Comparison of Videofluoroscopic Swallowing Study in Patients with Stroke-Associated Pneumonia

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Objective: To compare the findings of videofluoroscopic swallowing study (VFSS) in patients with stroke-associated pneumonia (SAP).

Methods: Between January 2015 and June 2019, 1245 patients diagnosed with pneumonia underwent VFSS examination. Data were collected through retrospective chart reviews. Depending on the diagnosis, 378 post-stroke patients identified were classified into two groups: 327 non-aspiration pneumonia (non-AP) and 51 aspiration pneumonia (AP). Aspiration pneumonia was diagnosed both clinically and radiologically. VFSS results included 11 items of functional dysphagia scoring (FDS) and 8 points of penetration-aspiration scale (PAS) that analyze the swallowing function by anatomical site.

Results: Based on the FDS score, the AP group showed significantly higher values in residue in pyriform sinuses ($P=0.01$), as compared to the non-AP group. There was a significant difference in the PAS score between both groups ($P<0.001$).

Conclusion: Based on the FDS results, AP in SAP is associated with residue in pyriform sinuses. VFSS tests therefore have the potential to be clinically applied to predict the occurrence of aspiration pneumonia in stroke patients. (JKDS 2021;11:52-58)

Keywords: Stroke, Aspiration, Pneumonia

INTRODUCTION

Stroke-associated pneumonia (SAP) is a frequent and an important medical condition relation to significant mortality and financial burden after stroke¹. There are two pathophysiological mechanisms of SAP: aspiration theory vs stroke induced immunodepression theory². Traditionally, SAP is thought to be secondary to aspiration related to dys-

phagia and impaired consciousness. It has been suggested that abnormal dopamine transmission and low substance P level would be involved in impaired swallowing mechanism leading to aspiration of oral content during sleep^{3,4}. Stroke induced immunodepression is thought to be the result of sympathetic system, parasympathetic system, and hypothalamic-pituitary-adrenal axis activation⁵⁻⁷. The activation is prominent among patients with large stroke and have

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predilection for stroke location such as the involvement of the insular cortex^{8,9}.

Many studies reported about risk factors of SAP such as stroke severity measured by the NIHSS or the modified Rankin Scale, old age, mechanical ventilation, male sex, atrial fibrillation, dysarthria, comorbid medical condition, etc^{10,11}. SAP is a complex disease and multiple factors are involved in the pathogenesis. Recently, many studies describe the clinical features and outcomes of patients with aspiration pneumonia (AP) compared to those of patients with non-aspiration pneumonia (non-AP) in SAP¹². However, there was no study about comparing the video-fluoroscopic swallow study (VFSS) finding between AP and non-AP in SAP patients. The VFSS has been the gold standard for evaluating patients with swallowing disorders for many years¹³. This method not only estimates the risks of aspiration and respiratory complications but also helps determine diet and compensatory strategies. Functional dysphagia scale (FDS) and penetration-aspiration scale (PAS) based on VFSS could be used to quantify functional dysphagia such as the oropharyngeal and esophageal phases of swallowing. Moon et al. reported that characteristic of VFSS findings in patients diagnosed with AP comparing with non-AP in neurologic deficit patients including central nervous system injury, neuromuscular disease, and neurodegenerative disease¹⁴. They reported that there were no significant differences in VFSS findings scored using the PAS and Pharyngeal Residue Grade (PRG) between groups. In stroke patients, however, it could be predicted that the results of the VFSS test would vary depending on the pathomechanism of SAP.

The aim of our study was to compare the VFSS findings between AP and non-AP in stroke patients.

MATERIALS AND METHODS

1. Subjects

This was a retrospective study that reviewed medical records and the results of VFSS who were referred for swallowing study to evaluate the cause of

pneumonia between January 2015 and June 2019. Exclusion criteria of subjects were as follows: 1) diagnosis was not stroke, 2) the diagnosis of pneumonia was not clear, and 3) incomplete swallowing study. SAP patients were divided into two groups depending on the diagnosis: non-aspiration pneumonia (non-AP) and aspiration pneumonia (AP). Aspiration pneumonia group was classified based on records of receiving antibiotics treatment after diagnosis of aspiration pneumonia in consultation with internal medicine. Physicians diagnosed aspiration pneumonia based on clinical symptoms, images, and blood test results.

Flowchart of study subjects was showed in Fig. 1. This study was approved by the Samsung Changwon Hospital Institutional Review Board (No. 2020-SCMC-070-13).

2. Videofluoroscopic swallowing study

VFSS test was done by fluoroscopic X-ray (sonial vision G4, shimadzu, Kyoto, Japan) according to protocol standardized by developing a sequence of liquid and solid foods, starting with those that are easiest for most patients to swallow, and progressing to more difficult consistencies.

3. Functional dysphagia scale (FDS) measures

The FDS was devised to quantify the results of the VFSS test by Han et al.¹³. Lip closure (intact 0, inadequate 5, none 10), bolus formation (intact 0, inadequate 3, none 6), residue in oral cavity (none 0, $\leq 10\%$ 2, $10\%-50\%$ 4, $\geq 50\%$ 6), and oral transit time (≤ 1.5 s 0, > 1.5 s 6) constitute an oral phase. Triggering of pharyngeal swallow (normal 0, delayed 10), laryngeal elevation and epiglottic closure (normal 0, reduced 12), nasal penetration (none 0, $\leq 10\%$ 4, $10\%-50\%$ 8, $\geq 50\%$ 12), residue in valleculae (none 0, $\leq 10\%$ 4, $10\%-50\%$ 8, $\geq 50\%$ 12), residue in pyriform sinuses (none 0, $\leq 10\%$ 4, $10\%-50\%$ 8, $\geq 50\%$ 12), coating of pharyngeal wall after swallow (no 0, yes 10), and pharyngeal transit time (≤ 1.0 s 0, $1.0 > s$ 4) constitute pharyngeal phase. The total score is 100 and the higher the score, the more severe the dys-

Fig. 1. Flowchart of subjects.

Table 1. Demographic characteristics of subjects with pneumonia.

	Non-aspiration (n=327)	Aspiration (n=51)	P-value
Age (years)	72.63±12.11	74.76±10.84	0.235
Sex			0.001
Female	168 (51.38)	39 (76.47)	
Male	159 (48.62)	12 (23.53)	
Disease			0.440
Cerebral infarction	233 (71.25)	39 (76.47)	
Cerebral hemorrhage	94 (28.75)	12 (23.53)	
NIHSS (n=127)	7.75±6.19	10.00±5.42	0.158
MMSE (n=101)	14.07±9.63	16.13±9.07	0.442
VFSS score total	32.95±12.69	38.55±12.00	0.003
PAS score	5.03±2.49	6.75±2.00	<0.001

Continuous variables are presented as mean±standard deviation (SD), and categorical variables are presented as number and percent. Independent samples t-test or χ^2 -test as appropriate. Bold number means $P<0.05$ and significant difference.

phagia.

4. Penetration–aspiration scale (PAS) measures

The PAS is an 8-point, equal-appearing interval scale to describe penetration and aspiration events¹⁵. Scores are determined primarily by the depth to which material passes in the airway and by whether or not material entering the airway is expelled.

Higher score means a poorer swallowing function.

5. Statistical analysis

Statistical analysis was performed using STATA 14.0 (Stata Corporation, College Station, TX, USA), and average and standard deviation of the data were obtained using the descriptive statistics. We compared differences between the two groups using independent samples t-test or Fisher's exact test or Pearson's chi-square test as appropriate. The P-value

of <0.05 was considered to be statistically significant.

RESULTS

Data from a total of 1,245 subjects who were referred for swallowing study to evaluate swallowing problems or dysphagia that might cause pneumonia

Table 2. Comparison for functional dysphagia scale using VFSS.

	Non-aspiration (n=327)	Aspiration (n=51)	P-value
Lip closure			>0.999
0	318 (97.25)	50 (98.04)	
5	9 (2.75)	1 (1.96)	
10	0 (0.00)	0 (0.00)	
Bolus formation			0.229
0	52 (15.90)	5 (9.80)	
3	273 (83.49)	45 (88.24)	
6	2 (0.61)	1 (1.96)	
Residue in oral cavity			0.372
0	72 (22.02)	8 (15.69)	
2	219 (66.97)	38 (74.51)	
4	30 (9.17)	3 (5.88)	
6	6 (1.83)	2 (3.92)	
Oral transit time			0.524
0	224 (68.50)	33 (64.70)	
6	103 (31.49)	18 (35.29)	
Triggering of pharyngeal swallow			0.225
0	148 (45.26)	18 (35.29)	
10	179 (54.74)	33 (64.70)	
Laryngeal elevation and epiglottic closure			>0.999
0	6 (1.83)	0 (0.00)	
12	321 (98.17)	51 (100.00)	
Nasal penetration			0.191
0	314 (96.02)	46 (90.20)	
4	12 (3.67)	5 (9.80)	
8	1 (0.31)	0 (0.00)	
12			
Residue in valleculae			0.060
0	99 (30.28)	11 (21.57)	
4	215 (65.75)	35 (68.63)	
8	13 (3.98)	4 (7.84)	
12	0 (0.00)	1 (1.96)	
Residue in pyriform sinuses			0.014
0	158 (48.32)	16 (31.37)	
4	148 (45.26)	26 (50.98)	
8	19 (5.81)	8 (15.69)	
12	2 (0.61)	1 (1.96)	
Coating of pharyngeal wall after swallow			0.059
0	273 (83.49)	37 (72.55)	
10	54 (16.51)	14 (27.45)	
Pharyngeal transit time			0.119
0	147 (44.95)	17 (33.33)	
4	180 (55.05)	34 (66.67)	
Total	32.95 ± 12.69	38.55 ± 12.00	0.003

Categorical variables are presented as number and percent. Fisher's exact test or Pearson's chi-square test as appropriate. Bold number means $P < 0.05$ and significant difference.

Fig. 2. Comparison for penetration-aspiration scale using VFSS.

between January 2015 and June 2019 were considered for analysis. Initially, 420 subjects whose diagnosis was not stroke were excluded. And then, 447 subjects were excluded because of unclear pneumonia diagnosis and incomplete swallowing study. Finally, 378 subjects included in analysis comparing non-AP and AP in stroke patients.(Fig. 1) The gender and dysphagia score were statistically significant between non-AP and AP groups in demographic characteristics.(Table 1) Based on the FDS score, the AP group showed significantly higher values in residue in pyriform sinuses ($P=0.014$) compared with non-AP group. (Table 2) The PAS score of non-AP group and AP group was 5.03 ± 2.49 and 6.75 ± 2.00 , respectively. There was a significant difference between two groups ($P < 0.001$) as showed in Fig. 2.

DISCUSSION

In this study, we compared FDS score and PAS score of AP patients with that of non-AP patients based on VFSS in stroke patients. Residue in pyriform sinuses based on FDS was higher score in AP group compared with non-AP group. In previous studies, stroke survivors with penetration and aspiration tended to have more vallecular and pyriform sinus residue than other group and residue of food in the pharynx raised the risk of aspiration^{16,17}. This might be because the stroke impaired motor and sensory control of the muscle that involved in swallowing.

Mann et al. reported that more than 30% of post-stroke survivors showed weak sensorimotor control of tongue and submental muscles during the oral stage of swallowing¹⁸. Stokely et al. reported that increased post-swallowing residue in the valleculae and pyriform sinuses had correlation with increased pharyngeal area at maximal contraction¹⁹. The results of our study were consistent with those in previous study, however, compared to previous studies, the significance of this study was that these changes showed a significant difference in patients with AP compared to those with non-AP among SAP. Stroke-associated infection mainly includes SAP and urinary tract infections (UTI) and overall infection rate is 30%. UTI and SAP show a similar prevalence, whereas SAP is significantly associated with death²⁰. Many factors influence SAP, however, based on accumulating evidence, changes in immunity triggered by an acute cerebral injury is the main cause of SAP²¹. Xabier et al. reported that infarct volume has an association with the occurrence of stroke-associated infections and specific brain locations such as the superior and lateral temporal lobe and the orbitofrontal cortex are also associated with increased infectious risk, especially pneumonia²². In our study, we could not identify whether or not pneumonia developed according to anatomical location because stroke was classified simply as cerebral hemorrhage and infarction. PAS score was significantly higher in AP group than non-AP group in SAP as observed in other studies of dysphagia. However, PAS score had limitation to providing anatomical information regarding aspiration. According to the results of the previous study of clinical differences between patients with AP and non-AP, AP were frequent residence in a nursing home, long-term facility, more severe form of pneumonia, and poorer outcome²³. If the VFSS test could identify and prevent the possibility of aspiration pneumonia, many prognosis factors such as length of hospitalization and mortality for stroke patients will improve. Thus, early performance of the VFSS after stroke could facilitate the determination of appropriate feeding methods and prevent aspiration and

improve of quality of life for stroke patients.

This study had some limitations. First, ischemic and hemorrhagic stroke patients were analyzed together. We could not classify the possibility of aspiration by type of stroke. Second, the results of our study were consistent with the previously reported findings of studies that used similar designs. However, we only included stroke patients to compare the results of VFSS between AP and non-AP. Third, patient comorbidities were not analyzed. That could affect the possibility of aspiration and also the changes in VFSS results.

CONCLUSION

The pathophysiology of SAP is likely explained by aspiration combined with stroke-induced immunodepression through complex humeral and neural pathways that include the hypothalamic-pituitary-adrenal axis, parasympathetic and sympathetic systems. However, AP in SAP was associated with residue in piriform sinuses based on FDS in the current study. The authors speculated that it would be clinically useful to predict the occurrence of aspiration pneumonia in stroke patients with VFSS tests.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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