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Impact of Thermal Stimulation on the Triggering of the Swallowing Reflex

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Abstract. This study was designed to quantify the effects of thermal sensitization on the oral and pharyngeal transit times of the swallow following sensitization in a group of 25 neurologically impaired patients exhibiting delayed triggering of the swallowing reflex. Thermal sensitization consists of applying cold (thermal) contact to the base of the anterior faucial arches in order to sensitize the area of the oral cavity where the reflex is triggered. Thermal sensitization improved triggering of the swallowing reflex in 23 of the 25 neurologically impaired patients on swallows of at least one food consistency. Results are discussed in relation to neurologic recovery and carryover of these effects.

Key words: Swallowing reflex – Tongue – Oral stage – Stimulation – Pharyngeal stage.

Delayed triggering of the swallowing reflex has been found to occur among a large number of dysphagic patients, particularly among those who are neurologically impaired or who have had ablative surgery to the posterior oral cavity (Logemann 1983; Veis and Logemann 1985). The therapy procedure known as thermal stimulation of the reflex is designed to sensitize or stimulate the area of the oral cavity where the reflex triggers; it consists of applying cold (thermal) contact to the base of the anterior faucial arches. Cold contact was selected because it has been identified as the strongest stimulus. The anterior faucial arches have been defined as one of the most sensitive areas for triggering of the swallowing reflex (Pommerenke 1928). Clinical experience indicates that when a foreign object, such as a laryngeal mirror, is introduced into the oral cavity posterior to the anterior faucial arch, it is very likely to trigger a gag reflex, rather than a swallow.

Limited physiologic data are available regarding the actual impact of thermal sensitization or stimulation on the triggering of the swallowing reflex in dysphagic patients. This study was designed to quantify the immediate effects of thermal sensitization on the oral and pharyngeal transit times of the swallow following sensitization in a group of 25 neurologically impaired patients exhibiting delayed triggering of the swallowing reflex.

In normal individuals the voluntary oral stage of the swallow is initiated when the tongue begins to propel the material posteriorly, and it is terminated when the swallowing reflex triggers at the moment when the material passes the anterior faucial arches. At this point, the involuntary pharyngeal stage of the swallow is initiated. The lingual action to initiate the voluntary swallow appears to be a major component of the stimulus for triggering of the swallowing reflex (Logemann 1985). Once the reflexive swallow is initiated, the material is then moved through the pharynx, and the pharyngeal stage is terminated at the point when the material passes through the upper esophageal valve into the esophagus. Transit times for the oral and pharyngeal stages of the swallow are each typically 1 s or less (Blonsky et al. 1979).

In normal individuals the swallowing reflex marks the termination of the voluntary oral stage and the initiation of the involuntary pharyngeal stage of the swallow. It is triggered predominantly from the glossopharyngeal nerve. Afferent signals are then sent to the reticular formation in the brainstem where, it is hypothesized, a pattern recognition system decodes incoming information and

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Fig. 1. Anterior view of the oral cavity, illustrating the position of the size 00 laryngeal mirror against the anterior faucial arch during thermal stimulation/sensitization of the swallowing reflex.

initiates the motor patterns for the pharyngeal response to the swallow (Miller 1982).

The pharyngeal response to the reflex is composed of four neuromuscular activities:(1) elevation and retraction of the velum (to close the velopharyngeal port), (2) closure and elevation of the larynx (to protect the airway), (3) peristaltic-like contraction of the pharyngeal constrictors (to carry the bolus through the pharynx), and (4) relaxation of the upper esophageal sphincter (to allow entry of the bolus into the cervical esophagus). Unless the swallowing reflex is triggered, none of these motor acts necessary for successful completion of the pharyngeal stage of the swallow will occur (Logemann 1983).

Cold (thermal) stimulation or sensitization to the base of the anterior faucial arches is performed by lightly touching the area with the back of an iced size 00 laryngeal mirror, as shown in Figure 1. Theoretically, with this procedure, the sensitivity of the area eliciting the reflex is heightened by the cold contact so that, when a voluntary swallow is attempted by the patient immediately following the cold contact, the swallowing reflex will trigger at a more normal speed. The patient's voluntary attempt to swallow is most important in eliciting the more normal swallow after the stimulation (Logemann 1983).

Subjects

Subjects for this study were 25 neurologically impaired patients who were seen consecutively for videofluoroscopic evaluation and were found to have a delay in triggering of the swallowing reflex. This delay in triggering the swallowing reflex was identified when the bolus fell over the back of the tongue into the pharynx without eliciting any response in the pharynx, i.e., no laryngeal elevation and closure, cricopharyngeal opening, or peristalsis. This free-falling bolus may come to rest in the vallecculae or pyriform sinuses, may cling to the pharyngeal walls, or may fall into the open airway during the delay time when the reflex has not triggered. The neurological diagnoses of the 25 patients included left CVA, right CVA, Parkinson's disease, multiple sclerosis, head trauma, brain tumor, and pseudobulbar palsy. There were 15 males and 10 females.

Examination Procedures

Radiographic evaluation of swallowing involved a fluoroscopic study using a modified barium swallow to examine oral and pharyngeal stages of the swallow and the cervical esophagus while each patient performed two swallows of each of the following (food) consistencies: (1) 1/3 teaspoon liquid barium and (2) 1/3 teaspoon barium paste (pudding-like consistency).

After the second swallow of each barium consistency, each patient received thermal stimulation. Then the patient was immediately given another bolus of the same consistency to swallow. A maximum time lapse of 5 s occured between the thermal stimulation and the presentation of the bolus. The thermal stimulation followed the second swallow because clinical experience indicates that many neurological patients exhibit greater reflex delay on the first swallow of a substance, but improve on the second swallow. No further improvement is usually seen on subsequent swallows. All of the patients in this study exhibited a reflex delay of at least 1.5 s on the second swallow of each material. During the radiographic study, each patient was viewed in the lateral plane, with the radiographic tube focused on the lips anteriorly, the posterior pharyngeal wall posteriorly, the soft palate superiorly, and the cervical vertebra inferiorly. The entire examination for each patient was recorded on 3/4-inch videotape, using a Sony 5800 videocassette recorder coupled to a counter timer that burned numbers onto each frame of the videotape. This facilitated slow motion and frame-by-frame analysis of each swallow. Framing rate was 30/s so that each videoframe represented 33.3 msec.

Data Analysis

The videotapes were examined at normal speed, slow motion, and frame-by-frame. Three time measurements were obtained for the two swallows preceding and the one swallow following the thermal stimulation: (1) duration of oral transit (time elapsed from beginning of backward movement of the bolus until material passed the back of the tongue); (2) duration of pharyngeal transit (time elapsed from bolus passing the back of the tongue

Table 1. Nature of the neurological disorder, pharyngeal transit times, and total transit times (rounded to the nearest tenth of a second) on liquid and paste swallows for the 25 subjects studied

Subject number	Diagnosis	Pharyngeal transit times (s)				Total transit times (s)			
		Liquid		Paste		Liquid		Paste	
		No sens.	With sens.	No sens.	With sens.	No sens.	With sens.	No sens.	With sens.
1	Left CVA	1.5	0.5						
2	Left CVA	7.5	6.5						
3	Left CVA	4.6	3.1	4.2	3.1	5.2	3.3	6.1	4.2
4	Left CVA	2.9	2.9			6.1	3.6		
5	Left CVA	6.0	5.0	8.4	4.2				
6	Left CVA	2.0	0.8	0.9	1.6	2.7	0.8	2.0	1.4
7	Left CVA	3.4	5.0			4.1	5.2		
8	Left CVA			3.1	0.6			5.8	1.1
9	Left CVA	2.8	1.9			3.1	2.2		
10	Left CVA			2.8	2.6			7.3	3.1
11	Left CVA			1.6	0.4			3.8	2.9
12	Right CVA			3.1	0.3			6.5	3.7
13	Right CVA	5.5	0.8	8.6	0.5	12.7	3.8	8.9	7.9
14	Brainstem CVA	51.1	1.5						
15	Parkinson's	4.9	5.2	12.7	0.5				
16	Multiple sclerosis			4.1	1.8			4.1	3.3
17	Multiple sclerosis			3.9	2.2			9.5	6.4
18	Multiple sclerosis	6.1	0.6	2.0	1.2	8.4	3.6	9.1	7.2
19	Multiple sclerosis	29.1	1.2	2.8	1.4				
20	Multiple sclerosis	5.2	2.1			31.4	3.6		
21	Head trauma			2.7	1.7			3.0	1.6
22	Head trauma			5.1	2.5			9.0	7.2
23	Head trauma	6.2	1.6	3.0	2.0				
24	Brain tumor	1.8	0.9	2.6	1.3	3.1	1.2	8.1	4.2
25	Pseudobulbar Palsy	2.1	0.5	3.1	1.2	5.0	1.6	4.1	1.2
Means for all Patients:		8.4	2.4	4.1	1.6	8.2	2.9	6.2	4.0
Means minus #14 & #19: 4.2 s									

until it passed through the upper esophageal sphincter), which includes the reflex delay time and the pharyngeal response time once the reflex triggers; and (3) duration of total transit (sum of oral transit plus pharyngeal transit times).

Results

Results are be discussed in relation to changes in oral and pharyngeal transit times. Unfortunately, the measure of oral transit time could not be made for all patients. Some patients were unable to follow directions and initiated the oral stage of the swallow before videofluoroscopy could begin. Thus, only pharyngeal transit times are be reported for those patients. In addition, not all patients could tolerate both food consistencies. Some patients reportedly aspirated on liquids, and their attending physicians requested that they not be given liquids during the radiographic study; thus, they were given only the paste consistency. This is a common pattern in patients with a reflex delay, because liquid tends to splash into the pharynx during the reflex delay and can easily enter the open airway. In contrast, paste materials tend to cling to the tongue base, valleculae, pharyngeal walls, or pyriform sinuses and do not enter the airway so quickly or easily. Some patients were not given paste materials because the duration of the study reached the maximum desired radiation exposure (5 min exposure equivalent to 1 rad) or because their difficulty with liquid swallows precluded paste swallows.

Non-sensitized Swallows

As shown on Table 1, on liquid swallows that were not preceded by thermal sensitization, the mean pharyngeal transit times for each of the 17 individual subjects who were given liquids ranged from 1.5 to 51.1 s. Omitting the two patients with extremely delayed reflexes, the group mean pharyn-

geal transit time for the remaining 15 subjects was 4.2 s for liquid swallows without stimulation. Mean total transit times on the nonsensitized liquid swallows of the 10 patients whose total time could be measured ranged from 2.7 to 31.4 s with a mean of 8.2 s. Mean pharyngeal transit times during nonsensitized swallows of *paste* materials in the 18 patients who were given this consistency ranged from 9 to 12.7 s. The group mean for pharyngeal transit time for nonsensitized paste swallows was 4.1 seconds for the 18 patients. Normal pharyngeal transit time is a maximum of 1 s, and often less.

On nonsensitized swallows of paste for which measures of total transit times could be calculated from oral and pharyngeal transit times, the mean total transit time was 6.2 s. Normal total transit time is a maximum of 2 s for each material and often less.

In all nonsensitized swallows the bolus entered the pharynx before the reflex triggered and filled the valleculae and/or the pyriform sinuses before any reflexive velar, laryngeal, and pharyngeal movements were initiated. None of these patients aspirated.

Sensitized Swallows

On swallows of *liquid* following thermal sensitization, pharyngeal transit times were improved for 14 of the 17 patients for whom these times could be measured. Mean pharyngeal transit time was reduced from 4.2 to 2.4 s, excluding the two extremely delayed subjects whose improvement was over 20 s each. Pharyngeal transit time was reduced to within normal limits (1 s or less) for 50% of these 14 patients. For one of the patients, pharyngeal transit time remained unchanged. For two of the patients pharyngeal transit times were increased by a mean of 0.8 s.

On swallows of *paste* following thermal sensitization, pharyngeal transit times were improved from a mean of 4.1 s to a mean of 1.6 s for 16 out of 17, or 94%, of the patients. Pharyngeal transit time was reduced to within normal limits for five of the patients. For 1 of the 17 patients (#6), pharyngeal transit time was increased by 0.7 s.

Total transit times on *liquid* swallows were improved in nine of the ten patients for whom total transit times could be measured. The mean for nonsensitized swallows was 8.2 s which was reduced to 2.9 s after stimulation. One patient exhibited a 27-s improvement. Only one of these ten patients (#7) exhibited an increase in total transit time.

Table 2. Total transit time in seconds for the sequence of nonsensitized swallows and sensitized swallows in four subjects

	Nonsensitized		Sensitized	Nonsensitized			Sensitized
	1	2	3	4	5	6	7
Patient 1	6.9	7.2	2.1	1.9	6.3	7.2	1.9
Patient 2	5.8	4.1	2.2	4.0	4.5	–	2.4
Patient 3	3.8	3.6	2.7	3.5	3.7	–	–
Patient 4	3.5	6.8	2.9	2.8	6.1	–	–

Total transit times on *paste* swallows could be measured for 14 subjects. Total transit times were improved from a mean of 6.2 s on nonsensitized swallows to a mean of 4.0 s after sensitization for all 14, or 100%, of the patients. Total transit times were reduced to within normal limits in 29% of the patients.

In a second study, considered as a pilot project for future research, four patients received a series of two or three nonsensitized swallows of liquid following the sensitized swallow to determine the duration of the effect of the stimulation, i.e., its effect on subsequent swallows. The data on these four patients are shown in Table 2 and reveal that the effects of sensitization lasted for two to three swallows following the sensitization, but diminished by the third swallow. When sensitization was again applied, it again reduced the reflex delay in these four patients.

Discussion

Thermal sensitization improved triggering of the swallowing reflex in 23 of these 25 neurologically impaired patients on swallows of at least one consistency. Total transit time was improved in 82% of the patients for liquid swallows and in 100% of the patients for whom paste swallows were tested. The total speed of the swallow improved by a mean of 5.2 s for liquids and 2.2 s for pastes. These changes are large enough to reduce the chances of aspiration before the swallow that may result from a delayed reflex and reduce 37% of the total transit times to within normal limits. These improvements were immediate. That is, they occurred on the swallow following the sensitization and appeared to extend to one or two subsequent swallows. These data do not address the effect of this thermal stimulation or sensitization on overall neurophysiologic recovery of these patients. This issue needs to be addressed in further research.

Many measures were made while analyzing these swallows. The time measure that most accu-

rately assessed the effects of thermal sensitization was found to be total transit time (oral transit plus pharyngeal transit). In a patient who exhibits a delayed swallowing reflex, the point during the swallow that marks the termination of the (voluntary) oral phase and the initiation of the pharyngeal phase is arbitrarily defined as when the bolus passes the back of the tongue. In the absence of the normally occuring reflexive velar, laryngeal, and pharyngeal activities, this may not always be a consistent or reliable measure.

In this study none of the patients aspirated because of the small controlled amounts of material (1/3 teaspoon) that were used. It is very likely, however, that aspiration would have occurred in many cases if larger amounts of material would have been used, particularly on liquid swallows. This factor reinforces the importance of using the modified barium swallow test for diagnostic purposes. Because the patient is only given small amounts of material, the oral and pharyngeal stages of the swallow can be evaluated while minimizing the risk of aspiration.

Delay in the trigger of the swallowing reflex is one of the most frequently occurring swallowing disorders in neurologically impaired patients. It is theorized that providing cold thermal sensitization to the base of the anterior faucial arches heightens the sensitivity of the area so that when food or liquid is presented *and* the patient attempts a voluntary swallow, the reflex will be triggered more quickly. Clinicians have observed that the effects of this stimulation appear to continue for several nonsensitized swallows following the stimulated swallows and then to diminish. Pilot data on four subjects support this clinical observation.

The immediate effects and carryover of stimulation into subsequent swallows require further examination in a much larger number of patients, however. Unfortunately, the use of radiographic procedures to assess the triggering of the reflex limits the duration and design of such studies because repeating the swallows increases the patient's radiation exposure. Thus, some subject designs using repeated measures cannot be utilized. In clinical application, the therapist may not need to use stimulation before every swallow. Instead, in planning frequency of stimulation, the clinician may wish to assess the individual patient's reaction to the stimulation and the duration of that effect.

At our institution we have found that, in severely impaired patients with an absent reflex, it is likely that no reflex will be triggered after the stimulation and attempts to swallow (with or without liquid or paste) during the early sessions of reflex stimulation. Stimulation may need to be repeated several times daily for several weeks before a response is elicited. Progression of therapy in these patients is often slow, with restoration of feeding often taking up to a number of months.

A study is presently underway to examine long-term effects of thermal stimulation therapy to improve the swallowing reflex in a large number of patients who exhibit a severely delayed swallowing reflex. Other research is being conducted to examine further the immediate response of the swallowing mechanism to thermal sensitization in larger numbers of patients and to assess the carryover effect of this stimulation.

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