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Cerebral Infarction in the Left Hemisphere Compared with the Right Hemisphere Increases the Risk of Aspiration Pneumonia

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Abstract

Background

Aspiration pneumonia (AP) following cerebral infarction (CI) has been considered as one of its most serious complications. Nevertheless, there are no reports on the association between the type or location of CI and the incidence of AP. In addition, the association between dysphagia, which leads to aspiration, and the type or location of CI has never been investigated. Therefore we hypothesized that the laterality of CI affects the development of both dysphagia and AP.

Methods

We performed a retrospective cohort study to examine the association between the laterality of CI and the incidence of dysphagia and AP in 133 patients.

Results

AP was found in 6.0% of the group with left CI and in 0.8% of the group with right CI. A univariate logistic regression analysis revealed that left CI was a significant predictor of AP (hazard ratio, 8.81; 95% confidence interval, 1.07-72.59; p=0.043). Left CI was a significant predictor of AP even after adjusting for age, sex, CI type, or presence of diabetes mellitus. In addition, although the frequency of dysphagia as the direct cause of AP did not differ according to laterality, the frequency of AP that ensued from dysphagia in the left CI group was greater than that observed in the right CI group.

Conclusions

The group with left CI from the motor cortex to the internal capsule complicated by dysphagia exhibited a high risk of AP.

Key Words: Aspiration pneumonia; Cerebral infarction; Laterality

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Introduction

There are several well-known risk factors for aspiration pneumonia (AP), such as advanced age, diabetes, poor oral health, dysphagia, decreased consciousness, or neurological dysfunctions, including cerebral infarction (CI), Alzheimer disease, and Parkinson disease[1]. Among AP caused by these factors, AP following stroke has been considered as one of its most serious complications, because the mortality of stroke patients with AP is reportedly about 3 times higher than that of those without AP[2]. It is considered that an earlier preventive intervention for AP following CI is important for the improvement of the prognosis of this condition. Therefore, the early identification of high-risk groups with AP after stroke would be beneficial. Only one retrospective study has reported age, male sex, dysphagia, and nonlacunar stroke as independent predictors of post-CI pneumonia[3]. However, these findings have not been confirmed.

CI is pathogenetically categorized into 3 subtypes: lacunar ischemic, atheromatous thrombotic, and embolic stroke. Other subtypes are based on the location of CI: cerebral cortex, deep white matter, internal capsule (including the pyramidal tract and corticobulbar tract), brain stem, basal ganglia, and cerebellum. To our knowledge, there are no reports on the association between the type or location of CI and the incidence of AP. In addition, the association between dysphagia, which leads to aspiration, and the type and/or location of CI has never been investigated.

Swallowing and speaking movements are performed in part using the same muscles, which are controlled by the corticobulbar tracts that descend from the cortex to the brain stem. The functional impairment of these movements results in dysphagia and dysarthria, respectively. Only 1 prospective study examined the association between dysarthria and CI type and location[4]. That study showed that the prevalence of dysarthria after left hemisphere CI was higher than that observed after right hemisphere CI, which may indicate a relation between the laterality of CI and the development of dysarthria.

Based on these observations, we hypothesized that the laterality of CI affects the development of both dysphagia and AP. Therefore, we performed a retrospective cohort study to examine the association between the laterality of CI and the incidence of dysphagia and AP. Moreover, we investigated the effect of CI type and location on the development of these complications.

Methods

Study Subjects

This retrospective cohort study included 170 consecutive patients with no history of previous stroke who were admitted to the neurology section of the Japanese Red Cross Society in Wakayama between April 2004 and March 2008.

The background data of patients, including age, sex, type of CI, medical history, medication history, and presence of diabetes, dysphagia, and AP, were collected based on electronic medical records from admission to discharge.

The diagnosis of CI was established using both 1.5 T magnetic resonance imaging (MRI) and the medical report provided by a consultant neuroradiologist after confirmation of the presence and location of any acute CI lesion (high signal on diffusion imaging, low signal on apparent diffusion coefficient map) within 1 week after any neurological event, such as motor paralysis, sensory paralysis, visual field disturbance, ataxia, cranial nerve paralysis (eg, dysarthria, dysphagia, or diplopia), dizziness, or any neuropsychological disorders (eg, aphasia or apraxia).

Lacunar infarcts were defined as round and small (<2 cm in diameter) acute ischemic lesions located in the basal ganglia, internal capsule, centrum semiovale, or brain stem that were accompanied by clinical signs such as pure motor hemiparesis, pure sensory stroke, ataxic hemiparesis, dysarthria/clumsy hand syndrome, or sensorimotor stroke. Dysphagia after CI was diagnosed by asking about swallowing difficulties and observation of food intake. The diagnosis of pneumonia was established based on a combination of clinical features (high fever, coughing, and rales) and radiological findings that occurred within 30 days after stroke onset. We excluded patients with other risk factors of AP, such as disturbance of consciousness (Glasgow Coma Scale <15), Parkinson disease, dementia, malignant disease, periodontal disease, and alcoholism. We also excluded patients with prevention factors for AP, such as use of angiotensin-converting enzyme (ACE) inhibitors. Finally, patients with a history of previous CI, transient CI, or bilateral CI were not included in the study.

The study protocol was approved by the Institutional Review Board (IRB) of the Japanese Red Cross Society in Wakayama. A written informed consent was specifically waived by the approving IRB.

Statistical Analysis

To examine differences between the AP and non-AP groups we used unpaired *t* tests for continuous variables and χ^2 tests for categorical variables.

Univariate and multiple logistic regression analyses were used to estimate the odds ratio for the risks of AP after CI. The nonlinear effects of continuous, independent variables were evaluated using quadratic and log transformations. Multicolinearity was assessed using a variance inflation factor. A variance inflation factor exceeding 10 is regarded as indicating serious multicolinearity, and values >5.0 may be a cause for concern. We calculated the 95% confidence interval (CI) for each odds ratio. All statistical tests were interpreted at the 5% significance level. All p values and 95% CIs were two-sided. All statistical analyses were performed using the SPSS 12.0 software package (SPSS, Chicago, IL).

Results

Among the 170 consecutive patients, 37 were excluded based on the exclusion criteria mentioned above: 14 patients with bilateral CI, 5 patients with disturbance of consciousness, 5 patients with transient ischemic attack, 5 patients who were heavy drinkers, 3 patients with dementia, 3 patients with Parkinson disease, 1 patient with esophageal cancer, 1 patient with lung cancer, 1 patient with periodontal disease, 1 patient who was taking prednisolone, and 1 patient who was taking the ACE inhibitor lisinopril, with some overlapping.

Patient characteristics are listed in Table 1. Among the 133 patients selected, we confirmed 9 (6.8%) cases of AP and 124 (93.2%) cases of non-AP. AP was found in 6.0% of cases in the left CI group and in 0.8% of cases in the right CI group. Thus, the incidence of AP was significantly lower in the latter group. All patients with AP had dysphagia. The mean age was significantly higher in patients in the AP group compared with those in the group without pneumonia. No differences in other background data, such as sex, CI type, location of CI, and complications (such as diabetes mellitus), were found between these groups. Among the patients who exhibited the complication of dysphagia (n=81), AP was present in 9.9% (n=8) of cases in the left CI group and in 1.2% (n=1) of cases in the right CI group. This difference was significant. There were no differences in background data such as age, sex, CI type, location of CI, and presence of diabetes mellitus.

Table 1. Characteristics of study participants according to the development of aspiration pneumonia

Characteristics	Total	Aspiration pneumonia	No aspiration pneumonia	p value
	(n=133)	(n=9)	(n=124)	
Age, mean (range), years	71.20 (30-90)	78.67 (69-86)	70.65 (30-90)	0.029
Sex				
Male, n (%)	81 (60.9)	5 (3.8)	76 (57.1)	0.734
Female, n (%)	52 (39.1)	4 (3.0)	48 (36.1)	
Type of cerebral infarction				
Lacunar infarcts, n (%)	79 (59.4)	4 (3.0)	75 (56.4)	0.346
Embolism or thrombosis, n (%)	54 (40.6)	5 (3.8)	49 (36.8)	
Location of cerebral infarction				
From the motor cortex to the internal capsule (corticospinal and corticobulbar tracts), n (%)	83 (62.4)	8 (6.0)	75 (56.4)	
Brain stem, n (%)	15 (11.3)	0 (0.0)	15 (11.3)	0.163
Basal ganglia, n (%)	16 (12.0)	1 (0.8)	15 (11.3)	
Cerebellum, n (%)	5 (3.8)	0 (0.0)	5 (3.8)	
Others, n (%)	15 (11.3)	0 (0.0)	14 (10.5)	
Laterality of cerebral infarction				
Right cerebral infarction, n (%)	66 (49.6)	1 (0.8)	65 (48.9)	0.017
Left cerebral infarction, n (%)	67 (50.4)	8 (6.0)	59 (44.4)	
Precerebral infarction complication				
Diabetes mellitus, n (%)	32 (24.1)	1 (0.8)	31 (23.3)	0.348
Non-diabetes mellitus, n (%)	101 (75.9)	8 (6.0)	93 (69.9)	
Postcerebral infarction complication				
Dysphagia, n (%)	81 (60.9)	9 (6.8)	72 (54.1)	0.013
Non-dysphagia, n (%)	52 (39.1)	0 (0.0)	52 (39.1)	

Data are n (%) or the mean (range).

Table 2. Univariate and multivariate analyses of risk of aspiration pneumonia in relation to the laterality of cerebral infarction and other baseline variables (n=133)

	Variable	Odds ratio (95% confidence interval)	p value
Univariate analysis			
	Left cerebral infarction (vs right)	8.81 (1.07-72.59)	0.043
	Age	1.11 (1.01-1.22)	0.034
	Sex	0.73 (0.32-4.95)	0.734
	Lacunar infarction	1.91 (0.49-7.48)	0.351
	Diabetes mellitus	0.38 (0.05-3.12)	0.364
Multivariate analysis			
Model 1	Left cerebral infarction (vs right)	9.49 (1.12-80.07)	0.039
	Age	1.11 (1.01-1.22)	0.032
Model 2	Left cerebral infarction (vs right)	8.78 (1.07-72.33)	0.043
	Sex	1.23 (0.30-4.94)	0.775
Model 3	Left cerebral infarction (vs right)	8.38 (1.01-69.43)	0.049
	Lacunar infarction	1.61 (0.40-6.50)	0.502
Model 4	Left cerebral infarction (vs right)	9.12 (1.10-75.45)	0.040
	Diabetes mellitus	0.34 (0.04-2.91)	0.326

A univariate logistic regression analysis revealed that left CI and older age were significant predictors of AP, whereas sex, CI type, or diabetes mellitus were not significant predictors of AP (Table 2).

We tested several regression models to assess the relation between the laterality of CI and the risk of AP. Left hemispheric CI was associated with increased odds of AP after adjusting for age, sex, CI type, or diabetes mellitus. Older age remained significant in the adjusted model (models 1-4, Table 2).

Furthermore, we investigated the relationship between the frequency of complications after CI and the laterality and location of CI. All AP cases occurred in patients with stroke from the motor cortex to the internal capsule, regardless of laterality. Moreover, the frequency of dysphagia as a direct cause of AP did not differ according to laterality, whereas the frequency of AP that ensued from dysphagia in the left CI group was greater than that observed in the right CI group. AP was present in 25.8% of cases in the group with left CI from the motor cortex to the internal capsule complicated by dysphagia (Table 3).

Table 3. Frequency of complications after cerebral infarction from the motor cortex to the internal capsule classified according to laterality

Location of the cerebral infarction	Right cerebral infarction from the motor cortex to the internal capsule (n=39)	Left cerebral infarction from the motor cortex to the internal capsule (n=44)	p value
Complication 1			
Dysphagia	23 (59.0)	31 (70.5)	0.357
Non dysphagia	16 (41.0)	13 (39.5)	
Complication 2 #			
Aspiration pneumonia	1 (4.3)	8 (25.8)	0.024
Non aspiration pneumonia	22 (95.7)	23 (74.2)	

Data are n (%).
Complication 2 consisted of patients with the complication of dysphagia.

Discussion

In the present study, we first demonstrated that left CI was strongly associated with an increased risk of AP. This association was independent of age, sex, CI type, or diabetes mellitus complication. In addition, as all patients with AP in this report exhibited corticobulbar tract infarction and dysphagia, AP was caused by dysphagia resulting from disturbances in the corticobulbar tract. Although the frequency of dysphagia after CI did not differ according to the laterality of CI, the frequency of AP after CI did. This result might indicate that the grade of dysphagia was affected by the laterality of CI.

Although the reason underlying the higher risk of AP observed in patients with left CI remains unclear, several mechanisms have been proposed and debated[5]. AP is generally considered to be caused by a decrease in the swallowing reflex: oral bacteria flow into the lungs with sputum, or stomach contents flow into the lungs backwardly. The cycle of swallowing consists of 3 phases: the oral phase, the pharyngeal phase, and the esophageal phase. The upper central nervous system adjusts the beginning of swallowing and facilitates the voluntary oral phase to reflexive pharyngeal phase[6]. Although some evidence suggests that the prepharyngeal stages of swallowing are

commanded by the bilateral cortical regions, the degree of hemispheric symmetry has not been established[7-9]. Recent reports using functional MRI, positron emission tomography (PET), and magnetoencephalography supported preferential left hemispheric activation during swallowing[10-12].

Taking these observations into account, we concluded on the existence of an asymmetry in descending corticobulbar projections that are relevant for swallowing efficacy, ie, left hemispheric dominance.

In the present study, we found that CI in the left hemisphere increases the risk of AP. In particular, the group with left CI from the motor cortex to the internal capsule complicated by dysphagia was at high risk for AP.

Our study might have some promising effect; preventive measures against AP, such as mouth care and maintenance of posture, may be worth being taken in such patients, starting soon after admission, neverthless our reserch is small[13-15]. Larger trial with more patients with AP after CI is needed to better investigate this effect.

References

1. Metheny NA. Risk factors for aspiration. JPEN Parenter Enteral Nutr 2002;26:S26-31.
2. Katzan IL, Cebul RD, Husak SH, Dawson NV, Baker DW. The effect of pneumonia on mortality among patients hospitalized for acute stroke. Neurology 2003;60:620-625.
3. Finlayson O, Kapral M, Hall R, Asllani E, Selchen D, Saposnik G. Risk factors, inpatient care, and outcomes of pneumonia after ischemic stroke. Neurology 2011;77:1338-1345.
4. Urban PP, Rolke R, Wicht S, Keilmann A, Stoeter P, Hopf HC, et al. Left-hemispheric dominance for articulation: a prospective study on acute ischaemic dysarthria at different localizations. Brain 2006;129:767-777.
5. Larson C. Neurophysiology of speech and swallowing. Semin Speech Lang 1985;6:275-291.
6. Miller AJ. Deglutition. Physiol Rev 1982;62:129-184.
7. Mosier K, Patel R, Liu WC, Kalnin A, Maldjian J, Baredes S. Cortical representation of swallowing in normal adults: functional implications. Laryngoscope 1999;109:1417-1423.
8. Kern M, Birn R, Jaradeh S, Jesmanowicz A, Cox R, Hyde J, et al. Swallow-related cerebral cortical activity maps are not specific to deglutition. Am J Physiol Gastrointest Liver Physiol 2001;280:G531-538.
9. Martin RE, MacIntosh BJ, Smith RC, Barr AM, Stevens TK, Gati JS, et al. Cerebral areas processing swallowing and tongue movement are overlapping but distinct: a functional magnetic resonance imaging study. J Neurophysiol 2004;92:2428-2443.
10. Martin R, Barr A, Maclntosh B, Smith R, Stevens T, Taves D, et al. Cerebral cortical processing of swallowing in older adults. Exp Brain Res 2007;176:12-22.
11. Harris ML, Julyan P, Kulkarni B, Gow D, Hobson A, Hastings D, et al. Mapping metabolic brain activation during human volitional swallowing: a positron emission tomography study using [18F]fluorodeoxyglucose. J Cereb Blood Flow Metab 2005;25:520-526.
12. Sörös P, Inamoto Y, Martin RE. Functional brain imaging of swallowing: an activation likelihood estimation meta-analysis. Hum Brain Mapp 2009;30:2426-2439.
13. Yoneyama T, Yoshida M, Matsui T, Sasaki H. Oral care and pneumonia. Lancet 1999;354:515.
14. Yoneyama T, Yoshida M, Ohrui T, Mukaiyama H, Okamoto H, Hoshiba K, et. al. Oral care reduces pneumonia in older patients in nursing homes. J Am Geriatr Soc 2002;50:430-433.
15. Matsui T, Yamaya M, Ohrui T, Arai H, Sasaki H. Sitting position to prevent aspiration in bed-bound patients. Gerontology 2002;48:194-195.