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Characteristics of Dysphagia in Children with Cerebral Palsy

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Abstract. Videofluoroscopic modified barium swallow (VMBS) examinations may provide clinically relevant information regarding deglutition in children with cerebral palsy and dysphagia. A retrospective review of clinical evaluations and VMBS studies on 90 consecutive children with cerebral palsy and dysphagia was completed. Most children were referred because of concerns regarding airway protection during oral feedings. Most children had multiple disabilities and 93% were nonambulatory. The majority of children were totally dependent for oral feedings (80%). Oral and pharyngeal phase abnormalities were present in almost all patients. Abnormalities of deglutition were observed only while swallowing specific food textures in the majority of patients. Aspiration of specific food textures was significantly more common than aspiration of all food textures ($p < 0.0001$). Finally, aspiration was silent in 97% of the patients. VMBS studies can provide clinicians with valuable information regarding the most appropriate food textures and rates of oral feeding for children with cerebral palsy and dysphagia.

Key words: Videofluoroscopic modified barium swallow — Cerebral palsy — Dysphagia — Oral, pharyngeal abnormalities — Deglutition — Deglutition disorders.

Dysphagia is a common problem in children with multiple severe disabilities. Recognized complications include aspiration, recurrent pneumonia, and chronic lung disease [1–5]. Evaluations of the oral, pharyngeal, and esophageal phases of deglutition are essential in the evaluation of patients with dysphagia [6,7]. The videofluoroscopic modified barium swallow (VMBS) examination is the procedure of choice for evaluation of the pharyngeal phase of deglutition. Currently, oral and pharyngeal motility and aspiration can be assessed accurately only by VMBS studies [8–11].

There have been limited radiographic studies of deglutition in children with dysphagia and multiple disabilities. A cinefluorographic study of children with cerebral palsy and dysphagia documented for the first time the common occurrence of both oral and pharyngeal phase abnormalities [12]. There have been few videofluoroscopic studies of children with cerebral palsy and multiple disabilities, and all have emphasized the common occurrence of pharyngeal phase abnormalities, including aspiration [4,5]. These studies were limited, however, by the small number of children evaluated. There continues to be minimal information regarding the relationship between specific food textures and various abnormalities of deglutition [4,5]. Those abnormalities of deglutition that are most associated with aspiration continue to be poorly understood.

The purpose of this study was to examine whether VMBS studies provide clinically relevant information about dysphagia in children with multiple disabilities. Information regarding the influence of common treatment strategies, including diet texture and rate of oral feedings, on deglutition are presented. Finally, those features of dysphagia most closely associated with the occurrence of aspiration are identified.

Methods

A case-series design was used. VMBS studies were performed on 90 children with cerebral palsy consecutively seen for evaluation between 1989 and 1991. The study participants included children who ranged in

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age from 1 week to 22 years, mean age 7.5 years ± 6 years. Eight patients were less than 12 months of age, 22 were 1–3 years, and 60 were greater than 3 years. A comparable proportion of subjects were males and females (54% and 46%, respectively). Patients were referred by developmental pediatricians at a tertiary medical center or by community pediatricians.

A retrospective chart review was completed on all patients (n = 90). Feeding histories, diagnoses, and physical examination results were available for all patients. Clinical histories and physical examinations were obtained prior to all diagnostic procedures. Parents or primary caregivers were interviewed by a speech-language pathologist and a developmental pediatrician. Information from interviews included primary feeding concerns, functional skills, and previous diagnoses. A developmental pediatrician examined all children. Cerebral palsy was defined as a group of brain damage syndromes in which a static and nonprogressive cerebral lesion produces significant motor delay, abnormal neuromotor findings, onset during the developmental period and other central nervous system deficits in areas of cognition and neurobehavior [13]. Diagnoses of cerebral palsy were made after 6 months of age. Diagnoses of mental retardation or other developmental delays were made by developmental pediatricians or school personnel.

VMBS studies were performed by a speech-language pathologist (J.A.) and a pediatric radiologist. Studies were performed according to the protocol of Logemann [14]. Children were upright and in sitting position for all studies except infants who were semi-upright (approximately 75°). Lateral head supports were used when needed to maintain midline position. Lateral videofluoroscopic recordings were made in all patients and occasionally, antero-posterior (AP) views were obtained when asymmetries were suspected in the pharyngeal phase. A Philips Super 80 CP generator and conventional fluoroscopy unit were used with digital spot imaging and laser cameras. Sony 3/4″ video tape recordings were made. The durations of various deglutition phases were estimated by both the speech-language pathologist and the radiologist. Transit delays were estimated but not timed on line. Results of each patient's initial VMBS study were analyzed. Follow-up studies were not included in this sample.

All food textures taken during routine oral feedings were used for swallow studies. Barium sulfate liquid was used for liquid swallows. Barium esophatrast was mixed with pureed foods (Stage 2). Solids including crackers, small pieces of bread, or sandwiches were coated with barium esophatrast. The food texture best tolerated by the child was presented first, followed by those of greater concern. Two to three swallows per texture were recorded.

Observations of the oral phase included placement of the food bolus on the dorsum of the tongue and its posterior propulsion to the tonsillar pillars. If the duration of this process was estimated to be greater than 3 sec, the oral phase was described as delayed. Abnormalities of tongue control included limitation of lateral movement with solid food, excessive tongue thrusting and pumping, or poor expulsion of liquid from the nipple during bottle feedings. Piecemeal deglutition described fragmentation of the barium bolus over the dorsum of the tongue. Multiple swallows represented three or more swallows per bolus.

Pharyngeal phase abnormalities include delayed swallowing, pharyngeal pooling prior to swallow, reduced pharyngeal peristalsis, residue after swallows, and aspiration. Swallow initiation was delayed when the barium bolus remained in the pharynx for 3 sec or more prior to swallow production. Pooling of barium represented the presence of barium in the vallecula and/or pyriform sinuses prior to entry into the esophagus. Reduced pharyngeal peristalsis described slow passage of barium textures through the pharynx (greater than 1 sec) and usually resulted in pharyngeal residue after swallows. Aspiration represented movement of barium below the true vocal folds and into the trachea, before, during, or after swallows [15]. Aspiration of less than 10% of the barium bolus was described as "trace." Volume of barium aspirated was not quantified objectively, but was only estimated from lateral, two-dimensional x-ray films. Silent aspiration represented the absence of coughing within 20 sec of aspiration.

Descriptive statistics used for data analysis included frequencies, cross-tabulations, and measures of central tendency using SPSSPC statistical software package [16]. Age was dichotomized for analysis with other subject study variables. Statistical significance ($p \leq 0.05$) was determined using Yates corrected Chi-square statistic, or Fisher's exact test (two-tail) for cell sizes less than five. The Chi-square contingency test was used for determining statistical significance for tables larger than 2 × 2 (RXC).

Results

The study cohort consisted of infants and children with multiple disabilities. Eighty-four patients (93%) were nonambulatory. Cognitive assessments were available for 86 patients (96%) of whom 80 (93%) were diagnosed with mental retardation. Other developmental disabilities were noted in 37 patients (41%). Fifty-four percent of the study cohort (n = 49) had epilepsy. Although the mean age was 7.5 years ± 6 years, 80% of the sample was totally dependent for oral feedings. Feedings were only given orally in 64 (71%), combination of oral and gastrostomy tube in 24 (27%), and by gastrostomy tube only in 2 (2%).

Caregivers' most common concerns related to airway protection during oral feedings. Coughing, choking, and trouble breathing during meals were reported for 57% of the sample, and specific concerns regarding aspiration were noted for 45 patients (50%). "Troubled breathing" described patients with increased chest excursions or rapid rate during oral feedings. Feedings were described as too long (>40 min) in 22% of children, and outright food refusal was noted in 14%. A concern regarding the swallowing of a specific food texture was mentioned by caregivers for 43 patients (48%). These concerns involved liquids in 25 children and pureed or solid foods in 18 children. Less common problems included gagging (14%) and emesis (19%).

The results of VMBS studies are shown in Table 1. Almost all patients had abnormalities of both the oral and pharyngeal phases of deglutition. Tongue control abnormalities and delays in the oral phase of deglutition were noted in over 90% of the patients. No significant associations were observed between presence of oral phase abnormalities and age at assessment, i.e., ≤3 years or >3 years.

Slow initiation of swallows was found in 97% of the patients. Swallows were often inefficient (multiple swallows per bolus 83%, and pharyngeal residue 58%). Aspiration occurred in 34 (38%) patients. Seventeen patients aspirated prior to or during swallowing, and 17 aspirated after swallows. Aspiration occurred without coughing or choking (silent) in 97% of patients. Less

Table 1. Description of VMBS studies (n = 90)

Barium swallow findings	≤3 Years (n = 30)		>3 Years (n = 60)		Total (n = 90)	
	#	(%)	#	(%)	#	(%)
Oral phase abnormality						
Any	28	(93)	60	(100)	88	(98)
Delay	26	(87)	58	(97)	84	(93)
Tongue control	24	(80)	58	(97)	82	(91)
Piecemeal deglutition	22	(73)	48	(80)	70	(78)
Pharyngeal phase abnormality						
Any	29	(97)	60	(100)	89	(99)
Swallowing delay	28	(93)	59	(98)	87	(97)
Reduced peristalsis	9	(30)	28	(47)	37	(41)
Residue after swallow[a]	12	(40)	40	(67)	52	(58)
Multiple swallows	23	(77)	52	(87)	75	(83)
Aspiration	11	(37)	23	(38)	34	(38)

[a] $p < 0.01$.

Table 2. Deglutition abnormalities in children evaluated with all three food textures

Barium swallow findings	≤3 Years (n = 16)		>3 Years (n = 44)		Total (n = 60)	
	#	(%)	#	(%)	#	(%)
Delay in swallow						
Liquids (any)[a]	3	(19)	10	(23)	13	(22)
Purees and/or solids	6	(37)	15	(34)	21	(35)
All textures	7	(44)	19	(43)	26	(43)
None	0	(0)	0	(0)	0	(0)
Pharyngeal pooling prior to swallow						
Liquids (any)	3	(19)	10	(23)	13	(22)
Purees and/or solids	5	(31)	12	(27)	17	(28)
All textures	8	(50)	22	(50)	30	(50)
None	0	(0)	0	(0)	0	(0)
Pharyngeal residue after swallow						
Liquid (any)	3	(19)	12	(27)	15	(25)
Purees and/or solids	2	(12)	13	(30)	15	(25)
All textures	0	(0)	5	(11)	5	(8)
None	11	(69)	14	(32)	25	(42)
Aspiration						
Liquid (any)	5	(31)	14	(32)	19	(32)
Purees and/or solids	0	(0)	1	(2)	1	(2)
All textures	2	(12)	3	(7)	5	(8)
None	9	(57)	26	(59)	35	(58)

[a] Liquids alone or in combination with purees *or* solids.

Table 3. Radiographic features among children who did and did not aspirate

Radiographic and clinical features	Aspiration			
	Yes (n = 34)		No (n = 56)	
	#	(%)	#	(%)
Mealtime coughing, choking	25	(76)	26	(47)[a]
Oral stage abnormalities	33	(97)	55	(98)
Tongue center of abnormality	31	(91)	51	(91)
Piecemeal deglutition	28	(82)	42	(75)
Pharyngeal stage abnormality	34	(100)	55	(98)
Delayed swallowing	33	(97)	54	(96)
Pharyngeal pooling prior to swallow	33	(97)	53	(95)
Pharyngeal residue	27	(82)	25	(46)[b]
Multiple swallows	27	(82)	40	(74)
Reduced pharyngeal peristalsis	24	(71)	13	(23)[c]

Note: All radiographic and clinical features dichotomized (yes/no) for analysis.
[a] $p < 0.05$; [b] $p < 0.01$; [c] $p < 0.0001$.

than 10% of barium boluses were aspirated in 32 (94%) patients. Statistical analysis of the occurrence of pharyngeal phase abnormalities with age (≤3 years and >3 years) revealed a significant difference only with respect to food residue after swallows. Food residue after swallows was present in 12 (40%) patients ≤3 years of age and 40 (67%) patients >3 years of age ($p < 0.01$).

Table 2 reflects the results of VMBS examinations performed in 60 patients who could be tested with all three food groups. Delays in swallow initiation, food residue after swallows, and aspiration were more common while swallowing one or two food textures than for all three food textures. Twenty-five of the 34 patients who aspirated underwent VMBS utilizing three major textures (liquids, purees, solids). Aspiration occurred while ingesting one or two food textures in 20 of these patients ($p < 0.0001$). Liquids alone or in combination with purees or solids were aspirated in 19 patients. Purees alone were aspirated by 1 patient. Five patients aspirated all three food textures (Table 2). Liquid was the substance most commonly aspirated by children (n = 24; 96%), followed by purees (n = 11, 48%) and solid (n = 6, 24%).

Table 2 also describes various oral and pharyngeal phase abnormalities in relation to specific food textures and age at assessment. Delays in swallow and pharyngeal pooling prior to swallow were observed in all patients. However, there were no significant differences in the proportion of swallow delays or barium pooling prior to swallows and age at assessment. Age at assessment was somewhat associated with pharyngeal residue, ($p = <0.10$). The findings suggest that younger children were less likely to have texture-specific food residue than older children.

The clinical as well as radiological features of patients with aspiration are shown in Table 3. Concerns regarding coughing, choking, or trouble breathing during oral feedings were significantly associated with aspiration ($p < 0.05$). It is important to note, however, that of the 51 patients with coughing, choking, or trouble breathing during oral feedings, only 25 (49%) aspirated. Of the 37 patients without these concerns, 8 (22%) aspirated. The sensitivity and specificity of this history for aspiration on barium swallow were 76% and 53%, re-

spectively. The only features of deglutition that were significantly associated with aspiration were pharyngeal residue ($p < 0.01$) and reduced pharyngeal peristalsis ($p < 0.0001$). Pharyngeal residue had a sensitivity of 52% and a specificity of 83% for aspiration. The sensitivity and specificity of reduced pharyngeal peristalsis for aspiration were 65% and 81%, respectively.

VMBS findings resulted in texture and rate of feeding changes in the management of 67 (74%) patients. Recommendations included changes in food texture in 41 (61%) patients and changes in the rate of oral feedings in 35 (52%). Changes in the rate of oral feedings were made by altering the time between food boluses. Review and analysis of the clinical effects of these changes is planned.

Discussion

In this investigation, pharyngeal phase abnormalities of deglutition were present in most children with cerebral palsy and dysphagia. Various food textures were associated with specific pharyngeal phase abnormalities including swallow initiation delay, food residue after swallows, and aspiration. Deglutition abnormalities important in determining the appropriate rate of oral feedings were well characterized by VMBS studies. These abnormalities included delayed swallows, piecemeal deglutition, pharyngeal residue, and multiple swallows per bolus. Results of VMBS studies assisted physicians and oral-motor feeding specialists in identifying optimal feeding programs in the majority of children evaluated.

Signs of respiratory distress including coughing, choking, congestion, and wheezing are commonly observed during oral feedings of children with multiple disabilities and dysphagia [1,2]. Well-recognized health complications include aspiration pneumonia, chronic lung disease, and malnutrition [1–5,17,18]. However, investigations of dysphagia in children with multiple disabilities have been limited. To our knowledge, there have been only two previous studies utilizing VMBS in children with multiple disabilities. In a case-series of 6 patients, Helfrich-Miller et al. [4] demonstrated barium texture-specific abnormalities of the pharyngeal phase of deglutition, including aspiration. A subsequent investigation confirmed these observations in a case-series of 10 children with multiple disabilities [5]. Limitations of these studies included small sample size, restricted use of barium consistencies during swallow studies, and incomplete descriptions of deglutition [4,5].

In this investigation, VMBS studies were performed on a relatively large group of children with cerebral palsy and dysphagia. Systematic evaluations of various aspects of both oral and pharyngeal phases were completed on all patients. In contrast to previous investigations, barium textures utilized were foods commonly consumed by the patients [4,5]. Both oral and pharyngeal phase abnormalities were present in almost all patients. In the majority of patients, specific pharyngeal phase abnormalities including delayed swallowing, pharyngeal pooling prior to swallow, pharyngeal food residue after swallows, and aspiration occurred with only specific food textures. VMBS studies were also performed in a manner to appropriately assess patients of varying ages. Utilizing these methods, the occurrence of pharyngeal residue after swallows was the only deglutition abnormality that was significantly associated with patient age at assessment. Pharyngeal residue after swallows was significantly more common in patients older than 3 years of age.

The size of this cohort permitted the addressing of specific aspects of aspiration during oral feedings. It was demonstrated that aspiration can occur before, during, or after swallows. The occurrence of aspiration was significantly associated with specific food textures. Liquids were much more frequently aspirated than any other food texture. This observation differs from previous investigations of children with multiple disabilities [4,5] but confirms previous observations of adults with dysphagia [19]. Aspiration during VMBS studies also did not result in patients coughing or choking. Patients who aspirated during these studies could not be reliably identified by clinical histories. Aspiration was not significantly more common in younger or older patients. A history of mealtime coughing, choking, or trouble breathing was significantly associated with the occurrence of aspiration. However, the sensitivity and specificity of this history were unacceptably low (76% and 53%, respectively).

The etiology of aspiration in children with cerebral palsy remains unclear. In this investigation, reduced pharyngeal peristalsis and pharyngeal residue after swallows were significantly associated with aspiration. However, there were a number of children with these abnormalities who did not aspirate. The occurrence of aspiration may be dependent not only on specific pharyngeal phase abnormalities, but also on the coordination of deglutition with respiration. Future studies utilizing non-invasive methods of monitoring respiration during VMBS studies may help clarify this relationship [20,21].

Conclusions regarding dysphagia in children with cerebral palsy must be made cautiously. The majority of the children evaluated in this study were severely disabled. Additionally, most were referred for concerns regarding airway protection during oral feedings. Thus, the study cohort was highly selective. Evaluations also were limited. Oral and pharyngeal delays in bolus transit were estimated by the speech-language pathologist and radiologist. Transit delays were not timed on-line with precision instruments in this investigation.

VMBS studies assisted physicians and oral-motor feeding specialists in selecting the most appropriate food textures and rates for oral feeding in children with cerebral palsy and dysphagia. Aspiration events (both silent and overt) were more accurately diagnosed. These studies have the potential of assisting physicians and oral-motor feeding specialists in identifying feeding techniques that can reduce the amount and frequency or possibly eliminate aspiration during oral feedings.

The long-term clinical implications of VMBS studies remain somewhat unclear. Further investigations are needed on the influence of such studies on the long-term nutritional and pulmonary health outcomes of children with dysphagia and multiple handicaps. Children's tolerance or enjoyment of oral feedings must also be considered in future intervention studies.

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