Effects of Body Positioning on Laryngeal Penetration and Aspiration in Children with Unilateral Vocal Cord Paralysis

Original Investigation

Neil Monaghan[1,2], Heather McGhee[3], Erick Yuen[1], Shaun A Nguyen[1], Clarice Clemmens[1]

[1]Department of Otorhinolaryngology, Medical University of South Carolina, Charleston, United States of America
[2]College of Medicine, Medical University of South Carolina, Charleston, United States of America
[3]Department of Speech Language Pathology, Medical University of South Carolina, Charleston, United States of America

Abstract

Objective: To evaluate laryngeal penetration and aspiration in upright and side-lying positions in children with unilateral vocal cord paralysis (VCP) who underwent modified barium swallow study (MBSS).

Methods: A retrospective chart review (Pro00089051) of pediatric patients who were diagnosed with unilateral VCP and underwent MBSS was performed. Patients were identified using diagnostic code for VCP and based on diagnosis via flexible laryngoscopy. Once identified, MBSS notes were reviewed for data regarding laryngeal penetration, tracheal aspiration, and body position during the exam. Information was collected on the various consistencies of liquids used. The order of positioning was recorded in patients who had undergone both positions during the study. Data was analyzed using chi-square analysis.

Results: 811 patients had undergone MBSS between 2011 and 2014. Of these, 90 patients were isolated with unilateral VCP, and of those 90 patients, 23 (26%) had undergone MBSS in both side-lying and upright positions. When all 90 patients were evaluated, there was no difference in penetration or aspiration noted in the side-lying or upright position with thin liquids. Importantly, among the 23 (26%) patients that had been studied in both positions, there were no significant differences in penetration or aspiration relating to body position with any consistency.

Conclusion: Rates of penetration and aspiration were not associated with body position in patients who had undergone MBSS at our institution. However, due to an incomplete data set and a small sample size of those who underwent MBSS in both positions, these results should be further explored in prospective studies.

Keywords: Vocal cord paralysis, children, aspiration, feeding, body position, modified barium swallow study

ORCID IDs of the authors:

N.M. 0000-0002-3631-5624;
H.M. 0000-0003-3996-8759;
E.Y. 0000-0002-2704-1086;
S.A.N. 0000-0003-0664-4571;
C.C. 0000-0001-6821-4740.

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Corresponding Author:
Clarice Clemmens;
clemmens@musc.edu

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Introduction

Vocal cord paralysis (VCP) is the second most common laryngeal anomaly in children and accounts for 10–20% of laryngeal disorders (1). Unilateral VCP has many underlying causes, often resulting from damage to the recurrent laryngeal nerve, with particularly high rates of unilateral VCP noted in children undergoing intervention for congenital heart disease due to the proximity of the recurrent laryngeal nerve to the aortic arch (2, 3). Other potential sources of VCP in children include viral infections, neoplasms, cardiac outflow tract disease, and idiopathic etiologies (3-5).

Swallowing is a complex motor skill that is largely driven by branches of the vagus nerve. During swallowing, respiration ceases and the airway closes at three levels: approximation of the true vocal cords to close the glottis, adduction of the false vocal cords and movement of the arytenoids superiorly and anteriorly to meet the base of the epiglottis, and close the laryngeal vestibule. These various levels of closure each serve to protect the airway during swallowing by preventing material from entering the airway (6). Without appropriate airway protection, swallowing can result in penetration (material enters the laryngeal vestibule but remains above the vocal folds) or aspiration (material enters the airway below the vocal folds) (7). Chronic tracheal aspiration is associated with several complications including recurrent pneumonia and lung injury (8, 9). In the setting of unilateral VCP, decreased laryngeal function places the patient at risk for reduced airway protection leading to aspiration (10-13). Recent studies have examined the effects of unilateral VCP on airway protection and swallowing in children. In 2019 Irace et al. (14) found that 16 of 28 children with VCP had silent aspiration in modified barium swallow study (MBSS), but any positional differences utilized during the examination were not reported. Additionally, in 2000, Heitmiller et al. (11) found the prevalence of aspiration in adults with unilateral VCP to be 18%.

Several studies have compared the effects of the elevated side-lying versus upright positions on variability in respiration and heart rate during bottle feeding in preterm infants. These studies had smaller sample sizes and demonstrated conflicting results on the benefits of the side-lying versus the upright positions. A systematic review examining the effects of positioning during bottle feeding in preterm infants determined that the evidence to define the role of positioning on physiological stability was still insufficient (15). Furthermore, these studies did not include infants with unilateral VCP or directly examine the effects of the elevated side-lying position versus the upright position on airway protection using measures such as the MBSS (16-18).

The reasoning for placing children with unilateral VCP in a side-lying position (functioning side down) is largely based on theory. The theory involves gravity helping to decrease aspiration by directing the flow of the liquid that enters the larynx down the side of the functioning cord as well as gravity helping passively adduct the non-functioning cord (19). Additionally, there is likely an element of improved coordination and slowed flow as evidenced by children taking fewer swallows per breath when placed in a side-lying position compared to an upright position (20).

One study by Hunt and Olney (21) in 2022 found that side-lying positioning "affects feeding success" in children with unilateral VCP, and stated that these children were more likely to be able to wean to oral feeding without thickening agents upon hospital discharge. However, there is no known study looking at the effects of positioning specifically on airway protection during swallowing in children with unilateral VCP.

The objective of our investigation was to evaluate laryngeal penetration and aspiration in upright and side-lying positions in children with unilateral VCP who underwent MBSS.

Methods

Ethical approval was obtained from the Office of Research Integrity at the Medical University of South Carolina Institutional Review Board for Human Research (Pro00089051, approval date: 10.10.2018).

Patient Selection

A retrospective review was performed on the charts of the children who had a diagnosis of VCP and underwent a MBSS at our institution. Patients were identified by diagnosis of VCP via laryngoscopy.

Data Collection

We conducted a retrospective chart review of MBSS performed on children less than 14 months of age to identify patients with a diagnosis of unilateral VCP. The data extracted included demographics, diagnosis, indications for MBSS, and comorbid conditions. MBSS data including penetration, aspiration, positioning, and liquid consistencies were collected. If a patient underwent multiple MBSS, only the first study was utilized for this review.

MBSS Procedures

MBSS examinations were conducted by trained speech language pathologists (SLPs) in conjunction with radiologists. Varibar® barium products of thin, nectar, or honey-thick liquids were administered as determined appropriate by the SLPs conducting the examination. Examinations were completed using continuous videofluoroscopy at 30 frames per second. Collimation protocols specify using the lips, hard/soft palate, posterior pharyngeal wall, and cervical esophagus as borders for the field of view. When available, the child's home bottle system was used to dispense the

barium. Dr. Brown's bottles and nipples were the most used bottle system if the child's bottle system was not sufficient. If the child refused to drink the barium, it may have been mixed with a preferred liquid to achieve cooperation. This was decided at the SLP's discretion and was not consistently documented in the MBSS report.

Statistical Analysis

All analyses were conducted using version 27.0 of SPSS (IBM Corporation, Armonk, NY) and GraphPad (GraphPad Software, San Diego, CA). Continuous variables were summarized by mean ± standard deviation/range or median and interquartile range (25–75th) where appropriate. All continuous variables were tested for normal distribution as determined by the Kolmogorov–Smirnov test. Categorical variables were summarized by frequency (N) and percentage (%). Comparisons between categorical variables were performed with a Fisher's or chi–square test. A p-value of <0.05 was considered statistically significant for all statistical tests.

Results

Of the 811 patients screened who underwent MBSS between 2011 and 2014, 90 were isolated with unilateral VCP. The median age of the patients was 5 months (range: 2 weeks–14 months). Forty eight (53%) patients were male, 42 (47%) were female. 93% (n=84) of patients' paralysis were left-sided, 7% (n=6) were right-sided (Table 1). 76% (n=68) of patients had cardiac comorbidities, 21% (n=19) had a history of prematurity, 17% (n=15) of patients had a diagnosis of GERD, 9% (n=8) of patients had neurological comorbidities, and 8% (n=7) were syndromic (Table 2). Of those 90 patients that were included, 23 (26%) underwent MBSS in both side-lying and upright positioning (Tables 3-7). Ninety

Table 1. Median age and sex of patients, and laterality of unilateral VCP as identified via flexible laryngoscopy

Patient characteristics	
Median age	5 months (range: 2 weeks–14 months)
Sex	48 male (53%), 42 female (47%)
Left-sided paralysis	84 of 90 (93%)
Right-sided paralysis	6 of 90 (7%)

VCP: Vocal cord paralysis

Table 2. Comorbid conditions identified among patients

Comorbidities	
Cardiac	68 of 90 (76%)
Prematurity	19 of 90 (21%)
Gastroesophageal reflux disease	15 of 90 (17%)
Neurological	8 of 90 (9%)
Syndromic	7 of 90 (8%)

Table 3. Comparison of laryngeal penetration and aspiration in upright (UR) and lateral decubitus/"side-lying" (LD) positioning in all patients with thin consistency. Penetration: p=0.2002, aspiration: p=0.1562

All patients Thin	**Penetration UR**	**Penetration LD**	**Aspiration UR**	**Aspiration LD**
Yes	74	22	58	19
No	16	1	32	4
Total	90	23	90	23

Table 4. Comparison of laryngeal penetration and aspiration in upright (UR) and lateral decubitus/"side-lying" (LD) positioning in the subset of patients that underwent the study in both positions with thin consistency. Penetration: p=0.6078, aspiration p=0.9999

Both positions Thin	**Penetration UR**	**Penetration LD**	**Aspiration UR**	**Aspiration LD**
Yes	20	22	18	19
No	3	1	5	4
Total	23	23	23	23

Table 5. Comparison of laryngeal penetration and aspiration in upright (UR) and lateral decubitus/"side-lying" (LD) positioning in all patients with nectar-thick consistency. Penetration: p=0.6960, aspiration: p=0.6008

All patients Nectar-thick	**Penetration UR**	**Penetration LD**	**Aspiration UR**	**Aspiration LD**
Yes	39	12	26	5
No	44	10	57	17
Total	83	22	83	22

Table 6. Comparison of laryngeal penetration and aspiration in upright (UR) and lateral decubitus/"side-lying" (LD) positioning in the subset of patients that underwent the study in both positions with nectar-thick consistency. Penetration: p=0.7507, aspiration p=0.326

Both positions Nectar-thick	**Penetration UR**	**Penetration LD**	**Aspiration UR**	**Aspiration LD**
Yes	14	12	9	5
No	7	9	12	16
Total	21	21	21	21

Table 7. Comparison of laryngeal penetration and aspiration in upright (UR) and lateral decubitus/"side-lying" (LD) positioning in all patients with honey-thick consistency. Penetration: p=0.222, aspiration: p=0.5304

All patients Honey-thick	**Penetration UR**	**Penetration LD**	**Aspiration UR**	**Aspiration LD**
Yes	4	2	3	1
No	12	1	13	2
Total	16	3	16	3

patients received the thin liquid consistency in total and 23 received thin liquid in both positions (Table 3). Eighty three patients received the nectar-thick liquid consistency in total and 21 received thin liquid in both positions (Table 5). Sixteen patients received the honey-thick liquid consistency in total (Table 7). For those receiving thin liquid, 90 were in the upright position, 23 in the lateral decubitus position, and 23 underwent the study in both positions (Tables 3, 4). For those receiving nectar-thick liquid, 83 were in the upright position, 22 in the lateral decubitus position, and 21 underwent the study in both positions (Tables 5, 6). For those receiving honey-thick liquid, 16 were in the upright position, three in the lateral decubitus position, and three underwent the study in both positions (Table 7). Among those who underwent the study in both positions, we found no significant difference in penetration or aspiration between body positions with any consistency (Tables 3-7).

Discussion

While commonly used in practice at our institution, there is a lack of significant scientific evidence supporting body positioning for airway protection in dysphagic infants with unilateral VCP, highlighting the need for further investigation.

While anecdotal and theoretical benefits to patient positioning in unilateral VCP have been noted, our pilot data, as seen in Tables 3-7, did not reveal a significant difference in airway protection between upright or side-lying positioning in this population. Limited by a small number of eligible MBSS, this data would suggest that further investigation of patient positioning is warranted.

The study has several limitations that primarily relate to the retrospective study design and the absence of a standardized protocol for evaluating laryngeal penetration and aspiration in upright and side-lying positioning in children with unilateral VCP who underwent MBSS. As a retrospective chart review, we are confined to the contents of the chart, as well as the quality and information included in the medical record which can result in a potential selection bias. MBSS in the infant population is often challenging, with difficulties noted with patient cooperation, ability to change positioning, and modification of liquid consistencies and flow rates. Additionally, patients were not randomized to starting position, meaning that fatigue could be a confounding factor, and we were unable to assess the order of positioning for all individuals in this study. Finally, MBSS relies on subjective interpretation of data collected during the study, which needs to be considered when interpreting this data.

It should also be noted that a large number of children in this study had cardiac comorbidities. This population is known to be at high risk for unilateral VCP following cardiothoracic procedures, with rates in the literature reported to be as high as 56% (22). At our institution, children undergoing cardiac procedures are routinely examined postoperatively to determine vocal cord mobility before oral feeding. This likely explains the high percentage of patients with cardiac comorbidities in our study. Given this highly complex patient population, it is reasonable to consider that other factors beyond vocal cord function may be playing a role in the airway protection of our sample.

Finally, this study is limited by the retrospective nature and inability to control for confounding factors associated with swallowing pathology during each MBSS. In the future, a prospective study designed to isolate changes in swallow with respect to positioning during the same bottle feed is needed. It has been demonstrated that swallowing physiology throughout feed changes in as little as 1.5 minutes in infants, therefore controlling for the variable of time is also important (23). Additionally, nipple flow rate control was not possible in our study. While our study was not able to address these issues, we believe this is important pilot data supporting the need for further analysis. This was the first study of its kind in children with unilateral VCP, so we did not have preliminary data from which to formulate highly specific a priori hypotheses or perform formal power analyses. As a result, we may have missed the associations due to a lack of statistical power (Type II errors) or identified spurious associations (Type I errors). Also, explanations of findings were limited by the survey level of data. Thus, our interpretations should not be considered conclusive, but rather hypothesis-generating for future investigations.

We believe this data could impact the way we educate patients' families on best feeding practices and impact how we perform MBSS, however, further prospective analyses are needed to draw these conclusions. Additionally, further research with stratification of specific populations would be of interest.

Conclusion

Rates of penetration and aspiration were not associated with body position in pediatric patients who underwent MBSS at our institution. However, due to an incomplete data set and small sample size of those who underwent MBSS in both positions, these results should be explored further prospectively.

Ethics Committee Approval: Ethical approval was obtained from the Office of Research Integrity at the Medical University of South Carolina Institutional Review Board for Human Research (Pro00089051, approval date: 10.10.2018).

Informed Consent: Informed consent was waived due to the retrospective nature of the investigation.

Authorship Contributions

Surgical and Medical Practices: H.M., E.Y., C.C., Concept: N.M., H.M., E.Y., S.A.N., C.C., Design: N.M., H.M., E.Y., S.A.N., C.C., Data Collection and/or Processing: N.M., H.M., E.Y., S.A.N., C.C., Analysis and/or Interpretation: N.M., H.M., E.Y., S.A.N., C.C., Literature Search: N.M., H.M., E.Y., S.A.N., C.C., Writing: N.M., H.M., E.Y., S.A.N., C.C.

Conflict of Interest: The authors have no conflicts of interest to declare.

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Main Points

- We do not identify a significant difference in laryngeal penetration or aspiration between upright and side-lying positioning on modified barium swallow study.
- Body positioning may not affect airway protection during feeds in this population.
- Further prospective analysis is needed to make strong conclusions.

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