

*Original Article***Revised classification of aspiration before, during, and after the swallow and its reliability**

Takashi Tanaka, MD, DMSc,¹ Hitoshi Kagaya, MD, DMSc,¹ Yasunori Ozeki, MD, DMSc,²
 Wataru Fujii, DDS, PhD,³ Takatoshi Iida, DDS, PhD,⁴ Seiko Shibata, MD, DMSc,¹
 Saki Tomita, SLHT,⁵ Yuriko Ishiguro, SLHT,⁶ Kikuo Ota, MD, DMSc,⁷ Eiichi Saitoh, MD, DMSc¹

¹Department of Rehabilitation Medicine I, School of Medicine, Fujita Health University, Toyoake, Aichi, Japan

²Department of Rehabilitation Medicine, Uno Hospital, Okazaki, Aichi, Japan

³Division of Special Needs and Geriatric Dentistry, Kyushu Dental University, Kitakyushu, Fukuoka, Japan

⁴Department of Prosthodontic, Dentistry for Function of TMJ and Occlusion, Kanagawa Dental University, Kanagawa, Japan

⁵Department of Rehabilitation, Fujita Health University Nanakuri Memorial Hospital, Tsu, Mie, Japan

⁶Department of Rehabilitation, Fujita Health University Hospital, Toyoake, Aichi, Japan

⁷Department of Rehabilitation Medicine, International University of Health and Welfare Hospital, Nasushiobara, Tochigi, Japan

ABSTRACT

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Objective: The purpose of this study was to re-evaluate the classification of aspiration before, during, and after the swallow, and to verify the reliability of the revised classification.

Methods: Aspirations occurring during swallowing reflex were classified as during the swallow; aspiration during the first swallowing reflex was subclassified as type D-1, and aspiration during the second or subsequent swallowing reflex as type D-2; aspirations occurring prior to the first swallowing reflex were classified as before swallow (type B); and aspirations other than the above types were classified as after the swallow (type A). In 212 patients (mean age, 66 years) who underwent videofluoroscopic examinations of swallowing (400 examinations), aspiration was classified retrospectively. Inter- and intra-rater reliability was analyzed using the data obtained from the evaluation of 20 patients with aspiration by four

observers accredited by the Japanese Society of Dysphagia Rehabilitation.

Results: The numbers of aspirations were in the order of D-1>D-2>A>B. The frequency showed variability depending on the bolus. The mean inter- and intra-rater kappa coefficients were 0.68 and 0.85, respectively.

Conclusion: Our revised classification for aspiration before, during, and after the swallow is easy and adequately reliable.

Key words: videofluoroscopic examination of swallowing, aspiration, classification, reliability

Introduction

The presence or absence of aspiration is extremely important in the diagnosis of dysphagia. Regarding the timing when aspiration occurs, the terms “before the swallow”, “during the swallow” and “after the swallow” are often used. In one previous study, among 392 cases of aspiration, 25% were before the swallow, 7% were during the swallow, and 68% were after the swallow [1]. In another study, 35% of 69 cases of aspiration were before the swallow, 10% were during the swallow, and 55% were after the swallow [2]. These reports indicate a high incidence of aspiration after the swallow. However, the definitions of these terms remain unclear. Logemann [3] defined aspiration before the swallow as that occurring prior to the beginning of swallowing reflex, and after the swallow aspiration as that occurring after laryngeal lowering. On the other hand, Murray [4] defined aspiration

Correspondence: Takashi Tanaka, MD, DMSc
 Department of Rehabilitation Medicine I, School of
 Medicine, Fujita Health University, 1-98 Dengakugakubo,
 Kutsukake-cho, Toyoake, Aichi 470-1192, Japan.
 E-mail: nqc28415@nifty.com

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There is no conflict of interest in this study.

Table 1. The classification of aspiration before, during, and after the swallow (first edition).

| | |
|---|-----|
| Aspiration occurring prior to the first swallowing reflex | B-1 |
| Aspiration of the residual food located between the oral cavity and the lower border of the mandible at the end of the last swallowing reflex before aspiration | B-2 |
| Aspirations occurring during swallowing reflex | |
| Aspirations during the first swallowing reflex | D-1 |
| Aspirations during the second or subsequent swallowing reflex | D-2 |
| Aspirations other than the above types | A |

B, before; D, during; A, after.

during the swallow as that occurring from the end of hyoid bone elevation until return of the larynx to the resting position, and all subsequent aspirations as after the swallow. Therefore, there are discrepancies in the definitions of aspiration before and during the swallow. Furthermore, in the clinical setting when swallowing occurs repeatedly, it is often difficult to decide whether to classify aspiration occurring in the absence of swallowing reflex as before the swallow or after the swallow. The objective of the present study was to re-evaluate the classification of aspiration before, during, and after the swallow, and to verify the reliability of the revised classification.

Re-evaluation of Aspiration Classification

1. Subjects and methods

We retrospectively classified the aspirations observed in 212 patients with suspected dysphagia admitted to Hospital A between October 2009 and November 2010, who underwent videofluoroscopic examination of swallowing (VF; 400 examinations) after written informed consent was obtained from the patient or the family. The concentration of barium used in VF was 50% w/v.

Aspirations occurring during swallowing reflex (from the beginning of rapid elevation of the hyoid bone until return of the larynx to the resting position) were classified as during the swallow; aspiration during the first swallowing reflex was subclassified as type D-1, and aspiration during the second or subsequent swallowing reflex as type D-2. Aspiration occurring prior to the first swallowing reflex was classified as before the swallow type B-1, while aspiration of the residual food located between the oral cavity and the lower border of the mandible at the end of the last swallowing reflex before aspiration was classified as type B-2. Aspirations other than types B-1, B-2, D-1, and D-2 were classified as after the swallow (type A) (Table 1).

2. Results

The subjects comprised 156 men and 56 women with a mean age of 66 years. The underlying diseases were cerebrovascular diseases in 77 patients, traumatic brain injuries in 15 patients, other brain diseases in 29

Table 2. Results of the classification of aspiration before, during, and after the swallow (first edition).

| Classification | Number | Ratio (%) |
|----------------|--------|-----------|
| B-1 | 36 | 9.0 |
| B-2 | 2 | 0.5 |
| D-1 | 146 | 36.5 |
| D-2 | 69 | 17.3 |
| A | 85 | 21.3 |
| B-1+D-1 | 5 | 1.3 |
| D-1+D-2 | 50 | 12.5 |
| D-1+A | 1 | 0.3 |
| D-2+A | 5 | 1.3 |
| B-1+D-1+D-2 | 1 | 0.3 |
| Total | 400 | 100.0 |

patients, respiratory diseases in 26 patients, gastrointestinal diseases in 18 patients, neuromuscular diseases in 13 patients, oropharyngeal tumors in 10 patients, and others in 24 patients. Among 400 VF examinations, aspiration occurred once in 338 examinations, twice in 61 examinations, and three times in one examination. The numbers of aspirations by type of aspiration were in the order of type D-1>A>D-2>D-1+D-2>B-1, with type B-2 detected in only two examinations (0.5%) (Table 2). For the aspirations classified as B-2, VF examination showed also pharyngeal residue at the end of the last swallowing reflex before aspiration, and it was difficult to decide whether the food causing aspiration was derived from the oral residue or the pharyngeal residue. Therefore, we revised the classification by including type B-2 in type A. In the revised classification, aspirations occurring prior to the first swallowing reflex were classified as before the swallow type B, aspirations during the first swallowing reflex as during the swallow type D-1, aspiration during the second or subsequent swallowing reflex as during the swallow type D-2, and all other aspirations as after the swallow type A (Table 3).

Frequencies of Aspirations before, during, and after the Swallow

1. Subjects and methods

For the above-mentioned 212 patients who showed aspirations on VF (400 examinations) conducted in

Hospital A, the aspirations were reclassified using the definitions shown in Table 3 and the frequencies were calculated. To analyze the differences in frequencies of aspirations before, during, and after the swallow according to bolus type, 62 VF examinations in which two or more aspirations were observed were excluded, and the remaining 338 examinations were analyzed. Among the boluses used in VF, thick liquid, thin liquid, jelly, mixture (corned beef+thin liquid), and total were compared using the chi-square test for goodness of fit. Statistical analyses were conducted using SPSS Statistics 21 (IBM Corporation, USA). A *p* value less than 0.05 was considered significant.

2. Results

A total of 9 aspiration patterns were observed: B, D-1, D-2, A, B+D-1, D-1+D-2, D-1+A, D-2+A, and B+D-1+D-2 (Table 4). Including multiple aspirations in one examination, the total numbers of aspirations by aspiration type were 42 for type B, 203 for type D-1, 125 for type D-2, and 93 for type A; in the order of D-1>D-2>A>B. When the frequencies by food type were analyzed using the 338 examinations in which only one aspiration was detected, significant differences were observed for thick liquid, thin liquid, mixture and total. Variability in frequency was observed for types B, D-1, D-2, and A. The frequencies of types A and D-1 were high for thick liquid, while the frequency of type D-1 was high for thin liquid and mixture, and the frequency of D-1 was also high for total (Table 5).

Reliability of Classification of Aspiration before, during, and after the Swallow

1. Subjects and methods

Reliability of the revised aspiration classification was verified in 20 patients selected randomly from cases showing aspirations on VF conducted in Hospital B between April 2013 and March 2014 after obtaining written informed consent from each patient or family. The barium concentration used in VF examinations was 50% w/v. One physiatrist, one dentist, and two speech-language-hearing therapists accredited by the Japanese Society of Dysphagia Rehabilitation classified the aspirations of the 20 subjects according to the definitions shown in Table 3, and inter-rater reliability was analyzed. Next, the sequence of the 20 patients was randomly re-sorted, and classification of aspiration was repeated one week later for analysis of intra-rater reliability. Inter- and intra-rater reliability were assessed using kappa coefficients. Statistical analyses were conducted using SPSS Statistics 21 (IBM Corporation, USA). A *P* value less than 0.05 was considered significant.

2. Results

Regarding, inter-rater agreement, the kappa

Table 3. The classification of aspiration before, during, and after the swallow (revised edition).

| | |
|---|-----|
| Aspiration occurring prior to the first swallowing reflex | B |
| Aspirations during the first swallowing reflex | D-1 |
| Aspirations during the second or subsequent swallowing reflex | D-2 |
| Aspirations other than the above types | A |

B, before; D, during; A, after.

Table 4. Results of the classification of aspiration before, during, and after the swallow (revised edition).

| Classification | Number |
|----------------|--------|
| B | 36 |
| D-1 | 146 |
| D-2 | 69 |
| A | 87 |
| B+D-1 | 5 |
| D-1+D-2 | 50 |
| D-1+A | 1 |
| D-2+A | 5 |
| B+D-1+D-2 | 1 |
| Total | 400 |

Table 5. The frequencies of aspiration by bolus type (338 examinations).

| Bolus | B | D-1 | D-2 | A | Total | <i>p</i> Value* |
|--------------|----|-----|-----|----|-------|-----------------|
| Thick liquid | 22 | 42 | 25 | 49 | 138 | 0.002 |
| Thin liquid | 9 | 69 | 31 | 16 | 125 | <0.001 |
| Jelly | 3 | 8 | 7 | 14 | 32 | 0.051 |
| Mixture | 4 | 24 | 5 | 6 | 39 | <0.001 |
| Others | 0 | 3 | 1 | 0 | 4 | |
| Total | 38 | 146 | 69 | 85 | 338 | <0.001 |

* χ^2 test for goodness of fit.

coefficients for six combinations of two observers each among the four observers were 0.57, 0.57, 0.64, 0.64, 0.74, and 0.92 (mean 0.68), showing substantial reliability. Regarding, intra-rater agreement, the kappa coefficients for the four observers were 0.74, 0.83, 0.83, and 1.00 (mean 0.85), showing almost perfect agreement. All the kappa values were significant, with *p* values less than 0.001.

Discussion

We re-evaluated the classification of aspiration before, during, and after the swallow. In the present study, the incidence of aspiration during the swallow was the highest, and that of aspiration before the swallow was the lowest. Most previous reports indicated a high incidence of aspiration after the swallow and a low incidence of aspiration during the swallow [1, 2]. These discrepancies may arise from

differences in definitions. According to the classification of Murray [4], aspiration that occurs from the beginning of swallowing reflex to the end of hyoid bone elevation is classified as before the swallow. On the other hand, type D-2 that we define as during the swallow could be considered as after the swallow. Regarding these issues, further comparative study is required using the same classification with clear definitions. Type D-2 is aspiration during the swallowing reflex, and probably involves aspiration of pharyngeal residue at the end of the last swallowing reflex or food invading the larynx. The significance of type D-2 aspiration also has to be examined in the future. Furthermore, the present results suggest that the frequencies of aspirations before, during, and after the swallow differ depending on the type of bolus. Although the frequency of aspiration during the swallow type D-1 was high overall, the frequency of aspiration after the swallow type A was the highest for thick liquid. Thick liquid has high viscosity, which may facilitate the collection of pharyngeal residue, contributing to the high incidence of aspiration after the swallow. In the present analysis of aspiration frequency by bolus type, we excluded cases showing two or more aspirations in one VF examination, because more than one type of aspiration may occur in the case of multiple aspirations. In fact, among those VF examinations showing multiple aspirations, we observed combinations of before the swallow and during the swallow, during the swallow and during the swallow, as well as during the swallow and after the swallow patterns.

The causes of aspiration before the swallow include poor tongue control [3], and absence or delay of swallowing reflex [3, 4]. Aspiration during the swallow has been reported to be caused by incomplete laryngeal closure [3], delayed or slowed laryngeal elevation [5, 6], vocal fold closure, false vocal fold closure, anterior tilting of the arytenoids, decreased epiglottic inversion and reduced coordination [4]. Aspiration after the swallow is caused by pharyngeal residue [3, 4, 7], and greater amount of residue increases the risk of aspiration after the swallow [3]. Other factors include reduced pharyngeal contraction, inadequate laryngeal elevation, incomplete opening of upper esophageal opening, spasm, lack of elasticity, and regurgitation from the digestive tract or diverticulum [4]. Originally, we considered that when the food residue located between the oral cavity and the lower border of the

mandible at the end of the last swallowing reflex is aspirated, the aspiration is not caused by pharyngeal residue. Therefore, we classified this type of aspiration as type B-2. In the actual clinical situation, type B-2 constituted only 0.5% of all aspirations, and pharyngeal residue was in fact also found in type B-2 cases. Eventually, we classified this type as after the swallow. By removing type B-2, the revised classification now contains four types instead of five types. With this classification scheme, aspiration before or after the swallow can be differentiated by whether aspiration occurs before or after the first swallowing reflex, which is very easy. The simplicity of this classification scheme may account for the very high inter- and intra-rater reliability, with kappa coefficients of 0.68 and 0.85, respectively. Therefore, the present data shows that this classification is easy and adequately reliable.

In conclusion, our revised classification of aspiration before, during, and after the swallow is easy to use and adequately reliable. This classification is expected to be utilized effectively in studies of the causes and methods of treating aspiration.

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