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Postoperative Measurement of the Retropharyngeal Space Predicts the Risk of Dysphagia After Anterior Cervical Diskectomy and Fusion

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BACKGROUND AND OBJECTIVES: Postoperative dysphagia is a common complication of anterior cervical diskectomy and fusion (ACDF), although its pathophysiology remains poorly understood. Patients with severe dysphagia may suffer from serious complications such as aspiration pneumonia, in addition to difficulty with oral intake or malnutrition; therefore, a prompt indicator for postoperative management would be helpful. We quantitatively evaluated the retropharyngeal space (RS) after ACDF and investigated its association with postoperative dysphagia.

METHODS: This multicenter retrospective study analyzed the clinical data of 82 consecutive patients who underwent ACDF. The anteroposterior distance (APD) of the RS was measured at the C2 level using a lateral radiographic view on postoperative day 1. Postoperative dysphagia was subjectively assessed using the Bazaz-Yoo Dysphagia Severity Scale. We statistically evaluated the association between the APD of the RS and postoperative dysphagia.

RESULTS: The mean APD of the RS in all 82 patients was 3.6 mm preoperatively and significantly increased to 8.2 mm postoperatively ($P < .0001$). Twenty-two patients (26.8%) had postoperative dysphagia. Multivariable analysis revealed that the postoperative APD was associated with postoperative dysphagia (odds ratio 1.27, 95% CI 1.10-1.50, $P = .0007$). The receiver operating characteristic curve (area under the curve 0.70, 95% CI 0.58-0.83) demonstrated that the postoperative APD of the RS cutoff value was 6.1 mm, with a sensitivity of 100% and a specificity of 35%. With this cutoff value, the positive and negative predictive values for postoperative dysphagia were 36% and 100%, respectively.

CONCLUSION: Our data demonstrate that a value of 6.1 mm for the APD of the RS is an effective indicator for dysphagia after ACDF, which contributes to optimizing the patient management in the acute postoperative period.

KEY WORDS: Anterior, Cervical, Dysphagia, Fusion, Retropharyngeal space, Spine

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Dysphagia is one of the typical and common complications developed after an anterior cervical approach in surgery for spinal disorders.[1,2] Although postoperative dysphagia shows a relatively benign prognosis, difficulty in oral intake may affect quality of life and cause potentially fatal conditions such as aspiration pneumonia and airway obstruction.[3,4] According to previous studies on anterior cervical diskectomy and fusion (ACDF), the incidence of early postoperative dysphagia during the first week after surgery varies widely, ranging from 33.1% to 87.5%.[1,5,6] Several risk factors, including age, female sex, revision surgery, upper cervical spine, multilevel fusion, use of plate instrumentation, surgical time, and intraoperative blood loss, have been reported.[1,2,7-16] Prevertebral soft tissue swelling of the retropharyngeal space (RS) has also been proposed as a risk factor.[17-21] However, its clinical significance in the assessment of the risk of postoperative dysphagia remains unclear. Herein, we evaluated the relationship between postoperative changes in the RS and the risk of dysphagia after ACDF and investigated its significance as a clinical indicator for the occurrence of dysphagia.

ABBREVIATIONS: ACDF, anterior cervical diskectomy and fusion; **APD,** anteroposterior distance; **JOA,** Japanese Orthopedic Association; **NPV,** negative predictive value; **PPV,** positive predictive value; **RS,** retropharyngeal space.

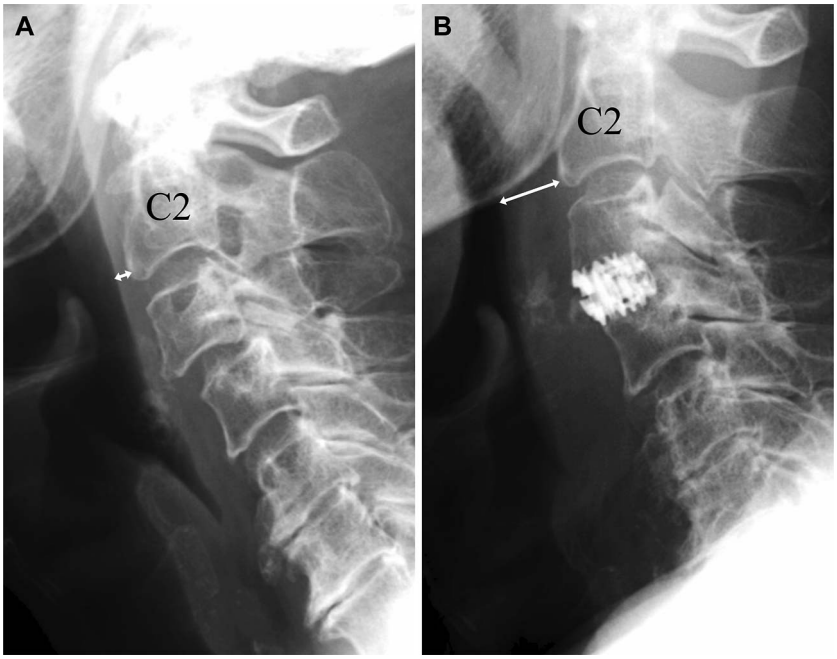

FIGURE 1. **A**, *The APD of the retropharyngeal space in a representative case of a 76-year-old man with severe postoperative dysphagia and exhibiting radiculomyelopathy secondary to cervical degenerative spondylosis at C3/4 was 4.3 mm, measured preoperatively from the caudal endplates of the C2 vertebral body to the air window on the lateral radiographic view.* **B**, *The patient exhibited an APD of 11.9 mm on day 1 after anterior cervical diskectomy and fusion, and it took approximately 1 month to improve postoperative dysphagia. APD, anteroposterior distance.*

METHODS

Patient Enrollment and Characteristics

This multi-institutional joint study was approved by the Institutional Research Board of the Saitama Medical Center, Saitama Medical University (approval number: SOU2023-020). The requirement for informed consent was waived because of the retrospective nature of the analysis, and an opt-out method was used for the patients at each institute. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Between January 2010 and April 2023, consecutive patients treated with ACDF for cervical radiculopathy or myelopathy at the Department of Neurosurgery and Orthopedic Surgery of Saitama Medical Center, Saitama Medical University and at the Department of Neurosurgery of Numata Neurosurgery & Cardiovascular Hospital were retrospectively enrolled. Patients with cervical vertebral fractures or dislocations, spinal tumors, or spinal vascular disorders were excluded from the analysis. In addition, patients with preoperative dysphagia or swallowing difficulties resulting from neck surgery, infections, or trauma were excluded.

For all patients, the anterior cervical Smith-Robinson procedure was selected.[22] In brief, after the anterior surface of the cervical spine was exposed, the retractor was placed medially in the dissected longus colli muscles. A TrimLine cervical retractor system (Medtronic Sofamor Danek) or a Casper cervical retractor system (Aesculap AG) was used. Subsequently, microsurgical diskectomy and fusion were performed. The choice of grafting or plate augmentation was based on the surgeon's preference or on pathological findings such as cervical instability. After the surgical procedure, each patient was released from general anesthesia and extubated immediately.

We retrospectively reviewed the medical charts and collected clinical data on age, sex, operative levels (upper cervical spine was defined as above the C3 vertebral body exposed during surgery), number of levels operated on (multilevel surgery was defined as 2 or more intervertebral spaces), presence of ossification of the posterior longitudinal ligament, revision surgery, plate augmentation, operative duration, intraoperative blood loss, and surgical complications. The Japanese Orthopedic Association scoring system for recovery rate was used to assess the surgical outcome for symptoms.[23]

Radiographical and Dysphagia Assessment

The anteroposterior distance (APD) of the RS was measured as the soft tissue shadow from the caudal endplate of the anterior surface of the C2 vertebral body to the posterior tracheal airway shadow on the lateral radiographic view (Figure 1). X-ray images were obtained from all patients within 24 hours after surgery to detect graft extrusion or mechanical failure and to verify spinal alignment.

Dysphagia after surgery was evaluated using the Bazaz-Yoo Dysphagia Severity Scale based on subjective symptoms.[24] Mild and moderate

TABLE 1. Patient Demographics (N = 82)

Factor	Value
Age, median (IQR), y	63.5 (48.8-72.3)
Sex, female, n (%)	29 (35.4)
Multilevel surgery, n (%)	30 (36.6)
Upper cervical spine, n (%)	22 (26.8)
Ossification of posterior longitudinal ligament, n (%)	11 (13.4)
Revision surgery, n (%)	2 (2.4)
Plate augmentation, n (%)	9 (11.0)
Operative duration, median (IQR), min	204.0 (178.5-255.3)
Intraoperative blood loss, median (IQR), mL	5.0 (5.0-5.0)
Recovery rate of JOA score, median (IQR), %	50.0 (33.3-76.3)
Anteroposterior distance of the retropharyngeal space	
Preoperative distance, mean (SD), mm	3.6 (0.8)
Postoperative distance, median (IQR), mm	8.2 (6.0-11.3)
Postoperative dysphagia, n (%)	22 (26.8)
Bazaz-Yoo Severity Scale, mild and moderate, n (%)	19 (23.2)
Bazaz-Yoo Severity Scale, severe, n (%)	3 (3.7)

JOA, Japanese Orthopedic Association.

dysphagia was defined as difficulty swallowing solids rather than liquids. By contrast, severe dysphagia was classified as difficulty swallowing both solids and liquids. Patients with postoperative dysphagia underwent a CT scan of the neck to promptly detect emergencies such as postoperative hematoma. In patients with severe or prolonged dysphagia, a fiberscopic examination and a swallowing function test were conducted by an otorhinolaryngologist.

Statistical Analysis

All analyses were conducted using JMP 16 software (SAS Institute). Continuous variables were evaluated using the Shapiro-Wilk test to determine whether the data set was normally distributed. Data with normal distribution were analyzed using the Student *t* test. If skewed, the Mann-Whitney *U* test was used instead. The Pearson χ^2 test was used to analyze categorical variables. When the cell counts of categorical variables were less than 5, the Fisher exact test was used instead. A *P* value lower than .05 was defined as statistically significant. In addition, multivariable analysis was performed using a logistic regression model.

The sensitivity and specificity of the postoperative APD of the RS for postoperative dysphagia were calculated, and the true-positive rate vs the false-positive rate was plotted for the receiver operating characteristic (ROC) curve. The cutoff point on the ROC curve corresponding to the Youden index was confirmed to be the optimal point at which it (sensitivity + specificity − 1) is maximized. To describe the diagnostic performance for postoperative dysphagia, a positive predictive value (PPV) was calculated using the following formula:

$$PPV = \frac{ratio\ of\ true\ positives}{true\ positives + false\ positives}$$

and a negative predictive value (NPV) was calculated using the following formula:

$$NPV = \frac{ratio\ of\ true\ negatives}{true\ negatives + false\ negatives}$$

RESULTS

The patient demographics are presented in Table 1. Eighty-two patients were included in this study. The median age was 63.5 years. Twenty-nine patients (35.4%) were women. Regarding surgical procedures, 30 surgeries were for multilevel lesions and 22 were specifically for upper cervical spine lesions. Eleven patients (13.4%) underwent ACDF for ossification of the posterior longitudinal ligament. Plate augmentation was conducted in 9 patients (11.0%). There were only 2 redo surgeries. The median operative duration and intraoperative blood loss were 204 minutes and 5 mL, respectively. Postoperatively, the median recovery rate for the Japanese Orthopedic Association score was 50%. The

TABLE 2. Univariable and Multivariable Analyses of Variables for Postoperative Dysphagia (N = 82)

	Univariable analysis			Multivariable analysis		
Factor	Postoperative dysphagia (+) N = 22	Postoperative dysphagia (−) N = 60	*P* value	OR	95% CI	*P* value
Age, median (IQR), y	64.0 (48.0-75.3)	63.5 (49.8-71.8)	.80			
Sex, female, n (%)	7 (31.8)	22 (36.7)	.68			
Multilevel surgery, n (%)	8 (36.4)	22 (36.7)	.98			
Upper cervical spine, n (%)	9 (40.9)	13 (21.7)	.09	2.20	0.67–7.24	.19
Ossification of posterior longitudinal ligament, n (%)	3 (13.6)	8 (13.3)	1.00			
Revision surgery, n (%)	0 (0)	2 (3.3)	1.00			
Plate augmentation, n (%)	3 (13.6)	6 (10.0)	.70			
Operative duration, median (IQR), min	186.5 (165.3-232.5)	210.0 (181.3-259.0)	.09	0.99	0.98–1.00	.07
Intraoperative blood loss, median (IQR), mL	5.0 (5.0-5.0)	5.0 (5.0-12.5)	.34	1.00	0.99–1.00	.85
Recovery rate of JOA score, median (IQR), percent	50.0 (31.7-68.8)	50.0 (33.3-83.5)	.73			
Anteroposterior distance of the retropharyngeal space						
Preoperative distance, mean (SD), mm	3.7 (0.6)	3.5 (0.9)	.41	0.98	0.46–2.00	.95
Postoperative distance, median (IQR), mm	10.2 (6.8-16.4)	7.8 (4.9-10.4)	.005	1.27	1.10–1.50	.0007

JOA, Japanese Orthopedic Association; OR, odds ratio.

mean APD of the RS was 3.6 mm preoperatively and significantly increased to 8.2 mm postoperatively (Paired *t* test, $P < .0001$). Twenty-two patients (26.8%) experienced postoperative dysphagia. Of them, 19 (23.2%) had mild or moderate dysphagia, and 3 (3.7%) had severe dysphagia. No postoperative hematoma, iatrogenic pharyngoesophageal constriction, or implant dislodgement was detected in any of these 22 patients by CT scan. The 3 patients with severe dysphagia and 2 patients with protracted symptoms underwent fiberscopic examination performed by an otorhinolaryngologist; however, no nerve paralysis or pharyngoesophageal injury was identified. All the patients with mild-to-moderate dysphagia after surgery recovered in conjunction with the reduction of APD within 1–2 weeks. Patients with severe dysphagia showed complete recovery after 2 months of rehabilitation. No patient received steroid treatment in any form during the perioperative period.

Table 2 shows the relationship between clinical variables and postoperative dysphagia. The univariable analysis demonstrated that only APD of the RS after surgery was significantly associated with postoperative dysphagia occurrence (10.2 mm vs 7.8 mm, median, $P = .005$), whereas there was no difference in APD of the RS before surgery (3.7 mm vs 3.5 mm, mean, $P = .41$). Upper cervical spine surgery and short operative duration approached significance (both $P = .09$). Multivariable analysis demonstrated that the increased APD of the RS was an independent risk factor for postoperative dysphagia (odds ratio 1.27, 95% CI 1.10-1.50, $P = .0007$).

Figure 2 depicts the ROC curve obtained for the sensitivity and specificity of the APD of the RS for postoperative dysphagia prediction. The area under the curve was 0.70 (95% CI 0.58-0.83). The ROC curve revealed that the predictive cutoff value of the postoperative APD of the RS for dysphagia was 6.1 mm maximized the Youden index, with a sensitivity of 100% and a specificity of 35%. For this cutoff value, the PPV and NPV for postoperative dysphagia were 36% and 100%, respectively.

DISCUSSION

Our data demonstrated that the high APD of the RS was significantly associated with an increased risk of dysphagia after ACDF. We believe that this relatively simple assessment is effective in the selection of patients with high risk of postoperative dysphagia and may improve the safety of management for patients who underwent ACDF.

Postoperative dysphagia in the early postoperative period can be attributed to multifactorial causes, including injuries to the nerve and the esophagus or inappropriate use of plate.[25-30] The RS is the loose connective tissue between the cervical vertebrae and the pharynx, consisting of fat and lymph nodes.[31,32] Local inflammation in this soft tissue is speculated to cause the swelling and dysphagia after anterior cervical surgery.[33-36] A study that evaluated enlargement of the RS 2 weeks after surgery by radiography

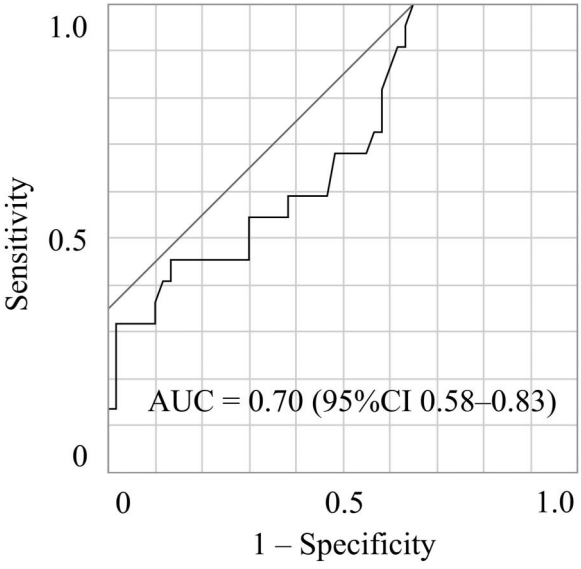

FIGURE 2. *Receiver operating characteristic analysis for the prediction of postoperative dysphagia after anterior cervical diskectomy and fusion based on postoperative anteroposterior distance of the retropharyngeal space. The area under the curve was 0.70 (95% CI 0.58-0.83), and the cutoff value of 6.1 mm maximized the Youden index, with a sensitivity of 100% and a specificity of 35%.*

concluded that the prevertebral soft tissue swelling was unrelated to postoperative dysphagia.[21] However, the timing of the radiographic examination may have prevented the proper evaluation of soft-tissue swelling during the acute phase. In our study, patients with mild-to-moderate dysphagia exhibited good recovery within 2 weeks after surgery. Considering this rapid improvement, mechanical obstruction due to the swelling of the prevertebral soft tissue may be the main cause of mild-to-moderate dysphagia after ACDF. Our data indicate that the APD of the RS is of diagnostic value to predict postoperative dysphagia in the acute postoperative phase.

Although X-ray imaging is simple and easy to execute, it may be less accurate than computed tomography scanning or magnetic resonance imaging. However, the average APD of the RS was 3.6 mm in our study, demonstrating a close approximation to the average APD of 3.7 mm previously reported in the literature.[37] We, therefore, consider that this method is reproducible and sufficiently accurate from a clinical perspective. Several studies have reported a relationship between dysphagia and prevertebral soft tissue swelling[17-20]; however, a clinically useful threshold has yet to be identified. Prompt examination based on the stratification of patients with increased risk of dysphagia might mitigate the development of malabsorption pneumonia. Based on our sensitivity and NPV results, all patients with APD of the RS < 6.1 mm can start oral intake immediately after surgery. In patients with APD of the RS ≥ 6.1 mm, detailed evaluation of swallowing function by an otorhinolaryngologist might be an option if there are subjective complaints of dysphagia. We believe that prompt and timely identification of patients with high risk of dysphagia is required before initiation of oral intake after surgery. Our findings indicate that the postoperative APD of the RS, evaluated using simple X-ray imaging routinely performed after ACDF in most facilities, is correlated with the risk of postoperative dysphagia.

Previously, several measures such as the effectiveness of endotracheal tube cuff pressure monitoring and designed anterior cervical plates have been reported to prevent the occurrence of dysphagia.[29,38,39] However, there is no standard treatment for postoperative dysphagia once it has occurred. There have been prospective trials on the efficacy of local steroid injections, but they failed to show efficacy.[33,35,36,40] Our data indicate that different results may be obtained if the focus is placed on patients with APD of the RS ≥ 6.1 mm, who are at high risk of dysphagia.

Limitations

This study had several limitations. First, we retrospectively analyzed observational data obtained from clinical charts. Second, because of the multicenter nature of the study, the surgical procedures were performed by several different spinal surgeons using their own instrumentation. Third, the Bazaz-Yoo Dysphagia Severity Scale is based on the subjective assessment of difficulty swallowing, rather than objective imaging methods such as laryngoscopy.[17] Unfortunately, we had no assessment of swallowing function before the intervention. Finally, because none of the patients included in this study experienced a potentially fatal event such as severe aspiration pneumonia or airway obstruction, the usefulness of this cutoff value for the prediction of dysphagia severity could not be determined.

CONCLUSION

The increased APD of the RS after ACDF due to prevertebral soft tissue edema caused by a surgical intervention was associated with increased risk of postoperative dysphagia. This study demonstrates that the APD of the RS of 6.1 mm is an effective cutoff value for the prediction of dysphagia after ACDF and can be used to optimize patient management during the acute postoperative period.

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