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Effectiveness of the Abdominal Thrust Maneuver for Airway Obstruction Removal: Analysis of Data from the National Emergency Medical Services Information System

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Background: Foreign body airway obstruction (FBAO) is a life-threatening emergency. Abdominal thrusts are recommended as first aid, but the success rate for this technique is unclear. Using information from a large database of emergency medical services (EMS) data in the United States, we evaluated the success rate of abdominal thrusts and identified patient characteristics that were associated with the success of the technique.

Methods: A retrospective observational study was conducted using data from the National Emergency Medical Services Information System (NEMSIS) to ascertain the success of abdominal thrusts in patients with FBAO from nearly 14,000 EMS agencies. Success was defined by positive evaluations on subjective and objective EMS criteria.

Results: Analysis of 1,947 cases yielded a 46.6% success rate for abdominal thrusts in removing obstructions. The age distribution was bimodal, with peaks during infancy and old age. June had the highest incidence of FBAO. Incidents were most frequent during lunch and dinner times, and most cases occurred in private residences. The first-time success rate was 41.5%, and a lower level of impaired consciousness was associated with lower success rates. A lower incidence of cardiac arrest was noted in successful cases. The success rate was high (60.2%) for children (age ≤15 years), with differences in demographic characteristics and a lower rate of impaired consciousness and cardiac arrests, as compared with unsuccessful interventions in the same age group.

Conclusions: Our study showed a 46.6% success rate for abdominal thrusts in patients with FBAO. The success group had a lower proportion of impaired consciousness and cardiopulmonary arrest than the failure group. Future studies should attempt to identify the most effective maneuvers for clearing airway obstruction. (J Nippon Med Sch 2024; 91: 270–276)

Key words: Heimlich maneuver, airway obstruction, first aid, emergency medical service, cardiac arrest

Introduction

Foreign body airway obstruction (FBAO) is a life-threatening emergency and ranks as the fourth leading cause of unintentional death in the United States, resulting in approximately 5,000 deaths annually[1]. FBAO contributes significantly to mortality and morbidity, particularly in infants and older adults[1].

Early removal of foreign bodies is crucial because of the correlation between the duration of airway obstruction and patient outcomes[2]. The latest international consensus recommends abdominal thrusts when back blows are ineffective[3]. Invented by Heimlich in 1974, abdominal thrusts are a widely used first aid technique for FBAO[4]. This maneuver involves increasing pressure in the chest

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cavity to remove foreign objects obstructing the trachea. The performer stands behind the choking individual; wraps their arms around the waist; forms a fist with one hand and places the thumb side of that hand against the person's abdomen, just above the navel but below the ribcage; secures their fist with the other hand; and performs up to five quick, upward, and inward thrusts. The technique is repeated until the obstruction is cleared.

The efficacy of abdominal thrusts is unclear because few studies have compared it to other first aid maneuvers or airway clearance devices. Furthermore, numerous fatal complications of abdominal thrusts have been reported[3]. Therefore, using a large database of information collected by EMS personnel in the United States, we investigated the success rate of the abdominal thrust maneuver and identified patient characteristics that were associated with the effectiveness of this technique.

Materials and Methods

Study Design

We conducted a retrospective observational study of data from the National Emergency Medical Services Information System (NEMSIS), a comprehensive nationwide database that standardizes collection of information on EMS activities in the United States[5]. This study was approved by the Institutional Review Board of the Nippon Sports Science University (approval number: 023-H071).

Setting

The database encompasses approximately 50 million records submitted by 13,946 EMS agencies in 54 states and territories of the United States. The study included cases from January 1, 2018, to December 31, 2020, in which the abdominal thrust maneuver was performed. Duplicate data were excluded. Patients with undocumented outcomes (success or failure) were excluded from the analysis.

Data Collection

Data were anonymized to ensure confidentiality and were input by EMS staff without specific training. Data extracted from the NEMSIS database included age, sex, race, presence of cardiac arrest, performance of the abdominal thrust maneuver, number of times the maneuver was performed, type of performer, success or failure of the maneuver, and whether the maneuver resulted in improvement. We did not investigate whether patients received back blows, because NEMSIS does not include information on this procedure.

Definition of Abdominal Thrust Maneuver Success

NEMSIS has two variables to evaluate procedure outcomes[5,6]: one (eProcedures_06) is a subjective evaluation by EMS personnel and the other (eProcedures_08) is an objective evaluation based on vital signs. In this study, the abdominal thrust maneuver was defined as successful if both the subjective and objective evaluations were described as successful, regardless of the number of attempts. This is consistent with the existing definition of success for first aid maneuvers for FBAO[6,7]. Although the number of procedures was recorded in NEMSIS, success was defined as an improvement in both subjective and objective ratings, regardless of the number of procedures.

Statistical Analysis

A descriptive analysis was conducted on patients for whom the abdominal thrust maneuver was performed, as recorded in the NEMSIS database. A subgroup analysis was performed for children (age ≤15 years) because of anatomical differences from adults. Continuous variables are represented by the median and interquartile range and were evaluated using the Mann-Whitney U test. Categorical variables were evaluated using the chi-square test. A P-value <0.05 was considered statistically significant. All data were analyzed using Python (version 3.11.0; Python Software Foundation., Beaverton, OR, USA)[8].

Results

A total of 1,947 cases were included in the analysis (**Fig. 1**). The age distribution exhibited a bimodal pattern, with peaks during infancy and old age (**Fig. 2**). The frequency of FBAO was highest in June and lowest in December. The peak occurrence times were lunchtime (12:00-13:00) and dinnertime (18:00-21:00; **Fig. 3**). The most common site of FBAO was private residences (55.6%), followed by nursing homes (7.8%), and hospitals (6.0%; **Fig. 4**). Bystanders performed abdominal thrusts in 113 cases (5.8%). Cardiac arrest occurred in 223 (11.5%) cases.

Abdominal thrusts were successful in 908 (46.6%) patients. The first-time success rate for the abdominal thrust maneuver was 808 of 1,870 cases (43.2%), and the success rate for subsequent attempts was 59 of 150 cases (39.3%). The success rates for the first or subsequent procedures were calculated on the basis of the reported number of cases. However, 77 cases were excluded from the calculation because the number of procedures was not reported. These cases were still included in the overall analysis.

The success and failure groups did not significantly differ in age, sex, race, or site of occurrence. The success

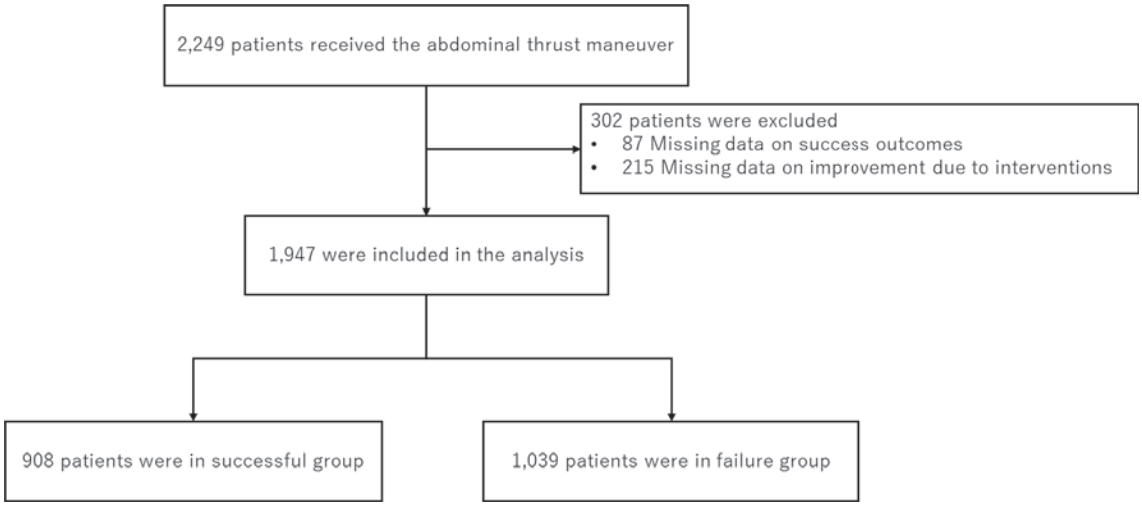

Fig. 1 Selection of study participants.

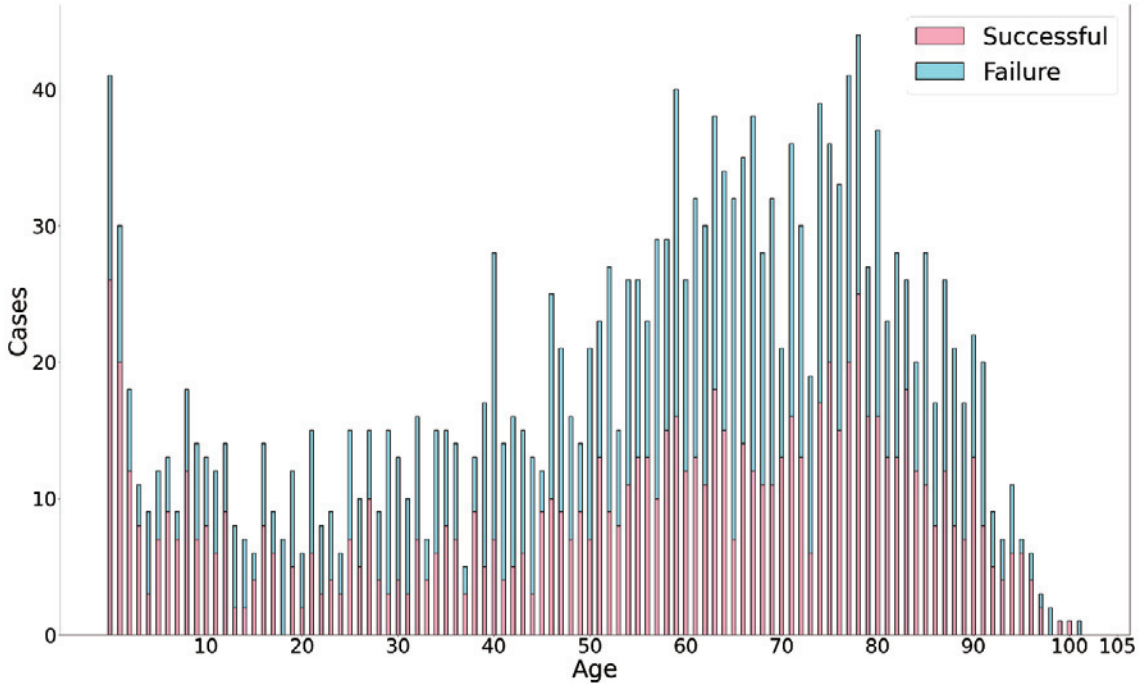

Fig. 2 The age distribution of cases in which the abdominal thrust maneuver was performed.
The age distribution was bimodal, with peaks during infancy and old age. Blue indicates failed cases and red indicates successful cases.

group had a lower proportion of patients with impaired consciousness (Glasgow Coma Scale 8 or lower) at the scene, a lower frequency of abdominal thrusts performed by healthcare professionals, and a higher first-time success rate than the failure group (**Table 1**). The success rate for abdominal thrusts was lower at healthcare facilities than at other facilities (42.6% vs. 47.5%, $p = 0.14$) (**Fig. 5**). In addition, the rate of cardiac arrest before hospital admission was lower in the success group than in the failure group (5.3% vs. 55.8%, $p < 0.001$). There were 229 children, constituting 11.8% of the total study population. The success rate was significantly higher for children than for persons 16 years and older (60.2% vs. 44.2%, $p < 0.001$). Among children, the success group had a significantly lower proportion of whites, a lower rate of impaired consciousness at the scene (Glasgow Coma Scale 8 or lower), and a lower rate of cardiac arrest before hospital arrival than did the failure group (**Table 1**).

Discussion

Using the largest dataset available, this study showed

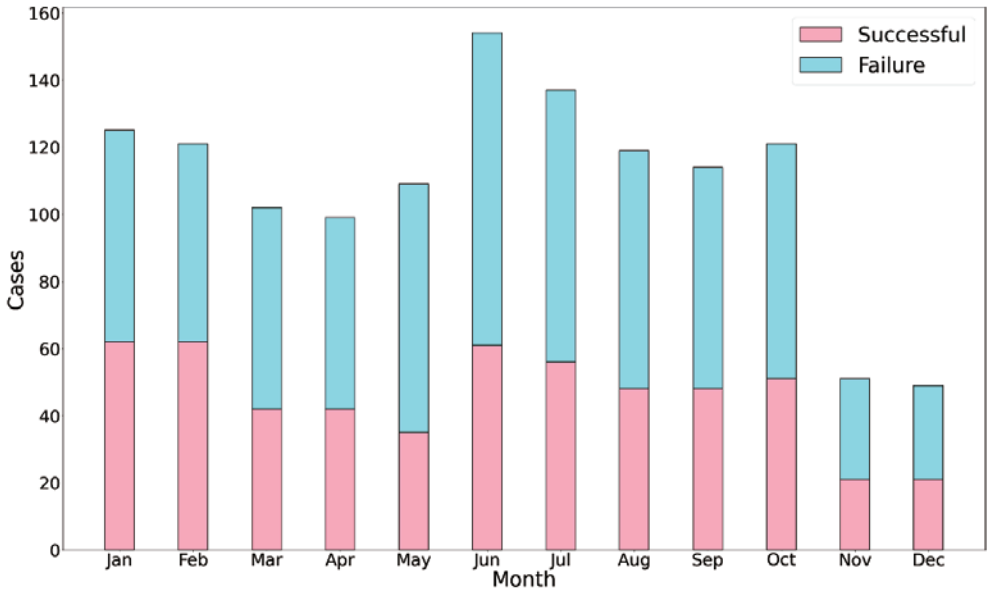

Fig. 3 Diagram illustrating the monthly distribution of cases in which the abdominal thrust maneuver was performed.

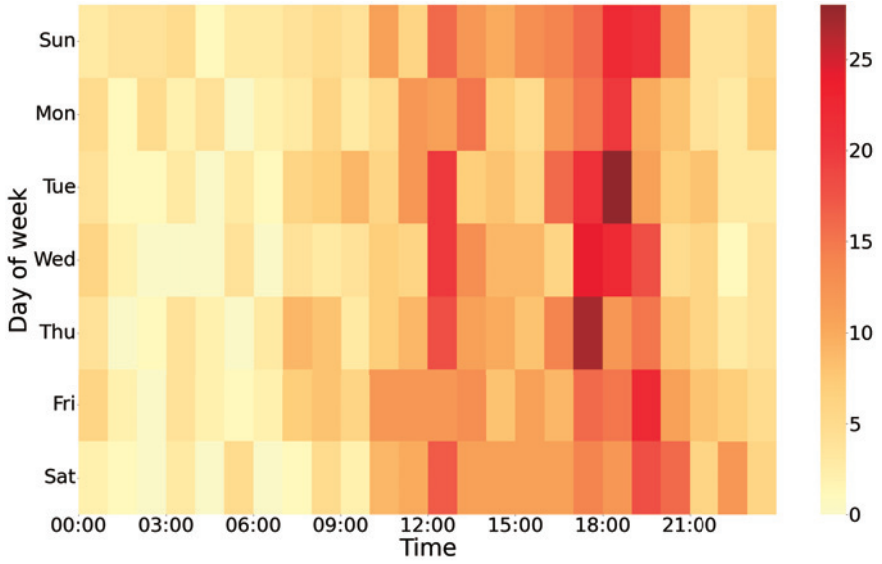

Fig. 4 Heat map of the frequency of the abdominal thrust maneuver, by day of the week and time of day.
Use of the abdominal thrust maneuver was most frequent during the lunch and dinner hours, with few cases between 23:00-06:00.

that the success rate of abdominal thrusts was 46.6% in the United States. The incidence of cardiac arrest was lower after successful completion of abdominal thrusts than after failure of abdominal thrusts.

The maneuver was successful for approximately half the patients, which is lower than rates reported in previous studies[3]. Heimlich et al.[9] reported a success rate of 100% for abdominal thrusts; however, this may be influenced by selection bias and publication bias. Other retrospective studies and government studies reported success rates of 86.5% and 60.6%[10,11]. However, those studies could not determine whether the foreign body was successfully removed by abdominal thrusts or by subsequent procedures. Therefore, the actual success rate for abdominal thrusts alone may be lower. A recent retrospective study of in-hospital choking incidents reported a success rate of 21% for abdominal thrusts when used as the initial attempt to remove foreign bodies from the airway[12]. Few studies have investigated success rates for specific procedures, and further research is needed to

Table 1 Patient demographic characteristics

Variables	All			Children			Adults		
	Success (n=908)	Failure (n=1,039)	P Value	Success (n=138)	Failure (n=91)	P Value	Success (n=763)	Failure (n=963)	P Value
Age (IQR)	61 (34-78)	62 (41-75)	.54	6 (2-9)	7 (2-11)	.08	66 (50-79)	64 (47-76)	.02
Sex (female)(%)	438 (47.8%)	478 (46.0%)	.38	62 (45%)	37 (41%)	.58	374 (50.8%)	436 (45.3%)	.36
Race (white)(%)	261 (28.7%)	317 (30.5%)	.27	36 (26%)	40 (44%)	<.01	224 (30.4%)	277 (28.8%)	.70
Site (healthcare facility)(%)	120 (13.2%)	162 (15.6%)	.14	11 (8%)	12 (13%)	.28	108 (14.7%)	149 (15.5%)	.34
GCS on arrival of EMS (≤8)(%)	407 (44.8%)	520 (50.0%)	.02	128 (93%)	72 (79%)	<.01	332 (45.1%)	461 (47.9%)	.13
Performer (non-healthcare professional) (%)	64 (7.0%)	49 (4.7%)	.01	14 (10%)	5 (6%)	.29	49 (6.7%)	44 (4.6%)	.07
Cardiac arrest before hospital arrival (%)	49 (5.4%)	174 (16.7%)	<.001	2 (1%)	8 (9%)	<.01	47 (6.1%)	164 (17%)	<.001

Abbreviations: IQR, interquartile range; GCS, Glasgow Coma Scale; EMS, Emergency Medical Service

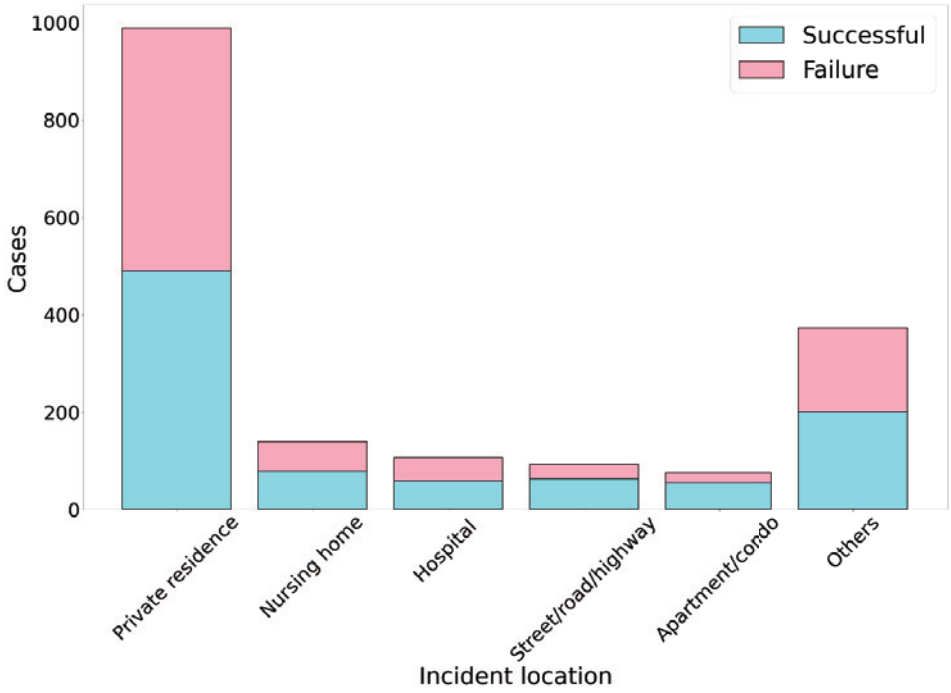

Fig. 5 Top five incident sites where the abdominal thrust maneuver was performed.
The home was the most common site (55.6%), followed by nursing homes (7.8%), and hospitals (6.0%).
Blue indicates failed cases and red indicates successful cases.

identify effective procedures.

The success rate for healthcare facilities was 42.6%, which is similar to the rate for other facilities. This low success rate, even in facilities where professional healthcare intervention is available, is obviously a concern. Studies of in-hospital choking incidents also suggest that many choking patients do not receive effective initial intervention, although this finding may be influenced by selection bias. Several causes for choking incidents have been identified, including the tendency of healthcare providers to use familiar suction techniques. Additionally, healthcare workers' retention of knowledge of basic life support (BLS) is low[13–15], and their BLS knowledge and skills may be inadequate. Abdominal thrusts, even when performed properly, have a lower success rate than previously reported, and the likelihood of foreign body removal is not high[16].

A sub-analysis showed that the success rate for ab-

dominal thrusts was higher in children than in adults. Previous studies have reported better outcomes in pediatric patients with FBAO than in adults with FBAO[17]. In children, removal of foreign objects is easier because body size and the strength of the cough reflex increase the effectiveness of lifesaving measures[18]. In addition, children are more likely to receive immediate intervention, as they typically eat while supervised by adults.

The characteristics of US patients with FBAO differed from those of patients in other countries. No seasonal differences were reported in a study conducted in London, while seasonality was observed in a study conducted in Tokyo, where choking was more frequent in winter, particularly during the New Year holiday[17,19,20]. In the United States, however, choking incidents are more common during the summer. In addition, there were patients with FBAO in all age groups, not just infants and elderly adults, whereas other studies were exclusively bimodal, reporting only FBAO cases in infants and older adults.

This study has several limitations. First, it is a retrospective analysis of EMS transport records, which may lack important data on FBAO incidents, such as the type of foreign body and details of bystander first aid. Second, the definition for successful first aid is debatable. In this study, we used subjective and objective criteria from database entries to define success. Third, it is unclear which procedure was most effective when multiple procedures were performed. Therefore, the success rate of abdominal thrusts may be lower. Fourth, one-third of the study period coincided with the COVID-19 pandemic, which might have affected bystanders and EMS first aid. However, it appears that the impact was limited because of the low rates of bystander first aid in this study and the absence of any changes in protocols regarding abdominal thrusts, except for the use of personal protective equipment by EMS.

Conclusions

This study of the real-world use of abdominal thrusts in choking cases showed a 46.6% success rate. The success group had a lower proportion of impaired consciousness and cardiopulmonary arrest than the failure group. Future studies should attempt to identify the maneuvers that are most effective in removing foreign bodies in the airway.

Data availability: The data supporting the findings of this study are openly available in the Harvard Dataverse Repository.

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Conflict of Interest: The authors report no competing interests.

References

1. National Safety Council. Injury Facts [Internet]. Itasca (IL): National Safety Council; 2024. Available from: https://injuryfacts.nsc.org
2. Igarashi Y, Yokobori S, Yoshino Y, Masuno T, Miyauchi M, Yokota H. Prehospital removal improves neurological outcomes in elderly patient with foreign body airway obstruction. Am J Emerg Med. 2017 Oct;35(10):1396–9. doi: 10.1016/j.ajem.2017.04.016
3. Couper K, Abu Hassan A, Ohri V, et al. Removal of foreign body airway obstruction: A systematic review of interventions. Resuscitation. 2020 Nov;156:174–81. doi: 10.1016/j.resuscitation.2020.09.007
4. Heimlich HJ. Pop goes the cafe coronary. Emerg Med. 1974;6:154–5.
5. National Emergency Medical Services Information System Technical Assistance Center [Internet]. Salt Lake City (UT). [cited 2023 May 7]. Available from: https://nemsis.org/NEMSIS
6. NEMSIS Data Dictionary Version 3.4.0 [Internet]. Salt Lake City (UT): NEMSIS; 2020 Sep 10 [cited 2023 May 7]. Available from: https://nemsis.org/media/nemsis_v3/release-3.4.0/DataDictionary/PDFHTML/DEMEMS/index.html
7. Norii T, Igarashi Y, Sung-Ho K, et al. Protocol for a nationwide prospective, observational cohort study of foreign-body airway obstruction in Japan: the MOCHI registry. BMJ Open. 2020 Jul 20;10(7):e039689. doi: 10.1136/bmjopen-2020-039689
8. Sahoo K, Samal AK, Pramanik J, Pani SK. Exploratory data analysis using Python. Int J Innov Technol Explor Eng. 2019 Oct;8(12):4727–35. doi: 10.35940/ijitee.L3591.1081219
9. Heimlich HJ, Hoffmann KA, Canestri FR. Food-choking and drowning deaths prevented by external subdiaphragmatic compression. Physiological basis. Ann Thorac Surg. 1975 Aug;20(2):188–95. doi: 10.1016/s0003-4975(10)63874-x
10. Soroudi A, Shipp HE, Stepanski BM, et al. Adult foreign body airway obstruction in the prehospital setting. Prehosp Emerg Care. 2007 Jan-Mar;11(1):25–9. doi: 10.1080/10903120601023263
11. Takeda Y, Ochi M, Hatanaka T, Shirakawa Y. [Study on the removal of foreign bodies by emergency medical services personnel and citizens in airway obstructions. (1999 Commissioned research report by the Fire and Disaster Management Agency of the Ministry of Internal Affairs and Communications)] [Internet]. [cited 2023 Nov 16]. Available from: https://plaza.umin.ac.jp/~GHDNet/00/kajiti2.htm Japanese.
12. Norii T, Igarashi Y, Akaiwa M, et al. Food choking incidents in the hospital: Incidents, characteristics, effectiveness of interventions, and mortality and morbidity outcomes. Resuscitation. 2023 Jul;188:109806. doi: 10.1016/j.resuscitation.2023.109806
13. Hamilton R. Nurses' knowledge and skill retention following cardiopulmonary resuscitation training: a review

of the literature. J Adv Nurs. 2005 Aug;51(3):288–97. doi: 10.1111/j.13652648.2005.03491.x
14. Smith KK, Gilcreast D, Pierce K. Evaluation of staff's retention of ACLS and BLS skills. Resuscitation. 2008 Jul;78 (1):59–65. doi: 10.1016/j.resuscitation.2008.02.007
15. Nambiar M, Nedungalaparambil NM, Aslesh OP. Is current training in basic and advanced cardiac life support (BLS & ACLS) effective? A study of BLS & ACLS knowledge amongst healthcare professionals of North-Kerala. World J Emerg Med. 2016;7(4):263–9. doi: 10.5847/wjem.j.1920-8642.2016.04.004
16. Norii T, Igarashi Y, Akaiwa M, et al. Food choking incidents in the hospital: Incidents, characteristics, effectiveness of interventions, and mortality and morbidity outcomes. Resuscitation. 2023 Jul;188:109806. doi: 10.1016/j.resuscitation.2023.109806
17. Suga R, Igarashi Y, Norii T, et al. Characteristics and outcomes of emergency transferred patients with foreign body airway obstruction in Tokyo, Japan. Prehosp Disaster Med. 2023 Jun;38(3):326–31. doi: 10.1017/S1049023X23000353
18. Rimell FL, Thome A Jr, Stool S, et al. Characteristics of objects that cause choking in children. JAMA. 1995 Dec 13;274(22):1763–6.
19. Pavitt MJ, Nevett J, Swanton LL, et al. London ambulance source data on choking incidence for the calendar year 2016: an observational study. BMJ Open Respir Res. 2017 Dec 10;4(1):e000215. doi: 10.1136/bmjresp-2017-000215
20. Igarashi Y, Norii T, Sung-Ho K, Nagata S, Yokota H. Seasonal choking in Japan: Japanese rice cake (mochi), ehomaki, and beans for Setsubun. Resuscitation. 2020 May;150:90–1.

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