Nutrition 127 (2024) 112534

Contents lists available at ScienceDirect

Nutrition

journal homepage: www.nutritionjrnl.com

Applied nutritional investigation

Temporal recovery and prognostic factors for dysphagia following cardiovascular surgery: Retrospective analysis and development of predictive score

Nao Hashida S.L.P. [a,*], Kiyohito Hosokawa M.D., Ph.D. [a,b], Ai Kawamura M.D., Ph.D. [c], Motoyuki Suzuki M.D. [a,b], Itsuki Kitayama M.D. [a,b], Masayuki Nozawa M.D. [a,b], Eri Okajima S.L.P. [a,b], Madoka Sugamoto S.L.P. [a,d], Akinari Sugauchi D.D.S., Ph.D. [a,e], Wataru Sahara M.D., Ph.D. [a,d], Shigeru Miyagawa M.D., Ph.D. [c], Hidenori Inohara M.D., Ph.D. [a,b]

[a] *Swallowing Center, Osaka University Hospital, Suita city, Osaka, Japan*
[b] *Department of Otorhinolaryngology-Head and Neck Surgery, Osaka University Graduate School of Medicine, Suita City, Osaka, Japan*
[c] *Department of Cardiovascular Surgery, Osaka University Graduate School of Medicine, Suita City, Osaka, Japan*
[d] *Department of Rehabilitation, Osaka University Hospital, Suita city, Osaka, Japan*
[e] *Unit of Dentistry, Osaka University Hospital, Suita city, Osaka, Japan*

ARTICLE INFO

Article History:
Received 1 May 2024
Received in revised form 3 July 2024
Accepted 13 July 2024

Keywords:
Dysphagia
Postextubation dysphagia
Swallowing rehabilitation
Nutritional management
Cariovascular surgery

ABSTRACT

Objective: Dysphagia is a common complication associated with cardiovascular surgery (CVS). This study sought to better understand recovery timelines, identify risk factors, and create a prognostic model for oral intake restoration.
Methods: This retrospective study included 134 patients who had CVS between April 2022 and March 2024. We assessed swallowing ability through fiberoptic endoscopic evaluation of swallowing (FEES). We randomly divided the patients' data into a training dataset and a test dataset in a ratio of 70/30 and Kaplan–Meier analyses and Cox regression were used to assess predictors of total oral intake. We also created a scoring system using the estimated regression coefficients.
Results: Most patients with CVS achieved total oral intake in 7–11 days after extubation. Over 168 h of intubation, the presence of penetration or aspiration, a poor FEES score (score > 6), and perioperative complications were significant risk factors for delayed total oral intake. The predicting score was calculated by adding the scores for each individual factor, including FEES score, penetration/aspiration, and preoperative complications. Scores ranged 0–8, categorizing patients into 0–2, 3–5, and 6–8 groups, clearly demonstrating that the higher the predicting score, the longer the time to total oral intake in both the training and the test dataset.
Conclusions: All risk factors for unsuccessful or delayed total oral intake were intubation for more than a week, poor swallowing ability, and the presence of perioperative complications. The scoring system accurately predicts the restoration of oral intake following CVS.

Introduction

In patients after cardiovascular surgery (CVS), dysphagia is a common complication, and some studies have found that risk factors for dysphagia after CVS include vocal cord paralysis, severity of heart failure, reoperation, transesophageal echocardiogram, intubation for more than 48 h, and a larger endotracheal size [1,2]. Dysphagia after CVS is known as post extubation dysphagia [3]. Patients who require tracheal intubation may develop dysphagia, with reported rates of 41% in critically ill patients with intubation in the intensive care unit [4]. Post-CVS dysphagia can cause delays in the resumption of oral intake, prolonged hospitalization, malnutrition, a decline in functional ability, aspiration pneumonia, and a poor prognosis [2,3,5,6]. Thus, assessing swallowing ability and

Abbreviations: FEES, fiberoptic endoscopic evaluation of swallowing; CVS, cardiovascular surgery; CABG, coronary artery bypass graft surgery; CVA, cerebrovascular attack

*Corresponding author. Tel.: +81-6-6879-3951; fax: +81-6-6879-3959
E-mail address: nhashida@ent.med.osaka-u.ac.jp (N. Hashida).

https://doi.org/10.1016/j.nut.2024.112534

Central Message

A new scoring system can predict the restoration of oral intake after cardiovascular surgery and may be useful for nutritional management and swallowing rehabilitation.

predicting recovery are critical for avoiding complications and adverse events such as aspiration pneumonia, malnutrition, and a decline in functional ability. However, the time it takes for patients to regain oral feeding abilities, as well as the specific characteristics that impede the improvement of dysphagia and oral intake are unknown.

Accurate data on the restoration of the ability of oral intake expectancy of patients following CVS is critical for making appropriate nutritional management and swallowing rehabilitation recommendations.

Consequently, the purposes of this study were to identify the prognostic factors that impede the acquiring oral feeding capabilities and to clarify the temporal aspect of patients' recovery in oral food intake with Time-to-Events analysis, as well as to develop a scoring system for the restoration of oral intake capability for patients following CVS.

Materials and methods

Patients

We conducted a retrospective study of patients referred to our hospital's Swallowing Center for evaluation of swallowing function following CVS between April 2022 and March 2024. A total of 1199 patients underwent CVS in the Department of Cardiovascular Surgery at our hospital. Among them, 155 patients (12.9%) were referred to the swallowing center. We excluded patients with dysphagia before surgery, those who were not evaluated with FEES, and those aged under 18 years old. Five of them did not have CVS during their hospitalization, eight were under the age of 18, two had dysphagia before CVS, two were not evaluated with FEES due to the patients' medical condition or refusal, and four were not followed up on swallowing ability due to deterioration in medical condition within a week after FEES. Consequently, 134 patients were included in this study (Fig. 1). Preoperative swallowing function was assessed using the Functional Oral Intake Scale (FOIS) [7]. Patients with a FOIS level under 6 were classified as having preoperative dysphagia. Additionally, for some patients who exhibited symptoms of dysphagia, such as choking, their swallowing ability was further evaluated using Fiberoptic Endoscopic Evaluation of Swallowing (FEES). The average age was 70 years, with 87 (65%) were male patients. To develop a scoring system for achieving total oral intake and assess model performance, we randomly divided the patients' data into a training dataset and a test dataset using a 70/30 split with holdout method. Given that our dataset was not particularly large, we opted for a 70:30 split. This approach balances the need for sufficient training data with the necessity of retaining a large enough test set for accurate evaluation [8].

Data collection

We recorded parameters, including swallowing function, age, sex, type of surgery, length of intubation, and perioperative complications. The surgeries were divided into six categories: aortic surgery, coronary artery bypass graft surgery (CABG), heart valve surgery, a combination of aortic surgery, CABG, and valve surgery, left ventricular assist device or heart transplant surgery, and others, such as endovascular aortic aneurysm repair and thoracic endovascular aortic aneurysm repair. Postoperative complications were defined as those that occurred within the first 30 days following surgery. Data on postoperative complications were derived from a review of electronic medical records, which were divided into categories such as cerebrovascular attack (CVA), pneumonia, and others such as delirium, postoperative hemorrhage, and spinal cord infarction.

Swallowing assessment

We evaluated patients' swallowing function using FEES with 3 ml of thin and thickened water, and the FEES score was calculated using the Hyodo scoring system [9]. This method has four parameters: salivary pooling on the pharynx, induction of the glottal closure reflex tested by inducing it with endoscopic contact to the epiglottis or arytenoid, swallowing reflex initiation timing based on the bolus location at swallowing initiation as measured by "white-out" timing, and post swallowing pharyngeal clearance. Each of these parameters is rated on a 4-point scale (0: normal, 1: mildly impaired, 2: moderately impaired, and 3: severely impaired) (Supplementary Table 1). The FEES score was then computed as the sum of the scores for each parameter, yielding a total score ranging from 0 to 12. The scores were then divided into three categories: Good (Score < 4), Moderate (Score 4–6), and Poor (Score > 6). We also evaluated observations of aspiration or penetration with 3ml of thickened water, vocal cord paralysis, and tracheotomy. If patients underwent FEES more than once, we used the results from the first FEES. Swallowing rehabilitation intervention by the SLP was selectively provided based on the findings of FEES. Patients identified with dysphagia during FEES underwent swallowing therapy thereafter.

The primary outcome of this study is the time required to achieve total oral intake (FOIS Scale > 4) based on each factor that may affect swallowing function after extubation [7]. The appropriate food form was recommended by otolaryngologists and SLPs at the Swallowing Centre based on the results of the FEES. For patients with moderate to severe dysphagia, advancing the patients' diet was recommended based on periodically reevaluating the patients' swallowing ability using FEES and mealtime observation.

Statistical analysis

We recorded the demographic data of all patients before dividing into the training dataset and the test dataset.

Kaplan–Meier analysis was used to evaluate the impact of various factors on the achievement of total oral intake, including sex, age (under 65, 65–75, over 75) [10], surgical procedure type, intubation hours (under 48 h, 48–168 h, over 168 h), presence of penetration or aspiration with 3ml thickened water, FEES score (Good [Score < 4], Moderate [Score 4–6], Poor [Score > 6]), and vocal cord paralysis status (No vocal cord paralysis, Unilateral vocal cord paralysis, Bilateral vocal cord paralysis), presence of tracheostomy, and perioperative complications (no, pneumonia, CVA, others) in the training dataset. These covariates were chosen based on their clinical significance and predicted impact on the observed outcomes.

Variables deemed potentially influential on the outcomes with Kaplan–Meier curves were included as covariates in the Cox regression analysis. To ensure robustness of our analysis, we conducted additional analyses incorporating fundamental information such as: Model 2—age and Model 3—surgical proceedur (cardiac surgery or not) performed.

We then created a scoring system using Cox regression analysis. We calculated the prediction score for each predictive factor using the estimated regression coefficients, which are the natural logarithm of the hazard ratio. Subsequently, the test dataset was utilized to evaluate the effectiveness of the scoring system using Kaplan–Meier survival analysis.

All statistical analyses were performed using R (The R Foundation for Statistical Computing), with a two-sided significance level of 5%. In estimating the sample size for the study, we considered a three-month observation period. Assuming a 70% oral intake acquisition rate for Group 1 and a 90% acquisition rate for Group 2, a priori statistical power analysis indicated that 47 patients in each group would provide a statistical power of 80% with an alpha error of 0.05.

This study was performed following the ethical standards outlined in the 1964 Declaration of Helsinki and subsequent amendments and was approved by the ethics committee of Osaka University Hospital (approval number 16329-2). The ethics committee at Osaka University Hospital waived the requirement for informed consent because of the retrospective nature of the study. Instead, an opt-out technique with an online announcement on the hospital's webpage gives patients the option to withdraw to participate in the study.

In accordance with the Transparent Reporting of a multivariable prediction model for Individual Prognosis Or Diagnosis (TRIPOD) guidelines, we have adhered to the recommended reporting standards for presenting predictive indicators in our study.

Results

Patients

Table 1 shows demographic data of all patients before they were divided into the training dataset and the test dataset. The most common surgeries, in descending order of frequency, were aortic surgery (37 patients, 27.6%), heart valve surgery (27 patients, 20.2%), CABG (23 patients, 17.2%). Regarding perioperative complications, 13 patients (9.7%) suffered a cerebral infarction and 13 patients (9.7%) contracted pneumonia. The average duration of intubation was 6.3 $\pm$ 8.9 days, while the average time from extubation to FEES was 5.8 $\pm$ 3.5 days. In FEES, 55 patients (41.0%) had unilateral

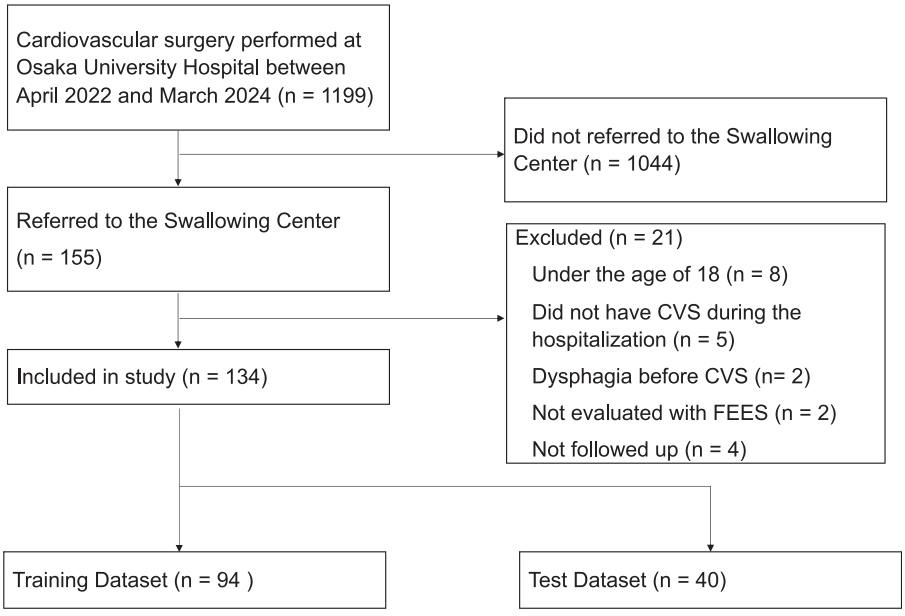

Fig. 1. Patient flow diagram. In this study 134 patients were included.

vocal cord paralysis, 10 patients (7.5%) had bilateral vocal cord paralysis, and 36 (26.9%) had penetration or aspiration of 3 ml of thickened water. A total of forty-seven patients (42.5%) had a good FEES score (score $<$ 4), 55 (40.3%) had a moderate score (score 4–6), and 23 patients (17.2%) had a poor score (score $>$ 6).

Time-to-Events analysis

Figure 2 depicts the Kaplan–Meier curve and analysis for the duration of total oral intake in the training dataset. Most patients with CVS achieve total oral intake in 7–11 days after extubation. There were no discernible differences in age, gender, surgical procedures, or presence of vocal cord paralysis. However, patients with bilateral vocal cord paralysis tended to have delayed total oral intake. The duration of the intubation period was a significant factor in total oral intake; patients with more than 168 h of intubation took a median of 19 days, while those with less than 48 h of intubation took a median of 8.5 days. Furthermore, the presence of penetration or aspiration in FEES, a poor FEES score (score $>$ 6), tracheostomy, and postoperative complications were all significant risk factors for delayed total oral intake.

Table 1
Patients' characteristics

Factor		*n* = 134
Age, mean ± SD		70.5 ± 13.8
Sex (%)	Male	87 (65.4)
Surgical procedure (%)	Aortic surgery	37 (27.6)
	Heart valve surgery	27 (20.2)
	CABG	23 (17.2)
	Combination of aortic surgery, CABG, and valve surgery	20 (14.9)
	LVAD implant or heart transplant	17 (12.7)
	Others	10 (7.5)
Intubation days, mean ± SD		6.34 ± 8.93
Perioperative complications (%)	No	79 (59.0)
	Others	29 (21.6)
	Pneumonia	13 (9.7)
	Stroke	13 (9.7)
Vocal cord paralysis (%)	None	69 (51.5)
	Unilateral	55 (41.0)
	Bilateral	10 (7.5)
FEES score (%)	Good (0–3)	57 (42.5)
	Moderate (4–6)	54 (40.3)
	Poor (>6)	23 (17.2)
Penetration/aspiration with thickened water (%)		36 (26.9)
Presence of tracheostomy (%)		19 (14.2)
Operative duration (min), mean ± SD		321 ± 122

CABG, coronary artery bypass graft surgery; LVAD, left ventricular assist device; FEES, fiberoptic endoscopic evaluation of swallowing.

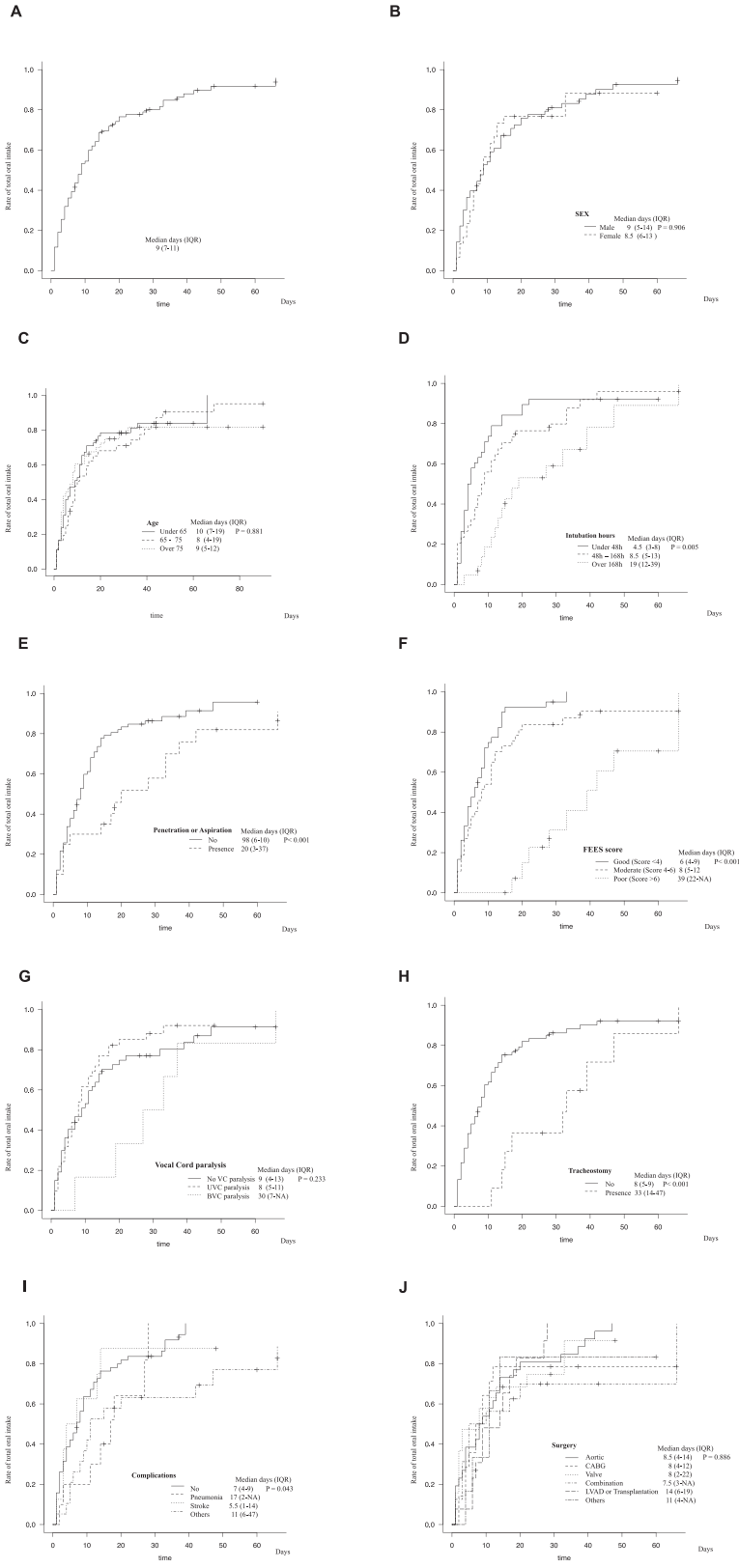

Fig. 2. Kaplan–Meier analysis of the probability of total oral intake after extubation in the training dataset. The *P* value was calculated using the Log-rank test. B, D, D, and H show no significant difference in the three age groups, gender differences, surgical procedures, or the presence of vocal cord paralysis. E, F, G, I, and J have over 168 h intubation group, a presence of penetration/aspiration with 3 ml thickened water group, a poor FEES score group, a tracheostomy group, and a presence of complication groups exhibited an extended duration before achieving total oral intake.

Table 2
Cox regression analysis of total oral intake

Factor		Hazard ratio	95% CI	*P* value
Intubation hours				
	0–48 h	Reference		
	48–168 h	0.96	0.54 to 1.63	0.83
	Over 168 h	0.33	0.17 to 0.61	< 0.001
Vocal cord paralysis				
	No	Reference		
	Unilateral	1.08	0.66 to 1.78	0.76
	Bilateral	1	0.40 to 2.52	1
Penetration/aspiration with thickened water		0.47	0.23 to 0.98	0.044
FEES score				
	Good (0–3)	Reference		
	Moderate (4–6)	0.55	0.34 to 0.91	0.02
	Poor (over 6)	0.17	0.08 to 0.38	< 0.001
Perioperative complications		0.63	0.39 to 1.04	0.072

FEES, fiberoptic endoscopic evaluation of swallowing.

Table 2 displays Cox regression analysis in the training dataset, which includes the following variables: intubation hours (<48 h, 48–168 h, >168 h), presence of penetration or aspiration with thickened water, FEES score (Good [0–3], Moderate [4–6], Poor [>6]), and presence of perioperative complications such as pneumonia, CVA, and others. The presence of tracheostomy was not included in the Cox regression analysis to avoid multicollinearity. The concordance index was 0.765 (se = 0.03), indicating good predictive accuracy. Additionally, the likelihood ratio test yielded a value of 49.39 on 8 degrees of freedom, with a *P*-value of less than 0.001, demonstrating the overall significance of the model. The lowest hazard ratio was the FEES score with a hazard ratio of 0.17 (95% CI 0.08 to 0.38, $P < 0.001$) for poor FEES scores (score > 6) and 0.55 (95% CI 0.34 to 0.91, $P = 0.02$) for moderate FEES scores (score 4-6). The hazard ratio for more than 168 h of intubation was 0.33 (95% CI 0.17 to 0.61, $P < 0.001$) and any perioperative complications were 0.63 (95% CI 0.39 to 1.04, $P = 0.072$). In the −age and −surgical procedure adjusted model, either Model 2 nor Model 3 showed substantial differences from Model 1 (Supplementary Table 2).

Table 3 shows developments of the scoring system based on the Cox regression analysis. To make the scoring process easier, we doubled the estimated regression coefficients and rounded them to the nearest whole number. This method assigns one point to the factors with the smallest regression coefficient, making the prediction score calculation easier to understand. As for the intubation period, over 168 h of intubation was worth three points. As for the FEES score, the poor FEES score was given three points, while the moderate FEES score was given one. The presence of thickened water penetration or aspiration was scored once, and any perioperative complications were scored once. The prediction score was calculated by adding the scores for each individual factor. Each patient was assigned a score ranging from 0 to 8 and was then divided into three groups based on the score: 0–2, 3–5, and 6–8. Figure 3 depicts the Kaplan–Meier curves for various predicting score groups, which clearly demonstrated that a higher predicting score was associated with a longer achievement of total oral intake in both training dataset and test dataset.

Table 3
Predicting factors and predicting score for each factor

Factor		Coefficients	Predicting score
Intubation hours			
	0–48 h	Reference	
	48–168 h	−0.06	
	Over 168 h	−1.75	3
Vocal cord paralysis			
	No	Reference	
	Unilateral	0.07	
	Bilateral	0.002	
Penetration/aspiration with thickened water		−0.74	1
FEES score			
	Good (0–3)	Reference	
	Moderate (4–6)	−0.59	1
	Poor (over 6)	−1.75	3
Perioperative complications		−0.45	1

FEES, fiberoptic endoscopic evaluation of swallowing.

Discussion

In this retrospective study of patients who underwent CVS, three important findings emerged. First, most patients after CVS achieved complete oral intake within one to two weeks of extubation. Second, the risk factors for unsuccessful or delayed total oral intake included intubation for more than one week, tracheostomy, poor swallowing ability, and perioperative complications with Time-to-Events analysis. Third, we created a scoring system that accurately predicts the restoration of oral intake following CVS.

The findings revealed that most patients after CVS achieved total oral intake in two weeks after extubation. In our study, as the patients were referred to the swallowing center, they had dysphagia symptoms, were suspected of having dysphagia, or were at risk of dysphagia (e.g., hoarseness or advanced age). Although these conditions were likely to have a negative impact on total oral intake, most patients who underwent CVS were able to achieve full oral intake without long durations after extubation. According to a previous study, 80% of patients with dysphagia who underwent FEES 4–6 h after extubation improved within 24–26 h after FEES [11]. Thus, patients who do not have severe dysphagia or a poor general condition may be able to resume oral food intake.

However, some risk factors for obstructing oral intake have been identified. Long intubation periods, particularly those lasting more than a week, severe dysphagia measured by FEES score > 6, thickened penetration or aspiration, tracheostomy, and perioperative complications were all risk factors for unsuccessful or delayed oral intake. According to a previous study, the intubation period was a significant risk factor for dysphagia [12,13]. Prolonged intubation durations were associated with dysphagia and were a predictor of its severity [14]. Prior research in cardiac surgery patients revealed an increased risk of dysphagia in those intubated for more than 48 h, and a previous study in patients with neurologic

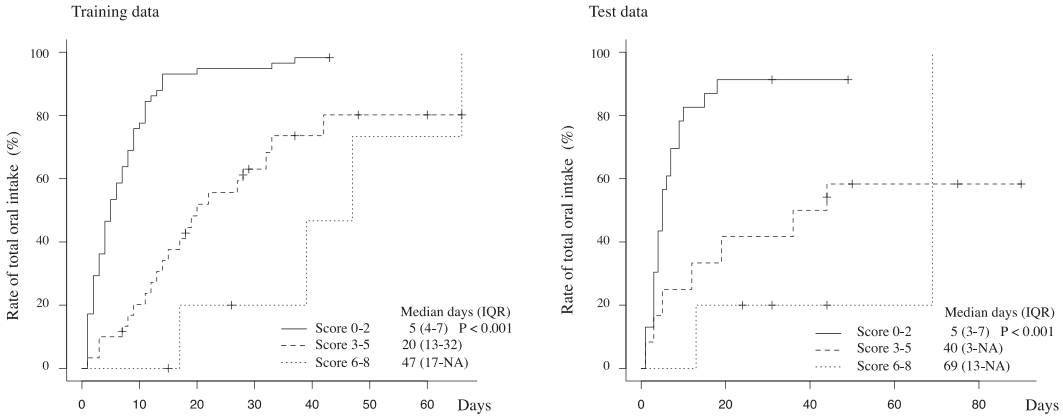

Fig. 3. Kaplan–Meier analysis of the probability for total oral intake following extubation by four different predicting score groups. On both training data set and test data set higher score is associated with a prolonged period required to achieve total oral intake.

impairment discovered that intubation for more than a week was associated with moderate–severe dysphagia [15,16]. Our current study supports the previous study's finding that patients with over a week of intubation are more likely to have difficulty in oral feeding. Prolonged intubation has been linked to laryngeal sensation and respiratory dysfunction, which can lead to dysphagia [17]. In addition, some studies found that sarcopenia and frailty were associated with dysphagia following CVS [12,18]. The prevalence of skeletal muscle mass loss in patients with dysphagia following CVS was very high, and activities of daily living (ADL) was associated with dysphagia after CVS [18]. Sarcopenia can cause dysphagia called sarcopenic dysphagia, which may appear in some patients following cardiovascular surgery [18,19]. Low activity, inflammation, and/or protein catabolism as a result of underlying diseases or surgery, as well as malnutrition, may cause sarcopenia. In this study, patients who were intubated for more than one week or had complications may have had lower activity levels, which could have resulted in decreased skeletal muscle mass, compromised ADL, and severe or prolonged dysphagia.

As unexpectedly observed, older patients, patients with unilateral vocal cord paralysis, and patients with moderate dysphagia who were evaluated with FEES did not experience significant delays in regaining oral feeding. It is possible that young patients had undergone high invasive surgery and/or higher severity heart failure, while older patients underwent low invasive surgery. However, this finding suggests that just because patients are older, there may not be a need to postpone the start of oral intake and the progression of the diet, though consideration of general condition and swallowing function is required. Minor dysphagia can improve quickly [11], and patients with mild to moderate dysphagia can eat and drink with some compensatory techniques and a texture-modified diet [20]. A previous study found that unilateral vocal cord paralysis is linked to dysphagia, but there is significant spontaneous recovery from dysphagia even with persistent unilateral vocal cord paralysis [1]. Furthermore, patients with unilateral vocal cord paralysis can frequently consume food and liquids through a compensatory mechanism. The outcome in this study was set to total oral intake (FOIS > 4), so mild dysphagia had no significant effect on the results.

We created a scoring system that can predict total oral intake more clearly and accurately than a single factor like intubation time, FEES score, or the presence of aspiration and/or penetration. Kaplan–Meier analysis of the test dataset shows a similar trend to the training dataset, which means the scoring system exhibits high accuracy, with a higher score associated with a prolonged period required to achieve total oral intake. The prediction score includes some factors related to oral intake. There are some reports that have developed a predictive score for dysphagia after CVS [21,22]. These studies aimed to predict post-CVS dysphagia, assessed by videofluoroscopic swallow study or the Gugging swallowing screen. However, there is currently no scoring system that addresses the time required to regain oral intake ability through Time-to-Event analysis. Ogawa et al. found that hospital-associated disability caused by postextubation dysphagia after CVS increases the risk of major adverse cardiac and cerebrovascular events, but postextubation dysphagia does not increase the risk of those adverse events on its own [3]. Thus, it is critical not only to detect dysphagia but also to predict the duration of total oral intake and prevent hospital-acquired disability following dysphagia after CVS by providing nutritional care, dysphagia rehabilitation with dysphagia assessment, and prediction of swallowing ability. Using our predicting score, patients' total oral intake duration would be assessed, allowing for nutritional management and swallowing rehabilitation, which could prevent malnutrition, hospital-associated disability, poor QOL, and mortality.

This study has several limitations. First, it did not include every patient after CVS; rather, it focused only on those who were referred to the swallowing center. However, most patients who were not referred to the swallowing center did not have long-term intubation, tracheostomy, or symptoms of vocal cord paralysis. They also passed dysphagia screening and were able to eat food without any problems. Therefore, it is likely that those who were not referred to the swallowing center did not suffer from swallowing problems, and their exclusion may have had minimal influence on our results. Second, we defined total oral intake as a primary outcome; however, patients were denied total oral intake due to both swallowing function and general conditions. Thus, it is possible that some patients achieved total oral intake sometime after acquiring the ability to swallow safely. Finally, the censoring rate in the low-score patients was high due to hospital transfer. A prospective study with a larger population that includes various characteristic patients is required.

In conclusion, most patients who undergo CVS and are referred to a swallowing center achieve total oral intake within one to two weeks of extubation. The risk factors for unsuccessful or delayed total oral intake were intubation for more than a week, tracheostomy, poor swallowing ability, and the presence of perioperative complications. We also created a scoring system that accurately predicts the restoration of oral intake after CVS and may be useful for nutritional management and swallowing rehabilitation. This

scoring system can be used for postextubation dysphagia patients as well as post-CVS patients; however, larger-scale studies are needed.

Data availability

The datasets generated and/or analyzed during the current study are not publicly available due to ethical restrictions but are available from the corresponding author upon reasonable request.

IRB approval

This study was performed following the ethical standards outlined in the 1964 Declaration of Helsinki and subsequent amendments and was approved by the ethics committee of Osaka University Hospital (approval number 16329-2).

Informed consent statement

The ethics committee at Osaka University Hospital waived the requirement for informed consent because of the retrospective nature of the study. Instead, an opt-out technique with an online announcement on the hospital's webpage gives patients the option to withdraw or consent to participate in the study.

Perspective statement

Most patients who undergo cardiovascular surgery achieve total oral intake within one to three weeks of extubation. A new scoring system can predict the restoration of oral intake after cardiovascular surgery and may be useful for nutritional management and swallowing rehabilitation.

Author contribution

In this manuscript, N.H. contributed to the Conceptualization, Data curation, Formal analysis, Writing—original draft. K.H. was involved in Data curation, Funding acquisition, Supervision, Writing—review & editing. A.K. and S.M. contributed to the Resources, Writing—review & editing. M.S. contributed to the Formal analysis, Writing—review & editing. I.K. contributed to the Data curation, Visualization, Writing—review & editing. N.M. and E.O contributed to the Data curation, Writing—review & editing. M.S., A.S., and W. H.I. contributed to the Project administration, Writing—review & editing.

Funding statement

This work was supported by JSPS KAKENHI grant number JP21K16842.

Clinical trial registry number

Not applicable.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

CRediT authorship contribution statement

Nao Hashida: Writing – original draft, Formal analysis, Data curation, Conceptualization. **Kiyohito Hosokawa:** Writing – review & editing, Supervision, Funding acquisition, Data curation. **Ai Kawamura:** Writing – review & editing, Resources. **Motoyuki Suzuki:** Writing – review & editing, Formal analysis. **Itsuki Kitayama:** Writing – review & editing, Visualization, Data curation. **Masayuki Nozawa:** Writing – review & editing, Data curation. **Eri Okajima:** Writing – review & editing, Data curation. **Madoka Sugamoto:** Writing – review & editing. **Akinari Sugauchi:** Writing – review & editing. **Wataru Sahara:** Writing – review & editing. **Shigeru Miyagawa:** Writing – review & editing, Resources. **Hidenori Inohara:** Writing – review & editing, Project administration.

Acknowledgment

The authors thank Enago for the English language review.

Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.nut.2024.112534.

References

[1] Kagaya H, Okada S, Shigeta R, Ogata N, Ota K, Shibata S, et al. Dysphagia associated with unilateral vocal cord immobility after cardiovascular surgery. Am J Phys Med Rehabil 2011;90:901–7.
[2] Plowman EK, Anderson A, York JD, DiBiase L, Vasilopoulos T, Arnaoutakis G, et al. Dysphagia after cardiac surgery: prevalence, risk factors, and associated outcomes. J Thorac Cardiovasc Surg 2023;165:737–746.e733.
[3] Ogawa M, Satomi-Kobayashi S, Hamaguchi M, Komaki K, Izawa KP, Miyahara S, et al. Postoperative dysphagia as a predictor of functional decline and prognosis after undergoing cardiovascular surgery. Eur J Cardiovasc Nurs 2023;22:602–9.
[4] McIntyre M, Doeltgen S, Dalton N, Koppa M, Chimunda T. Post-extubation dysphagia incidence in critically ill patients: a systematic review and meta-analysis. Aust Crit Care 2021;34:67–75.
[5] Barker J, Martino R, Reichardt B, Hickey EJ, Ralph-Edwards A. Incidence and impact of dysphagia in patients receiving prolonged endotracheal intubation after cardiac surgery. Can J Surg 2009;52:119–24.
[6] Clavé P, Shaker R. Dysphagia: current reality and scope of the problem. Nat Rev Gastroenterol Hepatol 2015;12:259–70.
[7] Crary MA, Mann GD, Groher ME. Initial psychometric assessment of a functional oral intake scale for dysphagia in stroke patients. Arch Phys Med Rehabil 2005;86:1516–20.
[8] Joseph VR. Optimal ratio for data splitting. Stat Analysis Data Mining 2022;15:531–8.
[9] Chiba Y, Sano D, Ikui Y, Nishimura G, Yabuki K, Arai Y, et al. Predictive value of the Hyodo score in endoscopic evaluation of aspiration during swallowing. Auris Nasus Larynx 2018;45:1214–20.
[10] Ouchi Y, Rakugi H, Arai H, Akishita M, Ito H, Toba K, et al. Redefining the elderly as aged 75 years and older: Proposal from the Joint Committee of Japan Gerontological Society and the Japan Geriatrics Society. Geriatr Gerontol Int 2017;17:1045–7.
[11] Marvin S, Thibeault S, Ehlenbach WJ. Post-extubation dysphagia: does timing of evaluation matter? Dysphagia 2019;34:210–9.
[12] Ogawa M, Satomi-Kobayashi S, Yoshida N, Komaki K, Izawa KP, Hamaguchi M, et al. Impact of frailty on postoperative dysphagia in patients undergoing elective cardiovascular surgery. JACC Asia 2022;2:104–13.
[13] Skoretz SA, Flowers HL, Martino R. The incidence of dysphagia following endotracheal intubation: a systematic review. Chest 2010;137:665–73.
[14] Medeiros GC, Sassi FC, Mangilli LD, Zilberstein B, Andrade CR. Clinical dysphagia risk predictors after prolonged orotracheal intubation. Clinics (Sao Paulo) 2014;69:8–14.
[15] Macht M, Wimbish T, Clark BJ, Benson AB, Burnham EL, Williams A, et al. Post-extubation dysphagia is persistent and associated with poor outcomes in survivors of critical illness. Crit Care 2011;15:R231.
[16] Skoretz SA, Yau TM, Ivanov J, Granton JT, Martino R. Dysphagia and associated risk factors following extubation in cardiovascular surgical patients. Dysphagia 2014;29:647–54.

[17] Borders JC, Fink D, Levitt JE, McKeehan J, McNally E, Rubio A, et al. Relationship between laryngeal sensation, length of intubation, and aspiration in patients with acute respiratory failure. Dysphagia 2019;34:521–8.
[18] Wakabayashi H, Takahashi R, Watanabe N, Oritsu H, Shimizu Y. Prevalence of skeletal muscle mass loss and its association with swallowing function after cardiovascular surgery. Nutrition 2017;38:70–3.
[19] Wakabayashi H. Presbyphagia and sarcopenic dysphagia: association between aging, sarcopenia, and deglutition disorders. J Frailty Aging 2014; 3:97–103.
[20] Speyer R, Baijens L, Heijnen M, Zwijnenberg I. Effects of therapy in oropharyngeal dysphagia by speech and language therapists: a systematic review. Dysphagia 2010;25:40–65.
[21] Grimm JC, Magruder JT, Ohkuma R, Dungan SP, Hayes A, Vose AK, et al. A novel risk score to predict dysphagia after cardiac surgery procedures. Ann Thorac Surg 2015;100:568–74.
[22] Zhou XD, Dong WH, Zhao CH, Feng XF, Wen WW, Tu WY, et al. Risk scores for predicting dysphagia in critically ill patients after cardiac surgery. BMC Anesthesiol 2019;19:7.