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Increasing risk of silent aspiration in stroke patients

Susyana TAMIN[1,*], Donald MARPAUNG[1], Freddy SITORUS [2]

[1]Department of Otorhinolaryngology- Head and Neck Surgery, Faculty of Medicine, Universitas Indonesia Cipto Mangunkusumo Hospital, Jakarta, Indonesia
[2]Department of Neurology, Faculty of Medicine, Universitas Indonesia Cipto Mangunkusumo Hospital, Jakarta, Indonesia

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Abstract

Dysphagia is a common complication of stroke that is often undiagnosed and leads to aspiration. This cross-sectional study aimed to detect the risk of silent aspiration during the swallowing process based on the location of the stroke lesion. A total of 48 stroke patients undergo a Fiberoptic Endoscopic Evaluation of Swallowing (FEES) examination to determine dysphagia profile based on penetration, standing secretion, residue, leakage, and silent aspiration. On the pre-swallowing assessment, there was an abnormal cough reflex and tongue movement weakness in 77.1% and 47.9% of patients. On the FEES assessment, penetration occurred in 72.9% of the patients and 100% of stroke patients with mixed lesions. Standing secretion occurred in 56.3% of the patients and 83.1% of stroke patients with brain stem lesions. Food residue occurred in 81.3% of patients and 100% of stroke patients with mixed lesions. Pre-swallowing leakage occurred in 91.7% of patients and 100% of stroke patients with mixed and brainstem lesions. Silent aspiration occurred in 29.2% of total patients and 60% of stroke patients with mixed lesions. The risk of silent aspiration in repeated strokes was five times higher than in first-stroke patients (P = 0.013). In conclusion, mixed lesions cause more severe oral and pharyngeal phase disorders as well as a higher risk of penetration and aspiration than other lesions.

Keywords: stroke, respiratory aspiration, deglutition disorders, swallowing, dysphagia

1. Introduction

Stroke is recognized as one of the world's five common causes of disability-adjusted life-years (DALY). It is associated with several medical complications that lead to high healthcare costs and prolonged hospital admissions (1, 2). In 2019, the Global Burden Disease (GBD) reported that stroke is the second-leading cause of death (11.6% of total deaths) and the third-leading cause of disability and death combined (5.7% of total DALYs). From 1990 to 2019, the incidence of strokes increased by 70%, the prevalence of stroke increased by 85%, deaths from stroke increased by 43%, and DALYs increased by 32%. The incidence and prevalence rates of stroke in young people significantly increase due to the increased metabolic risk factor for stroke, including elevated blood pressure, diabetes mellitus, and obesity among young people (3).

Patients with stroke are vulnerable to multiple complications (4). Dysphagia, defined as swallowing impairment, is a common complication in 33-73% of stroke patients (5). Most of the complications of stroke can recover within a week. However, dysphagia can persist for up to 6 months (4). Dysphagia is accompanied by stroke mortality and post-stroke complications, such as pneumonia, dehydration, malnutrition, and poor long-term outcome (6). Dysphagia is considered the main risk factor for pneumonia after stroke. Patients with dysphagia are three times more likely to have pneumonia (1). In addition, dysphagia also affects the quality of life, socialization, self-esteem, and increases healthcare-associated costs (7). Elderly stroke patients have more chance of having dysphagia due to the alterations in breathing coordination, swallowing, and reduced cough reflex.

Swallowing can easily be disrupted after stroke because it is a complex and fast neuromuscular mechanism that requires the coordination of more than 30 muscles, five cranial nerve, and several brain regions (7). Previous studies demonstrated the correlation between lesion location of stroke and post-stroke dysphagia. The brain stem (the pons and medulla) is the central control of swallowing (8). Damage to the brainstem structures is strongly suspected to be associated with dysphagia due to corticospinal fractures and superior longitudinal fasciculus connecting the swallowing centers in the cerebral cortex to the central pattern generator for deglutition (9).

The Flexible Endoscopic Evaluation of Swallowing (FEES) was proved to be a significant tool for assessing oropharyngeal dysphagia and aspiration severity. FEES is a comfortable, tolerable, and excellent procedure for assessing dysphagia as long as the focus is on the oropharyngeal structures and aspirations because the FEES directly visualizes these structures without the risk of radiation (10, 11).

*Correspondence: usyana@yahoo.com

Despite its association with stroke mortality and other post-stroke complications, post-stroke dysphagia is often undiagnosed and under-addressed. Stroke patients may not be aware of liquid or food entering the airway, leading to aspiration. Therefore, this study aimed to detect the risk of silent aspiration during the swallowing process using FEES examination in stroke patients based on the location of the stroke lesion.

2. Material and Methods

This cross-sectional descriptive study determines the prevalence of silent aspiration and features of swallowing in stroke patients with brainstem and non-brainstem lesions. The study was conducted at the Integrated Dysphagia Clinic, Endoscopic Bronco-Esophagology Division, Otorhinolaryngology-Head and Neck Surgery Department, Faculty of Medicine Universitas Indonesia (FMUI)/ Cipto Mangunkusumo Hospital (RSCM), Jakarta, Indonesia. A consecutive sampling technique was used in this study.

The inclusion criteria included stroke patients without swallowing difficulty before having a stroke, who have the results of computed tomography (CT) or head magnetic resonance imaging (MRI) examinations, can come to the Dysphagia Clinic, can be positioned semi-sitting or sitting, and willingness to undergo FEES examination. The exclusion criteria included unconscious, uncooperative, patients with severe cognitive impairment, or patients with contraindications for FEES examination, such as unstable vital signs or bleeding disorders. This study examined FEES on 48 stroke patients who came directly or were sent from the neurology treatment and outpatient room. The patients will undergo history taking, general ear nose and throat (ENT) examination, preswallowing assessment to analyze the structure of the swallowing process, and FEES examination to assess five parameters of swallowing, such as penetration, standing secretion, residue, leakage, and silent aspiration, using five different consistencies of food (oatmeal, puree, crackers, gastric rice, and milk). The FEES examination was performed by an ENT specialist using Fiberoptic nasopharyngolaryngoscopy Olympus visera ENF type V. All statistical analyses were performed using the Statistical Package for Social Sciences (SPSS) version 26 (IBM Corporation, Armonk, NY, USA). Differences between groups were considered statistically significant if the p-value of < 0.05.

3. Results

Of the 48 subjects, the largest gender is male, more than three times the number of female subjects, as shown in Table 1. The distribution of subjects based on age, which is divided into four age groups, is mostly found in the 50-59 years age group (22 subjects or 45.8%), followed by 18 subjects (37.5%) at age ≥60 years.

Based on the frequency or history of stroke, divided into two groups, the first-time stroke group (56.3%) was slightly more than the recurrent stroke group (43.7%). The distribution of subjects based on stroke onset was divided into two groups, and the group with an onset of less than one month (54.2%) was almost the same as the onset group of more than or equal to one month (45.8%).

Table 1. Characteristics of the subjects

Characteristics of research subjects		N (%)
Sex	Men	37 (77.1)
	Women	11 (23.9)
Age group	<40	3 (6.3)
	40-49	5 (10.4)
	50-59	22 (45.8)
	≥60	18 (37.5)
Stroke frequency	First	27 (56.3)
	Repeated	21 (43.7)
Stroke onset	< 1 month	26 (54.2)
	≥ 1 month	22 (45.8)
Stroke type	Hemorrhagic	9 (18.8)
	Ischemic / infarction	35 72.9)
	Hemorrhagic infarction/hemorrhagic transformation	3 (6.2)
	Computer tomography and MRI of the head normal	1 (2.1)
Location of the lesion	Brain stem	6 (12.5)
	Hemisphere/cortex and subcortical	37 (77.1)
	The mixture of brainstem and hemisphere	5 (10.4)
History/complaints of dysphagia	Elongated feeding time	24 (50)
	Hoarseness after eating/drinking	3 (6.3)
	Cough while swallowing	23 (47.9)
	Regurgitation	3 (6.3)
	Consistency of food consumed	
	• All consistency	32 (66.7)
	• Soft & fluid	14 (29.1)
	• Liquid	2 (4.2)
	History of pneumonia	5 (10.4)

Prolonged feeding time, followed by coughing while

swallowing, is the most common complaint of dysphagia. Regurgitation and hoarseness after eating or drinking was found in only three subjects (6.3%). Based on the consistency type of food consumed, most subjects (66.7%) still consumed all types of food, from solid to liquid. Due to medical instructions, two subjects (4.2%) consumed only liquid food via nasogastric tube (NGT).

From the results of computed tomography and MRI in Table 1, in general, the type of stroke in this study was ischemic stroke (72.9%) with a frequency of more than three times the hemorrhagic stroke (18.8%). Three subjects on the supporting examination showed a mixture of hemorrhagic and ischemic strokes. According to the location of the stroke lesion, as seen in the investigation, the location of most lesions was cortical or subcortical / hemisphere lesions (77.1%). One subject on investigation showed no stroke or normal lesions. Because the subject was clinically suspected as the cause of the brain stem lesion, it was included in the brainstem lesion group, but the type of stroke could not be determined as ischemic or hemorrhagic.

Table 2. FEES initial examination results (n = 48)

Characteristics of the subject	(%)
Drooling	4 (8.3)
Poor oral hygiene	19 (39.6)
Weakness in tongue movement	23 (47.9)
Weakness of the buccal muscles	15 (31.3)
Palate motion asymmetry	11 (22.9)
Weakness of closure of the velopharynx when swallowing	20 (41.7)
NGT	4 (8.3)
Vocal cords paralyze	14 (29.2)
Poor cough reflex	37 (77.1)
There is no swallowing motion on command	11 (22.9)

The initial FEES examination was carried out to evaluate the state of the structures involved in the swallowing process, and the evaluation results are shown in Table 2. The most common abnormality on this examination was abnormal cough reflex (77.1%). Furthermore, in sequence, it was followed by abnormalities of tongue movement weakness (47.9%), velopharyngeal weakness (41.7%), poor oral hygiene (39.6%), buccal muscle weakness (31.3%), vocal cord paresis (29.2%), there was no swallowing motion on orders/volunteers (22.9%), drooling (8.3%), and the use of NGT (8.3%).

The data in Table 3 shows that the mixed lesion group has the highest percentage of FEES parameters with the most (four parameters), namely preswallowing leakage, residue, penetration, and silent aspiration. Judging from the number of findings for each parameter, the hemispheric lesion group showed the highest number for all parameters. The highest number of these parameters is preswallowing leakage (33 subjects), and the lowest is silent aspiration (9 subjects).

Table 3. Distribution of FEES parameters according to the location of the brainstem, hemisphere, and mixed lesions

FEES parameter	Amount (percent of the total subjects, n = 48)	Lesions		
		Mixed (n=5)	Brain stem (n=6	Hemisphere (n=37)
Standing secretion	27 (56.3)	4 (80)	5 (83.3)	18 (48.6)
Preswallowing leakage	44 (91.7)	5 (100)	6 (100)	33 (94.3)
Residue	39 (81.3)	5 (100)	5 (83.3)	29 (82.9)
Penetration	35 (72.9)	5 (100)	4 (66.7)	26 (70.3)
Silent aspiration	14 (29.2)	3 (60)	2 (33.3)	9 (24.3)

Pearson Chi-Square test results on the relationship between the incidence of silent aspiration and stroke frequency in Table 4 showed a significant relationship with a significance level of p = 0.013 (OR=5,227; CI=1,336 – 20,450). The risk of silent aspiration in repeated strokes is five times greater than in the first stroke.

Table 4. Relationship between stroke frequency and silent aspiration

Frequency of stroke	Silent aspiration	
	Yes	No
Repeated	10 (71.4)	11 (33.4)
First	4 (28.6)	23 (67.4)

4. Discussion

The most predominant gender in our study is in accordance with a study by Wang et al. (12), which showed a higher incidence rate of stroke in men than women. The male predominance in stroke may be caused by the higher blood pressure in men than women, the higher proportion of alcoholic drinkers in men, and sex steroid hormones, which can alter vascular reactivity in the cerebral vasculature (12). However, a meta-analysis by Yang et al. (13) showed no gender differences in swallowing difficulties after stroke (13). The largest age group in our study is similar to a study by Setyopranoto et al. that found the highest prevalence rate of stroke in 50-59 years old (14). Age is one of the important factors affecting post-stroke dysphagia, which can be explained by a higher probability of advanced cranial nerve degeneration and abnormal swallowing reflex function in older patients (13). The most common type of stroke in our study is in accordance with the studies by Abdu et al. (15) and Salvadori et al. (16), which showed ischemic stroke as the most common type of stroke (15, 16).

Prolonged feeding time is the most common complaint by the patients in our study. Stroke can affect oral, pharyngeal, and esophageal transit time, leading to prolonged feeding time.

Stroke patients may have uncoordinated initiation of oral transport, slow chewing, delayed initiation of tongue movement, and tongue pumping, which can affect oral transit time (17, 18). It can be explained by several lesions involved in stroke. The left hemisphere stroke may lead to speech apraxia, further implicating oral movement regulation. The left superior and middle frontal gyrus lesions, basal ganglia, and a small portion of the insula are possibly associated with prolonged oral transit time. The frontal cortex affects oral phase delay due to its association with decision-making, planning complex cognitive behavior, and execution, which are required for swallowing. The insular lesion is also associated with oral phase prolongation because of its function as the primary integrative region for volitional swallowing (18). Stroke patients may also have reduced pharyngeal peristaltic and delayed swallowing reflexes, leading to prolonged pharyngeal transit time (17). Right-hemisphere stroke tends to impair the pharyngeal phase (19). However, a study by Han et al. (17) showed no significant hemispheric difference in the oropharyngeal transport time (17). Patients with stroke also have a significantly longer esophageal transit time than healthy adults (20).

In our study, the abnormal cough reflex is the most common abnormality in the initial FEES examination. Coughing and swallowing have similar muscles, nerves, and control mechanisms. Brain lesions associated with swallowing, such as the superior temporal gyrus and superior longitudinal fasciculus, overlapped with lesions involved in weak cough (21). Cough, produced voluntarily or reflexively, is important in airway protection (21, 22). Reflexive cough, controlled by the brainstem, is automatically generated by afferent activation. Voluntary cough, modulated by cerebral cortices, is a conscious activation of the respiratory muscles, including the diaphragm (21). Reflexive and voluntary coughs reduce after acute stroke (21, 22). Abnormally infrequent coughing may indicate impaired sensitivity of the cough reflex and reduced protection of the lower respiratory tract, putting patients at risk of developing pneumonia through silent aspiration (23). The second most common abnormality in the initial FEES examination in our study is tongue weakness. In swallowing, the tongue directs and squeezes the bolus to the pharynx by contact from the front of the hard palate backward, resulting in effective and safe transport to the pharyngeal cavity. If this oral phase is impaired, there will be an absence or delay of the sensory input transmission to the cortical areas for formed pharyngeal reflex response to protect against aspiration before swallowing (24).

Aspiration is a passage of liquid or food through and below the true vocal folds (25). It is common in stroke patients and increases the risk of chest infections (21). Aspiration is indicated by two or more symptoms, such as lack of gag reflex, dysphonia, voice quality change, inadequate cough, dysarthria, and cough after swallowing. Aspiration can also not be accompanied by symptoms, including cough, which is usually called silent aspiration (26). Of the patients who aspirated, approximately 67% have silent aspiration (27). The prevalence of silent aspiration obtained from our study was 29.2%. This is consistent with a study by Santos et al. (28) that stated the incidence of silent aspiration in stroke patients ranges from 28-52% (28). Silent aspiration increases the risk of pneumonia 1.3 times more than aspiration with clinical symptoms and 13 times more than healthy adults (26, 27). In our study, the mixed lesion is the most common lesion location found in patients with silent aspiration. A study by Garon et al. (25) showed that the prevalence rate of silent aspiration is 79.3% in brainstem stroke, 51% in right hemisphere stroke, and 40.3% in left hemisphere stroke (25). Brainstem and cortical regions of the brain control the sensory and motor airway protective mechanism. Patients with stroke have damage to these neural pathways, which can cause laryngeal motor or sensory loss that reduces the effectiveness of airway protection (27). Two main laryngeal mechanisms to prevent aspiration are glottis closure and material expulsion inhaled into the lungs (22). Prolonged pharyngeal transit time is also associated with aspiration in post-stroke patients (29). In addition, our study also found a significant association between the frequency of recurrent strokes and silent aspiration. To the best of our knowledge, this is the first study to report a higher risk of silent aspiration in recurrent strokes. The five times greater risk of silent aspiration in recurrent strokes should raise clinical precautions in managing recurrent strokes.

Our study found penetration in 72.9% of the subjects. Penetration can occur during, before, or after swallowing. Penetration before swallowing is caused by delayed swallowing reflex or glossopharyngeal closure impairment during the preparatory phase. Penetration during swallowing is caused by the insufficient larynx closure because of the vocal folds adduction failure or laryngeal elevation failure. Penetration after swallowing is caused by the static of food in the pharynx (30). Our study also found standing secretion in 56.3% of patients. A possible factor is the hyposensitivity of part of the hypopharynx, especially the vallecular region and the piriformis sinus. The findings of high preswallowing leakage (91.7%) also indicate a high problem of palatoglossal valve abnormalities which should prevent the leakage. The residue was also found to be relatively high (81.3%) in our study. The pharyngeal residue in stroke patients is considered to be associated with the impairment of several biomechanical oropharyngeal swallowing actions, such as pharyngeal contraction, oral propulsion, and pharyngoesophageal transition opening (31). The vallecular residue amount also correlates with the ability to cough (32).

Swallowing disorders, both the oral phase and the pharyngeal phase, are a problem that is commonly found in stroke patients, which is more common in men over 50 years of age. Based on the FEES examination in this study, the prevalence of silent aspiration was 29.2% in stroke patients. The risk of silent aspiration is five times higher in recurrent

strokes when compared to the first stroke. Mixed lesions (brainstem and hemispheres) cause more severe oral and pharyngeal phase disorders than other lesions and are at greater risk for penetration and aspiration.

Conflict of interest

The authors declared no conflict of interest.

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Authors' contributions

Concept: S.T., F.S., Design: S.T., D.M., F.S., Data Collection or Processing: S.T., D.M., F.S., Analysis or Interpretation: S.T., D.M., F.S., Literature Search: S.T., D.M., Writing: S.T., D.M.

Ethical Statement

This study was approved by the Committee of Medical Research Ethics in the Faculty of Medicine at Universitas Indonesia (No: 269/PT02.FK/ETIK/2008). The patients provided written and verbal informed consent before study participation.

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