J Neurosurg Spine 19:279–287, 2013

Dysphagia following combined anterior-posterior cervical spine surgeries

Clinical article

Ching-Jen Chen, B.A.,[1] Dwight Saulle, M.D.,[1] Kai-Ming Fu, M.D., Ph.D.,[2] Justin S. Smith, M.D., Ph.D.,[1] and Christopher I. Shaffrey, M.D.[1]

[1]Department of Neurosurgery, University of Virginia Medical Center, Charlottesville, Virginia; and [2]Department of Neurosurgery, Weill Cornell Medical College, New York, New York

Object. This study was undertaken to evaluate the incidence of and risk factors associated with the development of dysphagia following same-day combined anterior-posterior cervical spine surgeries.

Methods. The records of 30 consecutive patients who underwent same-day combined anterior-posterior cervical spine surgery were reviewed. The presence of dysphagia was assessed by a formalized screening protocol using history/clinical presentation and a bedside swallowing test, followed by formal evaluation by speech and language pathologists and/or fiberoptic endoscopic evaluation of swallowing/modified barium swallow when necessary. Age, sex, previous cervical surgeries, diagnoses, duration of procedure, specific vertebral levels and number of levels operated on, degree of sagittal curve correction, use of anterior plate, estimated blood loss, use of recombinant human bone morphogenetic protein-2 (rhBMP-2), and length of hospital stay following procedures were analyzed.

Results. In the immediate postoperative period, 13 patients (43.3%) developed dysphagia. Outpatient follow-up data were available for 11 patients with dysphagia, and within this subset, all cases of dysphagia resolved subjectively within 12 months following surgery. The mean numbers of anterior levels surgically treated in patients with and without dysphagia were 5.1 and 4.0, respectively ($p = 0.004$). All patients (100%) with dysphagia had an anterior procedure that extended above C-4, compared with 58.8% of patients without dysphagia ($p = 0.010$). Patients with dysphagia had significantly greater mean correction of C2–7 lordosis than patients without dysphagia ($p = 0.020$). The postoperative sagittal occiput–C2 angle and the change in this angle were not significantly associated with the occurrence of dysphagia ($p = 0.530$ and $p = 0.711$, respectively). Patients with postoperative dysphagia had significantly longer hospital stays than those who did not develop dysphagia ($p = 0.004$). No other significant difference between the dysphagia and no-dysphagia groups was identified; differences with respect to history of previous anterior cervical surgery ($p = 0.141$), use of an anterior plate ($p = 0.613$), and mean length of anterior cervical operative time ($p = 0.541$) were not significant.

Conclusions. The incidence of dysphagia following combined anterior-posterior cervical surgery in this study was comparable to that of previous reports. The risk factors for dysphagia that were identified in this study were increased number of anterior levels exposed, anterior surgery that extended above C-4, and increased surgical correction of C2–7 lordosis.

(http://thejns.org/doi/abs/10.3171/2013.6.SPINE121134)

Key Words • **anterior** • **cervical** • **complication** • **dysphagia** • **posterior** • **surgery**

Complications related to cervical spine surgery are well documented in the literature, including dysphagia, dysphonia, wound infection, neurological deficit, delayed C-5 palsy, adjacent-level disease, instrumentation failure, and pseudarthrosis.[4,7] Among these, dysphagia has been a consistently recognized early complication following anterior cervical spine surgery, and its reported incidence is highly variable, ranging from 1% to as high as 79%.[2,3,5,6,10,14,22,24,28,33] This variation is in part attributed to how dysphagia is defined by investigators and the threshold of severity at which it is considered to be a complication. Fortunately, most studies show dysphagia to be typically a transient phenomenon following anterior cervical surgery.[2,22,31]

The pathophysiology of dysphagia following cervical spine surgery remains poorly understood. Several factors have been suggested to be related to the development of postsurgical dysphagia, including patient age, female sex, obesity, length of surgery, specific spinal level(s) of surgery, multilevel surgery, use of instrumen-

Abbreviations used in this paper: FEES = fiberoptic endoscopic evaluation of swallowing; MBS = modified barium swallow; NG = nasogastric; NPO = nil per os; PEG = percutaneous endoscopic gastrostomy; rhBMP-2 = recombinant human bone morphogenetic protein-2; SLP = certified speech and language pathologist.

tation, retraction, magnitude of curve correction, tissue edema, adhesions, use of rhBMP-2, and graft-related problems.[2,5,6,9,10,12,16,18,21,22,27–29,31,32] However, the associations are not consistent among studies.

Although dysphagia is commonly seen following cervical spine surgeries, its implications are often underappreciated; in fact, some do not consider dysphagia to be a surgical complication unless it is severe. Riley et al.[23] showed that patients with dysphagia following cervical spine surgery experienced significantly more functional disability and poorer physical health status than those without dysphagia. Since dysphagia may be associated with increased risk for other complications, such as pneumonia, dehydration, and malnutrition, it should be identified and managed accordingly. Some cases may require periods of NPO status or dietary restrictions, and severe cases may require use of an NG tube or placement of a PEG tube.

Until recently, studies have largely focused on dysphagia associated with the anterior approach, and literature regarding rates of dysphagia following a combined anterior-posterior approach is much more limited. Recent reports have suggested that, compared with an isolated anterior or posterior approach, combined anterior-posterior approaches possess higher overall complication rates, including rates of dysphagia.[4,7] The risk factors associated with the higher rates of dysphagia in combined procedures have not been addressed to the same extent compared with those of isolated anterior approaches.

In the present study, we retrospectively evaluated the incidence of and risk factors associated with dysphagia in a series of consecutive patients who underwent same-day combined anterior-posterior cervical spine surgeries. This study will help to define the rates of dysphagia following combined anterior-posterior cervical approaches and may also prove helpful for preoperative patient counseling.

Methods

Patient Population

This study was a single-center retrospective review of consecutive cases performed by the senior author (C.I.S.) between May 2006 and August 2011. Patients were identified based on surgical records and case logs. Inclusion criteria included age 18 years or older and same-day combined anterior-posterior cervical surgery. Patients treated with staged (performed on separate days) anterior and posterior cervical procedures or with active infection of the cervical spine were excluded from the present study. This study was approved by the institutional review board of the University of Virginia.

Data Collection

For all patients meeting inclusion criteria, clinical and hospital records, as well as operative reports, were reviewed. Data collected included basic demographic information, history of previous cervical surgery, diagnoses, evidence of preoperative/postoperative dysphagia, description of surgical procedures performed (anterior and posterior), duration of each procedure, specific vertebral levels and number of levels surgically treated, number of corpectomies/discectomies, degree of sagittal curve correction, whether an anterior plate was used, estimated blood loss, rhBMP-2 use, and length of hospital stay following the procedures. In addition, available data were collected regarding evaluation by an SLP and evaluation by MBS or FEES. Whether patients required placement of a PEG or NG tube for nutrition was also noted.

Initial dysphagia screenings for all patients were performed using a protocol for evaluating patients undergoing multilevel anterior surgery by a trained registered nurse. The protocol is a 2-part screening (Table 1). Part 1 is the evaluation of case history/clinical presentation; this is followed by a bedside swallowing test using 90 ml of water in Part 2. If the patient meets any of the criteria specified in Part 1, or if the patient experiences coughing or demonstrates change in quality of voice in Part 2, a formal swallow evaluation by a SLP is requested. The patient must pass both parts of the screening in order for the results to be considered negative for dysphagia. An SLP evaluation included per os trials of ice chips, thin and thick liquids, puree, and soft and hard solids, with assessment of oral containment, bolus formation, oral transit, swallow reflex, laryngeal elevation, voice quality changes, and cough/signs of aspiration. Based on the results, MBS or FEES may have been recommended for further evaluation. Assessment for resolution of dysphagia during hospitalization was dependent on subjective evaluation by the treating team, nursing staff, and/or SLPs. Resolution of dysphagia following discharge from the hospital was determined by the patient's subjective ability to tolerate

TABLE 1: Dysphagia screening by registered nurse*

Part 1. Case history and clinical presentation†
brainstem stroke
decreased level of consciousness
difficulty/inability to sit upright
shortness of breath
slurred speech
facial weakness/droop
cognitive deficits (including aphasia)
pneumonia
weak cough
hoarse voice
wet/gurgly sounding voice
drooling
wet cough
Part 2. Three-ounce water swallow screening‡
experienced coughing while drinking water or w/in 1 minute afterwards
vocal quality wet or hoarse following test

* Patient must pass both Part 1 and Part 2 to pass the screening; patient who fails any part of the screening is evaluated by speech and language pathologist.

† If any Part 1 criteria are present, a formal swallow evaluation by a speech and language pathologist is requested.

‡ Patient is given 90 ml of water and asked to drink from a cup without interruption.

oral intake without difficulty (no formal swallow evaluations were performed).

Preoperative and postoperative anteroposterior and lateral cervical spine radiographs were routinely obtained. Radiographic measures were performed as previously described by Tian et al.[32] The occiput–C2 angle was defined as the angle of intersection of the McGregor line and a line drawn parallel to the inferior endplate of the C-2 vertebral body. The C2–7 angle was defined as the angle subtended by the intersection of lines parallel to the inferior endplates of the C-2 and C-7 vertebral bodies. For patients with C-7 corpectomies, the C2–7 angle was defined as the angle of intersection of lines parallel to the inferior endplates of the C-2 vertebral body and inferior border of the bone graft. All measurements were obtained on neutral lateral standing or sitting radiographs. Lordosis was indicated by positive angles. Correction of occiput–C2 angle (Δ occiput–C2) = postoperative occiput–C2 angle – preoperative occiput–C2 angle, and correction of C2–7 angle (Δ C2–7) = postoperative C2–7 angle – preoperative C2–7 angle.

Statistical Analysis

Frequency distributions and summary statistics were calculated for all clinical, operative, and radiographic variables. Normality of data was determined using the Shapiro-Wilk test. For categorical variables, cross-tabulations were generated, and the Fisher exact or Pearson chi-square test was used to compare distributions. For continuous variables, t-tests were used to investigate differences between subsets of patients classified by categorical data. Statistical tests were 2-sided, and $p < 0.05$ was considered statistically significant. Because the operative blood loss data and combined operative time were not normally distributed, these data were converted to ranked values for statistical comparisons. All other assessed data were normally distributed.

Results

Patient Population

A total of 30 consecutive patients treated with same-day anterior-posterior cervical surgeries met the study inclusion criteria (Table 2). A representative case is shown in Fig. 1. The study population included 17 men and 13 women, with a mean age of 59.1 years (range 36–80 years). Primary diagnoses included: cervical spondylotic myelopathy (14 cases, 47%), pseudarthrosis with kyphotic deformity (7 cases, 23%), rheumatoid arthritis (4 cases, 13%), adjacent-level disease (3 cases, 10%), and metastasis involving the cervical spine (2 cases, 7%). There were no significant differences in the distribution of diagnoses ($p = 0.488$) or patient demographic characteristics between the dysphagia and no-dysphagia groups (Table 3). Three patients in the study group were found to have minor dysphagia preoperatively. Two of these patients (Table 2, Cases 20 and 27) were formally evaluated by an otolaryngologist preoperatively with FEES (Case 20) and MBS (Case 27), and no evidence of aspiration or cause for dysphagia was identified. The remaining patient (Case 24) had very mild dysphagia that did not affect tolerance of a regular diet and did not undergo formal evaluation.

The surgical procedures performed are summarized in Table 2. Eighteen cases (60%) were revisions, including 9 cases (30%) in which the patients had previously undergone only anterior surgery, 6 (20%) in which they had previously undergone only posterior surgery, and 3 (10%) in which they had previously undergone anterior and posterior surgery (either same or different day). For the procedures assessed in the present study, the mean number of anterior levels treated was 4.5 (range 2–7 levels), and the mean number of posterior levels treated was 6.7 (range 2–9 levels). One patient presented with previous posterior C1–2 fusion with the use of wiring. Posterior instrumentation did not extend above C-2 for any other case in this series. Anterior plates were placed in 26 cases (86.7%) and spanned a mean of 4.7 vertebral levels (range 3–7 levels). The mean operative times for the anterior and posterior procedures were 178.8 ± 83.3 minutes (range 56–483 minutes) and 180.4 ± 66.3 minutes (range 82–416 minutes), respectively. Transverse incisions were made in all anterior procedures except for 3 cases (Cases 16, 28, and 29), and longitudinal incisions were made in all posterior procedures. The mean estimated blood loss for the procedures was 835 ± 901.4 ml (range 100–4000 ml). The overall mean length of hospital stay following surgery was 8 ± 4.4 days (range 3–19 days). The overall mean postoperative occiput–C2 angle and C2–C7 angle were 30.8° ± 12.5° and 5.8° ±11.8°, respectively. Overall changes in occiput–C2 angle and C2–7 lordosis were –2.1°± 10.6° and 13.3° ± 22.7°, respectively.

Recombinant human BMP-2 was used in 26 cases (86.7%), with a mean dose of 11.1 mg used per case (range 8.4–24 mg). For 25 of these cases, rhBMP-2 was only used for the posterior procedure. For the remaining case (Case 20), rhBMP-2 was used for both the anterior and posterior procedures (total dose of 8.4 mg). In 4 cases (Cases 11, 13, 29, and 30), no rhBMP-2 was used

Postoperative outpatient follow-up was obtained for 26 of 30 patients, and for these patients, the mean length of follow-up was 24.2 months (range 3.8–55.7 months). Of the 4 remaining patients, 3 (Cases 11, 14, and 30) were lost to follow-up after discharge from the hospital, and 1 patient (Case 29) died of probable pulmonary embolism on postoperative Day 8 after being found unresponsive. No significant difference in follow-up time between the dysphagia and no-dysphagia groups was observed. Preoperative and postoperative radiographs were insufficient for measurements or unavailable in 6 cases (Cases 6, 11, 16, 17, 28, and 30) and 4 cases (Cases 11, 14, 29, and 30), respectively.

Incidence of Dysphagia and Assessment of Risk Factors

Postoperatively, 13 patients (43.3%) were found to have dysphagia. Twelve of the patients in the dysphagia group were evaluated by SLPs, and for 1 patient (Case 28) formal evaluation was not clearly documented. Following evaluation by an SLP, 6 patients required further evaluation; FEES was performed in 3 of these cases and MBS evaluation in the other 3. Nasogastric tubes were placed in 8 cases (61.5%), and ultimately 5 patients (38.5%) required

TABLE 2: Summary of 30 cases involving patients treated with same-day combined anterior-posterior cervical surgeries*

Case No.	Age (yrs), Sex	Previous Ant Op	Diagnosis	Number Levels Operated (ant/pst)	Ant Exposure Above C-4	Postop Dysphagia (Y/N) & Evaluation	Follow-Up (mos)	Dysphagia Outcome
1	58, M	Y	pseudarthrosis	5/8	Y	N	6.6	NA
2	63, M	N	CSM	4/7	Y	N	25.0	NA
3	76, F	N	CSM	5/9	Y	N	28.2	NA
4	73, F	N	CSM	2/8	Y	N	7.2	NA
5	41, F	Y	pseudarthrosis	4/4	N	N	48.7	NA
6	80, M	Y	ALD	3/5	N	N	3.8	NA
7	52, F	Y	ALD	3/6	Y	N	38.0	NA
8	66, F	N	RA	3/9	N	N	19.8	NA
9	61, M	N	CSM	5/5	Y	N, SLP	6.7	NA
10	62, F	N	RA	5/8	Y	N, SLP	27.0	NA
11	55, M	N	CSM	3/2	N	N	NA	NA
12	46, M	Y	pseudarthrosis	5/5	N	N	25.8	NA
13	36, M	Y	CSM	5/5	Y	N	46.4	NA
14	47, M	Y	CSM	2/4	N	N	NA	NA
15	54, M	Y	pseudarthrosis	5/8	Y	N, SLP	14.5	NA
16	49, M	Y	pseudarthrosis	5/8	Y	N	8.2	NA
17	64, M	N	CSM	4/6	N	N	36.7	NA
18	56, F	N	CSM	5/7	Y	Y, SLP, FEES showed significant erythema & edema of laryngeal folds	24.5	required NG tube placement; resolved prior to discharge
19	76, M	N	CSM	5/8	Y	Y, SLP	3.8	required NG & PEG tube placement; resolved 4 mos after op
20	50, F	Y	pseudarthrosis	5/8	Y	Y, SLP	21.9	required NG tube placement; resolved prior to discharge
21	65, F	N	CSM	4/7	Y	Y, SLP, FEES showed laryngeal edema	33.3	resolved prior to discharge
22	64, F	Y	ALD	5/7	Y	Y, SLP	41.0	resolved prior to discharge
23	55, F	N	pseudarthrosis	5/8	Y	Y, SLP	52.8	required NG tube placement; resolved prior to discharge
24	63, M	N	CSM	5/8	Y	Y, SLP, MBS demonstrated evidence of severe aspiration	6.9	required NG & PEG tube placement; resolved 4 mos after op
25	72, F	N	RA	5/8	Y	Y, SLP	24.5	required NG & PEG tube placement; resolved 3.5 mos after op
26	57, M	N	CSM	6/6	Y	Y, SLP	7.3	resolved prior to discharge.
27	58, M	N	CSM	5/8	Y	Y, SLP, FEES showed left true vocal cord paralysis	55.7	required tracheostomy, NG & PEG tube placement; resolved 12 mos after op
28	60, F	N	RA	5/7	Y	Y (formal evaluation unclear from chart)	14.7	resolved prior to discharge

(continued)

TABLE 2: Summary of 30 cases involving patients treated with same-day combined anterior-posterior cervical surgeries* *(continued)*

Case No.	Age (yrs), Sex	Previous Ant Op	Diagnosis	Number Levels Operated (ant/pst)	Ant Exposure Above C-4	Postop Dysphagia (Y/N) & Evaluation	Follow-Up (mos)	Dysphagia Outcome
29	57, M	Y	metastasis	7/7	Y	Y, SLP, MBS demonstrated frank tracheal aspiration of thin barium material owing to incomplete hyoid excursion & airway closure	—†	NA
30	56, M	N	metastasis	4/4	Y	Y, SLP, MBS demonstrated small amount of laryngeal penetration & moderate amount of tracheal aspiration w/ puree liquids	NA	required NG & PEG tube placement

* ALD = adjacent level disease; ant = anterior; CSM = cervical spondylotic myelopathy; NA = not available; pst = posterior; RA = rheumatoid arthritis.
† The patient died on postoperative Day 8.

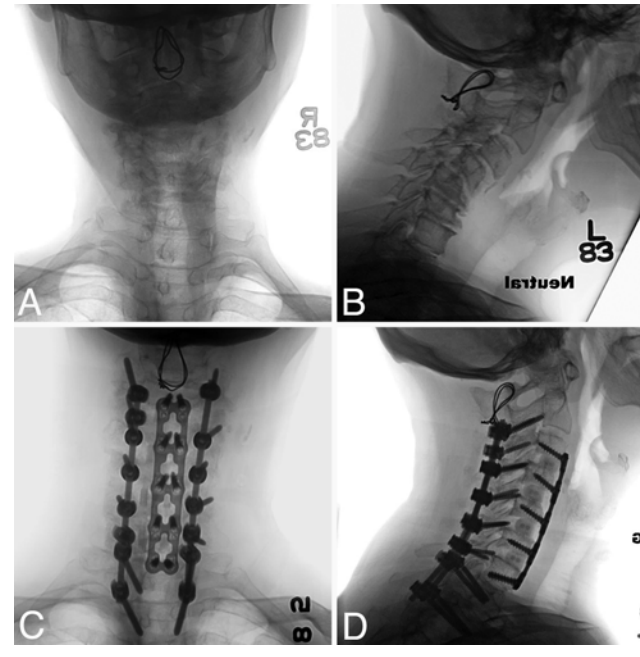

Fig. 1. Case 25. This 72-year-old woman with a 50-year history of rheumatoid arthritis had undergone posterior C1–2 fusion in 1987 and since then had had trouble with progressive ataxia, neck pain, and hand dexterity. Preoperative anteroposterior and lateral **(A and B)** radiographs demonstrated C2–3, C3–4, and C4–5 anterolisthesis and severe degenerative disc disease. She underwent same-day combined anterior-posterior surgery with C3–4, C4–5, C5–6, C6–7 anterior discectomies, and C3–7 anterior instrumentation and fusion with plating followed by C2–T2 posterior instrumented fusion **(C and D)**. The changes in occiput–C2 and C2–7 angles were −6° and 27°, respectively. Postoperatively the patient developed dysphagia and required an NG tube and subsequent PEG tube placement. The dysphagia resolved within 3.5 months following surgery.

placement of PEG tubes. All 3 patients who had preoperative dysphagia developed more severe dysphagia postoperatively; all 3 required NG tube placement and 2 eventually required PEG tube placement. Of the 11 patients with follow-up, 4 had dysphagia beyond the discharge date; 1 case resolved by 3.5 months, 2 cases by 4 months and 1 by 12 months (cases 25, 19, 24, and 27, respectively).

Results from comparisons between the dysphagia and no-dysphagia groups are summarized in Table 3. History of previous cervical spine surgery was not significantly associated with the development of dysphagia. The dysphagia group had a significantly greater number of anterior levels exposed compared with the no-dysphagia group (5.1 vs 4.0, $p = 0.004$). In addition, anterior exposure above the C-4 level was significantly associated with development of postoperative dysphagia ($p = 0.010$); notably, all cases (100%) in the dysphagia group had anterior exposure above C-4, in contrast to 58.8% of cases in the no-dysphagia group. However, the number of posterior levels exposed was not significantly associated with the development of dysphagia ($p = 0.153$). No significant association was found between the development of dysphagia and the use of an anterior plate ($p = 0.613$), length of anterior surgery (0.541), length of combined surgery ($p = 0.526$), or estimated blood loss during surgery ($p = 0.140$).

In analysis of radiographic parameters, occiput–C2

TABLE 3: Demographic, radiographic, and surgical parameters for 30 patients treated with same-day combined anterior-posterior cervical surgeries, stratified based on development of postoperative dysphagia*

Parameter	Postop Dysphagia†		p Value
	No (n = 17)	Yes (n = 13)	
demographic parameters			
mean age, yrs	57.8 (12.2)	60.7 (7.2)	0.457
sex, % F	35.3	53.8	0.460
mean length of follow-up, mos	20.2 (15.9)	22.1 (19.1)	0.766
surgical parameters			
previous ant surgery (%)	52.9	23.1	0.141
previous ant &/or pst surgery (%)	64.7	53.8	0.711
mean no. of ant levels	4.0 (1.1)	5.1 (0.8)	**0.004**
ant exposure above C-4 (%)	58.8	100.0	**0.010**
mean no. of pst levels	6.3 (2.0)	7.2 (1.1)	0.153
ant plate (%)	82.4	92.3	0.613
mean length of ant surgery (min)	187.1 (103.4)	167.9 (47.9)	0.541
mean length of combined surgery (min)‡	431.0 (156.3)	371.6 (64.1)	0.526
mean estimated blood loss, ml‡	1047.1 (1083.9)	557.7 (499.9)	0.140
mean length of hospital stay (days)	5.9 (2.6)	10.8 (4.9)	**0.004**
radiographic parameters			
occiput–C2 angle (°)			
mean postop	32.2 (13.8)	29.0 (10.9)	0.530
mean change (postop minus preop)	−1.3 (12.6)	−3.0 (8.1)	0.711
C2–7 lordosis (°)			
mean postop	3.0 (11.5)	9.5 (11.6)	0.166
mean change (postop minus preop)	3.5 (20.6)	24.1 (20.6)	**0.020**

* Significant p values are noted in bold type.
† Parenthetical values in these columns are SDs.
‡ Corresponding p value based on conversion to ranked values due to these data not being normally distributed.

angle was not significantly associated with dysphagia. The dysphagia and no-dysphagia groups had mean postoperative occiput–C2 angles of 29.0° and 32.2°, respectively (p = 0.530). Although the dysphagia group had a greater magnitude of change in the occiput–C2 angle (–3.0° vs –1.3°), this difference was not significant (p = 0.711). The difference in mean postoperative C2–7 angles between the dysphagia and no-dysphagia groups was also not significant (9.5° vs 3.0°, p = 0.166). However, patients in the dysphagia group had a significantly greater increase in C2–7 lordosis than patients in the no-dysphagia group (24.1° vs 3.5°, p = 0.020).

Patients in the dysphagia group also had significantly longer length of hospital stays than patients in the no-dysphagia group (p = 0.004). After adjustment for the effects of patient age, the difference in length of hospital stay remained statistically significant (p = 0.021).

Discussion

Isolated anterior or posterior approaches to the cervical spine can achieve satisfactory results in the majority of cases; however more complex pathologies may be better addressed by a combined anterior-posterior approach.[11] Reports have suggested that treatment of multilevel or unstable cervical disease using an isolated anterior approach can be associated with high rates of pseudarthrosis and graft dislodgement.[25,30,34] In addition to allowing for direct anterior and posterior decompression of the spinal canal, a combined approach also permits circumferential fixation for restoration of lordosis.[15,17,26] Combined anterior column lengthening and posterior column shortening for the correction of severe cases of kyphotic deformity are also a potential advantage of circumferential fixation.[17,19,20] Such approaches help to reduce the risks of pseudarthrosis, graft dislodgement and failure of instrumentation that may be seen with an isolated anterior approach and can be beneficial to patients with conditions that may negatively impact fusion.[15,17,30]

Although the combined approach can achieve dramatic correction of complex cervical kyphotic deformities in patients with lower rates of pseudarthrosis and instrumentation complications, they can be associated with significant morbidity. In a recent multicenter study of 302 patients undergoing surgical treatment for cervical spondylotic myelopathy by Fehlings et al.,[7] the overall rate of complications did not differ significantly between anterior-only (11%) and posterior-only (19%) procedures, but the complication rate was significantly higher for combined anterior-posterior procedures (37%). Mummaneni

et al.[17] reported an overall complication rate of 33.3% in a retrospective study of 30 patients with cervical kyphotic deformity undergoing combined procedures.

Dysphagia is a common complication following anterior cervical spine surgeries, but the incidence of dysphagia following combined surgeries is less well defined. In this study, we report a postoperative dysphagia incidence of 43.3%, which is within the range reported in the literature for combined procedures, as well as for isolated anterior procedures. Fehlings et al.[7] reported a rate of 21.3% following combined procedures in 19 patients, which was significantly higher than the rate for anterior-only (2.3%) or posterior-only procedures (0.9%). In studies investigating combined anterior-posterior cervical procedures, Hart el al.[8] and Aryan et al.[1] reported dysphagia rates of 46% and 19%, respectively. Although all cases of dysphagia with follow-up data in our study resolved subjectively by 12 months, there is morbidity associated with such complications; 61.5% and 38.5% of the cases required NG and PEG tube placement, respectively. In addition, patients with dysphagia had significantly greater length of hospital stay, even after adjusting for patient age.

Although there is a greater incidence of dysphagia in women in our study, this difference did not reach statistical significance, consistent with multiple previous reports.[5,6,9,23] However, there are a number of studies that have reported significantly higher incidences of dysphagia in women.[2,13,21] The potential relationship between patient sex and postsurgical dysphagia remains to be clarified. Also consistent with previous reports,[2,6,13,21,23] no significant association between age and dysphagia was found in our study.

Lee et al.[13] proposed that greater difficulty in soft-tissue dissection and anterior exposure in revision surgeries can lead to increased risk for esophageal and nerve compromise, which can contribute to higher rates of dysphagia. Their follow-up data at both 1 and 2 years suggest a significantly higher incidence of dysphagia in the revision group compared with the primary surgery group (29.7% vs 12.9% at 1 year, $p < 0.01$; 27.7 vs 11.3% at 2 years, $p < 0.01$). In contrast, we found no significant association between previous anterior cervical spine surgery and development of dysphagia ($p = 0.141$) or between previous cervical spine surgery and postsurgical dysphagia ($p = 0.711$).

Controversy remains regarding whether the number of cervical levels treated is associated with the development of postoperative dysphagia. Our study found that the number of anterior levels exposed was significantly associated with the development of postoperative dysphagia ($p = 0.004$). Our results support the findings of Kalb et al.,[9] who also reported that patients who developed dysphagia postoperatively had significantly more anterior cervical levels treated than those who did not develop dysphagia. Other studies have also found increased risk for dysphagia with increased numbers of levels of anterior exposure; Danto et al.[6] found that patients who underwent anterior cervical spine surgeries involving 4 or 5 vertebral levels had a significant (4-fold) increase in risk for dysphagia compared with patients who underwent only single-level surgeries. Lee et al.[13] reported that patients who underwent surgery at more than 2 levels had significantly higher rates of dysphagia at 2-year follow-up than did patients who had surgery at 2 or fewer levels. Bazaz et al.[2] and Riley et al.[23] both reported that patients who underwent anterior cervical surgery at 2 or more levels had a significantly higher risk for development of dysphagia than patients who underwent single-level surgery. It is probable that with increased level of anterior exposure there is a corresponding increase in tissue and nerve compromise that may favor development of postoperative dysphagia. However, in contrast, there are a few studies that found no significant correlation between the number of levels treated and the development of dysphagia.[5,28] There are few reports of dysphagia following a posterior approach to the cervical spine, although in the present study we did not confirm this association. It is possible that differences in rates of dysphagia and the association between dysphagia and numbers of surgically treated levels may relate to differences in patient populations, diagnoses, classification of dysphagia, and the surgeon's technique.

The specific cervical levels treated from an anterior cervical approach have also been evaluated as potential risk factors for the development of postoperative dysphagia. In contrast to other studies,[5,9,13,23,28] our study showed that exposure above C-4 was significantly associated with postoperative dysphagia. Notably, all patients in the dysphagia group had surgeries that included levels above C-4, compared with only 58.8% in the no-dysphagia group. Surgeries involving higher cervical levels may require more manipulation and traction compared with those involving lower levels. This may be associated with greater direct traction and manipulation of the oropharynx and may place the superior laryngeal nerve at greater risk of compromise, resulting in increased risk of developing dysphagia postoperatively. Consistent with previous studies,[2,13,23,28] we did not find a significant association between the use of an anterior plate and development of postoperative dysphagia.

In a retrospective study of 29 patients who underwent occipitocervicothoracic fusion, Miyata et al.[16] proposed that postoperative dysphagia was associated with oropharyngeal stenosis resulting from correction of the occiput–C2 angle. Their study demonstrated significant differences in the change of the occiput–C2 angle and the percentage change of the oropharyngeal space between those that did and did not develop dysphagia (–13.4° vs 2.0°, $p = 0.0024$, and –45.8% vs 11.0%, $p = 0.0017$, respectively). Their study found a linear correlation between the change of the occiput–C2 angle and the percentage change of oropharyngeal space (Spearman $r = 0.49$, $p = 0.0068$). Ota et al.[18] also found a strong positive linear correlation between the 2 parameters in a different sample of 40 healthy volunteers (Spearman $r = 0.839$, $p < 0.001$). However, we did not find any significant difference in the change of occiput–C2 angle between the dysphagia and the no-dysphagia groups ($p = 0.711$), which is consistent with a report by Tian et al.[32] It is certainly possible that the lack of association between change in the occiput–C2 angle and development of dysphagia observed in the present study may be due to the lack of cases in which fusion included the occiput.

We observed a significant difference in the magni-

tude of change in lordosis (C2–7 angle) between the patients who developed dysphagia and those who did not ($p = 0.020$); patients in the dysphagia group had a significantly greater increase in C2–7 lordosis (24.1° vs 3.5°). This finding is consistent with the report from Tian et al.,[32] in which they reported that increasing change in C2–7 lordosis was significantly associated with increased risk for the development of postoperative dysphagia, and all patients in their series with long-term dysphagia had correction of the C2–7 angle that was greater than 5°. However, their study may have been limited by recall bias, since they relied on interviews at 1 year postoperatively to assess dysphagia. Although not without limitations, our study provides a more objective evaluation in the immediate postoperative period. Restoration of cervical lordosis is often the objective of cervical spine surgeries, but it is possible that dramatic corrections of cervical lordosis may be associated with greater risk of dysphagia. The development of dysphagia following large cervical lordosis corrections could be related to direct stretching effects on the esophagus and/or to compressive effects on the posterior pharyngeal wall by the anterior surface of the cervical spine.

It is important to recognize the limitations of our study. Our study was retrospective in design, with all the limitations and weakness inherent to retrospective designs. The relatively small numbers of patients and the heterogeneous treatments and diagnoses are also limitations. In addition, the study did not include standardized and formal speech/swallow evaluation for all patients both pre- and postoperatively. The number of patients with dysphagia may be an underestimation, as microaspiration without obvious symptoms may not have been detected by the nurse. Ideally, all patients should undergo formal evaluations in the immediate postoperative period. Our study identified some possible risk factors for dysphagia in the immediate postoperative period, but it lacked stringent follow-up of dysphagia resolution with formal evaluation. Patients in our study had subjective resolution of dysphagia within 12 months; however it is possible that patients may have subclinical aspiration beyond this time. In addition to immediate postoperative evaluations, formal evaluations should be performed at constant intervals to determine resolution of dysphagia. Taking into account the lack of outpatient follow-up data for 2 patients who had postoperative dysphagia, the resolution of dysphagia at 12 months in our study is at worst 85%. With consistent formal evaluation this number may be lower.

Conclusions

Dysphagia is a common complication following combined anterior-posterior cervical spine surgeries and is often associated with increased length of hospital stay. In our study, increased number of vertebral levels exposed anteriorly, anterior exposure that extended above C-4, and a greater correction of C2–7 lordosis were risk factors associated with increased risk for postoperative dysphagia. A large, prospective study with formal pre- and postoperative dysphagia evaluation may be warranted to further clarify the factors that increase the risk for dysphagia following cervical spinal surgeries using either combined or isolated approaches.

Disclosure

Dr. Shaffrey reports receiving royalties from or holding patents with Biomet and Medtronic and serving as a consultant for Nuvasive, Globus, Biomet, Medtronic, and Stryker. Dr. Smith reports serving as a consultant for Biomet, Globus, DePuy, and Medtronic and receiving support for non–study related clinical or research effort from DePuy. Dr. Fu reports serving as a consultant for Medtronic.

Author contributions to the study and manuscript preparation include the following. Conception and design: all authors. Acquisition of data: Chen, Saulle, Fu. Analysis and interpretation of data: Smith, Chen, Saulle, Fu. Drafting the article: Smith, Chen, Saulle, Fu. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Smith. Statistical analysis: Smith. Administrative/technical/material support: Shaffrey. Study supervision: Shaffrey.

References

1. Aryan HE, Sanchez-Mejia RO, Ben-Haim S, Ames CP: Successful treatment of cervical myelopathy with minimal morbidity by circumferential decompression and fusion. **Eur Spine J 16:**1401–1409, 2007
2. Bazaz R, Lee MJ, Yoo JU: Incidence of dysphagia after anterior cervical spine surgery: a prospective study. **Spine (Phila Pa 1976) 27:**2453–2458, 2002
3. Bose B: Anterior cervical fusion using Caspar plating: analysis of results and review of the literature. **Surg Neurol 49:**25–31, 1998
4. Campbell PG, Yadla S, Malone J, Zussman B, Maltenfort MG, Sharan AD, et al: Early complications related to approach in cervical spine surgery: single-center prospective study. **World Neurosurg 74:**363–368, 2010
5. Chin KR, Eiszner JR, Adams SB Jr: Role of plate thickness as a cause of dysphagia after anterior cervical fusion. **Spine (Phila Pa 1976) 32:**2585–2590, 2007
6. Danto J, DiCapua J, Nardi D, Pekmezaris R, Moise G, Lesser M, et al: Multiple cervical levels: increased risk of dysphagia and dysphonia during anterior cervical discectomy. **J Neurosurg Anesthesiol 24:**350–355, 2012
7. Fehlings MG, Smith JS, Kopjar B, Arnold PM, Yoon ST, Vaccaro AR, et al: Perioperative and delayed complications associated with the surgical treatment of cervical spondylotic myelopathy based on 302 patients from the AOSpine North America Cervical Spondylotic Myelopathy Study. Clinical article. **J Neurosurg Spine 16:**425–432, 2012
8. Hart RA, Tatsumi RL, Hiratzka JR, Yoo JU: Perioperative complications of combined anterior and posterior cervical decompression and fusion crossing the cervico-thoracic junction. **Spine (Phila Pa 1976) 33:**2887–2891, 2008
9. Kalb S, Reis MT, Cowperthwaite MC, Fox DJ, Lefevre R, Theodore N, et al: Dysphagia after anterior cervical spine surgery: incidence and risk factors. **World Neurosurg 77:**183–187, 2012
10. Kang SH, Kim DK, Seo KM, Kim KT, Kim YB: Multi-level spinal fusion and postoperative prevertebral thickness increase the risk of dysphagia after anterior cervical spine surgery. **J Clin Neurosci 18:**1369–1373, 2011
11. Kim PK, Alexander JT: Indications for circumferential surgery for cervical spondylotic myelopathy. **Spine J 6 (6 Suppl):** 299S–307S, 2006
12. 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 18:**406–409, 2005

13. 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 7:**141–147, 2007
14. Lunsford LD, Bissonette DJ, Jannetta PJ, Sheptak PE, Zorub DS: Anterior surgery for cervical disc disease. Part 1: Treatment of lateral cervical disc herniation in 253 cases. **J Neurosurg 53:**1–11, 1980
15. McAfee PC, Bohlman HH, Ducker TB, Zeidman SM, Goldstein JA: One-stage anterior cervical decompression and posterior stabilization. A study of one hundred patients with a minimum of two years of follow-up. **J Bone Joint Surg Am 77:**1791–1800, 1995
16. Miyata M, Neo M, Fujibayashi S, Ito H, Takemoto M, Nakamura T: O-C2 angle as a predictor of dyspnea and/or dysphagia after occipitocervical fusion. **Spine (Phila Pa 1976) 34:**184–188, 2009
17. Mummaneni PV, Dhall SS, Rodts GE, Haid RW: Circumferential fusion for cervical kyphotic deformity. Clinical article. **J Neurosurg Spine 9:**515–521, 2008
18. Ota M, Neo M, Aoyama T, Ishizaki T, Fujibayashi S, Takemoto M, et al: Impact of the O-C2 angle on the oropharyngeal space in normal patients. **Spine (Phila Pa 1976) 36:**E720–E726, 2011
19. Pal GP, Routal RV: A study of weight transmission through the cervical and upper thoracic regions of the vertebral column in man. **J Anat 148:**245–261, 1986
20. Pal GP, Sherk HH: The vertical stability of the cervical spine. **Spine (Phila Pa 1976) 13:**447–449, 1988
21. 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) 32:**1089–1093, 2007
22. 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 469:**658–665, 2011
23. Riley LH III, 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) 30:**2564–2569, 2005
24. Riley LH III, Vaccaro AR, Dettori JR, Hashimoto R: Postoperative dysphagia in anterior cervical spine surgery. **Spine (Phila Pa 1976) 35 (9 Suppl):**S76–S85, 2010
25. Sasso RC, Ruggiero RA Jr, Reilly TM, Hall PV: Early reconstruction failures after multilevel cervical corpectomy. **Spine (Phila Pa 1976) 28:**140–142, 2003
26. Schultz KD Jr, McLaughlin MR, Haid RW Jr, Comey CH, Rodts GE Jr, Alexander J: Single-stage anterior-posterior decompression and stabilization for complex cervical spine disorders. **J Neurosurg 93 (2 Suppl):**214–221, 2000
27. Shields LBE, Raque GH, Glassman SD, Campbell M, Vitaz T, Harpring J, et al: Adverse effects associated with high-dose recombinant human bone morphogenetic protein-2 use in anterior cervical spine fusion. **Spine (Phila Pa 1976) 31:**542–547, 2006
28. 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) 29:**1441–1446, 2004
29. Smucker JD, Rhee JM, Singh K, Yoon ST, Heller JG: Increased swelling complications associated with off-label usage of rhBMP-2 in the anterior cervical spine. **Spine (Phila Pa 1976) 31:**2813–2819, 2006
30. Song KJ, Johnson JS, Choi BR, Wang JC, Lee KB: Anterior fusion alone compared with combined anterior and posterior fusion for the treatment of degenerative cervical kyphosis. **J Bone Joint Surg Br 92:**1548–1552, 2010
31. Tervonen H, Niemelä M, Lauri ER, Back L, Juvas A, Räsänen P, et al: Dysphonia and dysphagia after anterior cervical decompression. **J Neurosurg Spine 7:**124–130, 2007
32. Tian W, Yu J: The role of C2-C7 and O-C2 angle in the development of dysphagia after cervical spine surgery. **Dysphagia 28:**131–138, 2013
33. Yue WM, Brodner W, Highland TR: Persistent swallowing and voice problems after anterior cervical discectomy and fusion with allograft and plating: a 5- to 11-year follow-up study. **Eur Spine J 14:**677–682, 2005
34. Zdeblick TA, Hughes SS, Riew KD, Bohlman HH: Failed anterior cervical discectomy and arthrodesis. Analysis and treatment of thirty-five patients. **J Bone Joint Surg Am 79:** 523–532, 1997

Manuscript submitted December 17, 2012.
Accepted June 6, 2013.
Please include this information when citing this paper: published online July 12, 2013; DOI: 10.3171/2013.6.SPINE121134.

Address correspondence to: Justin S. Smith, M.D., Ph.D., University of Virginia Medical Center, Department of Neurosurgery, P.O. Box 800212, Charlottesville, VA 22908. email: jss7f@virgina.edu.