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Original Article

Dysphagia Screening Using High-resolution Impedance Manometry in Acute Stroke

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SUMMARY

Background: Dysphagia is relatively common in patients with acute stroke and can lead to aspiration pneumonia and malnutrition. We evaluate the usefulness of dysphagia test using high-resolution impedance manometry during acute stroke.

Methods: Consecutive patients with acute stroke were enrolled, and all patients were stratified into three aspiration risk groups. High-resolution impedance-manometry (HRiM) was performed in patients with an intermediate aspiration risk. The diet plan was determined based on the results of evaluations and clinical outcome was determined by improved diet program and pulmonary complications.

Results: A total of 293 patients with acute stroke were enrolled. Among 91 patients with intermediate-risk, 36 revealed an impaired swallowing pattern in HRiM. Fifty-five patients with a preserved swallowing pattern and 169 with low-risk were started with a general diet and tolerated it well. Thirty-six patients with an impaired swallowing pattern were recommended for swallowing rehabilitation and a stepwise dysphagia diet of which 97.2% successfully adapted to the general diet. High-risk group patients received nasogastric tube feeding immediately. During admission, no patients with low- and intermediate-risk developed aspiration pneumonia. However, aspiration pneumonia frequently occurred in high-risk group patients.

Conclusions: Our assessment program was safe and effective for assessing swallowing function and for determining the appropriate diet plan.

1. Introduction

Stroke is a devastating event that carries a potential for long-term disability[1]. Malnutrition is frequently observed in patients with stroke, and dysphagia contributes to the malnutrition risk. Dysphagia is a common complication of the acute stroke stage[2]. The presence of dysphagia and associated aspiration increases the risks for pneumonia, mortality, and prolonged hospital stay[2–7].

Clinical bedside assessment is the simplest measure, which does not require much time or instruments. However, this assessment misses up to 40% of patients who aspirate (so-called silent aspirators)[7–9]. The modified barium swallow (MBS) is the alternative test for evaluating overall swallowing from a visual aspect. Although helpful clinically, the limitations of this technique are well known, as it does not always provide detailed diagnostic information about subtle abnormalities of the pharyngeal and esophageal musculature or transit. Furthermore, MBS carries a risk of aspirating contrast medium and chemical pneumonitis. Videofluoroscopy and videoendoscopy have also been used to identify the swallowing process and aspiration[10,11], but they require special techniques.

High-resolution manometry (HRM) has widened the pharyngeal domain and enables highly accurate spatiotemporal interpolation of dynamic pressure changes caused by luminal closure following contraction. HRM also allows for intuitive quantification of pharyngeal movements and of the opening of the upper

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esophageal sphincter (UES), as well as their timing[12]. Although some patients may feel uncomfortable during test, the procedure is generally safe and serious side effects are extremely rare[13]. Recent studies have revealed videofluoroscopic measurements of the swallowing function are significantly correlated with manometric analysis in patients with brainstem stroke[14].

In acute stroke patients, we investigated whether high-resolution impedance manometry (HRiM) is clinically useful to evaluate dysphagia in patients with acute stroke.

2. Methods

2.1. Patients

This study protocol (*D*ysphagia screening in *A*cute *S*troke using *H*igh-resolution impedance manometry (DASH)) was approved by the institution review board of Seoul St. Mary's Hospital, and informed consent was obtained from all participants or their relatives. Consecutive patients with acute stroke at the neurology department were enrolled. The clinical information obtained included age, gender, history of hypertension, diabetes mellitus, dyslipidemia, heart disease, and current cigarette smoking. All patients underwent a detailed clinical evaluation, including a neurological examination, laboratory tests, chest radiography, electrocardiography, 24-h Holter monitoring, brain magnetic resonance imaging (MRI), and contrast-enhanced MR angiography. Severity of stroke was assessed using the National Institute of Health Stroke Scale (NIHSS). Stroke was defined based on clinical history and the neurological examination with compatible new lesions on MRI. Patients were excluded if they had (1) hyperacute stroke and were receiving thrombolytic therapy; (2) symptom onset > 48 h; (3) history of stroke and dysphagia; (4) other neurological diseases causing oropharyngeal dysphagia, such as parkinsonism, dementia, and neuromuscular disorders; (5) history of cranial neurosurgery; (6) prior or current structural lesions causing oropharyngeal dysphagia; or (7) pulmonary diseases such as chronic obstructive pulmonary disease or pneumonia. In addition, patients who died in the incipient stage of acute stroke, and those with neurological deterioration (increase in NIHSS $\geq$ 4) and transient ischemic attack were also excluded in a retrospective manner.

2.2. Study protocol

The protocol consisted of two evaluation steps; the first step was to identify patients with risk of possible aspiration and the second step was for detecting silent aspirators. The first step was performed on hospital days 1 and 2 and the second step was done on hospital day 2.

2.3. Step 1: neurological evaluation and bedside water swallow test

Patients were interviewed regarding difficulties with food intake, chewing, and swallowing, and neurological signs were confirmed.

Patients with impaired consciousness (stupor or coma) and those were unable to sit upright or control their head, were categorized to be at high risk of aspiration pneumonia, and they received immediate nasogastric tube feeding without further testing. The remaining patients underwent a bedside indirect water swallow test. This swallowing screening consisted of an initial saliva swallow followed by escalated intake of up to 10 mL of water (saliva, 2, 5, and 10 mL water). Failure on the water swallow test was defined if one of the four aspiration signs (deglutition, cough, drooling, and voice change) was positive. Patients who did not pass this step were also categorized into the high-risk group, and nasogastric tube feeding was performed.

The remaining subjects were classified into low- and intermediate-risk groups according to oropharyngeal neurologic deficits (if any one of following was positive, the patient was categorized into the intermediate-risk group: (1) dysarthria, (2) motor or global aphasia, (3) inability to close and open lips, (4) facial weakness, (5) tongue deviation, (6) uvular deviation, (7) loss of gag reflex, or (8) inability to cough voluntarily). The low-risk group was permitted to start a general diet and the intermediate risk group underwent the step 2 test.

2.4. Step 2: HRiM testing

HRM was performed using a solid HRiM catheter with a 4.2 mm outside diameter, 36 circumferential sensors spaced at 1-cm intervals, and 14 impedance recording rings (12 impedance segments) spaced at 2-cm intervals (Sierra Scientific Instruments, Los Angeles, CA, USA). Patients fasted for at least 6 h before the examination, and the tests were conducted in a sitting or semi-Fowler position. The assembly was placed to record from the hypopharynx to the proximal stomach with approximately five intragastric pressure sensors, and the catheter was fixed in place by taping it at the nostril. The impedance sensors were thus positioned from the UES through the distal esophagus and into the proximal stomach.

Basal UES and lower esophageal sphincter (LES) pressures were measured during and at 30 s after dry swallowing. Pharyngoesophageal peristalsis was measured using 15 swallows of 5 mL of normal saline at 30-s intervals. The next step was the multiple rapid swallow (MRS) test with 200 mL of water within 10–20 s to evaluate activity of the deglutitive vagal inhibitory pathway. Finally, the HRiM catheter was pulled back by 15 cm, and the same sessions were repeated because of inability to assess all the pharyngeal manometric information and bolus transit of the pharyngoesophageal segment.

Pressure topography parameters were analyzed using the Chicago classification for the liquid swallows with a modification for pharyngeal function monitoring[15–18]. The proximal contractile integral quantifies contractile activity in a space-time box by multiplying the length from the velopharynx to the hypopharynx by the duration of contractile wave front propagation, and the mean pressure in the entire box excluding pressures <20 mmHg. The transition zone was defined as the distance between the proximal and distal esophageal contractile segments with an isobaric contour at 30 mmHg.

Impedance flow analysis for each water swallow was conducted for bolus clearance. Multichannel impedance sensors detected bolus entry and exit at four levels. Bolus transit was assessed by defining bolus entry and bolus exit at each level. Bolus entry was considered as a decline in impedance $\geq$50% from baseline, and bolus exit was determined as return to this 50% point on the impedance recovery curve. Complete bolus transit was confirmed by defining the bolus entry and sequential bolus clearance at all impedance-recording sites. This was measured by percentage of waves, which had complete bolus transit, and $\geq$80% of the measured value was regarded as normal[19].

All HRiM tracings were analyzed using ManoView analysis software 2.0. All data were corrected for thermal sensitivity of the pressure-sensing elements using the thermal compensation function in ManoView.

The impaired swallowing patterns were defined through the real-time assessments of the HRiM system and clinical presentation during the HRiM test. If the liquid was not cleared after one swallow, the pateint was considered to have an impaired swallowing pattern. In addition, patients with (1) continuous complaints of swallowing difficulties during the HRiM test, (2) defects in bolus

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