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

Narihito Nagoshi, MD, PhD*, Lindsay Tetreault, PhD*, Hiroaki Nakashima, MD, PhD, Paul M. Arnold, MD, Giuseppe Barbagallo, MD, Branko Kopjar, MD, and Michael G. Fehlings, MD, PhD, FRCS

Investigation performed at the Toronto Western Hospital, University of Toronto, Toronto, Ontario, Canada

Background: Although dysphagia is a common complication after anterior cervical decompression and fusion, important risk factors have not been rigorously evaluated. Furthermore, the impact of dysphagia on neurological and quality-of-life outcomes is not fully understood. The aim of this study was to determine the prevalence of and risk factors for dysphagia, and the impact of this complication on short and long-term clinical outcomes, in patients treated with anterior cervical decompression and fusion.

Methods: Four hundred and seventy patients undergoing a 1-stage anterior or 2-stage anteroposterior cervical decompression and fusion were enrolled in the prospective AOSpine CSM (Cervical Spondylotic Myelopathy) North America or International study at 26 global sites. Logistic regression analyses were conducted to determine important clinical and surgical predictors of perioperative dysphagia. Preoperatively and at each follow-up visit, patients were evaluated using the modified Japanese Orthopaedic Association scale (mJOA), Nurick score, Neck Disability Index (NDI), and Short Form-36 Health Survey (SF-36). A 2-way repeated-measures analysis of covariance was used to evaluate differences in outcomes at 6 and 24 months between patients with and those without dysphagia, while controlling for relevant baseline characteristics and surgical factors.

Results: The overall prevalence of dysphagia was 6.2%. Bivariate analysis showed the major risk factors for perioperative dysphagia to be a higher comorbidity score, older age, a cardiovascular or endocrine disorder, a lower SF-36 Physical Component Summary score, 2-stage surgery, and a greater number of decompressed levels. Multivariable analysis showed patients to be at an increased risk of perioperative dysphagia if they had an endocrine disorder, a greater number of decompressed segments, or 2-stage surgery. Both short and long-term improvements in functional, disability, and quality-of-life scores were comparable between patients with and those without dysphagia.

Conclusions: The most important predictors of dysphagia are an endocrine disorder, a greater number of decompressed levels, and 2-stage surgery. At the time of both short and long-term follow-up, patients with perioperative dysphagia exhibited improvements in functional, disability, and quality-of life scores that were similar to those of patients without dysphagia.

Level of Evidence: Therapeutic Level III. See Instructions for Authors for a complete description of levels of evidence.

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Anterior cervical decompression and fusion, a standard procedure for the treatment of degenerative cervical myelopathy, often results in significant improvements in clinical outcomes[1,2]. However, patients can experience undesirable perioperative complications, including difficulty or discomfort in swallowing known as dysphagia[3]. Reported rates of dysphagia vary substantially from 2% to 83% and depend on study design, sample size, method of data collection, and definition[4-24]. There is a trend

*Narihito Nagoshi, MD, and Lindsey Tetreault, PhD, contributed equally to this work.

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TABLE I Description of Clinical and Surgical Variables Assessed as Possible Predictors of Dysphagia

Variable	Description
Age (by decade)	Age in years at time of surgery
Baseline severity scores (continuous)	
mJOA	Investigator-administered degenerative cervical myelopathy-specific index used to separately evaluate upper and lower-extremity motor, sensory, and bladder function (scale of 0 to 18, with 18 indicating normal)
Nurick	Investigator-administered degenerative cervical myelopathy-specific index used to assess myelopathy severity (scale of 0 to 6, with 0 indicating normal)
NDI	Patient-reported outcome measure with 10 subscales (pain intensity, personal care, lifting, reading, headaches, concentration, work, driving, sleeping, and recreation) (scale of 0 to 100, with 0 indicating normal)
SF-36	Patient-reported outcome measure that incorporates physical and mental components (the lower the score, the greater the disability)
BMI (continuous)	Mass (kg)/height (m^2)
Duration of symptoms (5 categories)	No. of months between onset of symptoms and surgical intervention, divided into 5 categories: ≤3, >3 to ≤6, >6 to ≤12, >12 to ≤24, and >24
Comorbidities (present/absent)	Categorized as cardiovascular, respiratory, gastrointestinal, endocrine, psychiatric, rheumatologic, or neurological
Comorbidity score (continuous)	Patient was assigned a disease-severity grade (1 = mild, 2 = moderate, and 3 = severe decompensation) for each comorbidity category, and the grades were summated across all comorbidity categories. If severity was unknown for a particular comorbidity, a "1" was designated
Ossification of posterior longitudinal ligament (present/absent)	Determined with magnetic resonance imaging or computed tomography scan
Operative duration (15-min increments)	Time from incision to closure
No. of decompressed levels (continuous)	No. of cervical levels decompressed by surgery
No. of surgical stages (1 or 2)	1-stage (anterior) or 2-stage (anterior and posterior) surgery
Operation at C4 and/or above	Surgery that included decompression at C4 and/or C3, C2, or C1 (as opposed to C5, C6, and/or C7)

toward higher rates of dysphagia within the first month following surgery, which decrease postoperatively over time[4,11,13,14,16,18,21].

In other fields, such as cardiac and otolaryngological surgery, postoperative dysphagia can cause malnutrition, delay patient recovery, and increase the risk of aspiration pneumonia and mortality[25-27]. Furthermore, prolonged dysphagia may impair quality of life, result in social isolation, and cause anxiety and depression[28,29]. In contrast to the amount of evidence regarding dysphagia in other surgical specialties, only a limited number of studies have explored the impact of postoperative dysphagia on outcomes following anterior cervical decompression and fusion[19].

Several studies have identified important predictors of dysphagia following anterior cervical surgery, including sex, age, smoking status, comorbidities, and surgical characteristics[4-6,10,14,17-21,23,24,30,31]. Thicker implants[13] and longer retraction time[30] have also been associated with a higher risk of dysphagia. However, as a result of small sample sizes and the retrospective nature of these studies, it is difficult to draw firm conclusions about the most important risk factors for dysphagia after anterior cervical surgery.

It was therefore the objective of this study to evaluate important predictors of dysphagia after anterior cervical surgery and to examine the impact of postoperative dysphagia on functional recovery, disability, and quality-of-life outcomes in the short and long term.

Materials and Methods

Study Design and Setting

The AOSpine CSM (Cervical Spondylotic Myelopathy) North America (ClinicalTrials.gov NCT00285337) and CSM International (ClinicalTrials.gov NCT00565734) studies were both prospective, multicenter cohort studies conducted under the same investigational protocol. Data were contributed from 26 sites, including 12 in North America, 6 in Asia and the Pacific, 5 in Europe, and 3 in Latin America. Investigators were either neurosurgeons or orthopaedic spine surgeons.

Subjects

Study inclusion criteria were (1) an age of 18 years or older, (2) symptomatic degenerative cervical myelopathy with at least 1 clinical sign of myelopathy, (3) imaging evidence of cervical cord compression, and (4) no previous cervical spine surgery. Patients were excluded if they were asymptomatic or were diagnosed with active infection, neoplastic disease, rheumatoid arthritis, ankylosing spondylitis, or concomitant lumbar stenosis.

Data Collection

Extensive data were collected for each participating subject, including demographic information, causative pathological condition, medical history, symptoms, and surgical details. Functional impairment was evaluated preoperatively and at 6,

TABLE II General Demographic and Surgical Characteristics of All 470 Patients

Variable	Median (IQR) or Percentage
General demographic	
Age* *(yr)*	53.0 (16.0)
Male sex *(%)*	59.6
BMI* (n = 468) *(kg/m²)*	26.5 (6.4)
Duration of symptoms* *(mo)*	12.0 (18.0)
Smoker *(%)*	28.7
Baseline scores*	
mJOA	13.0 (4.0)
Nurick	3.0 (2.0)
NDI (n = 408)	38.0 (29.5)
SF-36 PCS (n = 455)	34.0 (13.3)
SF-36 MCS (n = 455)	39.2 (19.5)
Comorbidities *(%)*	61.1
Cardiovascular	40.2
Respiratory	10.2
Gastrointestinal	18.3
Endocrine	17.9
Psychiatric	14.5
Rheumatologic	4.0
Neurological	6.2
Comorbidity score*	1.0 (2.0)
Diagnosis *(%)*	
Spondylosis	70.2
Disc herniation	83.0
Ossification of posterior longitudinal ligament	21.1
Hypertrophy of ligamentum flavum	11.5
Subluxation	3.8
Surgical	
2-stage anterior and posterior surgery *(%)*	4.9
Anterior surgery (n = 441) *(%)*	
Discectomy	79.6
Corpectomy	3.0
Discectomy and corpectomy	17.5
Operative duration* *(min)*	164.0 (100.5)
No. of decompressed levels*	3.0 (2.0)
Operation at C4 and/or above *(%)*	58.1

*The values are given as the median with the IQR in parentheses.

12, and 24 months postoperatively using the modified Japanese Orthopaedic Association (mJOA) and Nurick scores. Disability and quality of life were measured with the Neck Disability Index (NDI) and version 2 of the Short Form-36 (SF-36), respectively. The reported minimum clinically important difference is 7.5 for the NDI, 4.1 for the SF-36 version-2 Physical Component Summary (PCS) score[32], 5.7 for the SF-36 version-2 Mental Component Summary (MCS) score[33], and 1.11 for the mJOA[34]. Table I summarizes the variables that were evaluated in this study to determine whether they were predictors of dysphagia.

Perioperative Dysphagia

Investigators and research coordinators were required to record all adverse events. Surgeons could select from a list of anticipated complications or specify the adverse event in an "other" text box. At each follow-up visit (before discharge and at 6, 12, and 24 months postoperatively), the investigator evaluated the patient for each complication on the list as well as any other adverse event. Dysphagia was included in the list of possible complications and was defined as "patient-reported difficulty regarding liquid or solid deglutition." The diagnosis of dysphagia was based on information volunteered by the patient or on the observations of the investigator. Subjects were encouraged to report complications occurring at any time during the study follow-up period. In addition, at each visit, the patient was asked whether he or she had consulted another physician since the last study visit; if necessary, efforts were made to obtain additional information on putative complications from the patient's family doctor. The time from surgery to the diagnosis of dysphagia was recorded. The severity of the dysphagia was assessed

TABLE III Data on Patients with Dysphagia After Anterior Cervical Surgery

Case	Onset After Surgery *(days)*	Severity of Dysphagia	Duration of Symptoms*	Status of Dysphagia at Follow-up	Treatment
1	0	Mild	NA	Continuing	None
2	2	Mild	NA	Continuing	None
3	1	Mild	9 days	Resolved, no residual symptoms	None
4	1	Mild	4 days	Resolved, no residual symptoms	None
5	1	Mild	6 mo	Resolved, no residual symptoms	None
6	1	Mild	NA	Continuing	None
7	12	Mild	NA	Continuing	None
8	1	Severe	2 days	Resolved, no residual symptoms	None
9	2	Mild	NA	Continuing	None
10	0	Mild	7 days	Resolved, residual symptoms	None
11	1	Severe	7 mo	Resolved, no residual symptoms	None
12	1	Mild	5 days	Resolved, no residual symptoms	None
13	0	Mild	3 days	Resolved, no residual symptoms	None
14	4	Mild	2 days	Resolved, no residual symptoms	None
15	0	Moderate	3.5 mo	Resolved, no residual symptoms	Nonoperative
16	1	Moderate	12 mo	Resolved, no residual symptoms	Nonoperative
17	0	Mild	2.5 mo	Resolved, no residual symptoms	Nonoperative
18	0	Mild	9 days	Resolved, no residual symptoms	Nonoperative
19	3	Mild	5.5 mo	Resolved, residual symptoms	None
20	0	Mild	2 days	Resolved, no residual symptoms	Nonoperative
21	0	Moderate	NA	Continuing	Nonoperative
22	4	Mild	10 days	Resolved, no residual symptoms	Nonoperative
23	3	Mild	NA	Continuing	Nonoperative
24	1	Mild	1 day	Resolved, residual symptoms	Nonoperative
25	14	Mild	NA	Continuing	Nonoperative
26	3	Moderate	12 mo	Resolved, no residual symptoms	Nonoperative
27	2	Mild	14 days	Resolved, no residual symptoms	Nonoperative
28	3	Mild	1 day	Resolved, no residual symptoms	Nonoperative
29	5	Mild	Unknown	Resolved, no residual symptoms	Nonoperative

*NA = not applicable.

qualitatively by each investigator as mild, moderate, or severe. All adverse events were processed at a central data management center and were classified, by a panel of adjudicators, as being related to degenerative cervical myelopathy, related to surgery, or unrelated. Perioperative dysphagia was defined as surgery-related dysphagia occurring within 30 days after the surgery. Results from swallowing studies or from assessments by speech language pathologists were not available.

Statistical Analysis

Medians and interquartile ranges [IQRs] or means and standard deviations (SDs) were used to describe distributions for continuous variables, and proportions were used to summarize categorical variables.

Logistic regression analyses were performed to determine the association between various clinical and surgical factors and perioperative dysphagia. Factors that yielded a p value of ≤0.20 in bivariate analyses were explored in multivariable models. It was decided that variables that yielded a p value of >0.20 but were considered clinically important would also be evaluated in multivariable analysis; however, there were no such variables.

Collinearity of predictors was assessed by calculating tolerance. Multivariable logistic regression analysis was used to determine the best combination of surgical and clinical predictors. Predictors were included in the final model if they (1) were significant ($p < 0.05$), (2) were deemed clinically important, and/or (3) contributed to the overall predictive performance. A limited number of predictors was included in the final model to prevent overfitting.

Of the 470 subjects, 403 (85.7%) had 6-month mJOA follow-up data and 350 patients (74.5%) had 24-month mJOA follow-up data. Missing follow-up data (at 6 and/or 24 months) were assumed to be missing at random and were imputed using a multiple imputation procedure (Markov chain Monte Carlo method with multiple chains and full imputation; covariates included in this procedure were age, sex, smoking status, levels of the operation, and type of procedure). Ten multiple sets were created and analyzed.

A mixed model resembling 2-way repeated-measures analysis of covariance was used to compare outcomes between patients with and those without perioperative dysphagia. In all analyses, the independent variable was dysphagia. The dependent variables were the change in functional impairment

TABLE IV Bivariate Analysis: Clinical and Surgical Predictors of Dysphagia

Variable	OR	95% CI	P Value*
Clinical			
Age (per decade increase)	1.71	1.22, 2.41	**0.002**
Sex (ref. = male)	0.65	0.29, 1.45	0.291
BMI	1.02	0.95, 1.08	0.631
Duration of symptoms†	1.11	0.84, 1.46	0.452
Smoker (ref. = non-smoker)	1.56	0.72, 3.40	0.261
Baseline myelopathy severity			
mJOA	0.90	0.78, 1.02	0.111
Nurick	1.12	0.80, 1.58	0.511
NDI	1.01	0.99, 1.03	0.187
SF-36 PCS	0.95	0.91, 0.99	**0.026**
SF-36 MCS	1.00	0.97, 1.03	0.955
Ossification of posterior longitudinal ligament (ref. = other forms of degenerative cervical myelopathy)	0.98	0.39, 2.47	0.960
Comorbidities (ref. = absence)	2.09	0.87, 4.99	0.098
Cardiovascular	2.58	1.19, 5.60	**0.016**
Respiratory	1.02	0.30, 3.49	0.981
Gastrointestinal	2.13	0.93, 4.85	0.073
Endocrine	4.23	1.95, 9.19	**<0.001**
Psychiatric	0.67	0.20, 2.27	0.517
Rheumatologic	1.85	0.41, 8.41	0.427
Neurological	1.84	0.52, 6.49	0.342
Comorbidity score	1.29	1.10, 1.51	**0.002**
Surgical			
No. of surgical stages (ref. = 1 stage)	6.51	2.34, 18.06	**<0.001**
Operative duration (per 15-min increase)	1.05	0.99, 1.15	0.083
Corpectomy + discectomy (ref. = corpectomy or discectomy)	0.74	0.21, 2.55	0.630
No. of decompressed levels	1.82	1.24, 2.66	**0.002**
Operation at C4 and/or above (ref. = no operation at C4 and/or above)	0.84	0.38, 1.86	0.663

*P values indicating significance (<0.05) are bolded. †See Table I for duration-of-symptoms categories.

(mJOA and Nurick scores), disability (NDI score), and quality of life (SF-36 PCS and MCS scores) between baseline and 6 or 24 months following surgery. We first created unadjusted mixed models between dysphagia and the outcome of interest (adjusting only for the baseline value of the analyzed outcome) and then developed an adjusted model that controlled for the baseline value of the analyzed outcome, endocrine and cardiovascular comorbidities, surgical factors, age, sex, and body mass index (BMI).

Results

Participants

Between December 2005 and September 2007, 278 patients were enrolled in the AOSpine CSM North America study from 12 North American sites. An additional 479 subjects participated in the CSM International study between October 2008 and January 2011 at 16 global sites. Of these 757 patients, 470 who underwent either an anterior or a 2-stage circumferential cervical decompression and fusion were included in the present analysis.

Our study included 280 men (59.6%) and 190 women (40.4%), with ages ranging from 21 to 87 years (median, 53.0 years). The patients had a wide range of preoperative functional impairment (mJOA scores ranging from 4 to 18 and Nurick scores ranging from 0 to 6), disability (NDI ranging from 0 to 100), and reduction in quality of life (SF-36 PCS scores ranging from 10.8 to 68.2 and SF-36 MCS scores ranging from 9.7 to 75.6). One or more comorbidities were diagnosed before the

TABLE V Multivariable Analysis: Predictors of Dysphagia

Predictor	OR	95% CI	P Value
Endocrine disorders (ref. = absence)	3.69	1.66, 8.19	0.001
No. of decompressed levels	1.52	1.00, 2.32	0.050
Number of stages (ref. = 1 stage)	3.42	1.08, 10.88	0.037

TABLE VI Results of Unadjusted and Adjusted Analyses of Functional, Disability, and Quality-of-Life Scores at 6 and 24 Months Following Surgery

	Mean Change in Score (95% CI) Between Preoperative and Follow-up Visits		
	No Dysphagia	Dysphagia	P Value
6 mo*			
Unadjusted†			
ΔmJOA	2.2 (2.0, 2.4)	1.4 (0.6, 2.3)	0.059
ΔNurick	1.3 (1.2, 1.5)	1.0 (0.5, 1.6)	0.210
ΔNDI	11.6 (10.0, 13.3)	9.2 (2.5, 15.9)	0.392
ΔSF-36 PCS	6.2 (5.3, 7.1)	3.4 (−0.4, 7.1)	0.089
ΔSF-36 MCS	5.9 (4.7, 7.0)	4.5 (−0.0, 9.0)	0.482
Adjusted‡			
ΔmJOA	1.9 (1.4, 2.4)	1.4 (0.4, 2.3)	0.206
ΔNurick	1.2 (0.9, 1.5)	1.1 (0.5, 1.7)	0.547
ΔNDI	9.2 (5.3, 13.0)	7.7 (0.5, 14.9)	0.547
ΔSF-36 PCS	5.2 (3.2, 7.2)	3.6 (−0.3, 7.6)	0.316
ΔSF-36 MCS	6.0 (3.2, 8.9)	4.8 (−0.2, 9.8)	0.504
24 mo§			
Unadjusted†			
ΔmJOA	2.7 (2.5, 3.0)	2.2 (1.3, 3.2)	0.291
ΔNurick	1.6 (1.4, 1.7)	1.5 (1.0, 2.1)	0.699
ΔNDI	13.1 (11.2, 15.1)	13.9 (6.6, 21.1)	0.612
ΔSF-36 PCS	6.7 (5.8, 7.7)	4.1 (0.3, 7.9)	0.150
ΔSF-36 MCS	5.6 (4.4, 6.9)	4.4 (−1.0, 9.8)	0.442
Adjusted‡			
ΔmJOA	2.4 (1.9, 2.9)	2.2 (1.2, 3.2)	0.599
ΔNurick	1.4 (1.1, 1.8)	1.6 (1.0, 2.2)	0.505
ΔNDI	10.7 (6.5, 14.8)	12.4 (4.6, 20.1)	0.527
ΔSF-36 PCS	5.8 (3.8, 7.8)	4.3 (0.3, 8.3)	0.401
ΔSF-36 MCS	5.8 (2.8, 8.8)	4.6 (−1.2, 10.5)	0.492

*Δ = difference in scores between the preoperative and 6-month postoperative visits. †Controlled for the baseline value of the analyzed outcome. ‡Controlled for the baseline value of the analyzed outcome, severity, age, number of surgical stages, number of decompressed levels, endocrine and cardiovascular comorbidities, BMI, and sex. §Δ = difference in scores between the preoperative and 24-month postoperative visits.

surgery in 61.1% of the patients, with cardiovascular disorders being the most common (40.2%) (Table II).

Four hundred and forty-seven (95.1%) of the patients underwent a 1-stage anterior procedure, whereas 2-stage circumferential surgery was performed in 4.9% of the sample. The median operative duration was 164.0 minutes (IQR = 100.5), and the median number of decompressed segments was 3.0 (IQR = 2.0). The operation was performed at C4 and/or above in 58.1% of the patients (Table II).

Prevalence of Perioperative Dysphagia

Twenty-nine patients (6.2%) experienced dysphagia within 30 days after the surgery. Eight (27.5%) of the 29 experienced symptoms of dysphagia on the day of surgery; 19 (65.5%), within 5 days; and 2 (6.9%), between 6 and 30 days after the surgery (mean, 2.3 ± 3.3 days). Twenty-three patients (79.3%) presented with mild dysphagia; 4 (13.8%), with moderate symptoms; and 2 (6.9%), with severe symptoms. All of the patients with dysphagia received either no treatment (n = 15) or nonoperative treatment consisting of diet modification and/or concomitant medication (n = 14). No patient required tube feeding. By the last follow-up evaluation, the dysphagia had resolved in 21 patients (18 with and 3 without residual symptoms) from 1 day to 1 year (mean, 76.7 ± 119.2 days) after the surgery and continued in 8 patients (Table III).

Bivariate Analysis

Clinical Predictors of Dysphagia

Patients with dysphagia were on average older (59.0 ± 13.0 years) than patients who did not experience dysphagia (52.9 ± 11.1 years) (odds ratio [OR] per decade increase = 1.71, p = 0.002). The risk of dysphagia was not increased by either a higher BMI (p = 0.631) or a longer duration of symptoms (p = 0.452). There also were no significant differences in the mean preoperative mJOA, Nurick, NDI, or SF-36 MCS scores between the patients

with and those without perioperative dysphagia. However, the mean preoperative SF-36 PCS score was significantly lower in patients who developed dysphagia (31.0 ± 8.2) than in those who did not (35.0 ± 9.2) (OR = 0.95, p = 0.026). Perioperative dysphagia was associated with a higher comorbidity score (OR = 1.29, p = 0.002) and a cardiovascular (OR = 2.58, p = 0.016) or endocrine (OR = 4.23, p < 0.001) disorder (Table IV).

Surgical Predictors of Dysphagia

There was a significant difference in the rate of dysphagia between patients treated with a single anterior procedure (n = 23, 5.1%) and those treated with 2-stage anteroposterior surgery (n = 6, 26.1%) (OR [reference, 1-stage procedure] = 6.51, p < 0.001). A greater number of decompressed levels was also associated with dysphagia (OR = 1.82, p = 0.002). Patients who experienced dysphagia in the perioperative period had a longer mean operative duration (205.5 ± 125.5 minutes) than patients who did not (178.0 ± 78.1 minutes), although this relationship did not reach significance (p = 0.083) (Table IV).

Multivariable Analysis

All variables that yielded a p value of ≤0.2 in the bivariate analyses were evaluated in multivariable analysis. Factors with a p value of >0.2 were not deemed clinically important enough in this context to warrant further investigation. According to the final model, patients had a higher likelihood of perioperative dysphagia if they had a concomitant endocrine disorder (primarily diabetes melltianitus) (OR [reference, no endocrine disorder] = 3.69, p = 0.001), a greater number of decompressed segments (OR = 1.52, p = 0.050), or 2-stage surgery (OR [reference, 1-stage] = 3.42, p = 0.037) (Table V). The area under the receiver operating characteristic curve was 0.74 (95% confidence interval [CI] = 0.64 to 0.83), indicating good model performance.

Functional and Quality-of-Life Outcomes

Patients without dysphagia demonstrated clinically meaningful improvements in functional, disability, and quality-of-life clinical outcomes at 6 months following surgery (p < 0.0001 across all outcome measures). In contrast, patients who developed dysphagia in the perioperative period did not exhibit clinically meaningful improvements in the SF-36 MCS score (mean improvement = 4.5, 95% CI = −0.0 to 9.0) or SF-36 PCS score (3.4, 95% CI = −0.4 to 7.1). However, at 6 and 24 months, there were no significant differences in the improvements in functional, disability, or quality-of-life incomes between the patients with and those without dysphagia. The results were similar following adjustment for important surgical and baseline characteristics (Table VI).

Discussion

This is the largest prospective analysis of the effect of dysphagia on the surgical outcomes of anterior cervical decompression and fusion and important risk factors for this complication. The overall prevalence of dysphagia was 6.2% after 1-stage or 2-stage surgery. This is relatively low compared with previously reported rates[4,15,21]. However, differences in frequencies across studies can be attributed to variations in definitions and methods of diagnosis. In our study, the diagnosis of dysphagia was based on patient reports of difficulty or discomfort with swallowing, and not on objective radiographic examination or a dysphagia grading system as used in other studies[4,15,21], and that may explain the low prevalence in our sample. Variability in rates of dysphagia across studies highlights a major knowledge gap in the literature; specifically, there are currently no standardized definitions or strategies for diagnosing complications of anterior cervical surgery, including dysphagia. Additional research should be conducted to establish universally accepted criteria to classify these complications.

In this study, both short-term and long-term improvements in functional, disability, and quality-of-life scores were comparable between patients with and those without dysphagia. Patients with dysphagia, however, did not exhibit clinically meaningful improvements[32,33,35] in SF-36 MCS and PCS scores at 6 months. Patients in both groups continued to improve over time and demonstrated greater change scores at 24 months than at 6 months. These results indicate that dysphagia does not affect short or long-term clinical, disability, or quality-of-life outcomes. This is probably because most patients in our study had mild perioperative dysphagia that resolved by the first follow-up visit.

Dysphagia can result in anxiety when eating, depression, isolation, and decreased socialization, all of which can severely impair activities of daily living. Since many social events involve eating, individuals who are disabled in this regard tend to feel isolated and may ultimately experience anxiety and depression[28]. Furthermore, patients who experience dysphagia may be initially dissatisfied with the result of the surgery, especially if they were not informed preoperatively about the possibility of this complication and its consequences. It is therefore essential for clinicians to educate patients about their risk of dysphagia and its impact on their initial quality of life.

Previous studies have indicated that the rate of postoperative dysphagia decreases with time following the surgery[4,13,14]. Although we did not investigate the effects of prolonged dysphagia, we did find that functional impairment, disability, and quality-of-life scores improved steadily over time in patients with this complication. In contrast to our results, Riley et al. reported that dysphagia caused an overall reduction in patients' quality of life that persisted until 24 months postoperatively[19]. However, our analysis (a 2-way repeated-measures analysis of covariance that adjusted for variations in baseline characteristics and surgical factors) was more rigorous than that used by Riley et al. Moreover, in contrast to those authors, we only considered cases of dysphagia that developed in the perioperative period (within 30 days after the surgery) and we examined both quality-of-life and functional outcomes, including the mJOA, Nurick, NDI, and SF-36 scores (as opposed to only the SF-36 and Oswestry Neck Disability Questionnaire). The results from our study are therefore more universal and generalizable.

The most common causes of surgical dysphagia are direct or indirect injury to the superior or recurrent laryngeal nerve and prevertebral or pharyngeal swelling. Furthermore, patients with preclinical dysphagia (i.e., abnormalities with swallowing that they themselves have not yet detected) before the operation have an increased risk of experiencing symptoms

of swallowing dysfunction following the surgery. Interestingly, in a barium swallowing study by Frempong-Boadu et al.[9], 66% of patients with myelopathy demonstrated radiographic evidence of swallowing abnormalities preoperatively but did not report any symptoms of dysphagia. Potential explanations for this association include (1) older patients, such as those with degenerative cervical myelopathy, have a decreased sensitivity in the pharyngeal and supraglottic area or (2) cord compression could interfere with the preganglionic, sympathetic outflow or spinal afferents. Because a high proportion of patients with myelopathy may have preclinical dysphagia, there may be a need to better evaluate dysphagia preoperatively, especially in patients with multilevel severe degeneration or diabetes[9].

Our study indicated that the major predictors of dysphagia are endocrine disorders (primarily diabetes mellitus), a greater number of decompressed levels, and 2-stage surgery. During an anterior cervical decompression and fusion procedure, retraction of the larynx may compress the recurrent laryngeal nerve between the endotracheal tube and the retracted larynx and cause postoperative neuropathy[36]. Patients with diabetes may present with preoperative neuropathy mainly in the autonomic neurons, and the fragile laryngeal nerves could be further damaged by the surgical procedure, resulting in swallowing dysfunction. These patients should be evaluated for preclinical dysphagia, and preventative intraoperative strategies should be implemented. In contrast to our results, no association between diabetes mellitus and dysphagia was reported in 2 previous studies of patients treated with anterior cervical decompression and fusion[9,21]. However, those analyses included far fewer patients than were evaluated in our study, and their statistical power was limited.

Combined anterior and posterior surgery was also a significant predictor of postoperative dysphagia. Two-stage operations often require posterior fixation, can restore cervical alignment, and are typically used in patients with more complex pathological conditions. Chen et al. reported that increased correction of C2-C7 lordosis with 2-stage surgery was a significant predictor of postoperative dysphagia[5]. In a study by Tian and Yu, all patients who experienced dysphagia had had at least a 5° correction of the C2-C7 angle[37]. Although we did not evaluate preoperative and postoperative images in our study, excessive alignment correction could increase the risk of this complication. Potential explanations include direct stretching of the esophagus and compression of the pharyngeal wall by the anterior surface of the cervical spine. Anteroposterior surgery may also be a surrogate for increased degeneration, greater surgical invasiveness, and increased soft-tissue swelling. Since soft-tissue swelling is often a cause of acute postoperative dysphagia[9,38], 2-stage surgery increases the risk of experiencing this complication. However, given the small number of patients who underwent 2-stage surgery in our study, future studies are required to confirm this association.

Our analysis confirmed the association, found in several other studies[4,5,9,14,19,20], between the number of surgical levels and postoperative dysphagia. A greater number of decompressed segments is often associated with a longer operation, increased tissue and nerve compromise, and postoperative edema.

This study has limitations. First, the diagnosis of dysphagia was based on patient-reported difficulty swallowing, and its severity was qualified by individual investigators without specific criteria. Previous reports have indicated that rates may vary substantially based on study design (prospective versus retrospective), methods of data collection (by a research coordinator, by the surgeon, or via patient report), and definitions[4-24]. The prevalence of dysphagia may have been low in our study because patients had to volunteer that they had difficulty swallowing; however, we encouraged subjects to report any adverse event throughout the study period. Second, we only reported on dysphagia within 30 days postoperatively and did not consider patients who developed dysphagia at a later time point in the study. Furthermore, our study protocol did not require patients to be evaluated between discharge and 30 days after the surgery; as a result, some cases of perioperative dysphagia may have been missed. Other specifications in the protocol, however, ensured that adverse events were collected as meticulously and thoroughly as possible. Third, there was no standardized surgical protocol; decisions regarding surgical technique were left to the discretion of the attending surgeon. Despite these limitations, this study presents important information on key risk factors for dysphagia and the impact of dysphagia on functional, disability, and quality-of-life outcomes.

In conclusion, the most important predictors of dysphagia were endocrine disorders (primarily diabetes mellitus), a greater number of decompressed levels, and a 2-stage anteroposterior procedure. The short-term and long-term improvements in the functional, disability, and quality-of-life scores of patients with postoperative dysphagia were similar those of patients without dysphagia. ■

Narihito Nagoshi, MD, PhD[1,2]
Lindsay Tetreault, PhD[1]
Hiroaki Nakashima, MD, PhD[1,3]
Paul M. Arnold, MD[4]
Giuseppe Barbagallo, MD[5]
Branko Kopjar, MD[6]
Michael G. Fehlings, MD, PhD, FRCS[1]

[1]Division of Neurosurgery and Spinal Program, Department of Surgery (N.N., L.T., H.N., and M.G.F.), and Institute of Medical Science (L.T. and M.G.F.), Toronto Western Hospital, University of Toronto, Toronto, Ontario, Canada

[2]Department of Orthopaedic Surgery, Keio University School of Medicine, Tokyo, Japan

[3]Department of Orthopedic Surgery, Nagoya University Graduate School of Medicine, Nagoya, Japan

[4]University of Kansas, Kansas City, Kansas

[5]Department of Neurosurgery, University Hospital Catania, Catania, Italy

[6]Department of Health Services, University of Washington, Seattle, Washington

E-mail address for M.G. Fehlings: Michael.Fehlings@uhn.on.ca

References

1. Matz PG, Holly LT, Mummaneni PV, Anderson PA, Groff MW, Heary RF, Kaiser MG, Ryken TC, Choudhri TF, Vresilovic EJ, Resnick DK; Joint Section on Disorders of the Spine and Peripheral Nerves of the American Association of Neurological Surgeons and Congress of Neurological Surgeons. Anterior cervical surgery for the treatment of cervical degenerative myelopathy. J Neurosurg Spine. 2009 Aug;11 (2):170-3.

2. Fehlings MG, Barry S, Kopjar B, Yoon ST, Arnold P, Massicotte EM, Vaccaro A, Brodke DS, Shaffrey C, Smith JS, Woodard E, Banco RJ, Chapman J, Janssen M, Bono C, Sasso R, Dekutoski M, Gokaslan ZL. Anterior versus posterior surgical approaches to treat cervical spondylotic myelopathy: outcomes of the prospective multicenter AOSpine North America CSM study in 264 patients. Spine (Phila Pa 1976). 2013 Dec 15;38(26):2247-52.

3. Veeravagu A, Cole T, Jiang B, Ratliff JK. Revision rates and complication incidence in single- and multilevel anterior cervical discectomy and fusion procedures: an administrative database study. Spine J. 2014 Jul 1;14(7):1125-31. Epub 2013 Oct 11.

4. Bazaz R, Lee MJ, Yoo JU. Incidence of dysphagia after anterior cervical spine surgery: a prospective study. Spine (Phila Pa 1976). 2002 Nov 15;27(22):2453-8.

5. Chen CJ, Saulle D, Fu KM, Smith JS, Shaffrey CI. Dysphagia following combined anterior-posterior cervical spine surgeries. J Neurosurg Spine. 2013 Sep;19(3):279-87. Epub 2013 Jul 12.

6. Chin KR, Eiszner JR, Adams SB Jr. Role of plate thickness as a cause of dysphagia after anterior cervical fusion. Spine (Phila Pa 1976). 2007 Nov 1;32 (23):2585-90.

7. Edwards CC 2nd, Karpitskaya Y, Cha C, Heller JG, Lauryssen C, Yoon ST, Riew KD. Accurate identification of adverse outcomes after cervical spine surgery. J Bone Joint Surg Am. 2004 Feb;86(2):251-6.

8. Fogel GR, McDonnell MF. Surgical treatment of dysphagia after anterior cervical interbody fusion. Spine J. 2005 Mar-Apr;5(2):140-4.

9. Frempong-Boadu A, Houten JK, Osborn B, Opulencia J, Kells L, Guida DD, Le Roux PD. Swallowing and speech dysfunction in patients undergoing anterior cervical discectomy and fusion: a prospective, objective preoperative and postoperative assessment. J Spinal Disord Tech. 2002 Oct;15(5):362-8.

10. Kang SS, Lee JS, Shin JK, Lee JM, Youn BH. The association between psychiatric factors and the development of chronic dysphagia after anterior cervical spine surgery. Eur Spine J. 2014 Aug;23(8):1694-8. Epub 2014 Apr 3.

11. Kepler CK, Rihn JA, Bennett JD, Anderson DG, Vaccaro AR, Albert TJ, Hilibrand AS. Dysphagia and soft-tissue swelling after anterior cervical surgery: a radiographic analysis. Spine J. 2012 Aug;12(8):639-44. Epub 2012 May 5.

12. Khaki F, Zusman NL, Nemecek AN, Ching AC, Hart RA, Yoo JU. Postoperative prevertebral soft tissue swelling does not affect the development of chronic dysphagia following anterior cervical spine surgery. Spine (Phila Pa 1976). 2013 Apr 20;38(9):E528-32.

13. Lee MJ, Bazaz R, Furey CG, Yoo J. Influence of anterior cervical plate design on dysphagia: a 2-year prospective longitudinal follow-up study. J Spinal Disord Tech. 2005 Oct;18(5):406-9.

14. Lee MJ, Bazaz R, Furey CG, Yoo J. Risk factors for dysphagia after anterior cervical spine surgery: a two-year prospective cohort study. Spine J. 2007 Mar-Apr;7 (2):141-7. Epub 2007 Jan 22.

15. Mendoza-Lattes S, Clifford K, Bartelt R, Stewart J, Clark CR, Boezaart AP. Dysphagia following anterior cervical arthrodesis is associated with continuous, strong retraction of the esophagus. J Bone Joint Surg Am. 2008 Feb;90(2):256-63.

16. Min Y, Kim WS, Kang SS, Choi JM, Yeom JS, Paik NJ. Incidence of dysphagia and serial videofluoroscopic swallow study findings after anterior cervical discectomy and fusion: a prospective study. Clin Spine Surg. 2016;29(4):E177-81.

17. Papavero L, Heese O, Klotz-Regener V, Buchalla R, Schröder F, Westphal M. The impact of esophagus retraction on early dysphagia after anterior cervical surgery: does a correlation exist? Spine (Phila Pa 1976). 2007 May 1;32(10):1089-93.

18. Rihn JA, Kane J, Albert TJ, Vaccaro AR, Hilibrand AS. What is the incidence and severity of dysphagia after anterior cervical surgery? Clin Orthop Relat Res. 2011 Mar;469(3):658-65.

19. Riley LH 3rd, Skolasky RL, Albert TJ, Vaccaro AR, Heller JG. Dysphagia after anterior cervical decompression and fusion: prevalence and risk factors from a longitudinal cohort study. Spine (Phila Pa 1976). 2005 Nov 15;30(22):2564-9.

20. Singh K, Marquez-Lara A, Nandyala SV, Patel AA, Fineberg SJ. Incidence and risk factors for dysphagia after anterior cervical fusion. Spine (Phila Pa 1976). 2013 Oct 1;38(21):1820-5.

21. Smith-Hammond CA, New KC, Pietrobon R, Curtis DJ, Scharver CH, Turner DA. Prospective analysis of incidence and risk factors of dysphagia in spine surgery patients: comparison of anterior cervical, posterior cervical, and lumbar procedures. Spine (Phila Pa 1976). 2004 Jul 1;29(13):1441-6.

22. Starmer HM, Riley LH 3rd, Hillel AT, Akst LM, Best SR, Gourin CG. Dysphagia, short-term outcomes, and cost of care after anterior cervical disc surgery. Dysphagia. 2014 Feb;29(1):68-77. Epub 2013 Aug 14.

23. Tervonen H, Niemelä M, Lauri ER, Back L, Juvas A, Räsänen P, Roine RP, Sintonen H, Salmi T, Vilkman SE, Aaltonen LM. Dysphonia and dysphagia after anterior cervical decompression. J Neurosurg Spine. 2007 Aug;7(2):124-30.

24. Zeng JH, Zhong ZM, Chen JT. Early dysphagia complicating anterior cervical spine surgery: incidence and risk factors. Arch Orthop Trauma Surg. 2013 Aug;133 (8):1067-71. Epub 2013 May 21.

25. Ferraris VA, Ferraris SP, Moritz DM, Welch S. Oropharyngeal dysphagia after cardiac operations. Ann Thorac Surg. 2001 Jun;71(6):1792-5; discussion 1796.

26. Gee E, Lancaster E, Meltzer J, Mendelsohn AH, Benharash P. A targeted swallow screen for the detection of postoperative dysphagia. Am Surg. 2015 Oct;81 (10):979-82.

27. Ochoa JB. Nutrition assessment and intervention in the patient with dysphagia: challenges for quality improvement. Nestle Nutr Inst Workshop Ser. 2012;72:77-83. Epub 2012 Sep 24.

28. Nguyen NP, Frank C, Moltz CC, Vos P, Smith HJ, Karlsson U, Dutta S, Midyett A, Barloon J, Sallah S. Impact of dysphagia on quality of life after treatment of head-and-neck cancer. Int J Radiat Oncol Biol Phys. 2005 Mar 1;61(3):772-8.

29. García-Peris P, Parón L, Velasco C, de la Cuerda C, Camblor M, Bretón I, Herencia H, Verdaguer J, Navarro C, Clave P. Long-term prevalence of oropharyngeal dysphagia in head and neck cancer patients: impact on quality of life. Clin Nutr. 2007 Dec;26(6):710-7. Epub 2007 Oct 22.

30. Ratnaraj J, Todorov A, McHugh T, Cheng MA, Lauryssen C. Effects of decreasing endotracheal tube cuff pressures during neck retraction for anterior cervical spine surgery. J Neurosurg. 2002 Sep;97(2)(Suppl):176-9.

31. Siska PA, Ponnappan RK, Hohl JB, Lee JY, Kang JD, Donaldson WF 3rd. Dysphagia after anterior cervical spine surgery: a prospective study using the swallowing-quality of life questionnaire and analysis of patient comorbidities. Spine (Phila Pa 1976). 2011 Aug 1;36(17):1387-91.

32. Carreon LY, Glassman SD, Campbell MJ, Anderson PA. Neck Disability Index, Short Form-36 physical component summary, and pain scales for neck and arm pain: the minimum clinically important difference and substantial clinical benefit after cervical spine fusion. Spine J. 2010 Jun;10(6):469-74. Epub 2010 Apr 1.

33. Auffinger BM, Lall RR, Dahdaleh NS, Wong AP, Lam SK, Koski T, Fessler RG, Smith ZA. Measuring surgical outcomes in cervical spondylotic myelopathy patients undergoing anterior cervical discectomy and fusion: assessment of minimum clinically important difference. PLoS One. 2013 Jun 24;8(6):e67408.

34. Tetreault L, Nouri A, Kopjar B, Côté P, Fehlings MG. The minimum clinically important difference of the modified Japanese Orthopaedic Association scale in patients with degenerative cervical myelopathy. Spine (Phila Pa 1976). 2015 Nov;40 (21):1653-9.

35. Zhou F, Zhang Y, Sun Y, Zhang F, Pan S, Liu Z. Assessment of the minimum clinically important difference in neurological function and quality of life after surgery in cervical spondylotic myelopathy patients: a prospective cohort study. Eur Spine J. 2015;24(12):2918-23.

36. Apfelbaum RI, Kriskovich MD, Haller JR. On the incidence, cause, and prevention of recurrent laryngeal nerve palsies during anterior cervical spine surgery. Spine (Phila Pa 1976). 2000 Nov 15;25(22):2906-12.

37. Tian W, Yu J. The role of C2-C7 and O-C2 angle in the development of dysphagia after cervical spine surgery. Dysphagia. 2013 Jun;28(2):131-8. Epub 2012 Aug 24.

38. Song KJ, Choi BW, Kim HY, Jeon TS, Chang H. Efficacy of postoperative radiograph for evaluating the prevertebral soft tissue swelling after anterior cervical discectomy and fusion. Clin Orthop Surg. 2012 Mar;4(1):77-82. Epub 2012 Feb 20.