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Dysphagia

Effects of Nasogastric Tubes on the Young, Normal Swallowing Mechanism

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Abstract. The present study aimed to investigate the effects of different-sized nasogastric tubes on swallowing speed and function in 10 young normal volunteers. Using X-ray visualization, liquid barium swallows were recorded on video (videofluoroscopy) under three experimental conditions: no nasogastric tube, fine-bore nasogastric tube, and wide-bore nasogastric tube. Nasogastric tubes slowed swallowing but did not alter swallowing function, namely bolus transit and clearance, and airway protection. The presence of a wide-bore nasogastric tube caused significant duration changes in several swallowing measures, namely duration of stage transition, duration of pharyngeal response, duration of pharyngeal transit, and duration of upper esophageal sphincter opening. Similar trends were seen for the fine-bore tube. The implications for nonoral feeding of patients with swallowing disorders are discussed.

Key words: Nasogastric tubes — Swallowing — Duration measures — Swallowing speed and function — Deglutition — Deglutition disorders.

Dysphagia may be caused by a number of structural and neuromuscular disorders [1,2]. People with oropharyngeal dysfunction are at risk of developing respiratory complications due to aspiration or may become nutritionally compromised [3]. To prevent these complications, people with swallowing disorders are often fed nonorally. Nasogastric feeding is the most widely used nonoral feeding method [4]. However, there are several disadvantages to nasogastric feeding, including nasal ulceration, laryngeal injury, and pharyngeal discomfort [5]. Nasogastric tubes may also precipitate gastroesophageal reflux, which can lead to aspiration [6]. Nasogastric tubes are frequently self-extubated, especially in elderly or restless patients. Reintubation is labor intensive and distressing for the patient [4]. Reports have suggested that fine-bore nasogastric tubes are preferable to wide-bore tubes [4], but patients continue to be intubated with wide-bore tubes because they are less easily dislodged than fine-bore tubes [7].

Clinical evidence suggests that nasogastric tubes interfere with swallowing. However, the literature documenting the actual effects of nasogastric tubes on the swallowing mechanism is limited. Robbins et al. [8] conducted a study that contributed to an understanding of how a tube in the nasopharynx affects swallowing. They examined swallowing in normal adults of different ages and used manometry to measure pressure generation changes in the pharynx. The presence of a manometric tube led to a number of changes in swallowing, particularly in the duration of hyoid excursion and upper esophageal sphincter opening [8]. Because manometric and nasogastric tubes are passed through the nasopharynx into the esophagus, both types of tubes may have similar effects on swallowing. However, Robbins et al. [8] used only one size of manometric tube of unspecified circumference. Thus, conclusions regarding the effects of different size nasogastric tubes on swallowing cannot be drawn from their study. The aim of the present study was to evaluate the effects of two different-sized nasogastric tubes (wide and fine bore) on the speed and function of the young normal swallowing mechanism using videofluoroscopy. Temporal measures of swallowing events were used to determine swallowing speed. Nontemporal measures of swallowing function examined bolus containment, pharyngeal bolus clearance, and airway protec-

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tion mechanisms, which Dodds et al. [9] defined as the primary functions of swallowing.

Materials and Methods

The Research Ethics Committee of the University of Cape Town approved the study.

Subjects

The subjects were 10 young normal adults (three men, seven women) with an age range of 20–27 years (mean age-22.7 years). All were in good health. All subjects had normal oromotor, speech, and swallowing functions as assessed on a standard oral peripheral examination. None had undergone surgery to the head, neck, or digestive structures or used any medication that could interfere with swallowing function. All subjects were required to sign a consent form.

Data Collection

Equipment

Fluoroscopic examinations were performed in a radiological screening suite in the Radiology Department of Groote Schuur Hospital. The fluoroscopic unit consisted of a Shimadzu image intensifier and television chain at a screening setting of 30 MA, 75 kV. Subjects were exposed to a fluoroscopy dosage equivalent to 336 mR per 15-min maximum exposure period. The television monitor was linked to a Panasonic AG 6200 Videorecorder that recorded the fluoroscopic television image directly onto the 1-inch high quality videotape. The videorecorder had a built-in edit control facility that allowed for forward, rewind, slow motion, frame-by-frame analysis, and freeze-frame options. The control facility was used in slow motion to permit frame-by-frame analyses of the swallow motion and bolus transit times.

Procedure

All videofluoroscopic swallow studies were recorded in the erect lateral position. The subject's head faced forward in a neutral position, showing a lateral image of the posterior oral cavity, pharynx, and cervical esophagus. Each swallow view used 10–15 sec of fluoroscopy and was recorded from normal breathing through a solitary swallow to normal breathing. Subjects were required to swallow two 5-ml amounts of 96% (w/v) barium sulphate (EZ Paque-Protea Medical Laboratories) under three different experimental conditions.

- Condition 1: tube-out (no nasogastric tube)
- Condition 2: fine-bore nasogastric tube in situ (French gauge 8 × 85 cm length; Ven Medical Products)
- Condition 3: wide-bore nasogastric tube in situ (Levins tube, French gauge 16 × 122 cm length; Ven Medical Products)

The tube-out condition was always first in the experimental sequence. The order of the following two tube-in conditions was randomly decided for each subject. Intubation was conducted under radiologic guidance by a consultant radiologist. The tubes were lubricated with a nonanesthetic jelly and inserted transnasally into the esophagus. Liquid barium was syringed into the mouth with a 5-ml syringe. Subjects were instructed to hold the barium in the mouth and then to swallow it as a single bolus. This sequence was repeated for each condition to yield two swallows per condition. Six swallows were recorded per subject. A total of 60 swallows were recorded and submitted to visual temporal analysis.

The videotape was played on a Panasonic AG 6200 videorecorder and viewed on a Grundig PM 050 Colour Monitor. A built-in edit controller regulated playing speed. Initially, each swallow was viewed at normal and slow speeds. Several duration measures were then timed using the frame-by-frame facility as described in other studies [8,10]. Following the procedure outlined by Logemann [11], the number of video frames from the onset of the duration measure to its termination was counted. The frame counts were converted into seconds by multiplying by 0.04, which is the duration of one video frame in the PAL television system.

Swallowing Measures

For each recorded swallow, the following five duration measures of bolus movement and swallow events were obtained. All these measures have been described elsewhere [8,10].

1. Duration of velar elevation (DOVE) was calculated from the moment the maximal elevatory range of the velum was achieved until the moment of its release.
2. Duration of stage transition (DST) was measured from the moment the bolus head passed the mandibular ramus until maximal hyoid excursion was initiated.
3. Duration of pharyngeal response (DPR) was calculated from initiation of maximal hyoid elevation until the time the hyoid returned to rest.
4. Duration of pharyngeal transit (DPT) was measured from the time the bolus head arrived at the mandibular ramus to the time the bolus tail passed through the upper esophageal sphincter.
5. Duration of upper esophageal sphincter opening (DUESO) was calculated from the moment opening of the upper esophageal sphincter (UES) was seen to the time it closed.

In addition to the five temporal measures, three nontemporal measures of the swallows [10] were analyzed to examine swallowing function:

1. Adequacy of bolus containment demonstrated by the presence or absence of premature leakage of barium into the vallecular space prior to the swallow.
2. Adequacy of pharyngeal bolus clearance demonstrated by the presence or absence of barium residue in the valleculae or pyriform sinuses after the swallow.
3. Adequacy of airway protection mechanisms demonstrated by the presence or absence of any laryngeal penetration or aspiration. Penetration was defined as entry of material into the larynx. Aspiration was defined as penetration of material through the larynx below the level of the vocal cords [10].

Analysis of Data

Reliability

Twelve swallows were randomly selected from the data pool of 60 swallows. The judge responsible for making the original duration measures remeasured the duration measures of these swallows to calculate intrajudge reliability. A second judge experienced in temporal swallow analysis measured the same 12 swallows to provide a measure of interjudge reliability. The average intrajudge difference in scoring was 0.051 sec (1.27 video frames) for all duration measures. The average interjudge difference in scoring was 0.085 sec (2.13 video frames) for the duration measures. A Spearman-Brown correlation coefficient showed high correlations for all the measures ($r = 0.99$).

Similarly, intra- and interjudge reliabilities were calculated for the nontemporal measures using the same 12 swallows. There was complete intra- and interjudge agreement for all the nontemporal measures.

Statistics

Mean values of the five duration measures for each of the three conditions were calculated. One-way analysis of variance was used to determine whether statistically significant differences existed across the three conditions for each duration variable. Multiple range analyses using the least significant difference ($p < 0.05$) were performed to determine whether statistically significant differences occurred for individual duration measures between the three experimental conditions, namely conditions 1 and 2, 1 and 3, and 2 and 3.

Nontemporal measures were analyzed using frequency counts.

Results

Duration Measures

General Tube Effects

The presence of the wide-bore tube was associated with significant duration changes in four of the five duration measures, namely DST, DPR, DPT, and DUESO. Similar although less marked trends were associated with the presence of the fine-bore tube. Table 1 depicts the trend of duration changes in swallowing events in the presence of a nasogastric tube.

Table 1. Mean values (in seconds) of the five duration measures for the three conditions

Condition	DOVE	DST	DPR	DPT	DUESO
1	0.34	−0.14	1.09	0.68	0.65
2	0.56	−0.21	1.26	0.74	0.81
3	0.59	−0.23	1.43	0.79	0.92

DOVE, duration of velar elevation; DST, duration of stage transition; DPR, duration of pharyngeal response; DPT, duration of pharyngeal time; DUESO, duration of upper esophageal sphincter opening.

Tube Size

Statistically significant differences were found for DST, DPT, DPR, and DUESO between conditions 1 (no tube) and 3 (wide-bore tube) and between conditions 1 and 2 (fine-bore tube) for DUESO (Table 2). No statistically significant differences between the conditions were seen for DOVE (Table 2).

Table 2. Results of multiple range analyses between conditions

DOVE	DST	DPR	DPT	DUESO
1–2	1–2	1–2	1–2	1–2**
1–3	1–3*	1–3*	1–3*	1–3*
2–3	2–3	2–3	2–3	2–3

DOVE, duration of velar elevation; DST, duration of stage transition; DPR, duration of pharyngeal response; DPT, duration of pharyngeal time; DUESO, duration of upper esophageal sphincter opening.
Statistically significant differences ($p < 0.05$) are indicated between conditions 1 and 2 (*) and between conditions 1 and 3 (**).

Nontemporal Measures

Frequency counts for nontemporal swallowing measures suggested that adequacy of bolus containment, pharyngeal clearance, and airway protection was not influenced by the presence of either sized nasogastric tube.

Discussion

The main finding of this study was that the presence of a wide-bore nasogastric tube results in significant duration changes of swallowing events in young normal adults. Similar trends were seen for the fine-bore tube. Nasogastric tubes slowed swallowing but did not appear to affect swallowing function in young normal adults.

Duration Measures

Velar Elevation (DOVE)

Neither the presence of a tube nor tube size interfered significantly with velar elevation. However, DOVE values were longer for both tube-in conditions than for the tube-out condition, which may be related to elicitation of the gag reflex by a nasogastric tube. Five subjects gagged while swallowing with a tube in place. The velar elevation that occurred while gagging may have contributed to the longer DOVE values. In addition, premature velar elevation was seen in seven subjects with a tube in place. The tube may have simulated a bolus in the oropharynx, leading to premature triggering of the sequence of events that normally occur during swallowing, including velar elevation.

Stage Transition (DST)

It was expected that a tube would delay initiation of the pharyngeal swallow response and increase the DST values. The opposite occurred. There was a significant decrease in DST values for the wide-bore tube condition in comparison with the tube-out condition. A similar trend was seen for the fine-bore tube condition. Hyolaryngeal excursion, which signals the onset of the pharyngeal swallow response, occurred earlier with a nasogastric tube in place. This early hyolaryngeal excursion may have been an anticipatory behavior in response to the presence of the tube in the pharynx. Kidder et al. [12] observed anticipatory pharyngeal and laryngeal contractions during nasoendoscopy and considered these to be attempts to avoid pharyngeal discomfort. Because nasoendoscopy and nasogastric intubation both involve transnasal passage of a tube into the pharynx, early hyolaryngeal excursion seen in the present study and the anticipatory pharyngeal movements Kidder et al. observed during nasoendoscopy may be similar.

Alternatively, early hyolaryngeal elevation may be a compensatory behavior resulting in earlier closure of the laryngeal vestibule. Another possibility is that the tubes stimulated the pharyngeal wall and triggered the pharyngeal swallow response. This mechanical stimulation may help prevent aspiration by activating the swallow-induced glottal closure mechanism [13]. Early hyolaryngeal elevation, therefore, could facilitate swallowing because any penetration or aspiration of ingested material into the airway would be prevented. These findings suggest that a normal swallowing mechanism can compensate for the presence of a nasogastric tube during swallowing. This possibility needs to be investigated further in people with swallowing dysfunction. It is possible that a nasogastric tube could prevent aspiration by stimulating early closure of the laryngeal vestibule in a person with dysphagia.

It would also be interesting to examine the long-term effect of a nasogastric tube on triggering of the pharyngeal swallow response in young normal subjects and in subjects with oral and pharyngeal dysfunction. Sensory accommodation to the tube may counteract the earlier pharyngeal response triggering seen in this study, whereas prolonged accommodation of the tube may delay triggering of the pharyngeal swallow. This may hinder recovery of normal swallowing patterns in people with swallowing impairments and increase the likelihood of aspiration.

Pharyngeal Response (DPR)

DPR values were increased for the tube-in conditions, which implies that there was a longer period of hyoid excursion when a nasogastric tube was in place than when the tube was out. This may be attributable to two factors, namely earlier hyolaryngeal elevation and longer DUESO. Superior and anterior hyoid movements and UES opening are crucial components of the pharyngeal response [8,14]. UES opening depends on hyolaryngeal excursion to pull the cricoid lamina away from the posterior pharyngeal wall and open the UES prior to bolus arrival [14]. However, the nasogastric tube partially obstructs the UES which slows bolus flow through the sphincter and increases the duration of sphincteric opening needed to permit bolus transit [8]. Consequently, the duration of hyoid elevation must lengthen to maintain UES displacement. Thus, earlier hyolaryngeal elevation in combination with prolonged hyoid excursion contributed to the increased DPR for the nasogastric tube conditions.

Pharyngeal Transit (DPT)

DPT values were increased for the nasogastric tube conditions. The presence of a nasogastric tube possibly impeded bolus transit through the pharynx and UES and increased the overall bolus transit time. It would be useful to evaluate the impact of a nasogastric tube on pharyngeal structure, shape, and function using biomechanics and manometry. Slowed pharyngeal bolus transit due to a nasogastric tube may have clinical implications for patients with impaired oropharyngeal function. Thus, increased DPT may fatigue the swallowing mechanism in these patients and increase the likelihood of aspiration. Ultimately, a nasogastric tube may compromise the recovery and rehabilitation of patients with swallowing impairment.

Upper Esophageal Sphincter Opening (DUESO)

Both fine- and wide-bore nasogastric tubes significantly lengthened DUESO. Robbins et al. [8] made similar observations. They noted that even during rest the UES remained partially open to accommodate the manometric tube, which contributed to an increase in the overall length of DUESO. It would be interesting to perform manometric studies comparing UES pressure with fine- and wide-bore nasogastric tubes in place in normal subjects and patients with dysphagia. This comparison may clarify the interaction between a nasogastric tube, its size, and the function of the UES.

Nontemporal Measures

Neither size nasogastric tube appeared to cause any change in the studied swallowing functions, namely adequacy of bolus containment, pharyngeal clearance, and airway protection in young normal subjects. However, it would be beneficial to investigate these functions in subjects with oral and pharyngeal dysfunction who may not be able to compensate for the invasive nature of a nasogastric tube.

Conclusions

Wide- and fine-bore nasogastric tubes slowed swallowing but did not affect swallowing function in young normal adults. This result suggests that young normal swallowing mechanisms can compensate for the invasive effects of the tubes. A constant bolus volume of 5 ml was used in this study. However, the impact of the nasogastric tubes on swallowing may differ with different bolus volumes. Further studies could investigate smaller (2 ml) bolus volumes that simulate a saliva swallow and larger (20 ml) volumes that simulate normal bolus size.

It would be also be useful to determine the impact of nasogastric tubes on normal subjects who are older than 65 years because the majority of people receiving nasogastric feeding are in this age group. Additional studies are necessary to determine the effects of nasogastric tubes on subjects with oral and pharyngeal dysfunction. Nasogastric tubes slow swallowing in young normal adults. Thus, nasogastric tubes may detrimentally affect swallowing and swallowing recovery in persons with dysphagia. However, findings from the present study suggest that nasogastric tubes may be able to prevent aspiration by stimulating earlier closure of the laryngeal vestibule. Therefore, people with impaired swallowing may in fact benefit from a nasogastric tube for the purpose of airway protection; this needs to be investigated further.

The present study has important clinical implications for nonoral feeding. Fine-bore as opposed to wide-bore nasogastric tubes slowed swallowing less in young normal subjects. This observation suggests that fine-bore tubes affect swallowing less than wide-bore tubes. This finding needs further investigation in persons with swallowing dysfunction. However, in instances where nasogastric feeding is essential, fine-bore rather than wide-bore tubes should be used. Although the long-term effects of nasogastric tubes on swallowing recovery still need to be investigated, alternatives to long-term nasogastric feeding such as percutaneous endoscopic gastrostomy (PEG) should be considered whenever possible. PEG feeding eliminates the need for a tube in the pharynx. Thus, persons with dysphagia who are fed via PEG may recover speech and swallowing faster than those fed nasogastrically [15]. However this still needs to be examined and is an important area of multidisciplinary research on dysphagia.

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