

## The videofluoroscopic view of pill swallowing disorder in young patients

The radiophysiology of pill swallowing disorder

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### Abstract

**Aim:** The aim of the study was to evaluate the increasing frequency of pill swallowing disorders in young people, to compare pill intake by measuring fluid, semi-fluid pudding with anatomical and physiological images of videofluoroscopy.

**Material and Methods:** Twenty patients (eleven females, nine males) between the ages of 20 and 31 who had difficulty swallowing pills were included in the study. In an order of a cup of 20 ml of water, semi-fluid pudding and an opaque capsule were given. The oral, pharyngeal transition times and laryngeal elevation, proximal esophageal sphincter opening amount, upper esophageal opening amount were recorded for each.

**Results:** There was a statistically strong positive correlation between the total transit time of the pill and the amount of upper esophageal opening. The esophageal opening amount while the liquid intake was found to affect the esophageal opening of pill intake ( $p < 0, 001$ ). The laryngeal elevations of the pill affected pill oral transit times ( $p < 0, 01$ ). The pill pharyngeal passage time has been found to affect the pill upper esophageal opening amounts ( $p < 0,01$ ).

**Discussion:** The increased duration of the oral and pharyngeal phases for pill swallowing was found to be correlated with the amount of upper esophageal opening area, laryngeal elevation, and the prolonged pharyngeal transition time.

As a new finding, we observed that the fluid oropharyngeal transition times were found to affect pill oropharyngeal transition times. We concluded that the pill could not decrease laryngeal elevation and pharyngeal transit duration.

### Keywords

Pill swallowing; Videofluoroscopy; Pharyngeal transition

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## Introduction

Dysphagia is a condition that may occur due to structural, neurological, obstructive disorders. The subtitle of pill swallowing disorder has been studied in children, elderly people. This problem is getting common, especially in the young population who have been evaluated in studies [1]. For radiological evaluation, video-pharyngo-esophagography is a method used showing real-time functional images and pathologies, if any, from the formation of bolus (bite + saliva) to transport, especially in oro-pharyngeal and pharyngo-esophageal passages [2].

The aim of the study was to evaluate the swallowing function parameters of individuals with pill swallowing disorder radiologically.

## Material and Methods

A total of 20 patients with dysphagia diagnosed between 2018 and 2020 at the Gastroenterology Clinic due to difficulty in swallowing pills were included in the study. The study was approved by the local university Ethics Committee dated 27/02/2019, approval number 61351342-/2019-122. Written informed consent was obtained from patients who participated in this study. Our study included a total of 20 patients who applied to the Gastroenterology Clinic between 2018 and 2020 with the diagnosis of dysphagia. The patients who had aspiration pneumonia between 20 and 35 years of age, cranial nerve involvement, psychological disease, gastroesophageal reflux, and obstructive gastrointestinal tract mass, neurological and orthopedic diseases were excluded from the study. We used to evaluate the number and volume of swallows with a 100 ml water swallowing test (WST) where 100 ml of water is drunk by a person as quickly as possible sitting in upright position. The number of swallows until emptying the glass and the time until the larynx returns to the resting position in the last swallow was recorded. The time for swallowing was divided by the number of swallows; for each swallowing volume, the total amount of water is divided by the number of swallows. Later, EAT (eating assessment tool)-10 test was used to determine the severity of oropharyngeal dysphagia.

There are a total of 10 questions in this survey. Each question was responded 0-4, ranging from never to always. The total score is calculated as 40. If the total score obtained is two and above, it indicates that there is a swallowing problem. Then, patients underwent videofluoroscopy (VF) (barium swallowing study). VF examination is one of the objective methods and gold standard in evaluating the oral, pharyngeal, and esophageal phases of swallowing [3-5]. The patient was brought in a sitting position. First, the individuals drank 20 ml of pineapple juice. Pine-apple juice has been preferred to improve image quality. Then, pudding composed of 60% of 20 cc opaque substance (iopamidol) was given to the individuals. At the end, patients were asked to swallow the pill (empty of ingredients and ½ granulated sugar and ½ opaque substance (Figures 1-3). In all three applications, laryngeal elevation, PES opening amount, oral transit time, oropharyngeal transition time, pharyngeal transition time, total transit time, and upper esophageal opening amount parameters were recorded.

## Statistical analysis

SPSS version 22.0 statistical software was used to perform statistical analysis of our data. After descriptive statistics were recorded, the Mann-Whitney U test was used for inter-group comparisons of nonparametric data. When evaluating operating data, the plausibility of the parameters with the normal distribution was assessed by the Kolmogorov-Smirnov test.

A correlation analysis between the quantitative datas was performed by using the Spearman rank test. Simple linear regression analysis was used to see the impact rates of the variables that are related.  $P < 0.05$  was considered statistically significant.

## Results

In our study, there were 9 (45.0%) males and 11 (55.0%) females. The average age of the participants was  $23.40 \pm 2.14$  years. Three (15.0%) individuals with smoking and 9 (45.0%) with alcohol intake habits were identified, providing they did not use them regularly.

There was a statistically strong positive correlation between the total transit times of the pills and the amount of upper esophageal opening (mm) ( $p < 0.001$ ). In other words, while the total transition time of the pills had increased, the amount of the esophageal opening increased (Table 1).

The fluid oropharyngeal transition times were found to have an effect on pill oropharyngeal transition times ( $F(1,18) = 7.154$ ;  $p < 0.05$ ). Liquid oropharyngeal transition times affected 28.4% of pill oropharyngeal transition times. In other words, 28.4% of pill oropharyngeal transition times were explained by the symptoms of fluid oropharyngeal transition times.

The esophageal opening amount while the liquid intake was found to affect the esophageal opening when taking pill ( $F(1,18) = 25,220$ ;  $p < 0, 001$ ). The liquid upper esophageal opening amounts affected 58.4% of the pill upper esophageal opening amounts. It means that, 58.4% of pill upper esophageal opening amounts were explained by the symptoms of liquid upper esophageal opening amounts.

The laryngeal elevations of the pill had an effect on pill oral transit times ( $F(1,18) = 15,797$ ;  $p < 0, 01$ ). Laryngeal elevations of the pill affected 46.7% of pill oral passage times.

In other words, 46.7% of pill oral passage times were explained by the symptoms of laryngeal elevations of the pills.

The laryngeal elevations of the pill were found to have an effect on the upper esophageal opening amounts of the pills ( $F(1,18) = 20.387$ ;  $p < 0, 01$ ). Laryngeal elevations of the pill affected 83.7% of the pill upper esophageal opening amounts. It means that, 83.7% of pill upper esophageal opening amounts were explained by the symptoms of laryngeal elevations of the pills. Pill PES opening amounts were found to have an effect on the pharyngeal transition time of the pill ( $F(1,18) = 56.478$ ;  $p < 0,01$ ). Pill PES openings affected 75.8% of pill pharyngeal transition time. In other words, 75.8% of the pill pharyngeal transition time was explained by the PES opening amounts.

Pill pharyngeal transition time was found to have an effect on the pill oral transit time ( $F(1,18) = 7.582$ ;  $p < 0,05$ ). Pill pharyngeal passage time affected 29.6% of pill oral passage time. It means that, 29.6% of the pill oral passage time was explained by the symptoms of pill pharyngeal passage time. The

**Table 1.** Assessing relationships between the pill ingest values

		Pill Laryngeal Elevation	Pill Pes opening amount	Pill oral transit time	Pill oropharyngeal transition time	Pharyngeal Transition Time	Total transit time	Esophageal opening amount
Pill Laryngeal Elevation	r	1,000	,780	,836	,706	,710	,825	,770
	p	.	,000**	,000**	,001**	,000**	,000**	,000**
Pill Pes opening amount	r	,780	1,000	,722	,863	,899	,718	,937
	p	,000**	.	,000**	,000**	,000**	,000**	,000**
Pill oral transit time	r	,836	,722	1,000	,859	,812	,998	,729
	p	,000**	,000**	.	,000**	,000**	,000**	,000**
Pill oropharyngeal transition time	r	,706	,863	,859	1,000	,915	,866	,814
	p	,001**	,000**	,000**	.	,000**	,000**	,000**
Pharyngeal Transition Time	r	,710	,899	,812	,915	1,000	,818	,876
	p	,000**	,000**	,000**	,000**	.	,000**	,000**
Total transit time	r	,825	,718	,998	,866	,818	1,000	,721
	p	,000**	,000**	,000**	,000**	,000**	.	,000**
Esophageal opening amount	r	,770	,937	,729	,814	,876	,721	1,000
	p	,000**	,000**	,000**	,000**	,000**	,000**	.

\*p<.05    \*\*p<.01

**Table 2.** Swallowing function parameters detected with videofluoroscopic evaluation

Subject	Object	B	Standard deviation a B	β	t	p
Liquid oral phase	Constant Pill Total Phase	,199	,010		20,509	,000
		-,042	,016	-,533	-2,675	,015
R= ,533	R2= ,284		F(1,18) = 7,154			p=,015*
Liquid upper esophageal opening amount	Constant Esophageal opening amount	1,405	,057		24,711	,000
		,203	,040	,764	5,022	,000
R= ,764	R2= ,584		F(1,18) = 25,220			p=,000**
Pill Laryngeal Elevation	Constant	,649	,230		2,824	,011
	Pill oral transit time	,263	,066	,684	3,975	,001
R= ,684	R2= ,467		F(1,18) = 15,797			p=,000**
Pill Laryngeal Elevation	Constant	,071	,155		,458	,652
	Pill upper esophageal opening amount	1,057	,110	,915	9,598	,000
R= ,915	R2= ,837		F(1,18) = 20,383			p=,000**
Pill Pes opening amount	Constant	-,015	,055		-,278	,784
	Pharyngeal Transition Time	2,220	,295	,871	7,515	,000
R= ,871	R2= ,758		F(1,18) = 56,478			p=,000**
Pharyngeal Transition Time	Constant	,085	,031		2,762	,013
	Pill oral transit time	,024	,009	,544	2,754	,013
R= ,544	R2= ,296		F(1,18) = 7,582			p=,013*
Pharyngeal Transition Time	Constant	,003	,016		,194	,849
	Pill Upper esophageal opening amount	,125	,012	,931	10,829	,000
R= ,931	R2= ,867		F(1,18) = 117,262			p=,000**

\*p<.05    \*\*p<.01

pill pharyngeal passage time were found to have an effect on the pill upper esophageal opening amounts (F (1,18) = 11,262; p <.01). Pill pharyngeal transition time affected 86.7% of pill upper esophageal opening amounts. It means that, 86.7% of pill upper esophageal opening amounts were explained by the symptoms of pill pharyngeal transition time (Table 2).

**Discussion**

We selected a young population group in our study, with swallowing disorder of pill having the mean age of 23.40 ± 2.14

years. In the literature, this problem has been mentioned in the adolescence and child age group [6] and younger patients and women [7]. There is also literature indicating the young age group and children with this problem [7,8]. Also, existing literature mentioned that common occurrence of swallowing problems in women can be related to increased stress [9]. In our study, there were 9 (45.0%) male and 11 (55%) female patients. VF is an objective radiodiagnostic method to evaluate swallowing characteristics of liquids, soft foods, many swallowing abnormalities, such as delayed swallowing



**Figure 1.** Pineapple juice passage



**Figure 2.** Pudding passage



**Figure 3.** Pill passage

reflex, residue after swallowing, insufficient passage to the esophagus, regurgitation of swallowed food [3-5], that is why we preferred VF in our study.

Swallowing disorder is a problem of functional and anatomical differences related to age, gender, congenital reasons, or some diseases, and can also be explained by various dosage forms of pill [7,10]. In summary, the reasons have been explained by physiological processes and anatomical differences concerning the dimensions and function of mouth, pharynx, upper esophageal sphincter, and esophagus [7].

After the food is taken, it is processed with saliva and sent to the pharynx voluntarily. Thus, the involuntary pharyngeal phase is triggered. The muscles of soft palate almost all is innervated by the pharyngeal branches of the vagus and motor branch of the mandibular nerve (CN V/III) (tensor veli palatini). The soft palate closes nasopharynx; the larynx rises and bends forward; true and false vocal cords close, and pharyngeal constrictors contract sequentially, pushing the nutrient bolus into the esophagus. The upper esophageal sphincter (cricopharyngeal muscle) (UES) is innervated by the pharyngeal branches of vagus, ansa cervicalis (c1-c2-c3), and sympathetic nerves (from cervical ganglion). It relaxes simultaneously and remains open to receive the bolus of food. Then this bolus of food is delivered to the stomach through peristaltic movements. Problems in one or all of these stages cause swallowing disorder [11]. The three stages of swallowing are irrelevant to each other [12,13]. The brain stem associates three phases in consequence and the peripheral effects of stages depend on sensory feedback reflexes which are about the volume and consistency of the bolus. The reflexes of the pharynx and esophagus depend on the characteristics of the bolus. Reflexes that initiate the pharyngeal phase of swallowing also inhibit the esophageal phase, which ensures the proper timing of its formation to ensure effective bolus transport and prevents the occurrence of multiple esophageal peristaltic events [12-16]. During swallowing of the pill, the prolonged oral transit that is between the volunteer and unvolunteer phases may cause the disconnection of peripheral manifestations of pharyngeal reflexes with brain stem timing [3].

In our study, the increased duration of the pill between oral and pharyngeal phases was found correlated with the amount of upper esophageal opening, laryngeal elevation, and the prolonged pharyngeal transition time.

We observed that pill pharyngeal transition time showed correlation with laryngeal elevation (46.7%) and upper esophageal opening amount (75.8%) in a positive way. The increased amount of upper esophageal opening caused prolonged pharyngeal pill transition time and increased laryngeal elevation, which in turn would facilitate the opening of the UES. Pill pharyngeal transition time was approximately one-third of the pill oral transition time.

In our study, the fluid oropharyngeal transition times were found to have an effect on pill oropharyngeal transition times. This meant that a similar pattern of oral transport occurred while taking fluid and pill. This was different from the literature mentioning that the oral transport of the liquid bolus and solid food was different. During the liquid passage, the oral cavity and pharynx were separated rigidly whereas during food processing, open communication between the oral cavity and

pharynx was observed [17, 18].

The literature reported that an increase in bolus volume has no effect on the duration of oral and pharyngeal bolus transit times or pharyngeal peristaltic waves but leads to prolonged UES clearance, longer laryngeal closure time, and longer swallowing apnea [13, 19, 20]. As our study points out, the increased duration of the pill between oral and pharyngeal phases was found correlated with the amount of upper esophageal opening, laryngeal elevation, and the prolonged pharyngeal transition time.

### Conclusion

In our study, we evaluated the difficulty of swallowing pills by radiophysiological approach. Surprisingly, the passage of fluid in the oral cavity was determinative for the pill transport; maybe this observation should excite whether the pill behaves like a fluid but captured like solid when it could not decrease laryngeal elevation and pharyngeal transit duration.

### Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

### Animal and human rights statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

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### Conflict of interest

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### References

1. Llorca PM. Discussion of prevalence and management of discomfort when swallowing pills: orodispersible tablets expand treatment options in patients with depression. *Ther Deliv.* 2011; (5): 611-22.
2. Gerek M, Çiyiltepe M. Videofluoroscopic Evaluation in Swallowing Disorder. *KBB ve BBC Dergisi*, 2004;12 (2): 89-100.
3. Cassiani RA, Santos CM, Parreira LC, Dantas RO. The relationship between the oral and pharyngeal phases of swallowing. *Clinics (Sao Paulo)*. 2011; 66(8):1385-8.
4. Imam H, Shay S, Ali A, Baker M. Bolus transit patterns in healthy subjects: a study using simultaneous impedance monitoring, videoesophagram, and esophageal manometry. *Am J Physiol Gastrointest Liver Physiol.* 2004;288(5):G1000-6.
5. Miles A, Clark S, Jardine M, Allen J. Esophageal swallowing timing measures in healthy adults during videofluoroscopy. *Ann Otol Rhinol Laryngol.* 2016; 125(9): 764-9.
6. Hansen DL, Tulinius D, Hansen EH. Adolescents' struggles with swallowing tablets: barriers, strategies and learning. *Pharm World Sci.* 2008; 30(1):65-9.
7. Schiele JT, Quinzler R, Klimm HD, Pruszydlo MG, Haefeli WE. Difficulties swallowing solid oral dosage forms in a general practice population: prevalence, causes, and relationship to dosage forms. *Eur J Clin Pharmacol.* 2013;69(4):937-48.
8. Dantas RO, Alves LM, Santos CM, Cassiani Rde A. Possible interaction of gender and age on human swallowing behavior. *Arq Gastroenterol.* 2011; 48(3):195-8.
9. Aldridge KJ, Taylor NF. Dysphagia is a common and serious problem for adults with mental illness: a systematic review. *Dysphagia.* 2012;27(1):124-37.
10. Ney DM, Weiss JM, Kind AJ, Robbins J. Senescent swallowing: impact, strategies, and interventions. *Nutr Clin Pract.* 2009; 24 (3):395-413.
11. Boesch RP, Daines C, Willging JP, Kaul A, Cohen AP, Wood RE, et al. Advances in the diagnosis and management of chronic pulmonary aspiration in children. *Eur Respir J.* 2006;28(4):847-61.
12. Lang IM. Brain stem control of the phases of swallowing. *Dysphagia.* 2009;24(39):333-48.
13. Butler SG, Stuart A, Castell DO, Russel BG, Koch K, Kemp S. Effects of age, gender, bolus condition, viscosity, and volume on pharyngeal and upper esophageal sphincter pressure and temporal measurements during swallowing. *J Speech Lang Hear Res.* 2009;52(19):240-53.
14. Castell JA, Dalton CB, Castell DO. Effects of body position and bolus consistency on the manometric parameters and coordination of the upper esophageal sphincter and pharynx. *Dysphagia.* 1990;5(4):179-86.

15. Dantas RO, Kern MK, Massey BT, Dodds WJ, Kahrilas PJ, Brasseur JG, et al. Effect of swallowed bolus variables on oral and pharyngeal phases of swallowing. *Am J Physiol.* 1990;258(5):G675-81.
16. Mendell DA, Logemann JA. Temporal sequence of swallow events during the oropharyngeal swallow. *J Speech Lang Hear Res.* 2007;50(5):1256-71.
17. Hiimeae KM, Palmer JB. Food transport and bolus formation during complete feeding sequences on foods of different initial consistency. *Dysphagia.* 1999;14(1):31-42
18. Matsuo K, Hiimeae KM, Palmer JB. Cyclic motion of the soft palate in feeding. *J Dent Res.* 2005;84(1):39-42.
19. Tsukada T, Taniguchi H, Ootaki S, Yamada Y, Inoue M. Effects of food texture and head posture on oropharyngeal swallowing. *J Appl Physiol.* 2009;106(6):1848-57.
20. Cook IJ, Weltman MD, Wallace K, Shaw DW, McKay E, Smart RC, et al. Influence of aging on oral - pharyngeal bolus transit and clearance during swallowing: scintigraphic study. *Am J Physiol.* 1994;265:G972-7.

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