

# THE ASSOCIATION BETWEEN LOCATION OF BRAIN LESION AND FINDINGS OF FLEXIBLE ENDOSCOPIC EVALUATION OF SWALLOWING (FEES) IN STROKE PATIENTS: WHICH EXERCISE IS BENEFICIAL?

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## Abstract

Background: Dysphagia is a frequent occurrence following stroke. Various brain regions have been shown to control deglutition. However, it is still controversial as to which of the two hemispheres plays more important role in deglutition, and which injured hemisphere is more likely to cause the specific patterns of dysphagia seen in stroke patients. An accurate estimate of the incidence of dysphagia will be critical to assess benefits of dysphagia interventions. Objective: To investigate whether patterns of dysphagia are associated with the location of brain lesion in stroke patients and to examine whether pharyngeal strengthening exercise and hyolaryngeal exercise are proper for patients, based on the findings of FEES and location of brain lesion. Methods: The subjects were stroke outpatients who visited our clinic from January 2016 to April 2018. To localize brain lesion, Computed Tomography (CT) or Magnetic Resonance Imaging (MRI) have been employed. The locations of brain lesions were classified into cortical, subcortical, and brain stem. FEES was conducted to assess the patterns of deglutition disorders. These data were collected via retrospective chart review. Results: Of the 11 subjects, mean age (SD) was 62.73 (8.67) years and seven (63.64%) subjects were male. All subjects got ischemic stroke, eight (72.73%) had right hemispheric lesion and three (27.27%) had left hemispheric lesion. By brain lesion, there were nine subcortical, five cortical, and four brain stem lesions. All FEES findings, especially standing secretion, penetration, residue, and reduced hypopharynx sensitivity were higher in subcortical lesion, followed by brain stem and cortical lesion successively. Conclusion: Right hemisphere was involved more than left hemisphere in dysphagia patients. Standing secretion, penetration, residue, and reduced hypopharynx sensitivity occurs more often in subcortical lesion. Further studies on big samples in a perspective structure are needed. Based on this result, there is a place for pharyngeal strengthening exercise and hyolaryngeal complex range of motion and strengthening exercise to be implemented to the patients with neurogenic dysphagia after stroke.

## Background

Dysphagia, or deglutition disorder, occurs often in acute stroke patients. About 65% of stroke patients have swallowing disability.<sup>1</sup> In endoscopic clinic of Ear Nose and Throat-Head and Neck Surgery (ENT-

HNS) Department at Ciptomangunkusumo Hospital, there was 239 patients with neurogenic dysphagia oral phase and pharynx phase confirmed by flexible endoscopic evaluation of swallowing (FEES) in 2013. 51 of them were caused by stroke.<sup>2</sup>

There is deglutition area in the cerebral cortex, includes the prefrontal gyrus, somatosensory cortex, insula, cingulate gyrus and precuneus regions. When stroke occurs, the areas could be damaged, the network become disrupted and the command center is also debilitated. Deglutition disorder can also occur if a stroke lesion affects the brain stem. Therefore, deglutition becomes impaired.<sup>3</sup> It is still controversial as to which hemisphere has much role to associate with the specific patterns of deglutition disorders in stroke patients.<sup>4,5</sup>

The dysphagia has result in higher risk of pulmonary complications and also mortality.<sup>6,7</sup> The most common pulmonary complications is aspiration pneumonia resulting in deaths.<sup>8</sup> Pneumonia and other respiratory illnesses are still being the most common factor causing hospital readmission post stroke.<sup>9</sup> Besides, post stroke dysphagia is also associated with malnutrition.<sup>10</sup> Aspiration pneumonia will increase the catabolic condition and needs more energy, so that the demand will be increased too. However, dysphagia patient who has inability to swallow normally, could not afford to fulfill the elevated demand, creating a vicious cycle.<sup>3</sup>

Effective and efficient management of dysphagia becomes the most important thing. Behavioral exercise treatments are often used in newly research, because these treatments are focus on the underlying deficits and therefore have a long-life effect.<sup>11</sup> A precise estimation of the amount of dysphagia event in stroke patients and the risk of pulmonary complication it caused could be a guideline to make another research to have information about the benefits of dysphagia treatments.<sup>6</sup>

In this study, we would like to investigate firstly whether patterns of dysphagia are associated with the location of brain lesion in stroke patients and then examine whether pharyngeal strengthening exercise, hyolaryngeal complex range of motion and strengthening exercise are proper for patients with neurogenic dysphagia after stroke, based on the findings of FEES. The results of this study could guide us whether these exercises can be implemented and have benefits to this neurogenic dysphagia after stroke patients.

## Methods

Subjects of this study were: (1) ischemic stroke patients confirmed by brain imaging, (2) 40-70 years old, and (3) had neurogenic dysphagia confirmed by FEES. The exclusion criteria were as follow: (1) Patients who had other disease that might cause dysphagia, (2) patients with bilateral stroke. We reviewed the patients' medical records and examination results retrospectively. Their demographic and clinical characteristics were recorded. The interval between ischemic onset and FEES evaluation were all on subacute onset. The FEES was conducted by ENT-HNS specialist. About the interpretation of FEES, we evaluated the findings such as: (1) lip closure, (2) tongue movement, (3) buccal tone, (4) velopharyngeal movement, (5) standing secretion, (6) penetration, (7) aspiration, (8) residue, (9) laryngeal elevation, (10) hypopharyngeal sensitivity, (11) cough reflex, and (12) laterality. About the classification of brain lesion location, the results of brain computed tomography (CT) or magnetic resonance imaging (MRI) were classified into 3 groups; the cerebral cortical lesion, subcortical lesions, and the brain stem lesions. The lesions were divided into right and left hemispheric lesions.

Participants' characteristics were summarized as means and standard deviations for continuous data, and frequency counts for categorical data. We use Statistical Package for the Social Sciences (SPSS) 23.0 to analyze the data.

## Results

Eleven ischemic stroke patients participated in this study. Of the 11 subjects, mean age (SD) was 62.73 (8.67) years and seven (63.64%) subjects were male. All subjects got ischemic stroke, eight (72.73%) had right hemispheric lesion and three (27.27%) had left hemispheric lesion. By brain lesion, there were nine subcortical, five cortical, and four brain stem lesions.

Table 1. Characteristics of subjects

Patient characteristics	n
Sex (female/ male) number	4/7
Age, years, mean $\pm$ standard deviation	62.73 $\pm$ 8.67
Laterality, number	
Right hemispheric lesion	8
Left hemispheric lesion	3
Stroke type, number	
Ischemic stroke	11
Hemorrhagic stroke	0

Table 2. Characteristics of 3 subgroups

Patient characteristics	Cortical lesion	Subcortical lesion	Brain stem lesion
Number	5	9	4
Sex (female/ male) number	2/3	3/6	1/3
Age, years, mean $\pm$ standard deviation	61.00 $\pm$ 8.41	64.89 $\pm$ 8.04	60.75 $\pm$ 10.87
Laterality, number			
Right hemispheric lesion	4	7	3
Left hemispheric lesion	1	2	1

All FEES findings, especially standing secretion, penetration, residue, and reduced hypopharynx sensitivity were higher in subcortical lesion, followed by brain stem and cortical lesion successively. There was no predominance of hypopharynx sensitivity in stroke in subcortical lesion as well as decreased of cough reflex.

Table 3. Abnormal findings of FEES in 3 subgroups

Patient characteristics	Cortical lesion	Subcortical lesion	Brain stem lesion	Total
Lip closure, number	0	2	1	3
Tongue movement, number	2	3	3	8
Buccal tone, number	1	2	1	4
Velopharynx movement, number	1	2	2	5
Standing secretion, number	3	7	4	14
Penetration, number	3	6	4	13
Aspiration, number	2	3	2	7
Residue, number	2	5	3	10
Laryngeal elevation, number	1	2	1	4
Hypopharynx sensitivity, number	3	5	4	12
Cough reflex, number	3	4	4	13

## Discussion

The relationship between different variables such as site and type of lesion and the presence of dysphagia is controversial. Yet, the lesion localization as a predictor of dysphagia has recently obtained more interest.<sup>12</sup> While some studies have detected an association between lesion site and dysphagia, others have not found a significant relationship between the location of lesion and presence of dysphagia.<sup>13,14</sup>

From previous study, dysphagia occurred in 37% patients with unilateral hemispheric cortical lesion. They said that the lesion location gives greater influence than the size or affected hemisphere in estimating aspiration. However, other studies showed different results about the location of lesion effect.<sup>15</sup> Falsetti et al reported that dysphagia occurred more frequently in the non-dominant cortical lesion hemisphere, not subcortical nor the brain stem.<sup>16</sup>

Hemispheric dominancy in controlling swallow is not clear. Dehaghani et al conclude that the most important finding of their research was the higher frequency of dysphagia in the right hemisphere. As shown by descriptive findings, in most of the proposed regions related to dysphagia, the right hemisphere lesions can predict deglutition disorder, which is in line with some other previous studies.<sup>17</sup>

Both cortical hemispheres play an important role in deglutition. It is still controversial whether one hemisphere has dominant role. Some reports indicate that there was asymmetry between the deglutition hemisphere dominancy and the hemisphere which determine the handedness. Suntrup et al conclude that right hemispheric lesion caused deglutition disorder in higher rate, more severe and more long-lasting.<sup>17</sup>

Dehaghani et al mentioned that there is a significant relationship between the presence of dysphagia and the right primary sensory cortex lesion.<sup>17</sup> Other researchers such as Mozier and Bereznaya, Martin et al, Hamdy et al, Toogood et al, Malandraki et al, and Gonzalez-Fernandez et al also confirmed the role of this area in deglutition. The higher occurrence of primary sensory cortex lesion in the dysphagic patients may be attributed to the role of sensory inputs in controlling complex deglutition movements. Some research studies have shown the role of primary motor cortex in controlling normal deglutition in functional magnetic resonance imaging studies and presence of dysphagia in lesion studies. Although some dysphagic patients with primary motor area impairment were observed, the number was not statistically significant, which may emphasize a more critical role of sensory versus motor inputs for controlling deglutition.<sup>17</sup>

Neuroimaging studies on deglutition showed a consistent involvement of the primary and secondary sensorimotor cortex.<sup>18,19</sup> It means that the lesion on these locations was result in dysphagia. Moreover, the corticospinal tract and the superior longitudinal fasciculus on white matter substances showed strong associations. These structures connect the cortical deglutition centers and the central pattern generator for deglutition in the brain stem. Disconnection along the descending of these tracts from cortical to bulbar could be the reason that subcortical stroke alone may also impair deglutition.<sup>20-22</sup> So does if the lesion underlies in the supramarginal gyrus, it also significantly associated with dysphagia, penetration and aspiration since this area is a sensorimotor integration area. Besides, the right post-central gyrus as the primary sensory area for deglutition could predict the severe dysphagia, because there is a relevancy between intact sensory afferent pathways with the motor output network to make the deglutition safely and efficiently.<sup>23</sup>

Lesion on temporal regions also plays important role in causing penetration and aspiration. Even the

role of this area in deglutition has not been clear, there was an activation in the superior temporal gyrus, Heschl's gyri and temporopolar cortex during deglutition. The insulo-orbito-temporopolar unit has been speculated to have significant control of visceromotor functions.<sup>24</sup>

Lastly, the medulla and pons become the most important things of the deglutition functions. The central pattern generator of deglutition lies in the medulla and the sensory system in pons provides the information from receptors in oral, pharyngeal and laryngeal and relay the information to higher nervous system. Some systematic review of studies using MRI confirm that the lesion located in pons and medulla brought a higher event of dysphagia. On the contrary, there was limited or no incidence of dysphagia in the case of midbrain and cerebellum lesion.<sup>25</sup>

Standing secretion, penetration, residue, and reduced hypopharynx sensitivity occurs more often in subcortical lesion. The hyposensitivity or no sensitivity of larynx may result in laryngeal penetration and/ or silent aspiration. Some reports also showed that laryngeal penetration or aspiration occurred in stroke patient with reduced sensitivity of larynx.<sup>26</sup>

Pharyngeal strengthening training was designed to improve retraction of the tongue base so as to increase the propulsion of the tongue, increase oral pressure and laryngeal movements. In addition, this exercise also increases pharyngeal pressure and relaxation of the upper esophageal sphincter.<sup>27</sup> Patients are asked to swallow strongly or swallow with great effort by giving force to the bolus and prolonging the closure of the airway. This technique will increase posterior tongue base movement and anterior pharyngeal wall movement, so that the bolus passages also increase.<sup>28,29</sup> This exercise is performed as a compensation maneuver for patients who experience a decrease in tongue base retraction which can be seen from the presence of residues in the vallecula.<sup>28</sup>

Hyolaryngeal exercise prolongs laryngeal elevation and is thought to maintain increased velopharyngeal pressure. In addition, there is prolonged duration of the opening of the upper esophageal sphincter and increased contraction of the pharyngeal peak and conversely decreases the contraction pressure of the top of the esophageal sphincter. Elevation of the larynx will create a negative pressure effect on the upper esophageal sphincter so that this exercise will reduce this

negative pressure when deglutition. This will facilitate safe bolus displacement due to reduced resistance.<sup>29</sup>

#### Conclusion

In this study, we concluded that right hemisphere was involved more than left hemisphere in dysphagia patients. Sticking secretion, penetration, residue, and reduced hypopharynx sensitivity occurs more often in subcortical lesion. Further studies on big samples in a perspective structure are needed. Based on this result, there is a place for pharyngeal strengthening exercise and hyolaryngeal complex range of motion and strengthening exercise to be implemented to the patients with neurogenic dysphagia after stroke.

#### Declarations

##### Ethics approval and consent to participate

All procedures performed in this study involving human participants were in accordance with the ethical standards of the Faculty of Medicine, University of Indonesia and with the 1964 Helsinki declaration and its later amendments. The study was submitted and approved by the ethics committee of the Faculty of Medicine, University of Indonesia. The reference number was 0260/UN2.F1/ETIK/2018.

##### Consent to publish

Not applicable.

##### Availability of data and materials

All data generated or analyzed during this study are included in this published article. The confidential patient data could not be shared.

## Competing interests

The authors declare that they have no competing interests.

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## Authors' contributions

NI collected, analyzed and interpreted the patient data. WK and HP gave suggestions in writing the manuscript. All authors read and approved the final manuscript.

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Not applicable.

## Abbreviations

CT Computed Tomography

MRI Magnetic Resonance Imaging

FEES Flexible Endoscopic Evaluation of Swallowing

SD Standard Deviation

ENT-HNS Ear Nose and Throat-Head and Neck Surgery

SPSS Statistical Package for the Social Sciences

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