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Laryngeal penetration on videofluoroscopic swallowing study is associated with increased pneumonia in children☆

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ABSTRACT

Objectives: To determine whether children with laryngeal penetration on videofluoroscopic swallowing study are at higher risk for pneumonia than those with normal findings.
Methods: We reviewed the charts of 235 pediatric patients presenting to our Swallowing and Dysphagia clinic for videofluoroscopic swallowing study over a 3-year period. Patients with unsuccessful swallowing studies, incomplete charts, extra-laryngeal etiologies for recurrent pneumonia, or who were lost to follow up were excluded. Out of the 165 patients remaining, 58 had normal findings, 59 had laryngeal penetration, and 48 had tracheobronchial aspiration. The number of cases of pneumonia, aspiration events, and demographic data were recorded for all patients.
Results: Children with laryngeal penetration on videofluoroscopic swallowing study had significantly ($P = 0.032$) more pneumonia than patients with neither penetration nor aspiration (median 2 vs. 0; mean 2.22 vs. 1.60). Furthermore, analysis revealed that glottic abnormalities (e.g. laryngeal cleft) represented a significant independent risk factor ($P = 0.004$) for pneumonia and aspiration, while being diagnosed with a syndrome did not ($P = 0.343$).
Conclusion: To our knowledge, this is the first study to demonstrate that laryngeal penetration on videofluoroscopic swallowing study is associated with significantly more cases of pneumonia in children. While this remains a retrospective study demonstrating a weak association, the results suggest a need for future prospective studies to evaluate this important clinical question in children.

1. Introduction

It has been estimated that each year in the developed world, there are 2.6 million cases of pediatric pneumonia, resulting in 1.5 million hospitalizations and accounting for 3000 deaths at less than 5 years of age [1]. While the most common cause of community-acquired pneumonia remains viral and bacterial infections, oropharyngeal incoordination with aspiration has been cited as the primary etiology of recurrent pneumonia in childhood [2], accounting for an estimated 8% of pediatric pneumonia hospitalizations [3]. Aspiration is an important etiology of pneumonia in certain groups of patients, such as children with neurological abnormalities or syndromes [2,4–6]. The swallowing mechanism is complex and difficulty can be encountered at the preparatory, oral, pharyngeal, and esophageal phases [7]. The gold standard diagnostic test for prandial aspiration is a videofluoroscopic swallowing study (VFSS), where a patient ingests barium boluses of various consistencies under radiographic visualization in order to assess the oral and pharyngeal phases of swallowing [2,4,5]. Entry of bolus material below the true vocal folds, known as tracheobronchial aspiration, during VFSS is a clear risk factor for aspiration pneumonia (see Fig. 1A) [4,8]. Laryngeal penetration on the other hand, which is most commonly defined as the passage of material into the laryngeal vestibule but above the true vocal folds (see Fig. 1B) [7–9], requires further investigation [4,10].

There are different degrees of laryngeal penetration, as best described by Rosenbek and colleagues [9] in the Penetration–Aspiration Scale, and it may occur before, during, or after the pharyngeal phase of swallowing [7]. In 2000, Friedman and colleagues [8] demonstrated that out of 125 children with

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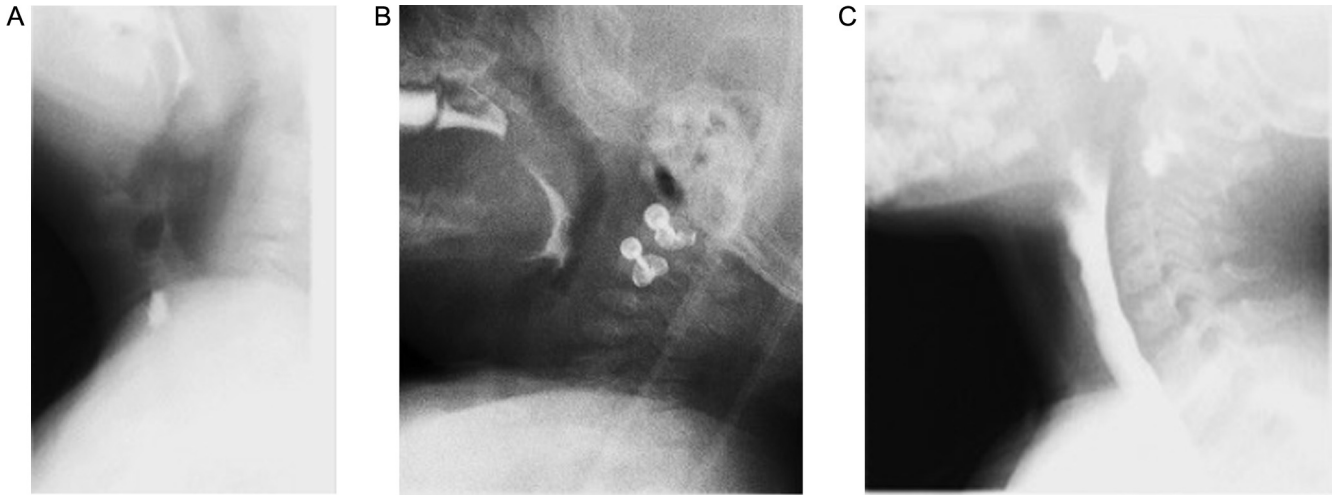

Fig. 1. VFSS outcomes. (A) Tracheobronchial aspiration in a 2-year-old male. (B) Laryngeal penetration in a 6-month-old female. (C) Neither aspiration nor penetration in a 5-year-old female.

dysphagia, 60% exhibited laryngeal penetration including 31% with deep laryngeal penetration (the bolus contacting the vocal cords). Importantly, 85% of these children aspirated later over the course of an extended VFSS, suggesting a strong correlation between laryngeal penetration and tracheobronchial aspiration [8]. However, this study did not look at clinical outcomes. Furthermore, a large study of 381 adults with 6 months of clinical follow up demonstrated that patients with laryngeal penetration were approximately four times ($P = 0.008$) more likely to develop pneumonia than those with normal swallowing [4]. Thus, there is evidence that laryngeal penetration on VFSS may represent an early sign of aspiration as well as evidence that laryngeal penetration increases the risk of pneumonia in adults, but presently there is no study evaluating the clinical significance of laryngeal penetration in children. The objective of this study is to determine if laryngeal penetration on VFSS is associated with increased pneumonia in this age group.

2. Materials and methods

2.1. Subjects

The study population consisted of 235 pediatric patients consecutively referred to our Swallowing and Dysphagia clinic for a VFSS from 2008 to 2011. Patients with a prematurely terminated VFSS, those who were not primarily followed at our hospital center, patients who exhibited extra-laryngeal etiologies of pneumonia, and those who were lost to follow up were excluded. This left 165 patients, representing a wide range of diagnoses (see Fig. 2).

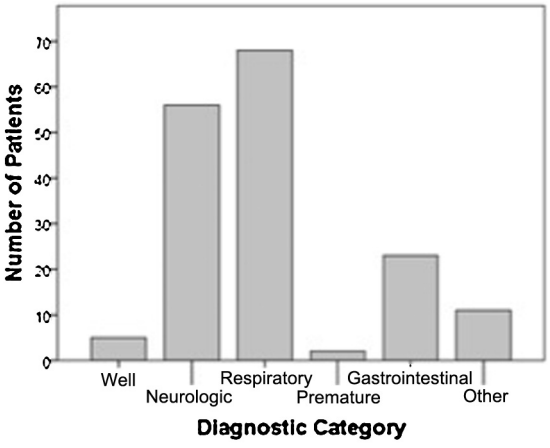

Fig. 2. Diagnostic categories of subjects.

2.2. Data collection

Videofluoroscopic swallowing studies were performed at our center in a standardized fashion in the presence of a radiologist and an occupational therapist. The patient was seated in a tumble form seat, and was given barium admixed with various textures of food under fluoroscopic monitoring. The reports of the occupational therapist and radiologist were reviewed in a retrospective fashion and patients were classified into three cohorts based on their findings: "neither penetration nor aspiration", "laryngeal penetration", or "tracheobronchial aspiration". When different degrees of swallowing dysfunction were seen with different textures, the most dysfunctional finding was recorded for that patient. A patient who exhibited laryngeal penetration but then aspirated later in the same VFSS was classified as an aspirator. If a patient had multiple swallowing studies, the first test was recorded.

After receiving institutional review board approval, each patient's complete medical history was reviewed in a retrospective fashion for the number of cases of pneumonia, aspiration events, clinical diagnoses, demographic data, syndromes, glottic abnormalities, days hospitalized as a result of pneumonia, and number of antibiotic prescriptions. A case of pneumonia was defined as a clinical diagnosis of pneumonia made by a physician along with consolidation on chest X-ray. Glottic abnormalities were documented via flexible laryngoscopy and rigid bronchoscopy reports. Syndromes were defined as clinically significant and recognized diseases having the word "syndrome" in their name. We also attempted to classify the degree of laryngeal penetration for each patient using the Penetration–Aspiration Scale [9].

2.3. Statistical analysis

Normality was determined using the Shapiro–Wilk test. Analysis of differences in central tendency was undertaken using the Mann–Whitney-*U* non-parametric statistic. A Chi-square test was used for demographic comparisons between cohorts. All analysis was performed using the Statistical Package for the Social Sciences (SPSS; IBM Inc.).