Risk Factors for Dysphagia After Anterior Cervical Spine Surgery

ZHIKUN LI, MD; GENGWU LI, MD; CHAO CHEN, MD; YIFAN LI, MD; CHANGWEI YANG, MD; WEI XU, MD; XIAODONG ZHU, MD, PhD

abstract

This study evaluated the risk factors for dysphagia after anterior cervical spine surgery by multidimensional analysis and investigated the predictive values of these risk factors for dysphagia. The patients underwent anterior cervical spine surgery and were followed for at least 6 months. Sex, age, tracheal mobility, smoking history, implant type, C3 anterior vertebral soft tissue swelling, narrowest esophageal distance before internal fixation, cervical curvature, operative time, occurrence of fusion, number of operative segments, and highest vertebral segment were recorded. Chi-square test and logistic regression were performed to analyze the predictive value of each dimension for dysphagia. A total of 158 patients were included in this study. The mean C3 anterior vertebral soft tissue swelling was 8.8±4.5 mm, the mean narrowest esophageal distance before internal fixation was 6.9±4.4 mm, and the mean operative time was 78.5±39.2 minutes. Chi-square test results showed that age 60 years and older, female sex, internal fixation with titanium plate/titanium mesh, narrowest esophageal distance before internal fixation of less than 5 mm, and 3 operative segments indicated a relatively high incidence of dysphagia. Logistic regression analyses showed that age, sex, implant type, narrowest esophageal distance before internal fixation, and number of operative segments were all risk factors predictive of postoperative dysphagia. The area under the receiver operating characteristic curve was 0.872. Age 60 years and older, female sex, internal fixation with titanium plate/titanium mesh, narrowest esophageal distance before internal fixation of less than 5 mm, and 3 operative segments were risk factors for dysphagia after anterior cervical surgery. The regression equation may be used to predict the occurrence of dysphagia. [Orthopedics. 2018; 41(1):e110-e116.]

The authors are from the Department of Orthopedics (ZL, CC, YL, WX, XZ), Tongren Hospital, Shanghai Jiao Tong University School of Medicine, and the Department of Orthopedics (GL, CY, XZ), Changzheng Hospital, Second Military Medical University, Shanghai, China.

Drs Z Li and Xu contributed equally to this work and should be considered as equal first authors. The authors have no relevant financial relationships to disclose.

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Correspondence should be addressed to: Xiaodong Zhu, MD, PhD, Department of Orthopedics, Tongren Hospital, Shanghai Jiao Tong University School of Medicine, 1111 XianXia Rd, Shanghai 200336, China (scoliosis_zhuad@126.com).

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terior cervical spine surgery has been used to treat various types of cervical spondylosis and posterior longitudinal ligament ossification because of its advantages of diminished surgical trauma and rapid postoperative recovery.1,2 The surgical methods include fusion and nonfusion. Although new dynamic nonfusion technologies such as those using artificial disks are currently available, interbody fusion is employed in most cases.3 Interbody fusion is currently accomplished using 2 methods: an unanchored “stand-alone” cage and a bone graft or a cage anchored by a plate.4 Increases in the number of patients undergoing anterior surgery and in the amount of follow-up clinical data have brought at-
Dysphagia has been considered one of the most common complications after anterior cervical spine surgery, with a reported incidence varying from 1% to 80%.1-7 Most investigators currently believe that the dysphagia occurring after anterior cervical spine surgery is related to the patient’s condition, the graft, and the number of operative vertebral segments.3,8-10 Although the risk factors for postoperative dysphagia are multidimensional, the literature lacks a comprehensive analysis of them. This study assessed the incidence of dysphagia after anterior cervical spine surgery and investigated the predictive values of the risk factors for dysphagia.

**Materials and Methods**

The medical records of 172 patients who underwent anterior cervical spine surgery at Tongren Hospital and Changhai Hospital, Shanghai, China, from January 2014 to December 2016 were prospectively analyzed. Patients with preoperative dysphagia, cervical trauma, cervical repair, spinal tuberculosis, and spinal tumors were excluded. A total of 158 cases with complete follow-up data were included (Tongren Hospital, 49 cases; Changhai Hospital, 109 cases).

**Surgical Procedures and Postoperative Regimen**

Endotracheal intubation was used for general anesthesia in all patients. A right anterior transverse incision was used, and the platysma was transected. For the muscle flap dissection, separation was performed along the inner edge of the sternocleidomastoid muscle. The trachea and esophagus were retracted medially, and the carotid sheath was retracted laterally. The anterior fascia was longitudinally incised to insert the anchoring needle, and the operative segments were determined using a C-arm radiograph imaging system. The narrowest distance between the anterior vertebral soft tissue from before surgery was calculated, signifying mobility was considered poor. To assess C3 anterior vertebral soft tissue swelling, the distance from the anterior inferior margin of the C3 vertebra to the posterior margin of the airway shadow was measured. When the vertebral margin was significantly hyperplastic and when an osteophyte had formed, the starting point of the measurement was selected from the anterior inferior margin of the hypothetical nonproliferative vertebral. For vertebral bodies covered by titanium plates, the corresponding anterior margin of the titanium plate was chosen as the starting point for the measurement (Figure 1A).

The change in the width of the anterior cervical soft tissue from before surgery to after surgery was calculated, signifying the width of the anterior vertebral soft tissue swelling (Figure 1B). The narrowest distance of the esophagus was measured as the narrowest distance between the anterior cervical internal fixation and the posterior margin of the thyroid cartilage (Figure 1C). Operative time was defined as the time the automatic distractor was used in the cervical spine surgical area.

**Diagnostic Criteria for Dysphagia After Anterior Cervical Spine Surgery**

In accordance with the description in the literature,11 when the following symptoms persisted after the first postoperative week, the authors considered dysphagia to be present: swallowing dysfunction while eating solids or liquids and swallowing discomfort (ie, choking, foreign body sensation, or burning sensation). Pain and discomfort experienced while eating during postoperative week 1 were excluded. Follow-up was performed within 6 months via outpatient review, mail, and telephone. Patients’ postoperative dysphagia was observed, and the related factors were analyzed.

**Factors Investigated**

The following were investigated: individual patient factors of sex, age, tracheal mobility, and smoking history; implant factors (ie, titanium plate internal fixation, Zero-P, and artificial disk); imaging indicators regarding C3 anterior vertebral soft tissue swelling, the narrowest esophageal distance before internal fixation, and cervical curvature; surgical factors of operative time and whether fusion was performed; and surgical segment factors (ie, the number of operative segments and the highest operated on vertebral segment).

The measurements were obtained from the lateral cervical spine radiographs performed within 1 week after surgery. Regarding tracheal mobility, good mobility was indicated when the trachea could be displaced from right to left to pass the median line by more than 1 cm without patient discomfort; otherwise, the mobility was considered poor. To assess C3 anterior vertebral soft tissue swelling, the distance from the anterior inferior margin of the C3 vertebra to the posterior margin of the airway shadow was measured. When the vertebral margin was significantly hyperplastic and when an osteophyte had formed, the starting point of the measurement was selected from the anterior inferior margin of the hypothetical nonproliferative vertebral. For vertebral bodies covered by titanium plates, the corresponding anterior margin of the titanium plate was chosen as the starting point for the measurement (Figure 1A).

The change in the width of the anterior cervical soft tissue from before surgery to after surgery was calculated, signifying the width of the anterior vertebral soft tissue swelling (Figure 1B). The narrowest distance of the esophagus was measured as the narrowest distance between the anterior cervical internal fixation and the posterior margin of the thyroid cartilage (Figure 1C). Operative time was defined as the time the automatic distractor was used in the cervical spine surgical area.

**Statistical Analysis**

All of the data were analyzed using SPSS version 18.0 software (IBM, Armonk, New York).
Figure 1: Internal fixation with the Zero-P fixation system (Johnson & Johnson, Zug, Switzerland) (A), the artificial cervical disk (PrestigeLP; Medtronic, Inc, Minneapolis, Minnesota) (B), and the anterior cervical plate (Slimlock; Johnson & Johnson) (C). The yellow line represents C3 anterior vertebral soft tissue swelling. The red line represents the narrowest esophageal distance before internal fixation.

### Table 1

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Mean±SD</th>
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<tr>
<td>Chronological age, y</td>
<td>61.7±17.6</td>
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<tr>
<td>C3 anterior vertebral soft tissue swelling, mm</td>
<td>8.8±4.5</td>
</tr>
<tr>
<td>Narrowest esophageal distance before internal fixation, mm</td>
<td>6.9±4.4</td>
</tr>
<tr>
<td>Operative time, min</td>
<td>78.5±39.2</td>
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The incidences of dysphagia among different groups were comparatively analyzed by chi-square test. Multiple logistic regressions were used to analyze the predictive factors for dysphagia. In the regression analysis, the following values were used: the occurrence of dysphagia was defined as 1 and the nonoccurrence as 0; age younger than 60 years was defined as 0 and age 60 years or older as 1; male sex was defined as 0 and female sex as 1; good tracheal mobility was defined as 1 and poor mobility as 0; a history of smoking without quitting was defined as 1 (have) and no smoking history or having quit for at least 1 year as 0 (no); titanium plate fixation for the graft was defined as 0, with Zero-P fixation defined as 1 and artificial intervertebral disk defined as 2; C3 anterior vertebral soft tissue swelling of 10 mm or greater was defined as 0 and of less than 10 mm as 1; narrowest esophageal distance before internal fixation of 5 mm or greater was defined as 1 and of less than 5 mm as 0; cervical curvature considered straight or kyphotic was defined as 0 and lordosis was defined as 1; operative time of less than 1 hour was defined as 0 and of 1 hour or greater as 1; fusion was defined as 0 and nonfusion as 1; 1 surgical segment was defined as 0, with 2 segments defined as 1 and 3 segments defined as 2; and a highest vertebral involvement equal to C2 or C3 was defined as 0, equal to C4 or C5 as 1, and equal to C6 or C7 as 2. P<.05 indicated a statistically significant difference.

### RESULTS

A total of 158 patients were included in this study (102 male and 56 female; median age, 61.7±17.6 years). The diagnoses were cervical spondylotic myelopathy in 72 cases, cervical spondylotic radiculopathy in 40 cases, mixed cervical spondylosis in 22 cases, and posterior longitudinal ligament ossification in 24 cases. General measurement data for the 158 cases of anterior cervical spine surgery are presented in Table 1.

A total of 44 patients (27.8%) developed dysphagia after surgery. The main symptoms included fatigue during swallowing or an inability to swallow solids; pain or a burning sensation with swallowing; difficulty in swallowing or an inability to swallow because of cough when swallowing liquids; and food retention in the throat. Although dysphagia had developed in 44 patients by the 1-week follow-up, the dysphagia symptoms of 27 patients resolved within 4 weeks. At 1-month follow-up, 11 patients still reported dysphagia. Three underwent esophageal angiography, with no significant esophageal stenosis or esophageal fistula observed, and 3 underwent electronic fiber laryngoscopy, which showed no significant laryngeal mucosal injury, vocal cord relaxation,
or paralysis. At 3-month follow-up, symptoms had improved or resolved in 8 of 11 cases. The remaining 3 patients had persistent dysphagia. At 6-month follow-up, the dysphagia had improved or resolved in 2 of these 3 patients. The remaining patient had no significant improvement and remains under clinical observation and treatment.

Data on the risk factors examined in this study are presented in Table 2. Chi-square test results indicated that age 60 years and older, female sex, titanium plate/titanium mesh fixation, narrowest esophageal distance before internal fixation of less than 5 mm, and 3 operative segments were associated with a high incidence of dysphagia. Logistic regression analysis indicated that, taken together, age, sex, implant type, narrowest esophageal distance before internal fixation, and number of operative segments were the risk factors predictive of dysphagia (Table 3).

According to the results of logistic regression analysis, the prediction equation for dysphagia was as follows: $Y = 3.428 - 1.316 \times \text{age} - 1.554 \times \text{sex} + 1.075 \times \text{graft} + 1.287 \times \text{narrowest esophageal distance before internal fixation} - 1.209 \times \text{operative segment number}$. The area under the receiver operating characteristic curve was 0.872, and the Youden index was 0.6116 (Figure 2).

**Discussion**

The incidence of dysphagia after anterior cervical spine surgery has been reported as ranging from 1% to 80%. Baron et al. believed that the incidence of transient dysphagia after anterior cervical fusion was as high as 80% and that the symptoms of most patients were...
patients, the 158 patients in this study were followed for an average of 6 months, which permitted an investigative focus on early postoperative dysphagia. This study found the incidence of postoperative dysphagia to be 27.8%, which is consistent with previous studies, indicating that dysphagia is one of the common complications after anterior cervical spine surgery. The main complaint regarding dysphagia varied. In some patients, the duration of symptoms was long, thus affecting postoperative nourishment and physical rehabilitation. Therefore, this complication warrants clinicians’ attention.

The specific mechanism of dysphagia after anterior cervical spine surgery is unclear. It may be related to anterior cervical tissue edema, hematoma, graft loosening, adhesions of the esophagus and the cervical vertebral anterior fascia, and nerve injury.\cite{13-16} Regarding age and sex, Bazaz et al\cite{11} found that 6 months after anterior cervical spine surgery, the incidence of dysphagia was significantly higher in female patients than in male patients, which may be related to the smaller average neck circumference and weaker muscles and soft tissues of females. In the current study, the proportion of female patients with dysphagia after anterior cervical spine surgery was significantly higher than the proportion of male patients (46.4% vs 17.6%). Smith-Hammond et al\cite{14} studied 38 patients undergoing anterior cervical spine surgery and found a significantly increased incidence of dysphagia after anterior cervical spine surgery among patients older than 60 years. It was considered that the anatomical and physiological changes of elderly patients would readily cause postoperative dysphagia. In the current study, the incidence of postoperative dysphagia was significantly higher in patients 60 years and older than in patients younger than 60 years, suggesting that age is a risk factor associated with the dysphagia occurring after anterior cervical spine surgery.

The impact of the number and location of the operative segments was investigated. On the basis of the postoperative follow-up of 454 anterior cervical spine surgery cases, Riley et al\cite{15} found that at 3 months postoperatively, the incidences of dysphagia with 1, 2, and 3 or more operative segments were 19.8%, 33.3%, and 39.1%, respectively. This indicated that as the number of operative segments increased, the incidence of dysphagia also increased within a certain follow-up period. In the current study, the incidence of postoperative dysphagia with multiple segments was as high as 63.2%, suggesting the need to inform patients about this potential complication before cervical spine surgery involving multiple operative segments. In anterior cervical spine surgery, the incidence of laryngeal and recurrent laryngeal nerve injury has been reported as ranging from 0.9% to 3%.\cite{18,19} The laryngeal nerve is divided into the internal and external branches. The internal branch is responsible for the control of pharyngeal sensation; its injury may cause coughing while eating. In the current study, operative segment position was also analyzed and stratified into 3 groups according to the highest segmental position: C2 or C3, C4 or C5, and C6 or C7. Although the results were not significant, the incidence of dysphagia was greater than 25% in each group. The process of swallowing at different segments is regulated by different nerves. For example, the glossopharyngeal nerve is mainly

### Table 3

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<thead>
<tr>
<th>Risk Factor</th>
<th>Correlation Coefficient</th>
<th>Odd Ratio</th>
<th>P</th>
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<tbody>
<tr>
<td>Chronological age</td>
<td>-1.316</td>
<td>0.268</td>
<td>.014</td>
</tr>
<tr>
<td>Sex</td>
<td>-1.554</td>
<td>0.211</td>
<td>.002</td>
</tr>
<tr>
<td>Implant factors</td>
<td>1.075</td>
<td>2.931</td>
<td>.022</td>
</tr>
<tr>
<td>Narrowest esophageal distance before internal fixation</td>
<td>1.287</td>
<td>3.623</td>
<td>.009</td>
</tr>
<tr>
<td>Number of operative segments</td>
<td>-1.209</td>
<td>0.299</td>
<td>.002</td>
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Figure 2: Receiver operating characteristic curve of predictive power of the occurrence of dysphagia after anterior cervical spine surgery.
involved at C3 and above, the laryngeal nerve at C4 or C5, and the recurrent laryngeal nerve at C6 and below. Therefore to avoid nerve damage and reduce the occurrence of postoperative dysphagia, the travel of the relevant nerves in anterior cervical spine surgery should be clarified.

This study found that the incidence of postoperative dysphagia was highest (35.8%) with the use of titanium plate fixation, with the incidences being 16.7% and 11.1% for Zero-P internal fixation and artificial disks, respectively, which were significant differences. These findings are consistent with those of Hacker et al. The current authors speculated that the titanium plate fixation in front of the cervical vertebrae would occupy a certain space, which may affect the swallowing function. Therefore, this study included the narrowest esophageal distance before internal fixation, a factor that more specifically quantifies the occupied space in front of the cervical spine. In the current study, the incidence of dysphagia was 37.7% when the narrowest esophageal distance before internal fixation was less than 5 mm, which differed significantly from that occurring with distances of 5 mm or greater (P<0.004). These results indicated that the anterior space after anterior cervical fixation is a risk factor for dysphagia.

Chi-square test results showed that age 60 years and older, female sex, titanium plate/titanium mesh graft, narrowest esophageal distance before internal fixation of less than 5 mm, and 3 operative segments indicated a high incidence of postoperative dysphagia (P<0.05). To further analyze the predictive value of each risk factor for dysphagia, the authors conducted a multivariate logistic regression analysis, which revealed the same risk factors as the chi-square test. Moreover, logistic regression showed the difficulty in obtaining an accurate predictive ability for dysphagia using a single factor. Together, however, multidimensional factors may provide a satisfactory predictive method to assess the incidence of dysphagia in patients after anterior cervical spine surgery. The greater the risk factors in patients undergoing an anterior cervical approach, the higher the risk of dysphagia. Therefore, preoperative and postoperative patient interventions should be used to identify the risk factors and thereby reduce the occurrence of postoperative dysphagia. Some prevention and treatment strategies to reduce dysphagia after cervical spine surgery reported to date include guiding patients to perform tracheal traction exercises preoperatively, adjusting the pressure of the tracheal intubation balloon preoperatively, using low-notch plates intraoperatively, and administering intravenous methylprednisolone postoperatively.

This study had some limitations. Not all patients with dysphagia were targeted to evaluate subjective and objective indicators (ie, quantitative questionnaires and barium meal bronchoscopy were not applied). Moreover, the number of patients reexamined postoperatively was small. A further prospective study should be designed using a standardized scoring system and postoperative examination. Additionally, the area under the receiver operating characteristic curve equation was as high as 0.872. The greater the area under the curve, the higher the diagnostic accuracy. However, the Youden index was relatively low (0.6116), and the corresponding sensitivity and specificity were 92.98% and 68.18%, respectively. Based on the receiver operating characteristic curve, the optimal cutoff value for dysphagia was predicted to be 0.6116 (Figure 2). An index of the indicators greater than 0.6116 means the probability of dysphagia is 92.98%; in contrast, an index less than 0.6116 means the probability of nondysphagia is 68.18%.

**Conclusion**

Dysphagia is one of the most common complications after anterior cervical spine surgery. Adequate preoperative counseling and active preoperative preparation should be provided, particularly for patients with the risk factors of age of 60 years and older, female sex, titanium plate/titanium mesh graft, narrow esophageal distance of less than 5 mm, and 3 operative segments. Additionally, effective prevention and treatment measures to reduce the incidence of postoperative dysphagia, which can hinder early rehabilitation, must be investigated.

**References**


9. Chen Y, Liu Y, Chen H, Cao P, Yuan W. Comparison of curvature between the Zero-P spacer and traditional cage and plate af-


