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ORIGINAL ARTICLE

Clinical outcomes before and after videofluoroscopic swallow study in children 24 months of age or younger

Fabiola Luciane Barth[1], Deborah Salle Levy[1,2], Marisa Gasparin[1], Cláudia Schweiger[1,3], Denise Manica[1,3], Camila Dalbosco Gadenz[4], Paulo José Cauduro Maróstica[1,5]

1. Programa de Pós-Graduação em Saúde da Criança e do Adolescente, Faculdade de Medicina, Universidade Federal do Rio Grande do Sul, Porto Alegre (RS) Brasil.
2. Departamento de Saúde e Comunicação Humana, Faculdade de Psicologia, Universidade Federal do Rio Grande do Sul, Porto Alegre (RS) Brasil.
3. Serviço de Otorrinolaringologia e Cirurgia de Cabeça e Pescoço, Hospital de Clínicas de Porto Alegre, Universidade Federal do Rio Grande do Sul, Porto Alegre (RS) Brasil.
4. Programa de Pós-Graduação em Ciências da Reabilitação, Universidade Federal de Ciências da Saúde de Porto Alegre, Porto Alegre (RS) Brasil.
5. Serviço de Pneumologia Pediátrica, Departamento de Pediatria, Hospital de Clínicas de Porto Alegre, Universidade Federal do Rio Grande do Sul, Porto Alegre (RS) Brasil.

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ABSTRACT

Objective: To evaluate the combined impact of videofluoroscopic swallow study (VFSS) and therapeutic feeding and swallowing interventions on clinical outcomes in children with oropharyngeal dysphagia (OPD). **Methods:** This was an uncontrolled longitudinal analytical study in which OPD patients were evaluated before and after VFSS. Children ≤ 24 months of age diagnosed with OPD in a clinical setting and undergoing VFSS for investigation and management of OPD were included in the study. The study participants received therapeutic feeding and swallowing interventions after having undergone VFSS, being followed at an outpatient clinic for pediatric dysphagia in order to monitor feeding and swallowing difficulties. Respiratory and feeding outcomes were compared before and after VFSS. **Results:** Penetration/aspiration events were observed in 61% of the VFSSs (n = 72), and therapeutic feeding and swallowing interventions were recommended for 97% of the study participants. After the VFSS, there was a reduction in the odds of receiving antibiotic therapy (OR = 0.007) and in the duration of antibiotic therapy (p = 0.014), as well as in the odds of being admitted to hospital (p = 0.024) and in the length of hospital stay (p = 0.025). A combination of oral and enteral feeding became more common than oral or enteral feeding alone (p = 0.002). **Conclusions:** A high proportion of participants exhibited penetration/aspiration on VFSS. Therapeutic feeding and swallowing interventions following a VFSS appear to be associated with reduced respiratory morbidity in this population.

Keywords: Fluoroscopy; Deglutition disorders; Respiratory tract diseases; Pneumonia, aspiration; Nutritional support.

INTRODUCTION

Swallowing and feeding require active coordination of the oropharyngeal mechanism, craniofacial structures, gastrointestinal tract, cardiopulmonary system, musculoskeletal system, central nervous system, and peripheral nervous system.[1] Oropharyngeal dysphagia (OPD) refers to impaired oral, pharyngeal, or oropharyngeal swallowing mechanics.[2]

The rate of diagnosis of OPD has increased as a result of improved diagnostic techniques and treatment in children with complex health conditions.[2-4] OPD is related to an increased risk of (acute or recurrent) aspiration of secretions, liquids, or food particulates,[5] representing a serious cause of morbidity and mortality in children (and a cause of morbidity in caregivers).[1,6-8] Some children with OPD continue to have lower respiratory tract infections and other respiratory diseases even after treatment. Patients presenting with recurrent lower respiratory tract infections without other overt signs of swallowing dysfunction should undergo a workup for dysphagia.[7,9]

Impaired swallowing biomechanics, as assessed by videofluoroscopic swallow study (VFSS), has been associated with increased respiratory morbidity.[9-15] OPD should be considered in any child presenting with unspecified respiratory difficulties.[7] Little is known about the predictive value of VFSS or the extent to which VFSS can contribute to the management of OPD, especially with regard to respiratory, nutritional, and developmental factors.[13,14] Thus, the objective of the present study was to evaluate the combined impact of VFSS and therapeutic feeding and swallowing interventions on clinical outcomes in children with OPD.

METHODS

This was an uncontrolled longitudinal analytical study conducted at the *Hospital de Clínicas de Porto Alegre*,

Correspondence to:
Fabiola Luciane Barth. Programa de Pós-Graduação em Saúde da Criança e do Adolescente, Faculdade de Medicina, Universidade Federal do Rio Grande do Sul, Rua Ramiro Barcelos, 2400, CEP 90035-003, Porto Alegre, RS, Brasil.
Tel.: 55 51 3359-8000. E-mail: flbarth@hcpa.edu.br or fblbarth@gmail.com
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a tertiary hospital located in the city of Porto Alegre, Brazil. The study was approved by the local research ethics committee (Protocol no. 2015.0418). The study sample consisted of patients followed at the *Hospital de Clínicas de Porto Alegre* Outpatient Clinic for Pediatric Dysphagia. All of the patients had been referred to the clinic by specialists at our hospital. The clinic provides dysphagia patients and their families/primary caregivers by guiding them on safe and efficient feeding approach during visits occurring monthly or more frequently as needed.

The inclusion criteria were as follows: being ≤ 24 months of age; having chronic respiratory symptoms; having undergone a clinical assessment of swallowing by a speech therapist; and having subsequently undergone a VFSS for assessment and management of OPD, in accordance with the American Speech-Language-Hearing Association guidelines.[16] Children were excluded if their electronic medical records contained no information regarding the VFSS or if < six months had passed since the VFSS.

The outcomes of interest were compared between two six-month periods (before and after the VFSS). For children < 6 months of age, the analysis period prior to the VFSS corresponded to their age. The following outcomes were evaluated: feeding route; hospitalization; and antibiotic therapy for respiratory infections. After analysis of the VFSS results, the primary caregivers were given guidance on the treatment of OPD, in accordance with the American Speech-Language-Hearing Association recommendations,[17] and the patients were followed at the *Hospital de Clínicas de Porto Alegre* Outpatient Clinic for Pediatric Dysphagia. The data were retrospectively collected from patient medical records.

The therapeutic interventions consisted of changes in food consistency, changes in feeding posture, changes in patient positioning, and use of utensils tailored to patient needs.[17] During the VFSS, efforts were made to maintain well-established home practices, although modifications aimed at increasing swallowing safety were made when necessary.

All VFSSs were performed with continuous fluoroscopy (Axiom Iconos R100 fluoroscopy system; Siemens Healthineers, Erlangen, Germany), with a maximum total duration of 150 s, a standard resolution of 30 frames per second, and radiation exposure as low as reasonably achievable, obtaining relevant information in the minimum possible time.[18] Images were recorded in digital format in a picture archiving and communication system for subsequent analysis. Barium sulfate was used as contrast at a concentration of 30%. Results were stored digitally. The VFSS was performed and analyzed by a speech-language pathologist and a radiologist with at least 20 years of experience in pediatric OPD and radiographic swallow studies.

All VFSS images were obtained with the patient in a lateral position. The primary caregiver was given the opportunity to accompany the patient, wearing the required protective equipment. The outcome variables for this study were the presence or absence of isolated penetration and the presence or absence of aspiration. The most severe finding among all consistencies tested was reported. For patients with previous or current evidence of aspiration, not all food consistencies were tested, given that aspiration was a concern.

Patient characterization included neonatal data. For those born prematurely, the age was corrected on the basis of gestational age at birth for analysis. Comorbidities such as central nervous system impairment, respiratory disease, and genetic disease were categorized.

Respiratory outcomes included duration of antibiotic therapy (in days), number of hospitalizations, and length of stay (in days) associated with pneumonia, asthma, bronchiolitis, bronchitis, acute respiratory failure, and other upper and lower airway infections. Respiratory diseases were analyzed as a single variable because of the diagnostic complexity of signs and symptoms in patients with OPD[6,7] and their relationship with manifestations of respiratory disease.[7,9,10,12,14,15]

Feeding routes were classified as follows: exclusively oral feeding; a combination of oral and enteral feeding; or exclusively enteral feeding. Therapeutic feeding and swallowing interventions after VFSS were classified as follows: no modifications; maintenance or initiation of oral feeding; discontinuation or continued suspension of oral feeding (contraindication of oral feeding and mandatory referral for speech-language therapy); or maintenance or initiation of a combination of oral and enteral feeding.

The Kolmogorov-Smirnov test was used in order to test the normality of the distribution. Variables were described as median [interquartile range] for continuous variables and as absolute and relative frequencies for categorical variables. Categorical variables were analyzed with Fisher's exact test or Pearson's chi-square test.

For paired groups, McNemar's test and the Wilcoxon test were used. Unpaired groups were compared by the Mann-Whitney U test or the Kruskal-Wallis test. All statistical analyses were performed with the IBM SPSS Statistics software package, version 21.0 (IBM Corporation, Armonk, NY, USA). The level of significance was set at $p < 0.05$. Multiple linear regression and generalized linear models were used in order to assess associations and correlations between clinical outcomes before and after VFSS, being adjusted for patient age at testing. Associations were expressed as ORs and 95% CIs.

RESULTS

Seventy-two children were included in the study. Of those, 43 (59.72%) underwent VFSS during

hospitalization. In addition, 21 (29.17%) had been advised to modify food consistency. The clinical characteristics of the study participants are described in Table 1.

On VFSS, most of the study participants showed penetration/aspiration. The aspiration events were silent in most cases. Although 38.9% of the study participants had a VFSS without penetration/aspiration, only 2 (2.8%) did not receive a recommendation to change their feeding strategies (Table 2).

Children who showed penetration/aspiration on VFSS were younger (median age, 4.5 months; IQR, 1-12.75 months) than were those who did not (median age, 8.5 months; IQR, 4.25-15.75 months; p = 0.039). Children born prematurely (n = 28) showed a higher frequency of penetration/aspiration (n = 20; 71.42%) than did those born at term (n = 19; 52.73%), although the difference was not significant (p = 0.129).

Table 1. Clinical characteristics of the participating patients (n = 72).[a]

Characteristic	Result
Age	6 [2.00-13.75]
< 12 months	50 (69.4)
≥ 12 months	22 (30.6)
Newborn characteristics	
Male sex	44 (61.1)
Median gestational age, weeks/days (n = 65)	37 [34]/2 [5-39]
Premature birth (n = 65)	28 (43.1)
Low birth weight (n = 45)	14 (31.1)
Length of hospital stay, days (n = 71)	37 [13.5-60.0]
Comorbidities	
Respiratory disease	49 (68.1)
Genetic disease	33 (45.8)
CNS impairment	33 (45.8)
Upper airway surgery	23 (31.9)
Cardiac impairment	25 (34.7)
Digestive impairment	18 (25)
Prematurity (n = 65)	28 (43.1)
Number of comorbidities	2 [1-2]

CNS: central nervous system. [a]Data expressed as median [IQR] or n (%).

Table 2. Results of videofluoroscopic swallow study and recommended feeding strategies (n = 72).[a]

VFSS result	Participant
Absence of penetration/aspiration	28 (38.9)
Penetration	25 (34.7)
Aspiration	19 (26.4)
Silent aspiration (n = 19)	17 (89.47)
Aspiration with cough (n = 19)	2 (10.53)
Recommended feeding strategy	
None	2 (2.8)
Oral feeding only	37 (51.4)
Initiate or maintain enteral feeding exclusively	18 (25)
Oral + enteral feeding	15 (20.8)

VFSS: videofluoroscopic swallow study. [a]Data expressed as n (%).

With regard to feeding routes, there were no significant differences between groups before and after the VFSS, being respectively 31 (43.1%) and 29 (40.3%) for oral feeding (p = 0.0842), 22 (30.6%) and 25 (34.7%) for a combination of oral and enteral feeding (p = 0.711), and 19 (26.4%) and 18 (25%) for enteral feeding (p = 1). However, with regard to changes in feeding routes during follow-up, there was a significant change in the number of patients in each group (p = 0.002).

When we compared the six-month periods before and after the VFSS, we found that there was an improvement in respiratory outcomes. The age-adjusted logistic regression model showed that the probability of being hospitalized decreased by 85% (p < 0.001) and the probability of not using antibiotics increased by 1.47 times (p = 0.007) after the VFSS and implementation of therapeutic feeding and swallowing interventions (Table 3). The multivariate model (Table 4) showed reductions in the length of hospital stay (p = 0.024) and duration of antibiotic therapy (p = 0.014). The number of hospitalizations (p = 0.037) did not remain significant after adjustment for age (p = 0.072).

DISCUSSION

The present study analyzed clinical outcomes before and after VFSS in a group of children referred to an outpatient clinic for pediatric dysphagia. In the period following the VFSS and therapeutic feeding and swallowing interventions, the probability of being hospitalized and using antibiotics was lower, as were the length of hospital stay and duration of antibiotic therapy for respiratory infections. The statistical models adjusted for age confirmed the results and the strength of the associations, the exception being the number of hospitalizations. We believe that although the number of hospital admissions did not change, the severity of these admissions was greater before the VFSS, as evidenced by other indicators of respiratory morbidity.

Benfer et al.[19] reported that, in children, the odds of having OPD decrease with increasing age and increase with increasing Gross Motor Function Classification System (GMFCS) level. However, they found that the reduction in OPD was significant only for children with GMFCS levels I and II. Although with time and conservative management many infants with aspiration will improve (within 1-2 years),[14,20] the authors reported that there was a lack of detailed intervention data and that they were unable to determine whether the changes were related to the provision of feeding interventions or were reflective of the early natural history of cerebral palsy (which for the sample had a mean of 27.3 months).[19] In contrast, our study evaluated clinical outcomes

before and after interventions (VFSS and specialized management of OPD) for a maximum period of 12 months, controlling for age.

During follow-up, the prevalence of a combination of oral and enteral feeding increased in comparison with that of oral or enteral feeding alone, highlighting the importance of tailored treatment.

The predominance of children < 12 months of age at the time of the VFSS in the present study, as well as the association between penetration/aspiration in younger children, can be explained by the process of physiological maturation. Safe swallowing requires active coordination of the central and peripheral nervous systems, the cardiopulmonary system, and the gastrointestinal tract, all of which develop through childhood.[1,21] In addition to the process of maturation, fewer changes on VFSS in older children might reflect the adoption of better feeding practices by caregivers, either spontaneously or under professional supervision.

We found a high prevalence of penetration/aspiration on VFSS in the study population. Penetration/aspiration is the most common finding of swallowing impairment in the literature. Although we agree that it is important to expand and describe quantitative swallowing measures to assist in clinical decision-making,[22,23] the objective of this study was to evaluate patient clinical course, the VFSS results being used as complementary data. Because of the risk of radiation exposure, VFSS referrals should be carefully considered, ideally in conjunction with clinical evaluation of swallowing by an experienced professional, who can identify signs suggestive of aspiration.[2,7,16,20] The absence of mechanisms of airway protection from aspiration (silent aspiration) was prevalent in the present study, corroborating previous findings in the pediatric population,[2,22,24,25] especially in children < 24 months of age in whom protective vagal reflexes are not fully developed.[2]

Therapeutic feeding and swallowing interventions following the VFSS in most of the children in the present study, including those with less evident signs and symptoms of DOF such as penetration/aspiration, are justified because of the primary objective of the VFSS, which is to assess feeding safety and the effectiveness of compensatory feeding strategies.[2,7,16,22,23] During the follow-up period, feeding strategies were modified despite the absence of severe findings on the VFSS. Therefore, we believe that VFSS findings alone do not provide appropriate evaluation and management of children with OPD.[10] The diagnosis and treatment of OPD should be based on clinical impression (clinical evaluation and history of episodes of aspiration pneumonia) and objective findings of changes in swallowing biomechanics.[26]

In the present study, VFSS findings of OPD followed by therapeutic management were associated with reduced respiratory morbidity. This suggests that airway protection can be achieved with greater attention to OPD. We found two studies evaluating outcomes before and after interventions in children with neurodevelopmental impairment. Silverio & Henrique[27] reported a decrease in respiratory events after speech and language therapy; however, their findings were based only on clinical diagnostic protocols for OPD. Sullivan et al.[28] performed VFSS on some of their patients and observed a decrease in the number of lung infections after gastrostomy.

Many of the children in the current study had a combination of oral and enteral feeding introduced during the follow-up period. This means that oral feeding was initiated in patients who had previously received enteral feeding alone and that there was an increase in the number of children who originally received oral feeding and who were started on a combination of oral and enteral feeding. These findings suggest that the recommendation of complementary feeding strategies was based on nutritional factors as well, rather than on OPD alone. Previous studies have hypothesized or showed that there is an association between diseases manifesting during the follow-up period and failure of exclusively oral feeding.[6,29] In addition, it is known that oral feeding alone is not enough for adequate nutrition in some patients.[7,30]

Our age-adjusted statistical model showed a lower probability of antibiotic use, a shorter length of hospital stay, and a shorter duration of antibiotic therapy after the VFSS. These data support the conclusion that specialized care reduces respiratory morbidity in children with OPD, and this reduction plays an important role in the well-being of patients and their families. It is challenging to establish a causal relationship between aspiration and respiratory symptoms, requiring analysis of factors that are known to be difficult to single out in retrospective studies.[9] Despite some limitations and confounding factors, the relevant findings of the current study remain significant after adjustment for age, warranting further attention. The investigation

Table 3. Logistic regression model adjusted for age at the time of videofluoroscopic swallow study.

Variable	Adjusted OR (95% CI)	p
Hospitalization	0.152 (0.068-0.338)	< 0.001
Antibiotic use	2.47 (1.286-4.744)	0.007

Table 4. Difference in means adjusted for age before and after videofluoroscopic swallow study.

Variable	Before (days)	After (days)	Difference in means (95% CI)	p
Length of hospital stay*	45.96	32.77	13.19 (1.73-24.65)	0.024
Number of hospitalizations**	1.44	1.01	0.43 (0.2-0.88)	0.072
Duration of antibiotic therapy*	25.35	16.36	8.99 (1.94-16.05)	0.014

*Generalized linear model for gamma distribution. **Poisson regression.

and treatment of OPD are conducted when there is suspicion of factors not yet fully understood within the clinical context of the child. Although this does not address the methodological issues, it reinforces the importance of the data. OPD is often underrecognized as a cause of chronic respiratory symptoms,[7,15] and its respiratory presentation may be less characteristic than previously understood.[6]

The limitations of the present study include its retrospective nature, data collection from medical records, the lack of a control group, the fact that different respiratory diagnoses were related to antibiotic therapy and hospitalization, and the heterogeneity of the study population. Studies involving homogeneous populations and randomized interventions should be carried out in order to clarify the impact of OPD and its management on respiratory morbidity; to improve the quality of life of patients and their families; and to promote the standing of referral facilities, which are still lacking in most centers.

AUTHOR CONTRIBUTIONS

All authors participated in the design and planning of the study; interpretation of the findings; writing and/or revision of all preliminary drafts and the final version of the manuscript; and approval of the final version of the manuscript.

CONFLICTS OF INTEREST

None declared.

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