Clinical Predictors of Aspiration on Radionuclide Salivagrams in Children

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Objective: To determine patient characteristics and clinical factors that are predictive of positive radionuclide salivagram results.

Design: Retrospective chart review (spanning 32 months).

Setting: Tertiary care children’s hospital.

Patients: The study included 129 consecutive pediatric patients with suspected chronic aspiration.

Intervention: All subjects underwent radionuclide salivagrams to evaluate for aspiration.

Main Outcome Measures: The association of 16 patient characteristics and clinical factors (eg, age, sex, diagnoses, study indications, medications, and previous surgical procedures) with salivagram results. Each factor was examined individually ($\chi^2$ or Fisher exact test). For those factors that were significantly associated with positive salivagram results, the risk was estimated with the odds ratio (OR). A multivariable logistic regression model was constructed to determine how well significantly associated factors together predicted positive salivagram results.

Results: The mean (SD) patient age was 4.5 (5.4) years. There were 84 boys (65%) and 45 girls (35%). Aspiration was identified in 27 of 129 salivagrams (21%). On univariate analysis, positive salivagram results were significantly associated with chronic respiratory infections and/or pneumonia (OR, 2.6), prescription of antireflux medications (OR, 2.7), developmental delay (OR, 2.8), and reactive airway disease exacerbations (OR, 3.3) ($P < .05$). None of the other clinical factors were significantly associated with salivagram results. On multivariate analysis, salivagram results were significantly associated with the 4 above-mentioned factors ($P = .009$). However, these 4 predictive factors were not independent of each other owing to the statistically significant associations among them.

Conclusions: We identified 4 clinical factors that are predictive of aspiration on salivagram. A high level of suspicion for aspiration should be maintained in children with these potential risk factors.


Chronic aspiration in children can cause substantial infectious and inflammatory pulmonary morbidity. Indeed, chronic aspiration can be the cause of frequent hospitalizations and recurrent pneumonitis. Although often suspected, aspiration in children can be very difficult to document objectively. The intermittent nature of aspiration, the small volumes aspirated, and the inability of infants and neurologically impaired children to cooperate with examination all contribute to the challenge of documenting aspiration in the pediatric population. Furthermore, there is currently no criterion standard for the evaluation of swallowing and aspiration in children.

Radionuclide scintigraphy can be used to detect occult aspiration of oral secretions and refluxed gastric contents.\(^1\)\(^2\) The radionuclide salivagram, which was introduced by Heyman\(^1\) in 1989, is designed to detect the passive aspiration of saliva. In that study, a small amount of radiolabeled technetium 99m sulfur colloid ($< 1$ mL) is placed sublingually. The patient is then serially imaged with a gamma camera to evaluate for the presence of the radiolabeled tracer in the tracheobronchial tree, suggesting that aspiration has occurred (positive study result).

Unlike videofluoroscopic swallowing studies (modified barium swallow or “cookie swallow”) and fiberoptic endoscopic evaluation of swallowing examinations, the radionuclide salivagram is an objective evaluation for the aspiration of saliva rather than a bolus of food. It is a relatively safe and sensitive study that can be used in patients who are not receiving oral feeding. Minimal patient cooperation is required to obtain a salivagram. Radionuclide salivagrams are often ordered in children with recurrent pulmonary infections and/or chronic lung disease.\(^1\)\(^2\)
Certain patient characteristics and clinical factors may suggest that patients are at higher risk for aspiration. The objective of this study was to determine which patient characteristics and clinical factors are predictive of positive radionuclide salivagram results.

**METHODS**

We conducted a retrospective medical record review that spanned 32 months. The study protocol was reviewed by the institutional review board of the Children's Hospital of Pittsburgh, Pittsburgh, Pennsylvania, and approved by expedited review, in compliance with guidelines of the Health Insurance Portability and Accountability Act (HIPAA). A total of 129 consecutive pediatric patients underwent radionuclide salivary scintigraphy for suspected aspiration. Salivagrams were ordered at the discretion of the multidisciplinary team of physicians who were caring for each patient, including pediatricians, pediatric intensivists, pediatric pulmonologists, pediatric gastroenterologists, and pediatric otolaryngologists.

All salivagrams were performed in the radiology department at the hospital. First, 0.2 to 0.7 mL of 1000-µCi technetium 99m sulfur colloid solution (CIS-US Inc, Bedford, Massachusetts) was administered sublingually. Then, digital images of the head, neck, chest, and abdomen were obtained every 10 seconds for 1 hour with a gamma camera. Posteroanterior and lateral static chest views were obtained after 5 minutes. Delayed static images were obtained after 2 and 4 hours if tracer was still present in the mouth. A positive study result was defined as radionuclide tracer being present in the tracheobronchial tree (Figure 1). A negative study result was defined as radionuclide tracer being absent in the tracheobronchial tree but present in the stomach (Figure 2).

The main outcome measure was the association of 16 individual patient characteristics and clinical factors with salivagram results (Figure 3). Each factor was examined individually using a χ² or Fisher exact test. For those factors that were significantly associated with positive salivagram results, the risk was estimated with the odds ratio (OR). A multivariable logistic regression model was constructed to determine how well the significantly associated factors together predicted positive salivagram results. For all statistical tests, significance was defined as *P* < .05.

**RESULTS**

The mean (SD) patient age was 4.5 (5.4) years (age range, 22 days–20.3 years). Eighty-four percent of patients (65%) were male and 45 (35%) were female. Aspiration was identified on 27 of 129 salivagrams (21% positive). On univariate analysis, positive salivagram results were significantly associated with developmental delay (global...
neurologic delay) (OR, 2.8), chronic respiratory infections or pneumonia (OR, 2.6), reactive airway disease exacerbations (OR, 2.8), and use of H2-blockers and/or proton pump inhibitors (OR, 2.7). On multivariate analysis, salivagram results were significantly associated with the 4 individually significant factors listed above (P = .009). However, these 4 predictors were not independent of each other because of significant associations or correlations among them.

There were no statistically significant associations between salivagram results and any other clinical factors, including age (P = .26), sex (P = .99), presence of an underlying congenital syndrome (P = .06), history of premature delivery (P = .95), history of apnea or apparent life-threatening events (P = .60), feeding-associated cough or shortness of breath (P = .36), presence of a surgical feeding tube (P = .66), history of gastric fundoplication (P = .26), presence of a tracheostomy tube (P = .66), use of gastric motility agents (P = .07), use of anticholinergic medications for drooling (P = .63), and use of continuous or biventricular positive airway pressure (P = .40).

Given the inherent challenge in trying to diagnose pediatric salivary aspiration in the absence of any criterion standard test, it was our hope with this study to at least identify those patients for whom a salivagram result was most likely to be positive, thereby at least improving the decision-making criteria regarding when such a test should be ordered. We labeled 1 of the 16 clinical factors that we assessed developmental delay, which implies global neurologic delay at our hospital. Nearly all of the patients had either severe cerebral palsy or marked neurologic impairment due to an underlying congenital syndrome. The results of the salivagrams were positive in 27% of the children with developmental delay, compared with only 11.5% of the children without developmental delay (P < .05). Therefore, developmental (eg, neurologic) delay was one of the key factors that we identified that predisposed to a positive salivagram result, in addition to chronic lower respiratory infections and frequent reactive airway disease exacerbations. It is in these patients that a salivagram is most likely to be of help. However, in reality, given the lack of a criterion standard test for salivary aspiration, overall clinical suspicion is still often used as a major factor when the diagnosis of chronic salivary aspiration is being considered and when treatment options are being recommended.

Treatment of chronic salivary aspiration typically involves a variety of both medical and surgical techniques to decrease saliva production as well as laryngotracheal separation for severe aspiration that is refractory to other treatment modalities. Salivagram results may help with the decision-making process regarding the need for these types of treatments for salivary aspiration. The role of gastroesophageal reflux disease and laryngopharyngeal reflux in chronic lung disease is unclear, but there is certainly a clinical association between these 2 entities in children. In our study, the use of antireflux medications was significantly associated with positive salivagram results. This association highlights the fact that many of the clinicians involved in our patients’ care are likely aware of the potential role of reflux in chronic lung disease and are willing to empirically treat for reflux.

Although we had thought that the presence of a tracheostomy tube might lead to increased salivary aspiration and that the use of anticholinergic medications for sialorrhea might lead to decreased salivary aspiration, these assumptions were not proved in our study. The lack of association between salivagram results and either the presence of a tracheostomy tube or the use of anticholinergic medications could be attributable to the potential inaccuracy of the salivagram itself (there is no criterion standard test for salivary aspiration) as well to the possibility that the underlying neurologic impairment and/or developmental delay of many of our patients was a more influential variable on aspiration than these other factors.

In conclusion, we identified 4 clinical factors that are predictive of aspiration on salivagram. These factors can be used to help determine which patients may benefit the most from undergoing this diagnostic study. A high level of suspicion for aspiration should be maintained in children with these potential risk factors.

COMMENT

Salivagrams are frequently ordered in the neurologically compromised pediatric population to evaluate for salivary aspiration as a potential contributing factor to chronic lung disease. The 4 factors in this study that were significantly associated with positive salivagram results may help indicate which patients are at greatest risk for aspiration of saliva and who may benefit the most from undergoing this diagnostic test.

Although our patient population was presumed to be at risk for salivary aspiration, the results of only 21% of the salivagrams were positive. In another study of similar patients with medical conditions presumed to predispose to salivary aspiration, 8 of 31 patients (26%) had positive salivagram results, similar to our findings. However, the results of 56% of salivagrams were positive in 1 study that included only nonambulatory patients with severe cerebral palsy associated with spastic quadriplegia. The differences between these studies suggest that patient inclusion criteria that are limited to the most severely neurologically delayed patients may be more likely to increase the yield of positive salivagram results.

Besides patient inclusion criteria, there are other potential considerations regarding the relatively low rate of positive salivagram results in our series. For example, it is quite possible that salivary aspiration occurs intermittently; therefore, similar to gastroesophageal reflux disease, it may not always be identified by a test that looks only at a relatively small window of time (in this case, 1−4 hours). Another issue is that there is currently no criterion standard test for salivary aspiration. Therefore, with no definitive test against which we can compare the salivagram, it is presently not possible to identify the difference between true- and false-positive results or between true- and false-negative results. Consequently, statistical data such as diagnostic accuracy and positive and negative predictive values cannot be calculated.
Submitted for Publication: August 13, 2007; final revision received November 30, 2007; accepted January 5, 2008.

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Author Contributions: Drs Simons and Mandell had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: Simons and Mandell. Acquisition of data: Simons and Mandell. Analysis and interpretation of data: Simons and Rubenstein. Drafting of the manuscript: Simons, Rubenstein, and Mandell. Critical revision of the manuscript for important intellectual content: Simons and Mandell. Statistical analysis: Rubenstein. Study supervision: Mandell.

Financial Disclosure: None reported.

Previous Presentation: This study was presented in part as a poster at the 22nd Annual Meeting of the American Society of Pediatric Otolaryngology; April 27-29, 2007; San Diego, California.

Additional Information: This study was the recipient of the American Society of Pediatric Otolaryngology 2007 First Place Award for Clinical Research Poster Presentation.

REFERENCES