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# New classifications for Life-threatening foreign body airway obstruction

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ABSTRACT

*Introduction:* Foreign body airway obstruction (FBAO) is a common medical emergency; however, few studies of life-threatening FBAO have been reported and no standard classification system is available.
*Methods:* We retrospectively evaluated patients who presented to the emergency departments of two hospitals and were diagnosed with FBAO. The primary outcome was cerebral performance category (CPC) score at discharge. To establish a new classification system for FBAO, FBAO was classified into three types based on the anatomical and physiological characteristics of the obstructed airway.
*Results:* A total of 137 patients were enrolled. Median age was 79.0 years. The most common cause of FBAO was meat, followed by bread, rice cake, and rice. Of all patients, 65.7% suffered cardiac arrest and 51.1% died. In contrast, 28.5% had favorable neurological outcomes, defined as CPC 1 and 2. Upper airway obstruction (type 1) was the most common (type 1, 78.1%), while trachea and/or bilateral main bronchus obstruction (type 2, 12.4%) showed significantly higher mortality than type 1 obstruction (82.4% vs 47.7%, P = 0.0078). Patients with unilateral bronchus and/or distal bronchus obstruction (type 3, 9.5%) were significantly more likely to consume a dysphagia diet than type 1 patients (23.1% vs 0%, P < 0.0001).
*Conclusion:* The majority of patients with life-threatening FBAO were elderly and had poor neurological outcomes. Our new classification system divides FBAO into three types, and revealed that mortality was significantly higher with type 2 than type 1 obstruction. This classification system may improve the management of patients with FBAO and assessment of patient outcomes.


## 1. Introduction

Foreign body aspiration is a common medical emergency whose presentation can range from asymptomatic to life-threatening [1-7]. Foreign body airway obstruction (FBAO) is responsible for the deaths of thousands of individuals every year worldwide, including the US [8]. In 2014, a population survey by the Ministry of Health, Labour, and Welfare (MHLW) in Japan revealed that 9223 people (7.4 per 100,000) died from FBAO and that it was the most common cause of accidental death in Japan [9]. While foreign bodies, mainly organic materials, are mostly often aspirated from geriatric populations, they are a problem for both pediatric and geriatric populations [2,4,10-12].

Patients diagnosed with FBAO are divided into non-life threatening and life-threatening cases. Non-life threatening FBAO is caused by relatively small food particles like nuts becoming lodged in the lower respiratory tract. The foreign body is found and removed by bronchoscopy [2,4,5,10,12-16]. The location of the foreign body is classified according to the anatomy of the bronchus [17]. In contrast, life-threatening FBAO causes hemodynamic instability and respiratory failure, which requires immediate intervention. Patients with life-threatening FBAO require resuscitation prior to bronchoscopy because they often suffer cardiac arrest [3,18,19]. Life-threatening FBAO is usually caused by relatively large food pieces that completely obstruct the larynx, which are removed using Magill forceps rather than by bronchoscopy [3,6,20].

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Although a few studies of life-threatening FBAO have been reported, no standard classification system is available. In this case series, we focused on adult patients with life-threatening FBAO because causes of FBAO in adult patients differ from those in child patients. We then proposed a new classification system of life-threatening FBAO. To our knowledge, this is the largest case series and the first classification system of life-threatening FBAO.

## 2. Methods

### 2.1. Ethics statement

This study was approved by the Ethics Committee of the Nippon Medical School Hospital and the Osaka Police Hospital (29-02-901). The need for informed consent was waived.

### 2.2. Study design

We retrospectively evaluated consecutive adult patients who presented to the emergency departments of two hospitals in Tokyo and Osaka, Japan, from January 2014 to February 2018 and were diagnosed with FBAO. These hospitals are academic hospitals and are equivalent to level 1 trauma centers in the US. We collected the following data from patients' medical records: age, sex, medical history, cause of airway obstruction, presence of out-of-hospital cardiac arrest, examination results (computed tomography [CT] and bronchoscopy), and patient outcome. The cause of airway obstruction (foreign bodies) was classified as follows: rice, rice cake (mochi), sushi, bread, noodle, meat, fish, fruit, vegetable, potatoes, jelly, others or unknown. The primary outcome was evaluated using cerebral performance categories (CPCs) at the time of discharge. A favorable outcome was defined as CPC 1 (full recovery) or 2 (moderate disability), and an unfavorable outcome as CPC 3 (severe disability), 4 (vegetative state), or 5 (death) because previous studies have shown that a high proportion of patients with FBAO suffer cardiac arrest [21]. Patient exclusion criteria were as follows: aspiration of sputum and gastric contents, choking with gas, drowning, unwitnessed cardiac arrest, loss of consciousness before FBAO, and giant thyroid tumor.

### 2.3. Prehospital and in-hospital setting

The emergency medical service (EMS) has a protocol for treating patients with FBAO. At the time of an emergency call, EMS personnel provide instructions over the phone if FBAO is suspected. EMS personnel encourage patients who showed a response after EMS arrival to cough, and perform abdominal thrust and back blow maneuvers. For patients with FBAO who show no response or suffer cardiac arrest, EMS personnel perform chest compressions and transfer them immediately to the hospital after attempting to remove the foreign body, performing tracheal intubation or administering epinephrine.

The two hospitals included in this study are emergency and critical care centers officially certified by the MHLW and located in the first and second largest cities in Japan. Patients who suffered cardiac arrest on arrival at the hospital received intubation and were administered epinephrine according to advanced cardiac life support procedures. The emergency physician decided whether or not to perform CT and bronchoscopy on patients with stable vital signs based on the patient's medical history, vital signs and physical examination findings.

### 2.4. Definition of multi-center observational choking investigation (MOCHI) classification

At the time the patients were treated, there was no standard classification system for FBAO, particularly life-threatening FBAO. We classified the location of the FBAO into one of three types based on anatomical and physiological characteristics: type 1, upper airway obstruction by a large foreign body that cannot pass through the vocal cord or a large amount of residue that completely obstructs the airway; type 2, trachea and/or bilateral main bronchus obstruction by a foreign body or a large amount of residue; and type 3, unilateral bronchus and/or distal bronchus obstruction by a foreign body, residue, or liquid (Fig. 2). Type 2 and 3 were differentiated on the basis that a foreign body that completely obstructs the trachea and/or bilateral main bronchus may cause patients to rapidly suffer cardiac arrest due to hypoxemia, while a foreign body that obstructs the peripheral bronchus is unlikely to immediately result in severe hypoxemia. We developed a practical manual so that the FBAO classifications could be assigned easily based on the results of examinations and procedures (Table 1). If a foreign body was located in $\geq$2 regions, the location closest to the mouth was selected for classification because foreign bodies on the oral side better reflect the pathophysiology of FBAO.

### 2.5. Determination of classification

Four raters evaluated the cases in a blinded manner and classified them into one of the three MOCHI types at the time of choking based on summaries in the patients' medical records (Supplementary Table 1) as well as CT and bronchoscopy findings. When all raters chose the same classification, the chosen classification was used. However, when their evaluations did not match, the raters

**Table 1**
Practical manual of the "MOCHI" classification for foreign bodies in airway obstruction, including maneuvers and examination results

| Type | Example of procedures and examinations | Illustrative cases |
|---|---|---|
| 1 | To remove the foreign body, use abdominal thrust or back blow maneuvers, or Magill forceps. Use a laryngoscope to locate a large foreign body that cannot pass through the vocal cord or a large amount of residue that completely obstructs the airway. | A piece of meat of size 4 cm was removed using the back blow maneuver; a lump of bread was found in the larynx and was removed by paramedics using suction; a piece of rice cake completely obstructed the airway before a doctor performed intubation and removed the food with Magill forceps. |
| 2 | Confirm that there is no foreign body within the upper airway using, for example, a laryngoscope. Additionally, use bronchoscopy or computed tomography (CT) to locate a foreign body in the trachea or bilateral main bronchus. To remove a foreign body from the trachea, use bronchoscopy after intubation. | Bronchoscopy revealed a piece of rice cake in the bilateral main bronchus; a large amount of residue was removed from the trachea using bronchoscopy or suction after intubation. |
| 3 | Use bronchoscopy to locate a foreign body in the unilateral main bronchus or distal bronchus. Bronchoscopy will not reveal any findings if the obstructing liquid is aspirated. Use a chest X-ray or CT to locate a foreign body in the bronchus or to identify atelectasis caused by a foreign body. | A large amount of rice grains was found and removed from the right lower bronchus using bronchoscopy; a CT revealed foreign bodies in the right main bronchus and atelectasis in the right lower lobe. |

discussed the case and chose the most suitable classification. When the raters determined that a case contained insufficient information, the case was excluded.

### 2.6. Statistical analysis

Age, as an asymmetric distribution, was reported as median and interquartile range. Categorical variables were reported as number of individuals and percentages and were analyzed using the chi-squared test. As the majority of cases were classified as type 1 and fewer cases were classified as type 2 and 3 in our pilot study, we compared the mortality of type 2 and 3 with type 1. Statistical analysis was performed using SPSS version 25 (IBM Company, Chicago, IL, USA). A P value of <0.05 was considered statistically significant.

To validate this classification system, the inter-rater reliability was measured for all cases using weighted kappa coefficients. First, one coefficient was calculated for a pair of evaluators, and the median of these coefficients was then calculated. A reliability statistical value of 0.00–0.20 was considered slight, 0.21–0.40 as fair, 0.41–0.60 as moderate, 0.61–0.80 as substantial, and 0.81–1.00 as almost perfect [22].

## 3. Results

A total of 137 patients with FBAO were enrolled in this study (Fig. 1). Patient characteristics are shown in Table 2. The median age was 79.0 years (interquartile range: 71.0–86.0 years). The most common foreign bodies were meat (20.4%), bread (19.0%), and mochi (13.9%). One hundred and twenty-three patients (89.8%) ate a normal diet and five (3.6%) patients ate a dysphagia diet regularly. Thirty-six patients (26.3%) received bronchoscopy. Ninety patients (65.7%) suffered cardiac arrest. Of all patients, 23 (16.8%) were categorized as CPC 1, 16 (11.7%) as CPC 2, 11 (8.0%) as CPC 3, 17 (12.4%) as CPC 4, and 70 (51.1%) as CPC 5 at the time of discharge.

One hundred and seven patients (78.1%) were classified as MOCHI type 1, 17 (12.4%) as type 2, and 13 (9.5%) as type 3. The median inter-rater agreement was substantial, with a kappa coefficient of 0.67. The demographic characteristics of patients classified as type 2 and 3 were not significantly different to those of patients classified as type 1. The proportion of type 2 and 3 patients who ate a dysphagia diet was significantly higher than the proportion of type 1 patients (11.8% and 23.1% vs 0%, P < 0.001 and P < 0.001, respectively). The proportion who received bronchoscopy was significant higher among type 2 (47.1%) and 3 (69.2%) patients than type 1 patients (19.6%) (P = 0.01 and P < 0.001, respectively). Patients who suffered cardiac arrest were most common among type 2 (88.2%) and least common among type 3 (46.2%) patients. However, there was no significant difference in the incidence of cardiac arrest between type 2 and type 1 (64.5%; P = 0.05), or between type 3 and type 1 patients (P = 0.20) (Table 3). The proportion of patients with a favorable outcome was highest among type 1 and lowest among type 3 patients, although the difference was not significantly different. Mortality was significantly higher among type 2 than type 1 patients (82.4% vs 47.7%, P = 0.008), but did not significantly differ between type 3 and type 1 patients (38.5% vs 47.7%, P = 0.53) (Fig. 3).

**Table 2**
Patient characteristics.

| | |
|---|---|
| Age, years, mean (interquartile range) | 79.0 (71.0–86.0) |
| Sex (male/female), n | 81/56 |
| Foreign object, n (%) | |
| Meat | 28 (20.4%) |
| Bread | 26 (19.0%) |
| Rice cake (mochi) | 19 (13.9%) |
| Rice | 9 (6.6%) |
| Sushi | 7 (5.1%) |
| Jelly | 7 (5.1%) |
| Vegetable | 6 (4.4%) |
| Fruit | 6 (4.4%) |
| Potato | 5 (3.6%) |
| Fish | 4 (2.9%) |
| Noodle | 3 (2.2%) |
| Others | 4 (2.9%) |
| Unknown | 16 (11.7%) |
| Diet, n (%) | |
| Regular | 123 (89.8%) |
| Dysphagia | 5 (3.6%) |
| Unknown | 10 (7.3%) |

## 4. Discussion

This study revealed that the majority of patients with life-threatening FBAO were elderly and had poor outcomes. The median age was 79.0 years. Of all patients, 65.7% suffered cardiac arrest and 51.1% died. Moreover, only 28.5% of the patients had favorable outcomes.

Our previous study revealed that risks of FBAO included neurological disorders, such as cerebral infarction and Parkinson's disease, psychiatric disorders, such as schizophrenia and depression, and recurrence of asphyxia [3]. In case of emergency, family members and nursing home staff caring for elderly at high risk of chok-

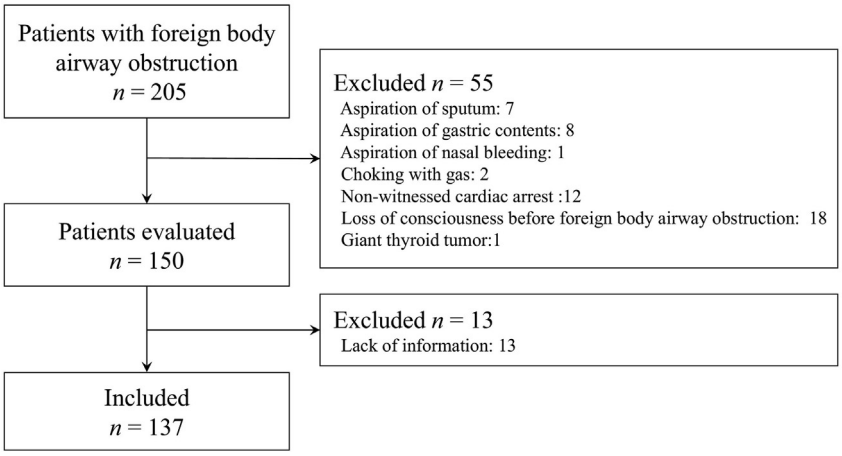



**Fig. 1.** Patient flowchart.

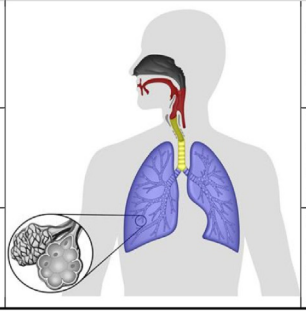
| Type | Anatomy | | Physiology | Definition |
|---|---|---|---|---|
| 1 |  | Oral cavity, pharynx, or larynx (red) | Possible complete obstruction | Upper airway obstruction by a large foreign body that cannot pass through the vocal cord or a large amount of residue that completely obstructs the airway. |
| 2 | | Trachea above carina (yellow) | | Trachea and/or bilateral main bronchus obstruction by a foreign body or a large amount of residue. |
| 3 | | Bronchi, bronchioles, and lungs (blue) | Partial obstruction | Unilateral bronchus and/or distal bronchus obstruction by a foreign body, residue, or liquid. |

**Fig. 2.** "MOCHI" classification of the location of foreign bodies in airway obstruction. MOCHI: Multi-center observational choking investigation.

ing should learn how to perform first-aid and cardiopulmonary resuscitation for patients with FBAO.

The most common cause of FBAO was meat, bread and mochi. Many people regularly eat meat, bread and rice; however, few people eat mochi every day. Mochi is a traditional food in Japan and is usually eaten on anniversaries, particularly the first day of the year. This ranking of mochi as the third-most common cause of FBAO despite not being eaten as a daily food is due to its unique texture and stickiness. The danger of mochi to the elderly should be made widely known, and mochi should be served warm and in smaller sizes to prevent choking.

Our new classification system revealed that mortality was significantly higher among type 2 than type 1 patients. The classification system also revealed the characteristics of each FBAO type: type 1 were the most common; type 2 patients had significantly higher mortality; and type 3 patients were significantly more likely to consume a dysphagia diet.

MOCHI classification is a new classification system for life-threatening FBAO. Previous research classified the location of the foreign body with bronchoscopy [17]; however, it is difficult to determine the location of the foreign body in patients with life-threatening FBAO because they require resuscitation prior to bronchoscopy. Our present classification system does not require additional examinations and can be determined from patients' medical records and examination findings. It also showed substantial agreement among evaluators regardless of board certification and years of experience. Moreover, mortality significantly differed among the types and each type had different characteristics. The availability of such a classification system is expected to improve research and the therapeutic assessment and management of patients with FBAO. In the current study, type 3 patients were older, and a higher proportion were examined by bronchoscopy and ate a dysphagia diet compared to type 1 patients. Because elderly people may have decreased deglutition function and cough reflux [23], the foreign body may reach peripheral bronchi. Bronchoscopy was often used for type 3 patients, and is the gold standard for diagnosis and treatment of patients with FBAO [24-27].

A higher proportion of type 1 and 2 patients experienced complete foreign body obstruction of the airway and suffered immediate cardiac arrest than type 3 patients. Although foreign bodies in type 1 patients can be removed with Magill forceps and chest compression, a laryngoscope and Magill forceps cannot reach the obstructed regions of the airway in type 2 patients. This may explain why cardiac arrest was most common among type 2 patients, who had the highest mortality among the three classifications.

This study has several limitations. First, it is difficult to accurately diagnose FBAO, particularly in patients who experience car-

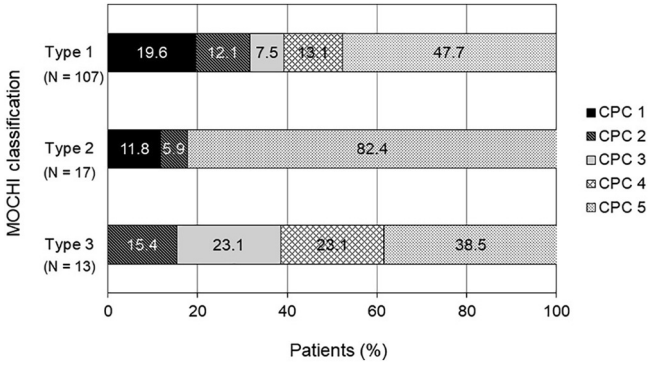



**Fig. 3.** Neurological outcomes according to cerebral performance categories among MOCHI classifications at the time of discharge.

**Table 3**
Comparison of patient characteristics and outcomes among the MOCHI classification.

| | Type 1 ($n$ = 107) | Type 2 ($n$ = 17) | | Type 3 ($n$ = 13) | |
|---|---|---|---|---|---|
| | | | P value | | P value |
| Age, years, mean (interquartile range) | 79.0 (71.0–86.0) | 81.0 (75.0–85.3) | 0.53 | 85.0 (80.0–87.3) | 0.06 |
| Sex (male/female), n | 66/41 | 8/9 | 0.25 | 7/6 | 0.58 |
| Foreign object, n (%) | | | | | |
| Meat | 26 (24.3%) | 1 (5.9%) | 0.09 | 1 (7.7%) | 0.18 |
| Bread | 21 (19.6%) | 3 (17.6%) | 0.85 | 2 (15.4%) | 0.71 |
| Rice cake (mochi) | 19 (17.8%) | 0 (0%) | 0.06 | 0 (0%) | 0.10 |
| Rice | 4 (3.7%) | 1 (5.9%) | 0.68 | 4 (30.8%) | <0.001 |
| Sushi | 4 (3.7%) | 2 (11.8%) | 0.15 | 1 (7.7%) | 0.50 |
| Jelly | 4 (3.7%) | 2 (11.8%) | 0.44 | 1 (7.7%) | 0.88 |
| Vegetable | 6 (5.6%) | 0 (0%) | 0.32 | 0 (0%) | 0.38 |
| Fruit | 5 (4.7%) | 1 (5.9%) | 0.83 | 0 (0%) | 0.43 |
| Potato | 3 (2.8%) | 1 (5.9%) | 0.50 | 1 (7.7%) | 0.35 |
| Fish | 4 (3.7%) | 0 (0%) | 0.42 | 0 (0%) | 0.48 |
| Noodle | 3 (2.8%) | 0 (0%) | 0.48 | 0 (0%) | 0.54 |
| Others | 4 (3.7%) | 0 (0%) | 0.42 | 0 (0%) | 0.48 |
| Unknown | 5 (4.7%) | 7 (41.2%) | <0.001 | 4 (30.8%) | <0.001 |
| Diet, n (%) | | | | | |
| Regular | 104 (97.2%) | 10 (58.8%) | <0.001 | 8 (61.5%) | <0.001 |
| Dysphagia | 0 (0%) | 2 (11.8%) | <0.001 | 3 (23.1%) | <0.001 |
| Unknown | 3 (2.8%) | 5 (29.4%) | <0.001 | 2 (15.4%) | <0.001 |
| Bronchoscopy, n (%) | 21 (19.6%) | 8 (47.1%) | 0.01 | 9 (69.2%) | <0.001 |
| Cardiac arrest, n (%) | 69 (64.5%) | 15 (88.2%) | 0.05 | 6 (46.2%) | 0.1973 |
| Outcome, n (%) | | | | | |
| Favorable | 34 (31.7%) | 3 (16.4%) | 0.24 | 2 (15.4%) | 0.22 |
| Death | 51(47.7%) | 14 (82.4%) | 0.008 | 5 (38.5%) | 0.53 |

diac arrest. Because choking is characterized under café coronary, it is difficult to identify whether the cardiac arrest is caused by another factor during a meal or by choking. In this study, patients with unwitnessed cardiac arrest were excluded to improve the accuracy of diagnosis, even when an airway foreign body was found. Additionally, it was difficult to classify cases whose medical records did not include sufficient details. Real time evaluation and classification on the field and at the emergency department (ED) might help to improve the accuracy of classification. Second, this study could not evaluate activity of daily life (ADL) before choking. Because patients who had disabilities were included in this study, it would have been useful to evaluate any decrease in ADL after choking compared to that before. Further studies are needed to resolve these issues. Third, given that the study included patients from two hospitals only, our results may not be representative of the general population. However, because we focused on patients with severe conditions, patients from these two hospitals were considered appropriate for this study.

## 5. Conclusions

This study revealed that the majority of patients with life-threatening FBAO were elderly people and had poor outcomes. Meat was the most common cause of FBAO, followed by bread, mochi, and rice. We developed a new classification system in which patients with FBAO were divided into three types according to their medical history and examination findings. We found that mortality was significantly higher among patients with trachea and/or bilateral main bronchus obstruction (type 2) than patients with upper airway obstruction (type 1). This classification system may improve the management of patients with FBAO and the assessment of patient outcomes.

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ajem.2019.03.015.

## Conflicts of interest

None declared.

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