

**ORIGINAL RESEARCH**

# Voluntary Cough and Swallowing Function Characteristics of Acute Stroke Patients Based on Lesion Type



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**Abstract**

**Objective:** To investigate the relation between voluntary cough and swallowing functions according to the type of lesion in patients with acute stroke.

**Design:** Cross-sectional study.

**Setting:** University rehabilitation hospital.

**Participants:** Acute stroke patients with dysphagia symptoms (N=397).

**Interventions:** Not applicable.

**Main Outcome Measures:** A peak cough flow meter was used to measure voluntary coughing ability. Swallowing function was evaluated using the functional dysphagia scale and the penetration-aspiration scale based on the results of a videofluoroscopic swallowing study. Stroke lesions were divided into one of the following 3 categories: cortical, subcortical, and brainstem. These evaluations were performed within 2 weeks after stroke onset.

**Results:** Of the enrolled 397 patients, 207 patients were classified as cortical stroke, 106 patients were classified as subcortical stroke, and 84 patients were classified as brainstem stroke. Among the subscores of the functional dysphagia scale, the amount of pharyngeal residue negatively correlated with peak cough flow meter results across all stroke lesion types. In the brainstem lesion, peak cough flow and penetration-aspiration scale scores were high compared with other lesions, but these 2 functions did not show a correlation.

**Conclusions:** This study revealed that large amounts of pharyngeal residue correlated with weak voluntary cough ability in all stroke lesion groups. We also showed a discrepancy between 2 functions in the brainstem lesion group. Our results suggest that voluntary coughing exercises could be a helpful therapeutic option for dysphagia to prevent pulmonary complications in some types of patients with stroke.

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Cough and swallowing functions play important roles in airway protection.<sup>1</sup> After a stroke, many patients suffer from airway infections and dysphagia caused by cough and/or swallowing dysfunction.<sup>2-4</sup> Coughing is an important protective mechanism for maintaining a clear airway, and many studies have revealed that patients with stroke can experience a decrease in cough function.<sup>4-6</sup> Swallowing disorders commonly occur in patients with stroke, and 38% to 64% of patients with stroke suffer from swallowing problems during the acute stage.<sup>2,3</sup> A swallowing

disorder caused by stroke presents with various clinical manifestations and can demonstrate different patterns according to the stroke lesion type.<sup>7,8</sup> Therefore, objective evaluation of cough and swallowing functions is important for deciding proper diet and treatment options.<sup>4,9,10</sup>

There are 2 types of cough: reflex and voluntary. Reflex cough is a brainstem-mediated involuntary reflex. This type of cough can be initiated by aspiration, which is a serious swallowing problem, and often causes aspiration pneumonia.<sup>3</sup> The afferent and efferent pathways of the cough reflex are shared with that of the swallowing reflex. After a stroke, some patients experience decreased or absent cough reflex because of swallowing reflex issues.

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Voluntary cough can be elicited intentionally, and a study by Smith Hammond et al<sup>4</sup> reported that adequate voluntary coughing reduces the risk of aspiration pneumonia. Both reflex and voluntary coughs are closely related to swallowing function and play an important role in airway protection. Previously, a study reported that both cough types are impaired in patients with hemispheric stroke.<sup>6</sup>

Previous studies have demonstrated the relations between cough and swallowing functions in patients with stroke.<sup>2-6,10-12</sup> Several studies have reported that a low peak cough flow (PCF) may be one of the predictive factors for aspiration pneumonia after stroke.<sup>5,10,12</sup> Other studies have revealed that patients with stroke who experience a normative cough reflex have a minimal risk for significant aspiration.<sup>11</sup> These studies focused exclusively on the relation between aspiration and voluntary cough. However, there are various clinical manifestations of dysphagia after stroke, including food aspiration and oral, pharyngeal, and esophageal disorders. Few studies have investigated the relation between voluntary coughing and swallowing functions other than aspiration. To our knowledge, no study has analyzed these functions according to stroke lesion type. We hypothesized that voluntary coughing would have relation with swallowing function and that this relation would vary according to the stroke lesion type because the severity and prognosis of dysphagia have been shown to differ according to stroke lesion type. The aim of this study was to investigate the relation between voluntary cough and swallowing functions according to stroke lesion type. The PCF was used to measure voluntary cough function, and the functional dysphagia scale (FDS) and penetration-aspiration scale (PAS) based on the results of videofluoroscopic swallowing study (VFSS) were used to evaluate swallowing function.

## Methods

### Participants

This study was designed as a cross-sectional study and was performed in the rehabilitation center of a university hospital. Acute ischemic or hemorrhagic stroke patients with dysphagia symptoms admitted to the stroke or rehabilitation center were recruited. All of the included patients had experienced their first stroke and were evaluated by VFSS and PCF within 2 weeks of stroke onset.

Patients who experienced previous strokes, displayed multiple stroke lesions, or displayed comorbid cardiopulmonary disease or oropharyngeal cancer were excluded. Patients who had cognitive impairments or aphasia to an extent that prevented VFSS testing or impaired their ability to produce a maximal voluntary cough on verbal direction were excluded. Patients with tracheostomy tubes were excluded, but the presence of a Levin tube was not considered an exclusion criterion if the patients could perform the VFSS and PCF tests. These patients were tested by VFSS and PCF after the removal of the Levin tube. After VFSS, we decided patients' diet according to the results of VFSS. The study protocol was

approved by the institutional review board (IRB no. 15-108), and all participants provided written informed consent.

## Evaluation

### Voluntary cough function

PCF was used as a parameter to measure voluntary coughing ability, which was assessed by having patients cough as forcefully as possible through a peak flow meter.<sup>3</sup> Before testing, patients were allowed to use the peak flow meter several times to become accustomed to the test; after this the patients were asked to make their maximal effort at least 3 times. PCF was defined as the highest point of the flow volume curve obtained during a cough. A maximum value of 3 attempts was used for analysis. PCF is the primary parameter used to assess voluntary cough efficacy, and many previous studies have used this parameter as a voluntary cough measurement tool.<sup>5,12-14</sup>

### Swallowing function

Swallowing function was evaluated using the FDS and PAS based on the results of VFSS. VFSS was performed with the patients in a sitting position to allow a lateral view. A modified version of the protocol from a study performed by Logemann was used.<sup>15</sup> First, 3ml of barium-containing thick liquid was administered to the subject. Then, pureed, semisolid, solid, and thin liquid were administered in this sequence. All of the food samples contained barium and were administered 2 or 3 times. All patients received individualized feeding therapy based on the results of VFSS.

The FDS is a scale that was developed to quantify dysphagia severity, and it correlates well with the American Speech-Language-Hearing Association's National Outcome Measurement System criteria.<sup>16</sup> The FDS consists of 11 items with weighted values representing 4 kinds of oral (lip closure, bolus formation, residues in oral cavity, oral transit time) and 7 kinds of pharyngeal (triggering of pharyngeal swallow, laryngeal elevation and epiglottic closure, nasal penetration, residue in valleculae, residue in pyriformis sinus, coating of pharyngeal wall after swallow, pharyngeal transit time) functions that can be observed by VFSS (table 1). To determine whether differences exist between parameters according to the stroke lesion type, the FDS score was divided into subsections and analyzed.

The PAS evaluates airway invasions<sup>17</sup> and has a maximum score of 8 points. Scores are determined primarily based on the depth to which material passes into the airway and based on whether material entering the airway can be expelled. The penetration category corresponds to level 5 on the scale, and levels 6 to 8 correspond to laryngotracheal aspiration. A PAS score of 8 means that material enters the airway, passes below the vocal folds, and no effort is made to eject. It is represented as silent aspiration caused by weak or absence of reflex cough.

Intra- and interrater reliability have been established in both scores. Higher FDS and PAS scores indicate poor swallowing function.

These evaluations were performed on the same day within 2 weeks of stroke onset. All test procedures were recorded, and the findings were analyzed by 3 physiatrists.

### Classification of stroke lesions

Stroke was diagnosed with cerebral infarction or hemorrhage by magnetic resonance imaging or computed tomography of the

#### List of abbreviations:

<b>FDS</b>	<b>functional dysphagia scale</b>
<b>PAS</b>	<b>penetration-aspiration scale</b>
<b>PCF</b>	<b>peak cough flow</b>
<b>VFSS</b>	<b>videofluoroscopic swallowing study</b>

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