Reduced Tongue Pressure Against the Hard Palate on the Paralyzed Side During Swallowing Predicts Dysphagia in Patients With Acute Stroke

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Background and Purpose—Dysphagia is important for prognosis in patients with stroke because this condition can cause aspiration pneumonia or nutritional deficits. The present study investigated the relationship between tongue motor deficits and dysphagia in patients with acute stroke.

Methods—Maximal tongue pressure on the hard palate when swallowing 5 mL of water was measured using a T-shaped sensor sheet with 5 measuring points in 33 dysphagic and 31 nondysphagic patients with acute stroke. Maximum tongue pressures at each measuring point were compared between dysphagic and nondysphagic groups and between paralyzed and nonparalyzed sides.

Results—Tongue pressure at each measuring point was significantly smaller in dysphagic patients than in nondysphagic patients with the largest significant difference on the paralyzed side. The magnitude of tongue pressure to predict dysphagia was calculated as 4.6 kPa on the paralyzed side, offering 71.4% sensitivity and 72.3% specificity.

Conclusions—Reduced tongue pressure on the paralyzed side may predict dysphagia in patients with acute stroke. (Stroke. 2010;41:00-00.)

Key Words: dysphagia ■ stroke ■ tongue

Dysphagia indicates a decline in swallowing function and represents an important issue in patients with stroke from perspectives of both preventing aspiration pneumonia and improving nutrition, mortality, and duration of hospitalization.1-3 Videofluoroscopic examination has been used as the gold standard for evaluating swallowing function but has limitations such as the inherent exposure to radiation, difficulty with performing the examination in disabled patients, and difficulties in quantitatively analyzing the biomechanics of swallowing-related organs.

Among the oral organs, the tongue plays a central role during swallowing by contacting the hard palate.4 The maximal tongue pressure (TP) exerted on the hard palate may thus offer a quantitative parameter for evaluating tongue motor biomechanics during swallowing. We therefore applied a newly developed TP measurement system5 to investigate relationships between tongue motor deficits and dysphagia in patients with acute stroke.

Methods

Subjects comprised 64 patients (38 men; mean ± SD age, 69 ± 13 years) who had been hospitalized for cerebral infarction or cerebral hemorrhage in the Department of Cerebrovascular Medicine at the National Cerebral and Cardiovascular Center and for whom level of consciousness without stimulation was alert. Written informed consent was obtained from each subject after explaining the aims of the study. The study protocol was approved by the ethics committee of the National Cerebral and Cardiovascular Center. Before measurement, patients were divided into a dysphagia group (n = 33; 19 men, 14 women; mean age, 67 ± 11 years) and a nondysphagia group (n = 31; 19 men, 12 women; mean age, 70 ± 16 years) according to the 5- and 30-mL water swallowing tests.6,7 The 30-mL water swallowing test was performed in patients who could sit upright in bed (≥30° position) and successfully swallow 5 mL of water fluently at least twice. In the dysphagia group, diagnosis was cerebral infarction in 22 subjects and cerebral hemorrhage in 11 subjects (supratentorial, n = 25; subtentorial, n = 8). In the nondysphagia group, diagnosis was cerebral infarction in 23 subjects and cerebral hemorrhage in 8 subjects (supratentorial, n = 24; subtentorial, n = 7).

TP at the time of swallowing 5 mL of water was measured using a sensor sheet (thickness, 0.1 mm; measurement points Channel 1 to Channel 5) attached to the hard palate (Figure 1; I-Scan; Nitta, Osaka, Japan).3 Channel 1 to Channel 3 were placed along the median line and Channel 5 was set at the side considered to show paralysis according to the region of cerebral infarction or hemorrhage. Five recordings were performed in each patient. Means of TP at each point were analyzed (Figure 1). We statistically compared TP
among 5 measuring points using 2-way analysis of variance following the Scheffe post hoc test and between the 2 groups using the Mann–Whitney U test ($P/H11021 0.05$). Comparisons of TP between paralyzed and nonparalyzed sides in each patient from both groups were statistically analyzed using the Wilcoxon signed-rank test ($P/H11021 0.05$). Sensitivity and specificity curves were produced to obtain the best cutoff value for use as a diagnostic criterion. All statistical analyses were performed using Dr SPSS II for Windows software (SPSS Japan, Tokyo, Japan).

**Results**

TP at Channel 4 (posterior–circumferential part on the nonparalyzed side) was larger than that of other areas in both groups. In the nondysphagic group, TP was larger at Channel 1 (anterior–median part) than at Channel 2 (midmedian part) and was larger at Channel 5 (posterior–circumferential part on the paralyzed side) than at Channel 2 or Channel 3 (posterior–median part; Figure 2). Compared with the nondysphagic group, TP at each channel was significantly smaller in the dysphagic group where the smallest probability value ($P/H11021 0.001$) was found at Channel 5 (Figure 2). TP was significantly lower at Channel 5 than at Channel 4 in all patients from both groups (data not shown).

Using a sensitivity–specificity curve analysis to discriminate between dysphagic and nondysphagic groups, we analyzed the cutoff point for the TP value at Channel 5 (paralyzed side). The cutoff point at Channel 5 to diagnose dysphagia was 4.6 kPa, offering 71.4% sensitivity and 72.3% specificity (Figure 3).

**Discussion**

Although various attempts have been made to assess dysphagia in patients with stroke, this is the first study to investigate the pathophysiology of dysphagia from the perspective of TP production during swallowing. Because the sensor sheet to measure TP is extremely thin and designed to evaluate TP production during swallowing, tongue motor deficits can be detected quantitatively in the natural state of swallowing. Our findings suggest the possibility of quantitative measurement for predicting dysphagia in patients with acute stroke. Although our measurements were limited to the oral phase, previous reports have suggested a high specificity of prepharyngeal problems in swallowing for identifying dysphagia.$^8$

Our results showed an overall decline in TP during swallowing in dysphagic poststroke patients compared with

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*Figure 1.* Sensor sheet for measuring tongue pressure with 5 measuring points (right upper) and a representative wave of tongue pressure when swallowing 5 mL of water in a nondysphagic channel. Ch indicates channel.

*Figure 2.* Maximal TP during swallowing at each measurement point (Channel 1 to Channel 5) in the dysphagic and nondysphagic groups. Ch indicates channel.

*Figure 3.* Sensitivity and specificity curve analysis for maximum TP at Channel 5 to discriminate between the dysphagic and nondysphagic groups.

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$^8$P<0.05, †: TP in non-dysphagic patients is larger than that in dysphagic patients ($P<0.05$).
nondysphagic patients. Notably, loss of symmetry in TP at the circumferential parts (Channel 4 and Channel 5) was also found in the nondysphagic group, suggesting that subclinical symptoms in poststroke patients could be detected by TP measurement. Further declines in TP on the paralyzed posterior–circumferential side (Channel 5) were considered critical for predicting dysphagia from sensitivity and specificity curve analyses. Such declines in TP were hypothesized to interfere with enveloping and transferring the bolus between the dorsum and palate, thus reducing prepharyngeal swallow efficiency.

TP was significantly larger at Channel 1 than at Channel 2 in the nondysphagic group but not in the dysphagic group. A decline in TP from anterior to posterior on the median line, which would be expected for propulsion of the bolus from the oral cavity into the pharynx, was confirmed in healthy subjects.\(^5\) Declines in TP at Channel 1 in the dysphagic group were considered as another factor associated with dysphagia, because contact of the tongue blade with the anterior part of the hard palate also acted as an anchor for stabilization of the mandible.

Quantitative parameters of TP that can predict dysphagia with reasonable sensitivity and specificity might not comprise a substitute for videofluorographic or videoendoscopic examination\(^8,^9\) but would improve the management of patients with acute stroke. One limitation in the present study was that swallowing function was evaluated using our protocol with simple screening tests and clinical observations, and silent aspiration without clinical symptoms might have been overlooked, because the sensitivity and specificity of the 5-mL water swallowing test for aspiration are 68\% and 82\%, respectively.\(^6\) Further analysis of relationships between tongue pressure and infarction or hemorrhagic lesions can be expected to contribute to elucidation of the mechanisms underlying tongue motor control during swallowing.

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Disclosures
None.

References
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