Presenting Signs and Symptoms do not Predict Aspiration Risk in Children

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Objectives To determine if any presenting symptoms are associated with aspiration risk, and to evaluate the reliability of clinical feeding evaluation (CFE) in diagnosing aspiration compared with videofluoroscopic swallow study (VFSS).

Study design We retrospectively reviewed records of children under 2 years of age who had evaluation for oropharyngeal dysphagia by CFE and VFSS at Boston Children's Hospital and compared presenting symptoms, symptom timing, and CFE and VFSS results. We investigated the relationship between symptom presence and aspiration using the Fisher exact test and stepwise logistic regression with adjustment for comorbidities. CFE and VFSS results were compared using the McNemar test. Intervals from CFE to VFSS were compared using the Student *t* test.

Results A total of 412 subjects with mean (±SD) age 8.9 ± 6.9 months were evaluated. No symptom, including timing relative to meals, predicted aspiration on VFSS. This lack of association between symptoms and VFSS results persisted even in the adjusted multivariate model. The sensitivity of CFE for predicting aspiration by VFSS was 44%. Patients with a reassuring CFE waited 28.2 ± 8.5 days longer for confirmatory VFSS compared with those with a concerning CFE ($P < .05$).

Conclusions Presenting symptoms are varied in patients with aspiration and cannot be relied upon to determine which patients have aspiration on VFSS. The CFE does not have the sensitivity to consistently diagnose aspiration so a VFSS should be performed in persistently symptomatic patients. *(J Pediatr 2018;■■:■■-■■).*

Infants and children are typically referred for swallow evaluation if they have signs or symptoms suspicious for aspiration.[1-3] These symptoms typically include coughing, choking, eyes turning red, difficulty feeding, or changes in color with feeding.[4] Little is known about the actual correlation between presenting symptoms and the risk of finding aspiration either by clinical feeding evaluation (CFE) or videofluoroscopic swallow study (VFSS).[4,5] The CFE typically consists of assessing feeding with 1 or more textures (eg, thin, nectar, honey thick, or purees) using 1 or more methods of feeding (eg, bottle, cup, spoon) by a speech-language pathologist (SLP) specializing in the treatment of pediatric dysphagia and feeding disorders.[3,6] A VFSS typically involves similar trials though the feeding is assessed using fluoroscopy of the oropharynx, larynx, and upper esophagus to determine if there is evidence of aspiration.[7-9] There is limited data on the sensitivity of CFE compared with the VFSS to assess for aspiration risk, and prior studies have only included small numbers of patients.[4,5,10-13]

Objective assessment of swallow function is critical in children with chronic respiratory symptoms because some of the classic signs of aspiration such as aspiration pneumonia are rare, occurring in less than 10% of children.[14-16] Determining the best method to assess for aspiration risk is not known, and each method has pros and cons. The VFSS can assess if there is direct aspiration or laryngeal penetration because the airways are visualized, but involves radiation exposure.[17-19] Although the CFE does not involve radiation risk, it can only identify signs and symptoms during feeding. This is not ideal because more than 80% of pediatric aspiration is silent and, therefore, occurs without overt clinical signs.[11,20-22] Choosing the most sensitive test is critical because inadequately treated aspiration can lead to a variety of poor outcomes including pulmonary injury, failure to thrive, and oral aversion.[1,23-25] The aim of this study was to describe the range of symptoms in children presenting for both CFE and VFSS and determine if any presenting symptoms, and the timing of those symptoms relative to meals, could predict aspiration risk in the pediatric population. An additional aim was to determine the reliability of the CFE in making the diagnosis of aspiration compared with VFSS in children.

Methods

We retrospectively reviewed the records of all children under 2 years of age who had both a CFE and VFSS for the evaluation of oropharyngeal dysphagia at Boston Children's Hospital in 2015. Records were reviewed for patient characteristics, comorbidities, and swallow study characteristics including radiation dose. VFSS

CFE	Clinical feeding evaluation
SLP	Speech-language pathologist
VFSS	Videofluoroscopic swallow study

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results were considered abnormal if there was evidence of aspiration or laryngeal penetration seen for any texture. Laryngeal penetration was considered abnormal based on our clinical experience that these patients have similar outcomes to patients with frank aspiration.[14,26] All CFEs were performed by speech language pathologists specializing in pediatric dysphagia, and all VFSS were performed by SLPs in conjunction with pediatric radiologists. The CFE and VFSS examinations were performed in standard fashion, starting with evaluation of thin liquids followed by increasing the thickness of liquids delivered in stepwise fashion (from thin to nectar to honey to puree) if there is concern for aspiration/penetration, as previously described.[6-9]

The primary aims were to determine if presenting symptoms could determine which patients would be at greatest risk for having an abnormal VFSS and whether the CFE could reliably predict aspiration or laryngeal penetration such that radiation exposure might be avoided. Presence of symptoms was obtained from the medical record based on parental and SLP report and included gastrointestinal symptoms and pulmonary symptoms in addition to how symptoms were related to meals (during, after, or both). We first described the prevalence of presenting symptoms in this cohort and then used the Fisher exact test to determine if there was any association between each individual symptom and the result of each subject's CFE and VFSS. A stepwise logistic regression model was used to determine symptoms independently associated with CFE and VFSS, after adjustment for age at VFSS, male sex, and all comorbidities (neurologic, cardiac, metabolic, immunologic, pulmonary, gastrointestinal, prematurity). The Firth penalized maximum likelihood estimation was used to reduce bias because of sparse table cells.[27] In addition, a multiple logistic regression model containing all presenting symptoms, adjusted for age at VFSS, male sex, and comorbidities (neurologic, cardiac, metabolic, immunologic, pulmonary, gastrointestinal, prematurity), using the Firth penalized maximum likelihood estimation, was used to obtain Wald χ^2 results and *P* values to put all symptoms in a single model to determine the relative strength of each effect.

We next compared the dichotomous assessment (normal vs abnormal) of CFE with VFSS as the gold standard to report test characteristics, including sensitivity, specificity, positive predicted value, and negative predicted value with 95% CI, and used the McNemar test to assess the concordance between these 2 modalities. Lastly, we used the Student *t* test to compare the time in days from initial CFE with initial VFSS for subjects who were ultimately found to have aspiration to determine the delay in aspiration diagnosis as a result of having a normal CFE. Data are presented as mean ± SE and % (n) unless indicated otherwise. Data were analyzed using SPSS (SPSS Inc, Chicago, Illinois) and multivariate analysis was conducted with SAS (SAS Institute, Cary, North Carolina). The study was approved by the Institutional Review Board at Boston Children's Hospital.

Results

We evaluated 412 total subjects with a mean age of 8.9 ± 6.9 months, all of whom had VFSS performed; 160 of these had both CFE and VFSS performed. Within the entire cohort, 38% (n = 156) of the VFSS showed aspiration, 33% (n = 137) showed penetration alone, and 27% (n = 107) did not show evidence of aspiration or penetration; 3% (n = 12) of subjects were unable to complete their VFSS. Subject characteristics, symptoms present at the time of referral, and subject comorbidities are shown in **Table I**. Notably, subjects were symptomatic for a mean (±SD) of 5.3 ± 5.0 months prior to their first formal swallow evaluation. Overall, 29% of the subjects had a neurologic comorbidity and 32% of the subjects were premature with a mean gestational age of 31.9 ± 0.3 months. A flow diagram of the patient population, including the overall rates of swallow testing by VFSS and CFE and the results of these evaluations, is shown in the **Figure**.

A total of 234 patients had radiation exposure reported in the VFSS results, with a mean exposure of 1.98 ± 1.30 mGy. There were significantly lower exposure values in subjects with normal VFSS (1.54 ± 0.12 mGy) compared with those with an abnormal VFSS (2.20 ± 0.11 mGy, $P < .0001$).

The association between individual symptoms and VFSS results are shown in **Table II**. No single symptom predicted

Table I. Subject characteristics and presenting symptoms

Patient characteristics	All subjects (n = 412)	Abnormal VFSS (n = 293)	Normal VFSS (n = 107)
Male	59% (243)	60% (177)	55% (59)
Age at VFSS	9.0 ± 0.4	8.8 ± 0.4	8.8 ± 0.7
Duration of symptoms prior to VFSS	5.3 ± 0.6	5.5 ± 0.7	4.3 ± 0.9
Abnormal VFSS result	71% (293)	100% (293)	0% (0)
Aspiration	38% (156)	38% (156)	0% (0)
Silent aspiration	81% (127/156)	81% (127/156)	0% (0)
Penetration	33% (137)	33% (137)	0% (0)
Comorbidities			
Neurologic	29% (120)	31% (90)	27% (25)
Cardiac	11% (46)	11% (33)	9% (10)
Metabolic	13% (53)	13% (37)	13% (14)
Immunologic	1% (3)	1% (2)	1% (1)
Pulmonary	14% (58)	16% (46)	11% (12)
Gastrointestinal	21% (81)	17% (50)	26% (28)
Prematurity	32% (130)	34% (100)	27% (29)
GI symptoms			
Choking/gagging	37% (153)	38% (112)	36% (38)
Regurgitation	29% (121)	28% (81)	33% (35)
Vomiting	27% (112)	25% (72)	33% (35)
Poor feeding	23% (94)	22% (63)	26% (28)
Slow feeding	6% (24)	6% (16)	8% (8)
Pulmonary symptoms			
Coughing	58% (239)	59% (173)	52% (56)
Noisy breathing	25% (104)	28% (81)	20% (21)
Congestion	21% (87)	20% (58)	24% (26)
Spells	17% (68)	18% (53)	14% (15)
Respiratory distress	12% (50)	13% (38)	11% (12)
Recurrent pneumonia	11% (44)	12% (34)	7% (7)
Oxygen requirement	5% (19)	6% (16)	3% (3)
Relationship to meals			
Only during	53% (217)	55% (162)	46% (49)
Only after	8% (34)	9% (25)	8% (9)
During and after	21% (87)	20% (58)	24% (26)
No relationship to meals	18% (74)	16% (48)	22% (23)

Baseline characteristics, VFSS results, and comorbidities are shown above. There were varied presenting symptoms for the cohort overall and those with abnormal and normal VFSS results are shown. Data are expressed as percentage (n) and mean ± SE. The total number of patients includes 12 patients who could not complete the VFSS. Therefore the abnormal VFSS column plus the normal VFSS column do not always add to the total number of patients.

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