Original Article

Food and Liquid Consistency Modification for Safe Swallowing in Elderly with Dysphagia Risk

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ABSTRACT

Objectives: This study aimed to evaluate the effect of food and liquid consistency modification on swallowing safety in healthy elderly with dysphagia risk.

Study design: Cross-sectional analytical study.

Setting: Outpatient clinic, Department of Rehabilitation Medicine, and Radiology Unit, Faculty of Medicine Ramathibodi Hospital, Mahidol University.

Subjects: Healthy elderly age > 65 who had mild to moderate dysphagia symptom, as defined by the 10-item Eating Assessment Tool (EAT-10) score ≥ 3

Methods: Each participant was performed a water swallowing test (WST), oropharyngeal physical examination, and videofluorographic swallowing study (VFSS). A bolus test, including four varying liquid consistencies and four modified food textures according to the International Dysphagia Diet Standardisation Initiative (IDDSI), was investigated. The Penetration-Aspiration Scale (PAS) was used to identify a primary outcome of safe swallow, which scores ≥ 2 was considered a high risk of penetration and aspiration. The residue in the oropharyngeal area was demonstrated by a pooling score (P-score), which was abnormal if ≥ 6. The pharyngeal transit duration (PTD) was also illustrated.

Results: Thirty-four subjects with a mean age of 72.0 (SD 6.8) years and mean EAT-10 score of 5.3 (SD 2.4) underwent VFSS. None of the subjects showed aspiration. The large volume of thin liquid (10 mL) revealed the highest frequency of penetration, 20.6%. There was no penetration during the test with 4 mL of moderately thick, extremely thick liquids, and all modified foods. A 10 mL of thin liquid and a pureed food were the highest occurrences of residue, 23.5%. Average PTD of regular food was the slowest at 120 ms, while small volume (4 mL) of thin liquid was the fastest at 69 ms.

Conclusion: In the elderly with dysphagia risk, a large bolus of thin liquid constituted the highest risk of penetration and aspiration. No penetration was found during the modified food test. However, a high frequency of abnormal pooling of residue was found after swallowing a pureed food and a large amount of liquid

Keywords: deglutition disorder, oropharyngeal dysphagia, food

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Introduction

Age-related change in swallowing mechanism (presbyphagia) is common among healthy senior citizens, with a prevalence of 40% in 65 years old or older.[1] There are many serious potential consequences of this condition, including malnutrition, dehydration, suffocation, aspiration, and aspiration pneumonia.[2,3]

There are several mechanisms by which presbyphagia can impair the swallowing process.[4,5] Regarding the oral phase of swallowing, tongue atrophy due to sarcopenia leads to a decrease in bolus propulsion force from oral to the pharyngeal cavity. Impaired oral sensation contributes to food sticking or pocketing in the oral cavity.[6] In some aging people, loss of tooth causes inadequate chewing of food. Age-related reduction of saliva production makes insufficient bolus forming, causing bolus transports to pharynx to be impaired.[7] In the pharyngeal phase, weakness of suprahyoid muscle and pharyngeal constrictor muscles cause bolus retention in vallecula and pyriform sinus area. Longer duration of swallowing results from decreasing pharyngeal sensation, the risk of laryngeal penetration and tracheal aspiration can be more pronounced.[5-7] Aspiration pneumonia also occurs commonly in those having aspiration.[4-8] To detect these symptoms of swallowing disorder, screening and self-assessment tests are popularly performed.

The common tests for swallow assessment include the water swallowing test (WST)[9] and the 10-items Eating

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Assessment Tool (EAT-10).[10] The WST is easily practiced as bedside screening, and the EAT-10 is frequently used to appraise the swallowing disorder by self-evaluation. However, these two techniques are used for screening of dysphagia risk. The videofluorographic swallowing study (VFSS) is a gold standard examination for detecting dysphagia and aspiration.[11,12] It also gives information on how to rehabilitate patients with dysphagia.

Food and liquid modification is a core component of swallowing rehabilitation in the elderly.[13] By changing a rate of eating and the physical properties of foods or liquids such as hardness, cohesiveness, and consistency, a bolus formation from oral to esophagus becomes more comfortable and safer. As a consequence, risks of bolus residue, choking, and suffocation decline. The International Dysphagia Diet Standardisation Initiative (IDDSI) has proposed standard terminology of food consistency and food texture modification.[14] A study from Catriona et al.[15] reported that thin liquid (IDDSI level 1) with low consistency and rapid flow rate increased the risk of laryngeal penetration, whereas mildly and moderately thick liquid (IDDSI level 2 and 3) with higher consistency and low flow rate decreased laryngeal penetration and aspiration. Homogenous consistency food (pureed food; IDDSI level 4) promotes comfortably chewing process, and reduces aspiration risk, as well as the study of Bingjie et al.[16] and Chen et al.[17] reported the same result.

There were many recommendations regarding food and liquid modification for patients with stroke and other neurological diseases. However, a study in the elderly with a subjective swallowing problem, but apparently healthy, was still lacking. Therefore, this study aimed to evaluate the effect of food and liquid texture modification of Thai foods in the aging population who had dysphagia risk.

Methods

Participants

We recruited volunteered participants from the outpatient Department of Rehabilitation Medicine, Faculty of Medicine, Ramathibodi Hospital, Mahidol University, during May 2017 – September 2017, with the following inclusion and exclusion criteria.

Inclusion criteria

- Age ≥ 65 years
- EAT-10 score ≥ 3
- Able to follow commands

Exclusion criteria

- Unable to communicate and answer the EAT-10
- Uncontrolled medical condition including unstable vital sign, and COPD or asthma exacerbation
- Allergy to contrast media
- History of disease or disorder that altered swallowing function such as stroke, Parkinson's disease, Alzheimer, motor neuron disease, multiple sclerosis, oropharyngeal anatomical distortion from head and neck cancer, and achalasia

Sample size calculation

After reviewing literature, the study of Kenichiro et al was selected for sample size calculation.[18] The study reported that the proportion of modified food and liquid penetration during the VFSS examination was 0.22. The power of 0.8 was set to determine the significant difference (5% type I error and 20% type II error). The sample size was calculated and a sample size of 34 participants was required.

Procedure

After obtaining informed consent, the EAT-10 (Thai version) questionnaire was completed by participants. For the illiterate subjects, one of the researchers read the questionnaire to the patients, asked them to answer, and filled in the form for them. Only those with the EAT-10 score of 3 or higher was defined as having dysphagia risk and the researcher proceeded to the next step.

Every subject received a dysphagia related physical examination and a water swallowing test (WST). The physical examination items included mouth opening, lip closure, tongue movement, and laryngeal excursion. For the WST, they swallowed 3 mL, 10 mL, and 50 mL of water. Change of respiratory rate ≥ 10% from baseline, choking, or wet voice after swallowing trials were considered abnormal and considered to fail the WST.[19] Next, they were scheduled for a VFSS.

The VFSS videos were acquired on a fluoroscopy (OmniDiagnost Eleva DI; Philips, Amsterdam, Netherland), carried out in lateral projection, at a frame rate 30 frames per second. The video was recorded by a digital video camera (Exmor R; Sony, Tokyo, Japan). The participants were comfortably sat in a wheelchair in an upright position. Different textures and consistencies of liquid and food mixed with contrast media were administered in order, as shown in Figure 1.

A fried rice was used as a regular diet sample, and as a base material for the preparation of other modified food consistency by the Institute of Nutrition, Mahidol University. All liquids were presented to the mouth of subjects in a 10 mL syringe. Pudding and foods were presented to the subjects in a regular tablespoon. Different consistencies of liquid and food texture modification were based on the IDDSI levels. An examiner gave a verbal cue for each participant to start each swallowing test. The VFSS was monitored live so that if aspiration were seen during the examination, the procedure would be stopped. Resuscitation and airway management were prepared ready for use within the examination room. If the residue was found at each bolus tested after first swallowing, the participant was instructed to repeat swallowing until there was no leftover bolus. In case of inability to clear the residue, transoral suction would be applied to empty the retention.

Outcome measurement

The demographic data were recorded. These include age, sex, body mass index (BMI), the EAT-10, and physical

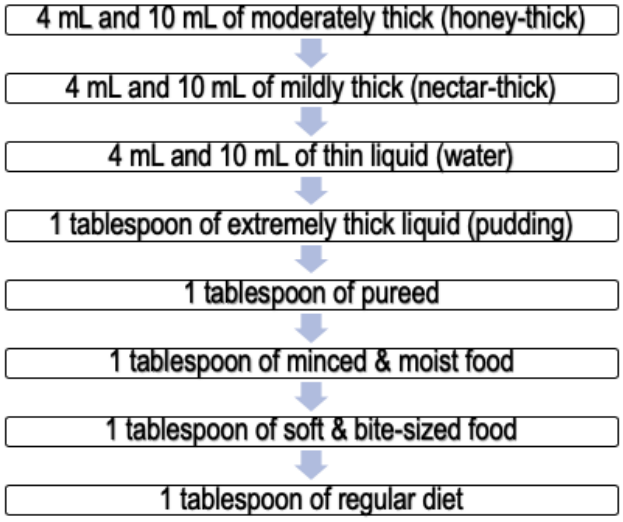

Figure 1. The order of liquid and food administration

examination findings. The VFSS video records were reviewed in a slow motion with frame-by-frame viewing when needed.

The severity of laryngeal penetration and aspiration of each swallowing conditions was assessed and scored separately according to the penetration aspiration scale (PAS) scoring criteria.[20,21] A score of 1 was given in case there was no observable penetration. Those with varying degrees of penetrations and aspirations received a score of 2 or greater. For the sake of this study, all of these were considered abnormal. The rating scale of PAS is shown as follows:

Score	Definition
1	No entry of bolus into larynx or trachea (no penetration or aspiration)
2	Penetration, entry of bolus into larynx above vocal cord and expelled out
3	Penetration, entry of bolus into larynx above vocal cord but
4	not expelled out
5	Penetration, bolus contacts vocal cord and expelled out Penetration, bolus contacts vocal cord but not expelled out
6	Aspiration, bolus enters the trachea and expelled out to larynx or pharynx
7	Aspiration, bolus enters the trachea but not expelled out following attempts
8	Aspiration, bolus enters the trachea without attempts to expel

The severity of bolus retention in the larynx was classified according to the pooling score (P-score).[22] It comprises of 3 domains: location, amount of residue, and the number of repeated swallowing needed to clear residue. The P-score of 6 and higher were considered abnormal. The P-score definition was illustrated as follows:

The pharyngeal transit duration (PTD) was recorded as the time from when the bolus head pass the ramus of mandible, to the time when the tail of the bolus has passed into the upper esophageal sphincter (UES). All scoring and timing were measured by one of the authors (BK) and reviewed by another (PB). If conflicting scores were found, the video recordings and the data forms were reviewed until an agreement was reached.

P-score		Score
Location of residue	Valleculae	1
	Pyriform sinus	2
	Larynx/vocal cord	3
	Below larynx	4
Amount	Coating	1
	Minimum	2
	Maximum	3
Management to clear the residue (repeated swallow)	< 2	2
	2 – 5	3
	> 5	4
Total score	No dysphagia	4-5
	Mild dysphagia	6-7
	Moderate dysphagia	8-9
	Severe dysphagia	10-11

Statistical analyses

The STATA version 15 (Stata Corp LLC, Texas, USA) was used to analyze the result. The Shapilo-Wilk test was used to evaluate the normality of data distribution. The demographic data were reported as frequency and mean (SD). The PAS score and P-score were shown in the frequency of abnormality, which was PAS ≥ 2 and P-score ≥ 6. The PTD of each liquid and food type were compared by using ANOVA. The $p < 0.05$ was considered to be a statistical significance.

This study was approved by the Committee on Human Rights Related to Research Involving Human Subjects, Faculty of Medicine Ramathibodi Hospital, approval number ID12-59-02.

Results

Table 1 shows the demographic data of 34 participants (19 females and 15 males) enrolled in this study. The mean age was 72.0 (SD 6.8) years old. The EAT-10 score was 5.8 (SD 2.4), which was mild to moderate dysphagia risk. Thirty-two participants passed all WSTs. Only two participants had a post-swallowing cough when tested with 50 mL of water. The PE findings were normal in all participants.

Modified liquid swallowing test (Table 2)

The first and second-largest percentage of subjects with a "failed" PAS score of 2 or greater, were found in the case of large volume 10 mL of thin liquid test (20.6%) and the case of small volume 4 mL of thin liquid (14.7%). 5.9% of the subjects showed abnormal PAS when swallowing 10 mL and 4 mL of thick liquid. Only one subject (2.9%) demonstrated abnormal PAS during the test with 10 mL of moderately thick liquid. The rest of the liquid swallowing tests were free from penetration.

Some subjects showed abnormal pooling, as defined by P-score of 6 or higher, in every liquid bolus condition tested. VFSS test with 10 mL thin liquid, resulted in the highest rate

Table 1. Demographic data of 34 participants

Data	Results
Sex, Male[1]	15 (44.0)
Age[2]	72 (7)
BMI2 (kg/m^2)	25.8 (4.9)
EAT-10[2]	5.8 (2.4)
Physical examination[1]	
- Normal mouth opening	34 (100.0)
- Normal lip closure	34 (100.0)
- Normal tongue movement	34 (100.0)
- Normal Laryngeal elevation	34 (100.0)
WST (passed the screening test)[1]	
- 3 mL (MWST)	34 (100.0)
- 10 mL	34 (100.0)
- 50 mL	32 (94.1)

[1]Mean (SD), [2]number (%)

BMI, body mass index; WST, water swallowing test; MWST, modified water swallowing test

of abnormal P-score of 23.5%, followed by 10 mL of mildly thick liquid (nectar) and 10 mL of moderately thick liquid, 17.7%. When compared in the same type of liquid, a more massive amount (10 mL) had a more abnormal P-score than a lesser amount (4 mL).

The slowest and the fastest PTD among the liquid swallowing test were the pudding-like (extremely thick liquid) at 97 msec, and the 4 mL-thin liquid at 69 milliseconds. There was an observable trend showing faster PTD in smaller volume and thinner consistency liquid than in larger volume and thicker consistency. There was a significant difference in PTD between 10 mL thin liquid, 71 (SD 23) ms, and extremely thick liquid, 97 (SD 33) ms, *p*-value = 0.003, 95%CI 13-38.

Modified food swallowing test (Table 2)

There was no penetration and aspiration seen during VFFS while testing with any type of modified food. The average P-score during thick pureed food swallowing condition was the highest among all the food swallowing tests at 23.5%, followed by minced and moist (20.6%), and regular diet (17.7%). As regarding PTD, swallowing regular food was the most prolonged (120 msec). However, there was no significant difference of PTD among different food types

Discussion

The enrolled healthy elderly had a mean score of the EAT-10 score, 5.8 (SD 2.4), a mild subjective symptom. However, the WST showed that two participants choked with 50 mL of thin liquid. Moreover, a higher frequency of abnormal penetration and pooling was reported when swallowing a larger amount in each type of liquid bolus during VFSS. These results are compatible with previous studies that in healthy elderly, the penetration and retention rate increased with higher volume of liquid.[23,24] Therefore, a large amount of liquid poses the highest risk.

For the VFSS findings with modified liquids, this study showed that thicken liquid (IDDSI 2-4) had lesser penetration and aspiration frequency than thin liquid. The more massive amount of liquid, the more occurrence of penetration and aspiration, was indicated. The 10 mL of thin liquid (IDDSI 0) established the highest rate of PAS ≥ 2, followed by 4 mL of thin liquid. No participants showed unsafe swallowing during testing with extremely thick liquid (pudding) and 4 mL of moderately thick (honey-thick) liquid. The thicken liquid had more prevalence of pharyngeal residue. The higher viscosity, the higher rate of residue was noted. The study of Catriona et al. also reported the same result that was the higher viscosity and lower velocity decreased the risk of material enter into the larynx and below vocal cord but increased the risk of post-swallowing residue in the pharynx, especially in the elderly who had dysphagia risk.[15] The thin liquid which had the lowest viscosity was the top of penetration and aspiration rate. Troche et al. displayed that pudding thick (extremely thick liquid) had a lower PAS score than thin liquid.[25] As the results from our study, we would say that older people

Table 2. The number of abnormality of PAS (PAS > 2), and P-score (P-score > 6) in each type of liquid and food modification

Material	PAS ≥ 2[1] N=34	P-score ≥ 6[1] N=34	PTD (ms)[2]
Modified liquid			
Thin liquid 4 ml (IDDSI 0)	5 (14.7)	3 (8.8)	69 (22)
Thin liquid 10 ml (IDDSI 0)	7 (20.6)	8 (23.5)	71 (23)
Mildly thick liquid 4 ml (IDDSI 2)	2 (5.9)	5 (14.7)	79 (24)
Mildly thick liquid 10 ml (IDDSI 2)	2 (5.9)	6 (17.7)	81 (26)
Moderately thick liquid 4 ml (IDDSI 3)	0 (0.0)	3 (8.8)	80 (21)
Moderately thick liquid 10 ml (IDDSI 3)	1 (2.9)	6 (17.7)	84 (23)
Extremely thick liquid (IDDSI 4)	0 (0.0)	2 (5.9)	97 (33)
Modified food			
Pureed (IDDSI 4)	0 (0.0)	8 (23.5)	119 (46)
Minced & moist food (IDDSI 5)	0 (0.0)	7 (20.6)	107 (27)
Soft & bite-sized food (IDDSI 6)	0 (0.0)	4 (11.8)	101 (40)
Regular food (IDDSI 7)	0 (0.0)	6 (17.7)	120 (45)

[1]Number (%), [2]mean (SD)

PAS, penetration-aspiration scale; P-score, pooling score; PTD, pharyngeal transit duration; IDDSI, International Dysphagia Diet Standardisation Initiative

should consume a small amount of clear water. Even though thicker liquids resulted in less pharyngeal residue after swallowing, the retention percentage was between 8.8%-17.7%. Repeated dry swallowing and throat clearing after ingestion of thickening liquids and frequent small sip rather than taking a big gulp of liquid should be recommended to this risk group.

Despite the reassuring finding that the rate of penetration during food swallowing was zero, it was worth mentioning that the rate of retention was very high in the case of minced & moist (IDDSI 5) (20.6%) and pureed (IDDSI 4) (23.5%). If swallowing of such food is repeated, the amount of retained food in the larynx may accumulate. This retention could consequently lead to post-swallowing aspiration. For this reason, we should not recommend pureed food over regular food for this group of people. The properties of a safest food with low retention is high adhesiveness, low cohesiveness, and low hardiness. The pureed and minced & moist food should match the most secured texture.[18,26] It was a contrast to the current result. A future study that considers "stickiness" of food bolus and swallowing risk would be needed to guide reasonable recommendations on food modification for this population. With the available data at hand, it seems that pudding-like or perhaps jelly-like food with low adhesion to the pharyngeal wall and a slow transit time may be the best suggestion for the healthy elderly population with mild to moderate dysphagia symptom to avoid aspiration and penetration.

This study found that the higher viscosity, the longer pharyngeal transit duration (PTD) was needed. The study of Catriona also demonstrated the same result that was the most prolonged PTD was found in an extremely thick liquid.[15] Slowing the flow of liquid allows more time for the airway protection mechanism. Thereby, the more thickening of liquid, the less risky laryngeal penetration and tracheal aspiration.[27-29] We would recommend that in the elderly, even with mild swallowing problems, slightly more viscosity would reduce the complication.

The limitation of this study was that each bolus consistency was tested only once. Therefore, it was plausible to expect that repeated swallowing, in a situation with distracting environmental factors, could result in a higher penetration rate. It is possible that in real life situation aspiration and choking can happen. This issue would be in a future study.

We can conclude that in the healthy elderly with dysphagia risk, ingesting a larger volume (10 mL) of thin liquid related to the highest risk of penetration and aspiration. A small amount of moderately thick liquid (4 mL) was the safest. In mild dysphagia cases, food types did not affect penetration and aspiration but high viscosity and cohesive food increased the residue rate in the pharyngeal area. Hence, soft & bite-sized food was recommended for this population to avoid food retention.

Disclosure

All authors declare no conflict of interest of any kind.

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