were not specified. Researchers indicated the size, type and number of boluses given, further improving reproducibility (Perlman et al., 2004; Setzen et al., 2003, Aviv et al., 2002; Setzen et al., 2001). Due to the complicated methodology and variability of child participants, this information was not provided for the Link et al. (2000) study. The variety of size, number and consistency of boluses trialed could vary

the level of challenge and risk for patients and subsequently could impact the outcome observed. Additionally, the prevalent use of the single bolus measure fails to address the potential impact of fatigue on the risk of aspiration for these patients.

In studies where both thin and puree boluses were provided (Aviv et al., 2002; Setzen et al., 2001; Link et al., 2000), consistencies were not randomized and therefore an order effect may have been present. As well, randomization of procedures (LAR, pharyngeal squeeze, and swallowing trials) was not controlled for by any of the researchers, again representing the potential for an order effect. Furthermore, no mention of the researchers being blinded to the results of the sensory testing was made in regards to the subsequent swallowing test. Consequently, bias may have been present in identifying penetration and aspiration.

Both Perlman et al. (2004) and Setzen et al. (2001) reported taking various additional measures during the swallowing trials, detailed case histories and conducted oral motor exams. However, this data was neither provided nor interpreted in either study, leaving the reader to question the intent of the researchers.

### **Measurement Tools and Outcomes**

Well-established tools were utilized to measure outcomes and if not described in detail, appropriate references were given. The use of FEESST, LPST, LAR and pharyngeal squeeze were appropriate in all cases. Of concern was the use of an unconventional definition of the LAR response by Link et al. (2000), which potentially affects the validity of the measure in this study. Additionally, this study failed to look at the motor aspect of the swallow which can create difficulty in discriminating between sensory versus motor impact when examining their results.

The outcome of the presence or absence of aspiration was conventionally defined and examined in all studies. However the outcome of penetration was only looked at in the final three studies (Aviv et al., 2002; Setzen et al., 2001; Link et al., 2000). Perlman et al. (2004) and Setzen et al. (2003) failed to look at penetration which is important as it is linked to aspiration. This is especially significant when doing a single bolus trial, as these studies do, because on a single trial a patient may not aspirate, but penetration may occur. Upon subsequent trials, fatigue may set in and the penetration may progress to aspiration.

Interrater reliability was addressed in two of the studies (Perlman et al., 2004; Link et al., 2000) by having the same Speech-Language Pathologist and one of several Otolaryngologists from the same practice interpret the results and outcomes.

### **Statistical Analysis**

All studies used appropriate statistical analyses for their data. Perlman et al. (2004) and Setzen et al. (2003) initially used parametric tests, but confirmed their results with non-parametric analyses that were more appropriate for the data. However Setzen et al. (2003) failed to specify what non-parametric tests were used, limiting reproducibility. Setzen et al. (2001) utilized the Fisher's exact test appropriately for their categorical data due to their small sample size. Several participants were excluded from the statistical analysis by Link et al. (2000); however the authors' explanation was adequate to support this choice given the issues surrounding the testing of young children.

### ***Recommendations for Future Research***

Future studies should attempt to examine all levels of LP sensory deficits to ensure the ability to generalize the findings to all patients. A greater attempt to control for confounds, randomize order and blind researchers should also be made to increase the strength of these results. Additionally, studies should clarify their inclusion criteria by providing a definition of dysphagia and be aware of referral bias.

A variety of textures (e.g. include thickened liquids) should be examined in these studies, as differences were seen on the impact of sensation for puree versus thin.

As identified in Setzen et al. (2003), the whiteout phase during FEES is a time of potential aspiration and presents the potential for a false-negative result. Therefore the determination of LP sensory thresholds in clinical practice should help to increase the diagnostic sensitivity of this test, at least for thin liquids. Future research should examine the addition of LPST to current test batteries (such as FEES or MBS) in order to determine if it can augment their accuracy and improve patient care/outcomes.

Finally, due to the limited research in this clinical area, several of the studies critiqued in this review (Perlman et al., 2004; Setzen et al., 2003; Setzen et al., 2001) include similar authors which has the potential for creating further bias. Therefore, replication of these studies should be carried out by independent researchers.

### ***Recommendations for Clinical Practice***

The findings of this research demonstrate a clear association between motor and sensory deficits; therefore, as clinicians, we must consider how these two components of the system interact and attempt to better directly assess our patients sensory status as

well as the motor status, in order to provide the most comprehensive plan of care.

LPST is an important option to consider as it can directly assess the sensory component of the swallow (which is not possible with MBS). Clinicians should be aware that findings of severe or absent LP sensation is a sign that their patient is at high risk of aspiration of thin liquid, regardless of their motor abilities. This is important to note, as the focus of assessment is often placed on motor rather than sensory capabilities. In clinical practice this evidence must be considered by the Speech-Language Pathologist when determining the appropriate treatment and dietary recommendations.

The use of LPST is simple and allows for the assessment of airway protection prior to administering food or liquid. As stated by Link et al. (2000), it also allows for the potential to follow the improvement or deterioration of swallowing function without the need for repeated exposure to radiation, as would be the case when using MBS. FEES(ST) is less invasive and more cost effective (Perlman et al, 2004), therefore Speech-Language Pathologists should advocate for this assessment protocol to become more accessible, as it is currently a delegated act in Canada.

### Conclusions

Based on a critical review of the current literature, a moderate level of evidence supporting the association between LP sensory deficits and risk of aspiration was found. This research demonstrates the importance of incorporating direct assessment of laryngopharyngeal sensation when evaluating swallowing safety. While impaired sensation alone was not seen to impact risk of aspiration for puree, it was shown to be an important factor when considering a patient's safety with respect to thin liquids. Additionally, all evidence supported a strong relationship between LP sensory deficits and pharyngeal motor deficits and concluded that patients with both these impairments were at greater risk of aspiration.

Further research is required in order to better control for confounds, increase generalizability of findings and eliminate researcher bias. Investigation of the ability to increase sensitivity of current procedures with the addition of LPST should also be investigated to determine the clinical significance of such testing.

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