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Original Article

Risk factors and clinical course of dysphagia after single-level anterior cervical spine surgery: a study in 187 patients

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Abstract: The aim of this study was to calculate the incidence of dysphagia and identify its potential risk factors. We prospectively included the patients undergoing primary single-level anterior cervical spine surgery in our hospital and recorded specific perioperative data. The Bazaz grading system and the Swallowing Quality of Life (SWAL-QOL) score were used to assess the presence and severity of dysphagia. Correlations between the potential variables and postoperative dysphagia were investigated by analyzing data from 187 patients who finished more than 1-year follow-up. The number of patients with dysphagia was 99 (52.94%) at 1 week after surgery, 60 (32.09%) at 1 month, 42 (22.46%) at 3 months, 29 (16.11%) at 6 months, and 16 (8.56%) at 1 year. The preoperative mean SWAL-QOL score was 65.62, which decreased to 58.72 after surgery and to 64.66 at the 12-month follow-up. The SWAL-QOL score at 1 week after surgery was correlated with the operative time ($r = -0.474$; $P < 0.001$). Multivariate analysis showed that preoperative tracheal exercise (odds ratio (OR) = 0.302; 95% confidence interval (CI) = 0.131-0.748), operative time < 90 minutes (OR = 0.407; 95% CI = 0.190-0.878), and arthroplasty (OR = 0.211; 95% CI = 0.102-0.425) were the independent factors associated with a lower incidence of postoperative dysphagia. In summary, our analysis described the natural course of dysphagia after surgery and demonstrated that tracheal exercise, short operative time, and arthroplasty were factors that may help to decrease the incidence of postoperative dysphagia. However, future prospective, randomized and controlled studies are needed to validate these findings.

Keywords: Risk factors, dysphagia, cervical surgery, total disc arthroplasty, anterior cervical decompression and fusion

Introduction

Anterior cervical spine surgery is commonly performed to treat many spine conditions, including trauma, tumor, and degenerative spinal disease; however, postoperative dysphagia is a common complication following the anterior approach [1, 2]. According to previous studies, the reported incidence of dysphagia varies widely and ranges from 4.8%-71% [3-5]. The wide range may reflect different definitions of dysphagia and variable lengths of follow-up in different studies. Although dysphagia is usually benign and transient, in several situations, it can induce severe problems, such as aspiration pneumonia [6, 7]. Joseph et al. reported that dysphagia in patients who undergo cervical spine surgery correlates with significantly increased length of hospital stay, 30-day readmissions, and in-hospital mortality [8].

The exact etiology of dysphagia has not been clarified. Previous studies have reported several potential risk factors associated with the incidence of postoperative dysphagia, including female gender, advanced age, involvement of C4-C5 and C5-C6 levels, prolonged operative time, and revision procedures [3, 9, 10]. However, results were inconclusive. For example, Yang *et al.* [11] considered that female gender was associated with a higher risk of postoperative dysphagia, whereas the study conducted by Reinard *et al.* [9] demonstrated that gender did not influence the incidence of dysphagia. We considered that these studies have not detected a true association because of the rel-

Table 1. The Bazaz grading system

Severity	Liquid	Solid
0-None	None	None
1-Mild	None	Rare
2-Moderate	None or rare	Occasional
3-Severe	None or rare or occasional	Frequent

atively small sample size or the inclusion of patients with apparent heterogeneity.

Considering the paucity of clinical data in this area, we conducted this study to record the incidence of postoperative dysphagia at different follow-up periods, and tried to identify possible risk factors that is associated with the occurrence of dysphagia. To the best of our knowledge, this is the first studies investigating risk factors for dysphagia following single-level cervical spine surgery.

Materials and methods

Inclusion and exclusion criteria

We prospectively included the patients undergoing primary single-level anterior cervical spine surgery in our hospital from January 2014 to November 2015. The inclusion criteria included adult patients with radiculopathy or myelopathy from single-level cervical disc disease with correlating magnetic resonance imaging findings and no response to nonoperative treatment for at least 3 months. Patients with preoperative dysphagia, cervical trauma, a history of central nervous system disorders, previous neck surgery, esophageal diseases, or multi-level surgery were excluded.

Surgical technique

Both anterior cervical decompression and fusion (ACDF) and cervical disc arthroplasty (CDA) were performed in our hospital. The choice of surgical procedure was discussed among the surgeons, but if patients were suitable for both procedures, patients could choose ACDF or CDA. Briefly, the patient was placed in the supine position with mild cervical extension following induction of general anesthesia. A standard right-sided approach through a transverse incision was used to expose the targeted level followed by removal of the compressive materials including osteophytes, herniated disc, and the posterior longitudinal ligament. During ACDF, a polyetheretherketone cage filled with excised osteophytes was inserted between vertebral bodies, and the plate was then fixed with screws inserted cranially and caudally. A soft collar was used for 8 weeks postoperatively. During the CDA procedure, the appropriate prosthesis was determined by preoperative templating and intraoperative evaluation using disc trials. After implant insertion, fluoroscopic imaging confirmed whether the device was correctly located and suitable. All surgeries in this study were performed by the same surgeon.

Data collection

Perioperative data, including age, gender, body mass index, history of smoking and alcohol use, operative time, estimated blood loss, target segment, length of incision and length of hospital stay were obtained from patients' medical records. Although all patients received instruction in tracheal traction exercises by nurses after hospitalization, some patients did not perform the exercises; the number of these patients was recorded.

Radiological measurements were taken from the lateral radiographs by two blinded researchers. Cervical alignment was defined as the angle formed by the inferior lines of C2 and C7 vertebral bodies. Change in angular alignment was calculated as the postoperative value minus the preoperative value.

The incidence of postoperative dysphagia was assessed by the criteria published by Bazaz et al. [5]. The dysphagia scoring system has four grades (none, mild, moderate, severe) for liquid and solid food: "mild" defines no dysphagia on liquid swallowing and rarely with solid food; "moderate" defines an absence of or rare dysphagia on liquid swallowing, and occasional (only with specific food) dysphagia on solid food; and "severe" defines dysphagia present on liquid swallowing, and frequent on solid food (**Table 1**). The Swallowing Quality of Life (SWAL-QOL) questionnaire with a total score of 70 (14 items with each item scored from 1-5) was completed by the patients to comprehensively evaluate the degree of dysphagia [12]. Dysphagia was evaluated preoperatively and at 1 week, 1 month, 3 months, 6 months, and 1 year postoperatively.

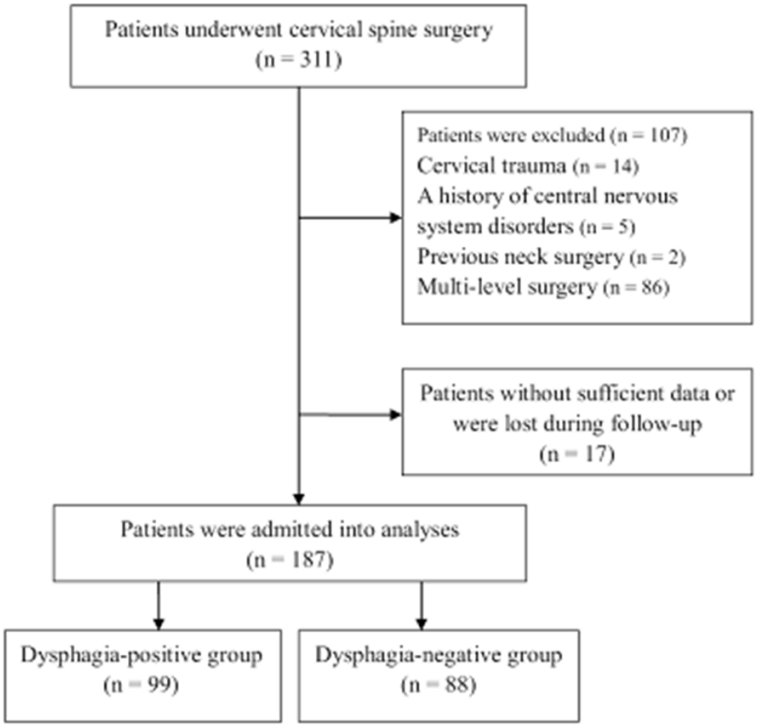

Figure 1. Flow diagram showing patient allocation in the current study.

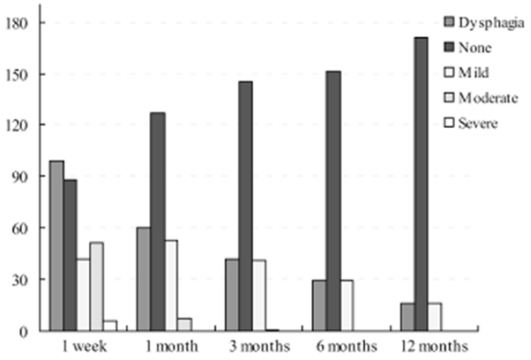

Figure 2. The number of patients with different degrees of dysphagia at 1 week, 1 month, 3 months, 6 months, and 1 year postoperatively.

Statistical analysis

Correlations between postoperative dysphagia and the influencing factors were analyzed. Patient characteristics were compared between groups using the Mann-Whitney *U*-test or Fisher's exact test. Variables found to be potentially predictive of the outcome variable from the univariate analyses ($P < 0.20$) were included in the multivariate logistic regression models. Pearson's correlation coefficient was also used to check the correlation between SWAL-QOL score and operative time. Statistical analysis was performed using the Statistical Package for Social Sciences software (version 17.0; SPSS Inc., Chicago, IL, USA), and a probability value < 0.05 was considered statistically significant.

Results

During this study, a total of 311 patients underwent cervical spine surgery, but only 204 patients were eligible based on the inclusion criteria. After surgery, 187 patients with sufficient data who finished more than 1-year follow-up were admitted into analyses (**Figure 1**). Of these patients, 117 were male (62.57%) and 70 were female (37.43%), and the mean age was 49.71 years. Fifteen cases involved C3-C4; 57 cases, C4-C5; 68 cases, C5-C6; 41 cases, C6-C7; and 6 cases, C7-T1. The total number of patients with dysphagia was 99 (52.94%) at 1 week after surgery, 60 (32.09%) at 1 month, 42 (22.46%) at 3 months, 29 (16.11%) at 6 months, and 16 (8.56%) at 1 year. Forty-eight patients underwent CDA, and 139 patients underwent ACDF (**Figure 2**). The preoperative SWAL-QOL score was 65.62, and the mean value of this score decreased to 58.72 postoperatively. At the 12-month follow-up, the mean SWAL-QOL score was 64.66. Changes in the SWAL-QOL score are shown in **Figure 3**.

According to the incidence of dysphagia one week after surgery, 99 patients were classified into the dysphagia-positive group and 88 patients comprised the dysphagia-negative group. Univariate analyses showed that there was no significant difference in age, gender, smoking, alcohol use, BMI, estimated blood loss, involvement of C4-C5 or C5-C6, length of incision, or length of hospital stay ($P > 0.05$, **Table 2**).

Seventy-five of the 99 patients in the dysphagia-positive group after surgery performed the

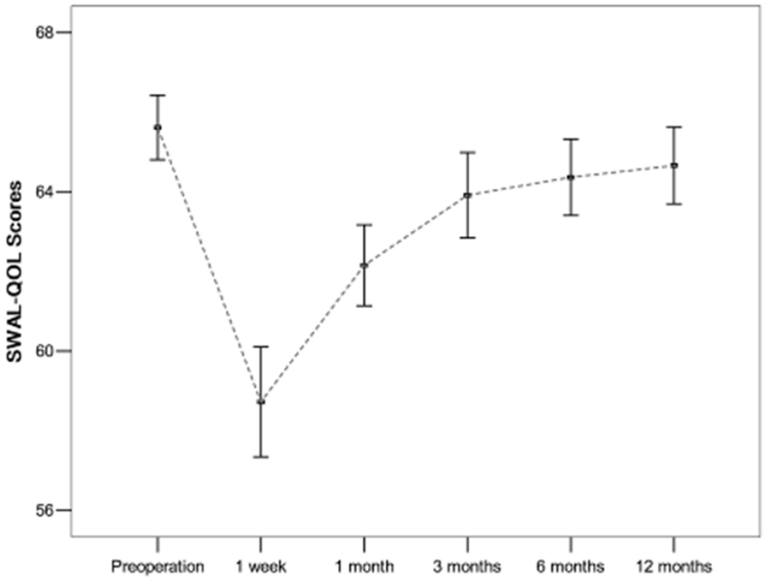

Figure 3. Error bar showing the Swallowing Quality of Life (SWAL-QOL) score at different follow-up times.

Table 2. Univariate analysis of the risk factors for dysphagia at one week after surgery

Characteristic	Dysphagia (+) group	Dysphagia (-) group	*P* value
No. of patients	99	88	
Age (years)	50.21±11.42	49.15±10.86	0.521
Gender (male/female)	57:42	60:28	0.173
Smoking (yes/no)	45:54	31:57	0.180
Alcohol (yes/no)	39:60	27:61	0.224
BMI (kg/m^2)	25.91±2.38	26.08±3.15	0.681
Tracheal exercise (yes/no)	75:24	80:8	0.007
Operative time (min)	67.31±8.69	56.06±11.20	0.015
Estimated blood loss (ml)	82.83±28.44	77.79±20.91	0.172
Involvement of C4-C5 or C5-C6	68:31	57:31	0.641
Arthroplasty (yes/no)	12:87	36:52	0.000
Change in angular alignment (degree)	6.37±4.52	4.73±6.15	0.046
Length of incision (mm)	64.32±10.75	67.06±8.66	0.061
Length of hospital stay (d)	14.65±2.76	13.97±3.59	0.154

BMI = body mass index.

tracheal exercises compared with 80 of the 88 patients in the dysphagia-negative group with a significant difference between the two groups (P = 0.007). Similarly, there was a significant difference between the two groups for the CDA procedure (P < 0.001). In the dysphagia-positive group, the mean operative time was significantly higher than that in the dysphagia-negative group (67.31 ±8.69 *vs*. 56.06 ± 11.20, P = 0.015), and mean changes in angular alignment in the dysphagia-positive group were also significantly higher than for the dysphagia-negative group (6.37 ± 4.52 *vs*. 4.73 ± 6.15, P = 0.046).

Pearson's correlation analysis was also used to check the correlation between SWAL-QOL score and operative time, and the result showed that the SWAL-QOL score 1 week after surgery correlated with operative time (r = -0.474; P < 0.001, **Figure 4**).

To investigate the impact of independent variables on the incidence of dysphagia, we also performed a multivariate analysis, which showed that preoperative tracheal exercise (odds ratio (OR) = 0.302; 95% confidence interval (CI) = 0.131-0.748), operative time < 90 minutes (OR = 0.407; 95% CI = 0.190-0.878), and arthroplasty (OR = 0.211; 95% CI = 0.102-0.425) were significant independent factors associated with dysphagia after cervical spine surgery (P < 0.05, **Table 3**).

Discussion

Anterior cervical spine surgery is one of the most common spinal procedures performed worldwide; however, dysphagia is a frequent postoperative complication. Calculating the incidence of dysphagia and identifying variables that may increase the risk of dysphagia following surgery leads to surgical strategies to decrease its incidence. Although several studies have been performed to investigate dysphagia, few studies have focused on single-level cervical spine surgery. In the current study, we used both the Bazaz grading system and the SWAL-QOL score to assess postoperative dysphagia, and we

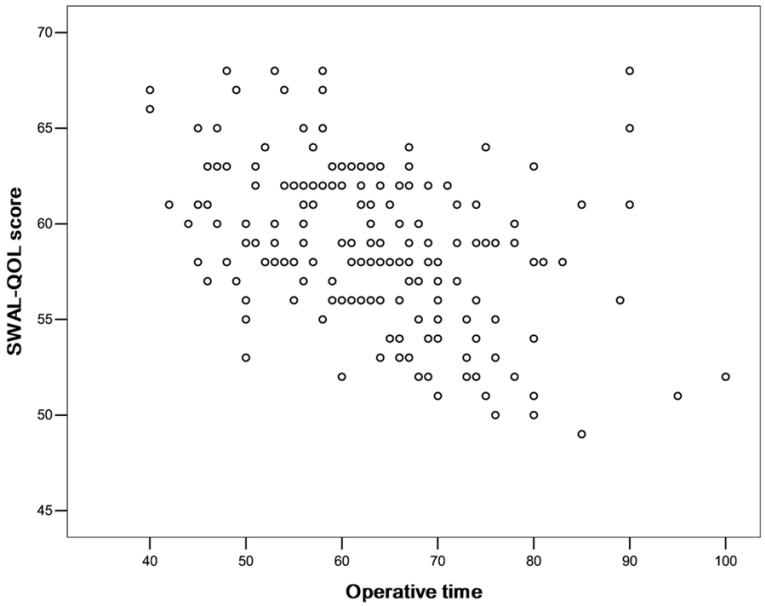

Figure 4. Correlation between the Swallowing Quality of Life (SWAL-QOL) score 1 week after surgery and operative time (r = -0.474; $P < 0.001$).

Table 3. Multivariate analysis of the risk factors for dysphagia

Risk factors	*P* value	OR	95% CI
Tracheal exercise (yes/no)	0.000	0.302	0.131-0.748
Operative time < 60 minutes	0.023	0.407	0.190-0.878
Arthroplasty (yes/no)	0.011	0.211	0.102-0.425

OR = odds ratio, CI = confidence interval.

found that the numbers of patients with dysphagia were 99 (52.94%) 1 week after surgery, 60 (32.09%) at 1 month, 42 (22.46%) at 3 months, 29 (16.11%) at 6 months, and 16 (8.56%) at 1 year, respectively. The SWAL-QOL score 1 week after surgery correlated with operative time (r = -0.474; $P < 0.001$). No preoperative tracheal exercise, prolonged operative time, and undergoing ACDF were significant independent risk factors for dysphagia after cervical spine surgery.

Many classification systems have been developed to define and grade postoperative dysphagia, but inconsistent usage and lack of consensus adoption has limited the research progress [13]. Video-fluoroscopic swallow evaluation has been considered the gold standard for assessing dysphagia [14]. However, Frempong-Boadu *et al.* [15] found a poor correlation between the objective and subjective findings of dysphagia. Thus, patient-reported questionnaires assessing the subjective symptoms may be a relatively reliable method to evaluate postoperative dysphagia clinically [16]. The Bazaz grading system is widely used to assess the incidence of dysphagia after cervical spine surgery [5]. The SWAL-QOL score, however, can evaluate the degree of dysphagia. Using both systems, we found that dysphagia after anterior cervical spine surgery is relatively common in the early postoperative period, and the incidence and severity of dysphagia progressively decreased over time. At the end of the 1-year follow-up, dysphagia had resolved in almost all patients with only a small number still suffering mild dysphagia.

The mechanism of dysphagia has not yet been fully understood and has been commonly accepted as a multi-factorial process [17]. In the current study, preoperative tracheal exercise was considered a strategy to decrease the incidence of dysphagia. Preoperative tracheal exercise may improve the compliance of the trachea and esophagus, which can decrease dysphagia after cervical spine surgery. Consistent with our results, Chen *et al.* [18] reported that Bazaz dysphagia scores for patients performing tracheal exercise were significantly better than for those without tracheal exercise. They proposed that this preoperative exercise should be performed twice a day, 15 counts each time, for 3 days, starting at least 4 days before the surgery. We propose that this measure is especially valuable in procedures associated with an increased risk, such as multilevel or revision surgeries [19, 20].

Operative time was another factor associated with the incidence of dysphagia in our study. In a similar study by Rihn *et al.* [4], prolonged operative time was the only variable correlated with the severity of dysphagia after 12 weeks.

We hypothesized that longer retraction of the trachea and esophagus results in more severe soft-tissue swelling. Thus, in complex cervical cases in which a long operative time is predicted, procedures performed by senior surgeons may reduce the incidence of dysphagia after surgery compared with those performed by fellows or residents.

Theoretically, if an anterior cervical plate is placed directly posterior to the esophagus, the plate may influence the incidence of postoperative dysphagia as any mechanical irritation or impingement against the esophagus may cause dysphagia. Non-profile implants are thought to be associated with a lower incidence of dysphagia compared with anterior plate and cage with artificial disc prostheses considered "non-profile" [21-23]. This theory was confirmed by our results. We suggest that choosing a low-profile, small, and smooth cervical plate may also help to decrease the incidence of dysphagia after surgery.

The current study has several limitations. First, all data were obtained from patients after single-level surgery. Although changes in angular alignment were not demonstrated as a risk factor after multivariate analysis, we cannot definitively conclude that this factor was not associated with the incidence of dysphagia because the magnitude of the change in angular alignment after single-level surgery was small. Therefore, our results may not be applicable to cases of dysphagia after multi-level surgery in which significant alignment changes are expected [24]. Second, we did not analyze certain potential risk factors, such as surgical approach, local steroid delivery, plate design, or the use of recombinant human bone morphogenetic protein. Although the effects of these factors remain controversial, [25-27] these variables should not be ignored in future research. Third, we focused on the most common anterior cervical procedures performed for degenerative disease. Therefore, our data may not be applicable to patients undergoing surgery at greater than two levels, revision anterior cervical surgery, or anterior cervical surgery for specific etiologies, such as trauma, infection, or tumor. We are expecting corresponding studies on these aspects in the future.

In summary, we found that the incidences of postoperative dysphagia were 52.94% at 1 week, 32.09% at 1 month, 22.46% at 3 months, 16.11% at 6 months, and 8.56% at 1 year, respectively; and tracheal exercise, operative time, and arthroplasty were associated with postoperative dysphagia. Awareness of this information may provide surgeons with a better understanding of postoperative dysphagia and decrease the incidence of this disorder.

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Disclosure of conflict of interest

None.

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