# Risk Factors and Assessment Using an Endoscopic Scoring System for Postoperative Respiratory Complications after Anterior Cervical Decompression and Fusion Surgery

Tetsuro Ohba[1], Hiroshi Akaike[2], Koji Fujita[1], Kotaro Oda[1], Nobuki Tanaka[1], Matsuoka Tomokazu[3], Daiju Sakurai[3] and Hirotaka Haro[1]

1) Department of Orthopaedic Surgery, University of Yamanashi, Yamanashi, Japan
2) Department of Rehabilitation, University of Yamanashi, Yamanashi, Japan
3) Department of Otorhinolaryngology, University of Yamanashi, Yamanashi, Japan

**Abstract:**

**Introduction:** Postoperative respiratory complications (PRC) are one of the most serious complications. Potentially life-threatening accidents can occur after an anterior cervical discectomy and fusion (ADF), such as airway obstruction and aspiration pneumonia. Despite numerous studies, preoperative predictive and preventive methodology has yet to be established.

As reported in our previous study, the evaluation of preoperative dysphagia using the eating assessment tool (EAT-10) and a flexible endoscopic evaluation of swallowing (FEES) is useful for predicting the incidence and risk factors of dysphagia after ADF.

**Methods:** This prospective study comprised 60 consecutive patients who underwent ADF. An otolaryngologist and a speech-language-hearing therapist preoperatively and 1 week postoperatively evaluated dysphagia using EAT-10 and Hyodo-Komagane (H-K) scores during FEES. Patient demographics, comorbidities, and pre- and postoperative dysphagia were compared between patients with and without PRC.

**Results:** Seven of 60 (11.6%) patients had preoperative dysphagia diagnosed using the H-K score. A significant positive correlation existed between the pre- and postoperative H-K scores. Of all 60 cases, eight (13.3%) had PRC. Among them, two required reintubation due to airway obstruction and six had aspiration pneumonia. The PRC(+) group was significantly older and more prone to diabetes and asthma. The preoperative H-K score of the PRC(+) group was significantly higher than that of the PRC(−) group. Postoperatively, but not preoperatively, EAT-10 was significantly higher in the PRC(+) group.

**Conclusions:** Preoperative dysphagia may potentially exacerbate postoperative dysphagia after ADF. A preoperative evaluation of dysphagia using the H-K score during FEES is a useful method for predicting and reducing the risk of PRC.

Level of Evidence: 3

**Keywords:**
Anterior cervical discectomy and fusion, Postoperative respiratory complications, Flexible endoscopic evaluation of swallowing, Eating assessment tool

## Introduction

Degenerative cervical spondylotic myelopathy (CSM) is a common type of cervical spinal disorder associated with age-related changes of the spine. Severe CSM causes progressive spinal cord impairment and significant physical and social disabilities[1,2]. Anterior cervical discectomy and fusion (ADF) is commonly used to treat symptomatic CSM, when pain and disability from cervical spondylosis and disc degeneration become refractory to conservative treatment. Dysphagia is one of the most common complications after ADF and occurs frequently[3-5]. Additionally, postoperative

respiratory complications (PRC) can cause serious problems and major issues after ADF. Past reports indicate that postoperative adverse events of a respiratory nature, such as pneumonia and airway obstruction, occur in 0.6%-14% of patients after ADF[6-9]. Sometimes, accidental airway obstruction becomes a potentially life-threatening event that may require reintubation, for which one must be prepared with an effective management plan. Although numerous studies have investigated the frequency of PRC and its associated risk factors, preoperative methodology that is predictive and aims to reduce the risk factors has yet to be established.

Over the last 5 years, the eating assessment tool (EAT-10) was established as a bedside clinical screening instrument to obtain patient-reported outcomes when evaluating dysphagia. The tool has been highly accurate in patients across several diseases[10,11]. The Hyodo-Komagane (H-K) score has been used during the flexible endoscopic evaluation of swallowing (FEES) using blue-dyed water. This test has utility in otolaryngology and has been validated for the evaluation of dysphagia and detection of the risk of aspiration pneumonia[12,13]. Our recent study demonstrated that evaluation of preoperative dysphagia, by an otolaryngologist and a speech-language-hearing therapist, using EAT-10 and FEES is useful for predicting the incidence and risk factors of postoperative dysphagia after ADF[14].

The purpose of the present study was to clarify the prevalence and risk factors of PRC after ADF and to investigate whether the preoperative evaluation of dysphagia using EAT-10 and the H-K score is a useful method for predicting and reducing the risk of PRC.

## Materials and Methods

### Patient groups and surgical techniques

This was a prospective analysis of 60 consecutive patients who had undergone ADF, performed using the Smith-Robinson technique and a left-sided approach. The surgeries were performed by two board-certified spinal surgeons at one institute between 2015 and 2018. Informed, written consent was obtained from all eligible patients. The patients included 31 females and 29 males of mean age 68.4 (range, 45-87) years. All patients underwent decompression, which included the simple excision of a disc and/or corpectomy following fixation using anterior cervical titanium plates with locking screws. All patients were treated using an anterior cervical plate system with 2.5-mm-thick plates (Zimmer Biomet Spine, Inc., Warsaw, IN, USA).

### Evaluations of dysphagia

A single experienced otolaryngologist and one speech-language-hearing therapist evaluated dysphagia using the 10-item EAT-10 instrument and H-K scores. A 5-point Likert scale was used to assess the severity of dysphagia with EAT-10 (Supplemental Table 1). Evidence shows that the EAT-10 tool is both reliable and valid[11]. Previous reports have shown that an EAT-10 score of ≥3 indicates the patient has dysphagia[15].

The H-K score was developed as a scoring system to evaluate endoscopic swallowing using blue-dyed water[12]. This simple, clinic-based scoring during FEES uses four parameters: (1) the degree of salivary pooling at the vallecula and piriform sinuses, (2) the glottal closure reflex induced by touching the epiglottis or arytenoid with an endoscope, (3) initiation of the swallowing reflex assessed by *white-out* timing, and (4) pharyngeal clearance after the blue-dyed water is swallowed, categorized as 0 = normal, 1 = mildly impaired, 2 = moderately impaired, or 3 = severely impaired (Supplemental Table 2). A representative case of preoperative dysphagia is shown in Fig. 1. This system has been reported as reliable and useful for evaluating the severity and features of dysphagia[12,16]. According to previous reports, dysphagia is defined as a total score >3.4[12]. All patients underwent evaluation of dysphagia by examining endoscopic swallowing and EAT-10 between 1-14 days preoperatively and 1 week postoperatively.

### Pulmonary function tests

All patients in the study had undergone pulmonary function tests (PFTs) to determine pulmonary volume before surgery. The tests were performed with the patients standing. Each spirometry test was repeated three times, and the highest value among the results was selected. The PFT data are represented as an absolute (best) value for forced expiratory volume in 1 s (FEV1) and forced vital capacity (FVC) as well as percent predictive values normalized to age, weight, and preoperative height or arm span. FVC provides an assessment of lung volume, and FEV1 provides an assessment of flow function. Obstructive impairment was defined as %FEV1 <70%, and restrictive impairment was diagnosed if %FVC was <80%.

### Statistical analyses

Data were analyzed using the unpaired $t$ test, the Mann-Whitney $U$ test, and Fisher's exact test to identify significant differences. The correlation between pre- and postoperative H-K scores and radiographic parameters was determined using Pearson's correlation coefficient. A receiver operating characteristic (ROC) curve was used to determine the sensitivity and specificity of the cutoff score for the preoperative H-K scores to diagnose sarcopenia. All statistical calculations were performed using Prism (version 8.0; Graph Pad Software, La Jolla, CA, USA). For all the tests, $P < 0.05$ was considered to be statistically significant.

## Results

The mean duration of operations was 122 ± 54.9 min, the mean blood loss was 46.9 ± 74.6 mL, and the mean number of fused vertebral levels was 2.4 ± 1.0. No patient withdrew from the study, and no revision surgery was necessary due to postoperative complications.
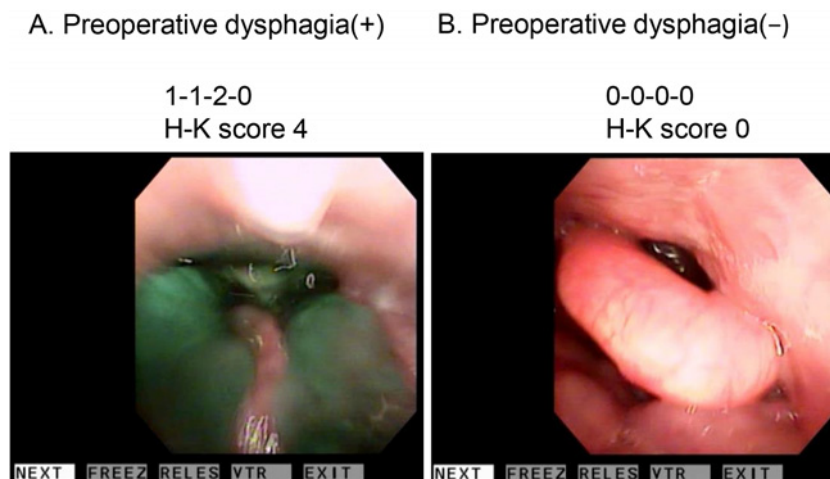
**Figure 1.** Comparison of pre- and postoperative (a) EAT-10 and (b) H-K scores.
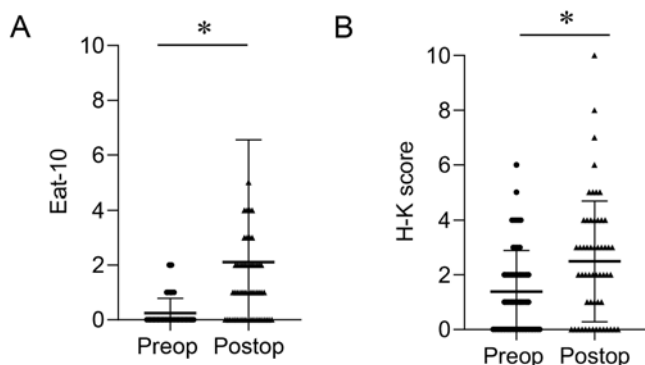H-K: Hyodo-Komagane; postop: postoperative; preop: preoperative.
*P<0.05.



**Figure 2.** Correlation between pre- and postoperative H-K scores.
H-K: Hyodo-Komagane; postop: postoperative; preop: preoperative.
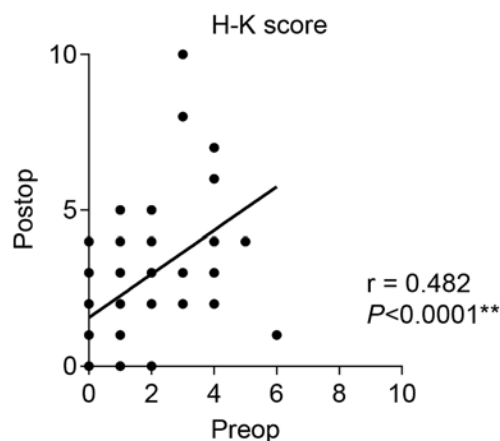


**Figure 3.** Total score comparisons for evaluations of dysphagia between the PRC(+) and PRC(−) groups.
(a) Preoperative EAT-10, (b) postoperative EAT-10, (c) preoperative H-K scores, and (d) postoperative H-K scores. *P<0.05, **P<0.0001.
(e) Receiver operating characteristic curve to determine the sensitivity of the H-K score to detect PRC in patients who underwent ADF.
H-K: Hyodo-Komagane; NS: not significant; postop: postoperative; preop: preoperative; PRC: postoperative respiratory complications.

### Incidence of pre- and postoperative dysphagia

The mean preoperative EAT-10 and H-K scores were $0.26 \pm 0.5$ and $1.4 \pm 1.6$, respectively. No patient who was diagnosed with preoperative dysphagia was evaluated via EAT-10. In contrast, seven of 60 (11.6%) patients had already been diagnosed with preoperative dysphagia using the H-K score. The mean early postoperative EAT-10 and H-K scores were $2.7 \pm 5.4$ and $2.9 \pm 2.4$, respectively. The prevalence rate of dysphagia among patients as evaluated in the early postoperative period was 12/60 (20%) using EAT-10 and 15/60 (25%) using the H-K score (Fig. 2A, 2B).

There was a significant positive correlation between the pre- and postoperative H-K scores ($r = 0.48$, $P < 0.0001$; Fig. 3).

### Incidence of PRC

Of all the 60 cases, eight had PRC (13.3%). Among them, two cases required reintubation due to airway obstruction and six cases had aspiration pneumonia.

### Comparison of patients with and without PRC

Table 1 compares patients with (+) and without (−) PRC. Patients in the PRC(+) group were significantly older and a higher percentage of them had diabetes and/or asthma than those in the PRC(−) group. In contrast, there was no significant difference in terms of gender, smoking status, dialysis, and restrictive and obstructive impairment measured using spirometry between the PRC(+) and PRC(−) groups. The duration of surgery, estimated blood loss, and number of

**Table 1.** Comparison of Patients with and without Postoperative Respiratory Complications.

| Variable | PRC(−) (n=52) | PRC(+) (n=8) | *P* value |
|---|---|---|---|
| Age, years | 66.6±11.1 | 77.1±9.1 | <0.05* |
| Female/male, n | 29/23 | 2/6 | 0.14 |
| Comorbidity, n | | | |
|     Smoking (NSO/CS or FS) | 30/22 | 4/4 | 0.72 |
|     Dialysis (+/−) | 4/48 | 2/6 | 0.18 |
|     Diabetes (+/−) | 4/4 | 8/44 | <0.05* |
|     Asthma (+/−) | 2/6 | 1/51 | <0.05* |
|     Restrictive impairment (%FVC was 80%) (+/−) | 6/46 | 1/7 | 0.92 |
|     Obstructive impairment (%FEV1<70%) (+/−) | 2/6 | 3/49 | 0.13 |
| Duration of surgery, min | 111.4±53.7 | 117.0±33.2 | 0.78 |
| Estimated blood loss, mL | 41.9±70.5 | 35.0±32.7 | 0.79 |
| Number of fused vertebral levels | 2.2±1.0 | 2.6±0.7 | 0.29 |

Interval and ratio values are presented as mean±standard deviation.

*Vs the PRC group.

PRC: postoperative respiratory complications; NSO: never smoker; CS: current smoker; FS: former smoker; FVC: forced vital capacity; FEV1: forced expiratory volume in 1 s.

vertebral fusion levels were not significantly different between the groups.

### Dysphagia and PRC

The preoperative H-K score of the PRC(+) group was significantly higher than that of the PRC(−) group (Fig. 4C). In contrast, there was no significant difference in preoperative EAT-10 between the groups (Fig. 4A). Both the postoperative EAT-10 and H-K scores were significantly higher in the PRC(+) group than in the PRC(−) group (Fig. 4B, 4D). The cutoff value of the preoperative H-K score was determined as 2.5 points to detect PRC in patients who underwent ADF using ROC curve analysis, which indicated a sensitivity of 62.5% (95%CI: 30.6%-86.3%), a specificity of 87.8% (95% CI: 75.8%-94.3%), and an area under the curve of 0.731 (Fig. 4E).

The flexible endoscopic evaluation of a representative case from the PRC(+) group who had developed preoperative dysphagia is shown in Fig. 1.

## Discussion

The present study aimed to clarify the risk factors of PRC after ADF and to establish a preoperative screening method for patients who are at a high risk of PRC. Interestingly, we found that the H-K score during FEES was useful in detecting patients who had dysphagia before surgery. Furthermore, a significant positive correlation between the H-K scores before and after surgery suggested that postoperative dysphagia after ADF could potentially have been exacerbated in patients who had dysphagia before surgery. The present study showed that 13% of all cases who underwent ADF were associated with PRC, and two cases required reintubation due to airway obstruction and six cases had aspiration pneumonia.

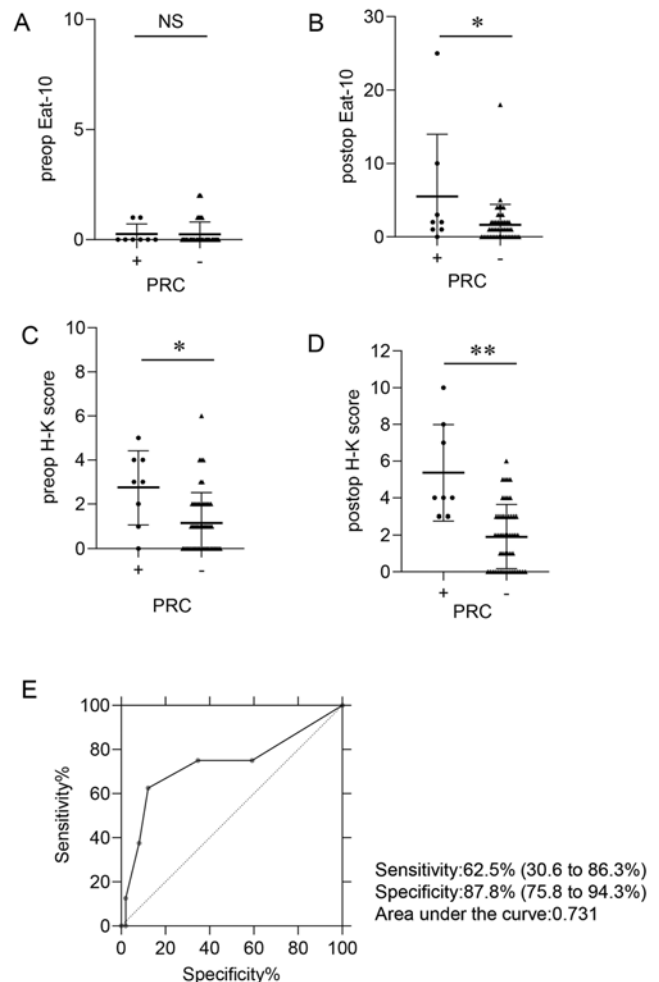A previous study drew attention to the prevalence of rein-



**Figure 4.** Images of a flexible endoscopic evaluation in representative cases who had developed preoperative dysphagia in (a) the PRC(+) group and (b) the PRC(−) group.
PRC: postoperative respiratory complications.

tubation being very low (0.1%) among cases who underwent ADF; however, serious complications can lead to death in worst-case scenarios[17]. Postoperative pneumonia is the third most common complication for all surgical procedures and is associated with increased patient morbidity and mortality[18]. Additionally, pneumonia is the fourth most common cause of mortality in the elderly in Japan[16].

Numerous studies have tried to clarify the risk factors linked to PRC, such as postoperative airway obstruction and pneumonia, older age, male gender, smoking, obesity, chronic obstructive pulmonary disease, bleeding disorders, an increased number of fused vertebral levels, blood loss, and prolonged operative durations[6,9,19,20]. However, the number of patients who experience severe PRC after ADF has not decreased. In line with previous reports, the present study also showed that older age and comorbidities of asthma and/or diabetes mellitus (DM) were risk factors for PRC after ADF. As an important new finding, high preoperative H-K scores were a risk factor for PRC after ADF. In contrast, postoperative PRC could not be screened using EAT-10, and we presume this cause as it is based on patient evaluations. The preoperative evaluation of PFTs using spirometry was also not useful to predict PRC after ADF in the present study.

It is well known in the otolaryngology specialty that dysphagia is one of the important etiologies of aspiration and airway obstruction[10,16]. Therefore, preoperative prediction of the risk of postoperative dysphagia has great clinical significance. Additionally, the H-K score has been established to be useful for detecting the risk of aspiration in the elderly in the otolaryngologic field because it can sensitively and objectively evaluate the swallowing function[16]. However, there is no study of the usefulness of the H-K score in the orthopedic field.

To our knowledge, this is the first study to indicate that the preoperative evaluation of dysphagia using H-K scores during FEES is a useful method for predicting and reducing the risk of PRC. A further study with an increased number of patients is warranted.

## Conclusion

Dysphagia after ADF may potentially be exacerbated in patients who have dysphagia before surgery. The preoperative evaluation of dysphagia using H-K scores during FEES is useful for predicting and reducing the risk of PRC.

**Conflicts of Interest:** The authors declare that there are no relevant conflicts of interest.

**Ethical Approval:** The study was approved by the institutional review board of our institute (application no. 1181).

## References

1. Okita G, Ohba T, Takamura T, et al. Application of neurite orientation dispersion and density imaging or diffusion tensor imaging to quantify the severity of cervical spondylotic myelopathy and to assess postoperative neurologic recovery. The Spine Journal. 2017; 18(2):268-75.

2. Iwama T, Ohba T, Okita G, et al. Utility and validity of neurite orientation dispersion and density imaging with diffusion tensor imaging to quantify the severity of cervical spondylotic myelopathy and assess postoperative neurological recovery. The Spine Journal. 2019;20(3):417-25.

3. Wu B, Song F, Zhu S. Reasons of dysphagia after operation of anterior cervical decompression and fusion. Clin Spine Surg. 2017; 30(5):E554-E9.

4. Nagoshi N, Tetreault L, Nakashima H, et al. Risk factors for and clinical outcomes of dysphagia after anterior cervical surgery for degenerative cervical myelopathy: results from the AOSpine International and North America Studies. J Bone Joint Surg Am. 2017; 99(13):1069-77.

5. Reinard KA, Cook DM, Zakaria HM, et al. A cohort study of the morbidity of combined anterior-posterior cervical spinal fusions: incidence and predictors of postoperative dysphagia. Eur Spine J. 2016;25(7):2068-77.

6. Lim S, Kesavabhotla K, Cybulski GR, et al. Predictors for airway complications following single- and multilevel anterior cervical discectomy and fusion. Spine. 2017;42(6):379-84.

7. Debkowska MP, Butterworth JF, Moore JE, et al. Acute postoperative airway complications following anterior cervical spine surgery and the role for cricothyrotomy. Journal of spine surgery (Hong Kong). 2019;5(1):142-54.

8. Yoshii T, Morishita S, Inose H, et al. Comparison of perioperative complications in anterior decompression with fusion and posterior decompression with fusion for cervical ossification of the posterior longitudinal ligament: propensity score matching analysis using a nation-wide inpatient database. Spine. 2020.

9. Li H, Huang Y, Shen B, et al. Multivariate analysis of airway obstruction and reintubation after anterior cervical surgery: a retrospective cohort study of 774 patients. International Journal Surg. 2017;41:28-33.

10. Cheney DM, Siddiqui MT, Litts JK, et al. The ability of the 10-item eating assessment tool (EAT-10) to predict aspiration risk in persons with dysphagia. Ann Otol Rhinol Laryngol. 2015;124(5): 351-4.

11. Nogueira DS, Ferreira PL, Reis EA, et al. Measuring outcomes for dysphagia: validity and reliability of the European Portuguese eating assessment tool (P-EAT-10). Dysphagia. 2015;30(5):511-20.

12. Hyodo M, Nishikubo K, Hirose K. New scoring proposed for endoscopic swallowing evaluation and clinical significance. Nihon Jibiinkoka Gakkai Kaiho. 2010;113(8):670-8.

13. Hyodo M. Diagnosis and treatment of deglutition disorders. Nihon Jibiinkoka Gakkai Kaiho. 2012;115(8):767-72.

14. Ohba T, Hatsushika K, Ebata S, et al. Risk factors and assessment using an endoscopic scoring system for early and persistent dysphagia after anterior cervical decompression and fusion surgery. Clin Spine Surg. 2020;33(4):E168-73.

15. Belafsky PC, Mouadeb DA, Rees CJ, et al. Validity and reliability of the eating assessment tool (EAT-10). Ann Otol Rhinol Laryngol. 2008;117(12):919-24.

16. Sakamoto T, Horiuchi A, Makino T, et al. Determination of the cut-off score of an endoscopic scoring method to predict whether elderly patients with dysphagia can eat pureed diets. World J Gastrointest Endosc. 2016;8(6):288-94.

17. Nagoshi N, Fehlings MG, Nakashima H, et al. Prevalence and outcomes in patients undergoing reintubation after anterior cervical spine surgery: results from the AOSpine North America Multicen-

ter Study on 8887 patients. Global Spine J. 2017;7(1 Suppl):96s-102s.

18. Chughtai M, Gwam CU, Mohamed N, et al. The epidemiology and risk factors for postoperative pneumonia. J Clin Med Res. 2017;9(6):466-75.

19. Bohl DD, Ahn J, Rossi VJ, et al. Incidence and risk factors for pneumonia following anterior cervical decompression and fusion procedures: an ACS-NSQIP study. The Spine Journal. 2016;16(3):

335-42.

20. Sagi HC, Beutler W, Carroll E, et al. Airway complications associated with surgery on the anterior cervical spine. Spine. 2002;27 (9):949-53.