The Use of Radionuclide Salivagram and Videofluoroscopic Swallow Study in the Evaluation of Aspiration Pneumonia in Children

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Purpose: To compare the abilities of radionuclide salivagrams (RS) and videofluoroscopic swallow studies (VFSS) to diagnose aspiration in children with aspiration pneumonia.

Methods: The records of children who were referred to the Asan Medical Center between April, 2006 and April, 2012 and who underwent both VFSS and RS to evaluate their recurrent aspiration pneumonia were reviewed (n=67). The aspiration positivity rates of the two tests were determined. The agreement between the tests was assessed by using the kappa statistic.

Results: VFSS was more frequently positive (n=26, 39%) than RS (n=23, 34%) (p=0.68). In the 11 children who repeat two test, Repeated examination increased positive rate in each tests (n=11), repeated RS (54%, p=1) is more frequent positive than repeated VFSS (46%, p=0.37). If a cumulative positive test had been defined as at least one positive result, the positive rate of two test was 56% (p < 0.05). There was a fair agreement between RS and VFSS (kappa=0.26).

Conclusion: The RS and VFSS positivity rates in children with aspiration pneumonia were similar but there was fair agreement between the two tests. This result suggests that these investigations to demonstrate aspiration are not interchangeable but complementary. (Pediatr Gastroenterol Hepatol Nutr 2012; 15: 160 ∼ 165)

Key Words: Aspiration, Pneumonia, Radionuclide salivagrams, Videofluoroscopic swallow studies

INTRODUCTION

Pulmonary aspiration may occur as a result of swallowing dysfunction, gastro-esophageal reflux, or an inability to protect the airway adequately from oral secretions. In children with pulmonary aspiration, more than one mechanism is often involved [1]. Therefore, pediatric gastroenterologists have to de-
cide the main cause of aspiration because therapeutic interventions for aspiration are different depending on cause of aspiration such as gastrostomy or fundoplication.

Multichannel intraluminal impedance and pH monitoring is considered gold standard for reflux [2]. While aspiration due to swallowing dysfunction or saliva may be very difficult to document objectively because of the intermittent nature of aspiration, the small volumes that are aspirated, and the inability of infants and neurologically impaired children to cooperate with examinations. In addition, the evaluation of swallowing and aspiration in children has not yet been standardized.

Videofluoroscopic swallow studies (VFSS) is the most frequently used technique for swallow evaluation [3]. Radionuclide salivagrams (RS) has been suggested repeatedly to be a better test of salivary aspiration as it is more sensitive. In addition, an oral bolus is not needed, and there is only minimal exposure to radiation in RS [1].

However, there are few studies to compare these tests in terms of the diagnostic usefulness. Therefore, the present study was performed to assess how often VFSS and RS yield positive results in children with aspiration pneumonia and how these results agree with each other.

MATERIALS AND METHODS

Patients
The medical records of 67 children (younger than 18 years) with aspiration pneumonia who underwent both VFSS and RS between April, 2006 and April, 2012 at Asan Medical Center Children’s Hospital were reviewed retrospectively. In addition, these tests were done within from a few days to several months of each other. The inclusion criteria for aspiration pneumonia included: 1) Radiographic signs of a new infiltrate in accordance with community-acquired or nosocomial pneumonia and/or pulmonary abscess after established or strongly suspected aspiration; 2) At least two of the symptoms of cough, chest pain, dyspnea, dullness on percussion or pulmonary rales needed to be present; 3) In combination with at least one clinical criterion: fever (> 38°C), hypothermia (< 36.5°C), leukocytosis (> 10/nL), leukopenia (< 4/nL), a left-shift of > 10%, or purulent sputum or secretion from trachea or bronchii [4].

Radionuclide salivagram
All patients fasted for 2 hours before the test. Each patient was placed in a supine position under a gamma camera that was fitted with a low-energy high-resolution collimator, after which 2 ∼ 3 drops of 0.3 mL saline containing 0.3 mCi Tc-99m phytate (11.1 MBq) was administered sublingually. Dynamic images from the mouth to the upper abdomen were acquired for the first 10 minutes, after which static anteroposterior and lateral chest images were obtained. A test was considered to be positive if radioactivity was observed in the tracheobronchial tree, both lung fields, or the tracheostomy site in the dynamic or static images. If the result of the test is positive, it was terminated. If a positive finding was not obtained during the first 10 minutes of the test, static anteroposterior and lateral chest images were acquired after 2 hours. To exclude reflux aspiration, we investigated only ‘first 10 minutes image’. The images were interpreted by two expert nuclear medicine physicians. The whole-body radiation dose to the patient in RS is approximately 0.05 mSv [5,6].

Video fluoroscopic swallow study
These children were only tested with the consistencies that they were currently eating at home. Most children were fed in the upright position. A radiologist performed the fluoroscopy screening. The field of view included the mouth, pharynx, larynx, and proximal trachea. The screening time varied considerably but was typically 3 to 4 minutes. The results were interpreted by a senior speech pathologist who is experienced in neurogenic dysphagia. The VFSS was considered to be positive when laryngeal penetration or frank aspiration was observed during the test.

In VFSS for the pediatric group, effective radiation
The frequency of aspiration that was demonstrated by VFSS and RS was expressed as a proportion along with 95% confidence intervals. The cumulative positive test had been defined as at least one positive test result of RS or VFSS. The agreement between the diagnostic modalities was assessed by using the kappa statistic (Cohen's kappa coefficient), which is a chance-corrected measure of agreement between two tests. The Kappa result ranges from 0 to 1 and the higher the Kappa value is, the stronger the agreement is (i.e., kappa = 1 indicates perfect agreement, while kappa = 0 indicates no agreement). All statistical analyses were performed by using SPSS version 19.0 (IBM Co., Armonk, NY, USA). For all statistical tests, significance was defined as p < 0.05.

RESULTS

In total, 80 RS and 80 VFSS in 67 children were performed. Of these 67 children, 10 had VFSS and RS twice and 1 had both tests four times. Median age was 10.5 months (1 month-17 years), 37 patients (55%) were male and 30 (45%) were female, and 15 had had a gastrostomy and/or fundoplication.

Most of the children (76%) had underlying medical conditions, with genetic syndromes (n=17, 25%) (Such as Williams syndrome, CHARGE syndrome and Noonan syndrome) and congenital heart disease or tracheo-esophageal fistula surgery (n=13, 20%) (Table 1). More than half of the patients were in a bed-ridden state (n=38, 58%).

The VFSS positivity rate was 39% while the RS positivity rate was 34%, however, there was no statistical difference (p=0.68) (Fig. 1). In the 11 children who repeat each test, the positivity rate of RS increased to 54% (p=1), and that of VFSS increased to 46% (p=0.37). However, this result is considered to be not statistically significant. The cumulative positive rate of two tests was 56% (p < 0.05). The agreement between RS and VFSS was fair (kappa=0.26) (Table 2).

DISCUSSION

Chronic pulmonary aspiration results in progressive lung disease, bronchiectasis, and respiratory
failure and is the leading cause of death in children with severe neurological disorders [7]. However, therapeutic interventions for aspiration are associated with morbidity and mortality and often increase the complexity of care for these children. Thus, it is important to determine whether aspiration is a significant cause of respiratory disease. However, a gold standard diagnostic test for pulmonary aspiration has not yet been established. Instead, diagnoses of aspiration are currently made clinically with some supporting diagnostic evaluations [1].

The radionuclide salivagram was introduced by Heyman and Respondek [8] in 1989 and involves the sublingual placement of a small amount of radiolabeled technetium 99 m sulfur colloid (<1 mL, 0.1 mCi). It is designed to detect the passive aspiration of saliva and is a more objective way to evaluate the aspiration of saliva than examining the aspiration of a bolus of food in VFSS. It is a relatively safe and sensitive study that can be used in patients who are not receiving oral feeding. Moreover, minimal patient cooperation is required to obtain a salivagram [8-12]. In the present study, the RS positivity rate was 34%, which was slightly lower than the 39% VFSS positivity rate ($p=0.98$). The positive predictive values of RS in previous studies range widely from 26% to 70% [8,9,12,13]. This reflects variations in the testing method, particularly the amount of radiopharmaceutical. Supporting this is that when Huxley et al. [13] used more amount of radiopharmaceutical than normal saliva during sleep, the positivity rate was 70%. By contrast, the droplet method (small volume like saliva), which is used in most other studies, is associated with lower positivity rates (26-28%). Heyman [11] also showed that when one patient with a neurological disorder underwent RS using the droplet method (100 μL of radiopharmaceutical placed on the tongue), the result was negative; however, when a larger bolus (10 mL radiopharmaceutical sucked through a straw) was used with the same patient, it triggered aspiration into both lungs. These studies support the notion that the RS positivity rate may depend on the amount of radiopharmaceutical that is used.

Notably, Baikie et al. [14] used a different RS method, namely, they instilled 20 mL of radiopharmaceutical in saline into the mouths of children with cerebral palsy for 1 hour by using a size 6 Fr plastic feeding tube. The distal end of the tube was closed to the parotid salivary ampulla. The positive predictive value of RS was 56%. This supports the notion that the study period may also influence the RS positivity rate because aspiration is usually intermittent: this means that a longer study period could increase the ability of the test to detect one or more aspiration events [14]. In the present study, the positivity value increased from 34% to 54% when the results of the 11 patients who had repeat RS were examined ($p=1$). In contrast, the positivity rate of VFSS for the patients who underwent repeated VFSS was lower than the RS positivity rate (39% to 46%, $p=0.37$). It seems that repeated RS tests have higher sensitivity, although it was not statistically significant.

In the present study, the positivity rate of VFSS of 39% is comparable to the rates reported by other authors who have studied children with cerebral palsy. For example, Mirrett et al. [15] found that 15 of 22 dysphagic children with cerebral palsy had positive results, while Rogers et al. [16] found 38% positive tests in 90 children with dysphagia, 93% of whom had cerebral palsy.

The agreement between VFSS and RS is fair and there are several possible explanations of this result. First, it may reflect the fact that the two tests assess different aspects of swallowing: swallowing position, bolus size, and bolus viscosity can all influence the frequency of aspiration [16-19].

RS assessed small bolus, fluid swallows in the supine position. Whereas, VFSS challenged the child’s swallowing ability as large boluses and various textures or viscosities of food in the upright position. The supine position might increase the frequency of aspiration. While, small bolus, fluid swallows might decrease its frequency.

Second, each investigation was performed over a different period. As mentioned before, aspiration is usually intermittent, the period studied might influence the test’s ability to detect one or more aspiration
Finally, it remains possible that the poor agreement between the tests arose because both tests have high false positive and false negative rates. However, in the absence of a standard test for aspiration, it is not possible to assess this. Moreover, the reliability of VFSS is variable. Multiple prospective studies have documented poor inter- and intra-observer reliability for all components of VFSS except for detection of actual aspiration events [3,20,21]. However, this information is of clinical importance to aid in the choice of test or tests, to investigate a child at risk of aspiration, and to explain why one test is positive and another not.

In children with pulmonary aspiration, more than one mechanism is often involved and the condition may be due to structural and/or medical conditions [1]. Since none of the currently available diagnostic tests can entirely rule out pulmonary aspiration on their own, it may be necessary to use more than one method when the clinical picture is that of ongoing aspiration. In the present study, the use of both VFSS and RS increased the cumulative positive rate to 56% ($p < 0.05$).

Boesch et al. [1] suggested that VFSS should be performed first in patients with suspected chronic aspiration; based on the presenting clinical signs and symptoms, esophagus pH monitoring or RS can then be performed. However, VFSS exposes children to radiation ($0.05$ mSv in RS, $0.26 \pm 0.30$ mSv in VFSS) [5,6], it is expensive and resource-intensive, and it is associated with poor inter- and intra-observer reliability. In children, we should consider accuracy of diagnostic modalities and safety, including amount of radiation. Therefore, we suggest that more safe and convenient RS may be suitable as the initial diagnosis tool and then repeat RS or VFSS can be performed if a patient has a negative RS result but is suspected to have aspiration.

In conclusion, the RS and VFSS positivity rates in children with aspiration pneumonia were similar, and repeated test did not significantly increase positive rate in both test. The agreement between the two tests was fair. This result suggests that these investigations to demonstrate aspiration are not interchangeable but are complementary.

**REFERENCES**