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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

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Clinical article

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Object. Rates of complications associated with the surgical treatment of cervical spondylotic myelopathy (CSM) are not clear. Appreciating these risks is important for patient counseling and quality improvement. The authors sought to assess the rates of and risk factors associated with perioperative and delayed complications associated with the surgical treatment of CSM.

Methods. Data from the AOSpine North America Cervical Spondylotic Myelopathy Study, a prospective, multicenter study, were analyzed. Outcomes data, including adverse events, were collected in a standardized manner and externally monitored. Rates of perioperative complications (within 30 days of surgery) and delayed complications (31 days to 2 years following surgery) were tabulated and stratified based on clinical factors.

Results. The study enrolled 302 patients (mean age 57 years, range 29–86) years. Of 332 reported adverse events, 73 were classified as perioperative complications (25 major and 48 minor) in 47 patients (overall perioperative complication rate of 15.6%). The most common perioperative complications included minor cardiopulmonary events (3.0%), dysphagia (3.0%), and superficial wound infection (2.3%). Perioperative worsening of myelopathy was reported in 4 patients (1.3%). Based on 275 patients who completed 2 years of follow-up, there were 14 delayed complications (8 minor, 6 major) in 12 patients, for an overall delayed complication rate of 4.4%. Of patients treated with anterior-only (n = 176), posterior-only (n = 107), and combined anterior-posterior (n = 19) procedures, 11%, 19%, and 37%, respectively, had 1 or more perioperative complications. Compared with anterior-only approaches, posterior-only approaches had a higher rate of wound infection (0.6% vs 4.7%, $p = 0.030$). Dysphagia was more common with combined anterior-posterior procedures (21.1%) compared with anterior-only procedures (2.3%) or posterior-only procedures (0.9%) ($p < 0.001$). The incidence of C-5 radiculopathy was not associated with the surgical approach ($p = 0.8$). The occurrence of perioperative complications was associated with increased age ($p = 0.006$), combined anterior-posterior procedures ($p = 0.016$), increased operative time ($p = 0.009$), and increased operative blood loss ($p = 0.005$), but it was not associated with comorbidity score, body mass index, modified Japanese Orthopaedic Association score, smoking status, anterior-only versus posterior-only approach, or specific procedures. Multivariate analysis of factors associated with minor or major complications identified age (OR 1.029, 95% CI 1.002–1.057, $p = 0.035$) and operative time (OR 1.005, 95% CI 1.002–1.008, $p = 0.001$). Multivariate analysis of factors associated with major complications identified age (OR 1.054, 95% CI 1.015–1.094, $p = 0.006$) and combined anterior-posterior procedures (OR 5.297, 95% CI 1.626–17.256, $p = 0.006$).

Conclusions. For the surgical treatment of CSM, the vast majority of complications were treatable and without long-term impact. Multivariate factors associated with an increased risk of complications include greater age, increased operative time, and use of combined anterior-posterior procedures.

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Key Words • **fusion** • **surgery** • **complication** • **laminoplasty** • **cervical spondylotic myelopathy**

Cervical spondylotic myelopathy is a progressive, degenerative disease that results in compression of the cervical spinal cord or nerve roots, leading to neurological dysfunction.[6,9,17,22,28,32] Although CSM often warrants surgical treatment, the associated complications have not been well defined.

Abbreviations used in this paper: BMI = body mass index; CSM = cervical spondylotic myelopathy; mJOA = modified Japanese Orthopaedic Association.

Prior reports have documented rates of complications associated with the surgical treatment of CSM,[1–4,6–8,11,12,14–16,18–20,31,33] but the data from these reports have key limitations, including retrospective design,[2–4,7,8,11,12,14–16,18–20,31,33] reporting of a single-surgeon or single-institution experience,[1,2,4,7,8,11,12,14,16,18,19,31] and reliance solely on inpatient ICD-9 codes.[3] In addition, many of these prior reports are based on small numbers of patients, which may be inadequate to estimate rates of less common complications.[4,7,8,12,16,19,33] Defining these risks is important for patient counseling and quality improvement.

Our objectives were to assess the rates of perioperative and delayed complications associated with the surgical treatment of CSM based on a prospective multicenter study and to determine clinical and surgical factors associated with the occurrence of perioperative complications.

Methods

Patient Population

The AOSpine North America Cervical Spondylotic Myelopathy Study is a recently completed prospective, multicenter study of patients surgically treated for CSM.[9] A total of 302 symptomatic patients with radiographically confirmed CSM were enrolled at 12 sites in the United States and 1 site in Canada between December 2005 and September 2007. Participating sites were selected from the membership of SpineNet, the clinical research network of AOSpine North America, a nonprofit organization for spine education and research. Sites were selected based on multiple factors, including expressed interest in study participation, past experience with similar clinical studies, and recognized reputation in the field of cervical spine surgery. All centers were either academic teaching centers or high-volume private practices, with a predominance of the former. Participants included both orthopedic surgeons and neurosurgeons, and all had practices that were predominantly focused on spine care. Most sites included either 1 or 2 contributing surgeons.

Consecutive patients were offered enrollment in the study, but a low number of patients declined enrollment. Patient inclusion criteria included age of 18 years or more, presence of symptomatic CSM, including clinical signs of myelopathy, MRI or CT myelography demonstrating objective cervical spinal cord compression, no prior surgical treatment for CSM, and no symptomatic lumbar stenosis. There were no enrollment criteria based on duration of symptoms or prior nonsurgical treatment. The operative approach, whether anterior, posterior, or combined anterior-posterior, was at the discretion of the operating surgeon. A baseline mJOA score was obtained preoperatively and used to classify CSM severity as mild (mJOA score ≥ 15), moderate (12–14), or severe (< 12). Internal review board approval was obtained from all participating sites.

Data Collection

Standardized forms were used to collect clinical and surgical data, including a detailed accounting of operative, postoperative, and delayed complications. Data collection forms included a predetermined list of 30 complications that may be associated with the surgical treatment of CSM (Table 1). All other complications were also collected and specified in a free-text format. For the purposes of this study, there were no central criteria for the definition of pseudarthrosis. Determination of pseudarthrosis was per standard of care at each participating institution. The AOSpine North America Study, including the collection of complications, was externally monitored to ensure that the data were accurate, reliable, and complete.

TABLE 1: Complication categories for which data were prospectively collected in cases of surgically treated CSM

Complication Category
pseudarthrosis
instrumentation failure
screw malposition
nonunion
C-5 radiculopathy
axial pain (nuchal or periscapular pain or neck fatigue)
new intractable neck pain
adjacent-segment degeneration (defined as the development of a new radiculopathy or myelopathy referable to a segment adjacent to a previously fused level)
instability
reoperation
dural tear
epidural hematoma
deep infection
new/additional iatrogenic fractures during op
deep venous thrombosis
superficial infection
graft site pain >6 mos postop
dysphagia
dysphonia
progression of myelopathy
new radiculopathy
periop worsening of myelopathy
graft dislodgment/migration
graft site pain
postop kyphosis
cardiopulmonary complications
relevant bleeding complications
thromboembolism
stroke
cortical blindness
other

Each center had a study coordinator that monitored the inpatient and outpatient medical record, and each site was audited for completeness of data entry for outcomes and complications by an external monitor to verify that complications were not missed. Records were reviewed regularly throughout postsurgery hospitalization and were reviewed at each predetermined visit (6, 12, and 24 months) and at any unplanned follow-up visits.

All reported adverse events were reviewed, and each adverse event was judged as to whether it constituted a po-

tential complication related to the surgical procedure by a panel of 4 physicians (M.G.F., J.S.S., B.K., and C.I.S.). Complications were further classified as minor or major. Complications were distinguished as major if they required invasive intervention, had permanent or prolonged morbidity, or resulted in substantial prolongation of hospital stay. Perioperative complications (within 30 days of surgery) and delayed complications (occurring between 30 days and 2 years of surgery) were collected and analyzed for the present study.

Comorbidities were quantified based on standardized forms completed for each patient at baseline. The presence of disease and severity (mild, moderate, or severe) for each of the following were collected: myocardial infarction, angina/coronary artery disease, congestive heart failure, arrhythmias, hypertension, venous disease, peripheral arterial disease, respiratory disease, hepatic disease, stomach/intestine disease, pancreas disease, end-stage renal disease, diabetes mellitus, psychiatric disease, rheumatological disease, stroke, paralysis, and neuromuscular disease. A comorbidity score was calculated for each patient by summing assigned points for each condition present, with 1, 2, and 3 points given for mild, moderate, and severe disease, respectively, for each of the aforementioned conditions.

Statistical Analysis

Frequency distributions and summary statistics were calculated for all clinical and operative variables. For categorical variables, cross-tabulations were generated, and the Fisher exact or Pearson chi-square tests was used to compare distributions. For continuous variables, t-tests or ANOVA tests were used to investigate differences in the distribution between subsets of patients classified by categorical data. Statistical analyses were 2 sided, and $p < 0.05$ was considered statistically significant. Mean values are presented ± SD.

Multiple clinical and surgical factors were assessed for association with the occurrence of perioperative complications (minor or major) based on univariate analysis. In addition, binomial logistic regression analysis using a forward step-wise approach was used to assess for best-fit models of clinical and surgical factors associated with the either occurrence of any complication (minor or major) or with the occurrence of a major perioperative complication. Because the operative blood loss data were not normally distributed, these data were converted to ranked values for statistical comparisons.

Results

Patient Population

A total of 302 patients met inclusion criteria and underwent surgery for CSM. The mean patient age was 57 years (range 29–86 years) and included 178 men and 124 women. The mean comorbidity score was 1.7 ± 1.9 (range 0–10). The mean BMI was 29.0 (range 17.2–53.1), and 76 patients (25%) were smokers. A history of cervical surgery (not for CSM) was reported by 17 patients (6%). Mild, moderate, and severe CSM (based on mJOA scores) was present in 99 (33%), 111 (37%), and 92 (30%) patients, respectively. Operative treatment included anterior-only (n = 176 [58%]), posterior-only (n = 107 [35%]), and combined anterior-posterior (n = 19 [6%]) procedures. Fusion, laminoplasty, and posterior decompression without fusion were performed in 85%, 13%, and 2%, respectively. The mean number of spinal levels operated was 3.9 ± 1.3, and the mean operative time and mean operative blood loss were 186 ± 89 minutes and 279 ± 535 ml, respectively.

Perioperative and Delayed Complications

Of 332 reported adverse events, 73 were judged to be perioperative complications, including 25 major and 48 minor (Table 2). The 73 complications occurred in a total of 47 patients, for an overall perioperative complication rate of 15.6%. The 48 minor complications occurred in a total of 35 patients, for an overall perioperative minor complication rate of 11.6%, and the 25 major complications occurred in a total of 21 patients, for an overall perioperative major complication rate of 7.0%. A single death (0.3%) was reported in which the patient was found in cardiopulmonary arrest during the postoperative hospital stay.

Of the total 302 patients, 2 withdrew from the study prior to completion, 3 died of causes unrelated to surgery

TABLE 2: Perioperative complications in 302 patients surgically treated for CSM*

Periop Complication	No. of Complications		
	Total (%)	Minor	Major
cardiopulmonary	10 (3.3)	9	1
infection			
superficial	7 (2.3)	5	2
deep	2 (0.7)		2
dysphagia	9 (3.0)	9	
C-5 radiculopathy/palsy	5 (1.7)	4	1
worsened myelopathy	4 (1.3)		4
radiculopathy/palsy (not C-5)	3 (1.0)	3	
epidural/wound hematoma	3 (1.0)	1	2
durotomy	3 (1.0)	3	
instrumentation malposition/migration	3 (1.0)	2	1
renal complications	2 (0.7)		2
worsened axial neck pain	2 (0.7)	2	
altered mental status	2 (0.7)	1	1
death	1 (0.3)		1
stroke	1 (0.3)		1
new neurological deficit (other)	1 (0.3)		1
pulmonary embolism	1 (0.3)		1
reoperation (not otherwise specified)	1 (0.3)		1
pneumonia	1 (0.3)	1	
dysphonia	1 (0.3)		1
wound dehiscence	1 (0.3)		1
miscellaneous	10 (3.3)	8	2
no. of patients affected (%)	47 (15.6)	35 (11.6)	21 (7.0)

* Complications were categorized as major if they required invasive intervention, had permanent or prolonged morbidity, or resulted in substantial prolongation of hospital stay.

during the 2-year follow up, and 22 patients lacked complete follow-up data. This resulted in a total of 275 patients for assessment of delayed complications. Among these patients, there were 14 delayed complications, including 8 minor and 6 major complications (Table 3). The 14 delayed complications occurred in a total of 12 patients, for an overall delayed complication rate of 4.4%. The 8 minor complications occurred in a total of 7 patients, for an overall delayed minor complication rate of 2.5%, and the 6 major complications occurred in a total of 6 patients, for an overall delayed major complication rate of 2.2%. Of the 12 patients with 1 or more delayed complications (14 overall), 12 underwent surgical procedures using anterior-only approaches, 1 underwent a posterior-only procedure (delayed complication of symptomatic adjacent-level disease), and 1 underwent a combined anterior-posterior procedure (delayed complication of pseudarthrosis). Of the 5 patients in whom pseudarthrosis developed, 2 (40%) were smokers. Among patients who underwent a fusion procedure, the pseudarthrosis rate was 1.7% for nonsmokers and was 3.2% for smokers ($p = 0.61$).

Factors Associated With Perioperative Complications

Of the patient factors assessed for association with the occurrence of perioperative complications (minor or major), only older patient age proved significant (Table 4). The comorbidity score was also not significantly associated with the occurrence of major perioperative complications ($p = 0.45$). Diabetes mellitus, present in 15% of patients (45 of 302), was not significantly associated with the occurrence of infection ($p = 1.0$), combined minor or major complications ($p = 0.26$), or major complications ($p = 0.75$). Seventeen patients (5.6%) had a history of cervical surgery performed for an indication other than CSM, and none of these patients was reported to have had a perioperative complication.

Of patients treated with anterior-only, posterior-only, and combined anterior-posterior procedures, 11%, 19%, and 37%, respectively, had 1 or more complications (Table 5). The rate of complications did not differ significantly between anterior-only (11%) and posterior-only (19%) procedures ($p = 0.11$), but the rate of complications was significantly higher for combined anterior-posterior procedures (37%) compared with the anterior-only or posterior-only procedures (14%) ($p = 0.016$). The occurrence of complications was also significantly associated with increased operative time ($p = 0.009$) and with increased operative blood loss ($p = 0.005$) (Table 5).

TABLE 3: Delayed complications in 275 patients surgically treated for CSM*

Late Complication	Total (%) (n = 275)	No. of Complications	
		Minor	Major
pseudarthrosis	5 (1.8)	2	3
postop deformity (kyphosis)	2 (0.7)	1	1
symptomatic adjacent-level disease	2 (0.7)	1	1
instrumentation/graft migration	2 (0.7)	2	
instrumentation failure	1 (0.4)	1	
superficial infection	1 (0.4)	1	
delayed dysphagia	1 (0.4)		1
no. of patients affected (%)	12 (4.4)	7 (2.5)	6 (2.2)

* A delayed complication was defined as one occurring 31 days to 2 years after surgery. Complications were considered as major if they required invasive intervention, had permanent or prolonged morbidity, or resulted in substantial prolongation of hospital stay.

TABLE 4: Perioperative complications (minor or major) associated with surgery for CSM stratified by patient factors*

Factor	Periop Complication		p Value
	No	Yes	
age (yrs)†	56 ± 12	61 ± 12	0.006
sex (%)			0.75
M	149 (84)	29 (16)	
F	106 (85)	18 (15)	
comorbidity score†	1.7 (2.0)	1.6 (1.7)	0.84
BMI†	29 (6)	28 (6)	0.48
baseline mJOA score†	12.9 (2.7)	12.3 (3.5)	0.28
smoker (%)			0.47
no	193 (85)	33 (15)	
yes	62 (82)	14 (18)	

* Patient comorbidities were quantified based on standardized forms completed for each patient at baseline. The presence of disease and disease severity (mild, moderate, or severe) were determined for each of 18 comorbidity categories. A comorbidity score was calculated for each patient by summing assigned points for each condition present, with 1, 2, and 3 points given for mild, moderate, and severe disease, respectively, for each of the 18 conditions. See text for further details.
† Except for the p value, data are presented as the mean ± SD.

Binomial logistic regression analysis was performed to identify best-fit models of clinical and surgical factors associated with any perioperative complication. The best-fit model for factors associated with the occurrence any complication (minor or major) included patient age (OR 1.029, 95% CI 1.002–1.057, $p = 0.035$) and operative time (OR 1.005, 95% CI 1.002–1.008, $p = 0.001$). Odds ratios for age and operative time are per year and per minute of surgery, respectively. Factors not included in the best-fit model included sex, comorbidity score, BMI, smoking status, baseline mJOA score, operative blood loss, whether a combined anterior-posterior procedure was performed, history of cervical surgery (not for CSM), whether an anterior or posterior procedure was performed, number of levels surgically treated, and whether the procedure included a laminoplasty or a corpectomy ($p > 0.05$).

Binomial logistic regression analysis was also performed to assess for clinical and surgical factors associated with any major perioperative complication. The best-fit model for factors associated with the occurrence of a major complication included patient age (OR 1.054, 95% CI 1.015–1.094, $p = 0.006$) and performance of a combined anterior-posterior procedure (OR 5.297, 95% CI 1.626–17.256, $p = 0.006$). Odds ratio for age is per year. Factors

TABLE 5: Perioperative complications (minor or major) associated with surgery for CSM stratified by surgical factors

Factor	Periop Complication		p Value
	No	Yes	
surgical approach (%)			0.11
anterior only	156 (89)	20 (11)	
posterior only	87 (81)	20 (19)	
no. of stages (%)			0.016
1 (anterior or posterior)	243 (86)	40 (14)	
2 (anterior-posterior)	12 (63)	7 (37)	
operated vertebrae*	3.8 ± 1.3	4.2 ± 1.3	0.067
spinal fusion performed (%)			0.82
no	38 (86)	6 (14)	
yes	217 (84)	41 (16)	
fusion approach (%)			0.064
anterior only	153 (88)	20 (12)	
posterior only	52 (79)	14 (21)	
laminoplasty performed (%)			0.48
no	221 (84)	43 (16)	
yes	34 (89)	4 (11)	
corpectomy performed (%)			0.84
no	211 (85)	38 (15)	
yes	44 (83)	9 (17)	
op duration (mins)*	178 ± 74	233 ± 138	0.009
op blood loss			
ranked values*	144 ± 83	183 ± 93	0.005
amount (ml)*	216 ± 243	622 ± 1192	

* Values are presented as the mean ± SD.

not included in the best-fit model included sex, comorbidity score, BMI, smoking status, baseline mJOA score, operative blood loss, operative time, history of cervical surgery (not for CSM), whether an anterior or posterior procedure was performed, number of levels operated, and whether the procedure included a laminoplasty or a corpectomy ($p > 0.05$).

Single-Approach Versus Combined Anterior-Posterior Approach Cases

Compared with patients treated with a single surgical approach (anterior- or posterior-only), patients treated with a combined anterior-posterior approach had a trend toward greater cervical disease at baseline (mJOA score of 11.6 vs 12.9, $p = 0.051$) and had a lower baseline BMI (25.9 vs 29.2, $p = 0.027$). In addition, the surgical procedure included a modestly, but significantly, greater number of spinal levels for the combined anterior-posterior procedures, compared with the single-approach cases (4.47 vs 3.86 levels, respectively, $p = 0.042$). There were no significant differences between the single and combined approach groups with regard to patient age (56 vs 60 years, respectively, $p = 0.18$) or baseline comorbidity score (1.63 vs 1.95, respectively, $p = 0.48$).

Laminoplasty Versus Posterior Cervical Decompression and Fusion for CSM

Patients treated with laminoplasty and those treated with posterior decompression and fusion did not significantly differ with regard to age or baseline disease severity (Table 6). The operative time and the surgical blood loss were significantly less for laminoplasty procedures than posterior decompression and fusion procedures ($p < 0.001$ and $p < 0.001$; Table 6). Although the overall complication rate was higher in the posterior fusion group (24.4%) than the laminoplasty group (11.8%), this did not reach statistical significance ($p = 0.14$). Similarly, there were trends toward higher rates of wound infection and dysphagia in the posterior fusion group, but these did not reach statistical significance (Table 6). The incidence of major complications and of C-5 radiculopathy/palsy did not differ significantly between the 2 groups.

Anterior-Only Versus Posterior-Only Surgery for CSM

Compared with patients treated with an anterior-only approach, patients treated with a posterior-only procedure were significantly older (62.9 vs 52.3 years, respectively, $p < 0.001$) and had greater baseline disease severity (mJOA score of 11.8 vs 13.6, respectively, $p < 0.001$) (Table 7). Although the operative time was remarkably similar between the 2 groups, the operative blood loss was significantly greater for the posterior-only procedures ($p < 0.001$). The posterior-only approach had a significantly greater incidence of wound infection (4.7%) than the anterior-only approach (0.6%, 1 of 176 cases [a superficial infection, resolved with antibiotic treatment]) ($p = 0.030$). The anterior- and posterior-only groups did not differ significantly with regard to the overall complication rates ($p = 0.11$), major complication rates ($p = 0.61$), incidence of C-5 radiculopathy/palsy ($p = 1.000$), or the incidence of dysphagia ($p =$

TABLE 6: Comparison of laminoplasty versus posterior cervical decompression and fusion in CSM*

Factor	Surgical Procedure		p Value
	Laminoplasty (n = 34)	Pst Decomp & Fusion (n = 82)	
age (yrs)†	61.9 ± 10.6	62.9 ± 11.5	0.65
baseline mJOA score†	12.5 ± 2.7	11.7 ± 3.0	0.18
op duration (mins)†	150 ± 53	225 ± 115	<0.001
surgical EBL in ml (mean rank)‡	198 (169)	476 (211)	<0.001
minor &/or major complication (%)	4 (11.8)	20 (24.4)	0.14
major complication (%)	2 (5.9)	7 (8.5)	1.00
wound infection (%)	1 (2.9)	7 (8.5)	0.43
C-5 radiculopathy/palsy (%)	1 (2.9)	1 (1.2)	0.50
dysphagia (%)	0 (0.0)	5 (6.1)	0.32

* Decomp = decompression; EBL = estimated blood loss; Pst = posterior.

† Values are presented as the mean ± SD.

‡ The p value for comparison of surgical estimated blood loss is based on ranked values, since these data were not normally distributed.

TABLE 7: Comparison of anterior-only and posterior-only surgery in CSM*

Factor	Surgical Procedure		p Value
	Ant-Only (n = 176)	Pst-Only (n = 107)	
age (yrs)†	52.3 ± 10.9	62.9 ± 11.1	<0.001
baseline mJOA score†	13.6 ± 2.5	11.8 ± 3.0	<0.001
op duration (mins)†	176 ± 71	182 ± 87	0.55
surgical EBL in ml (mean rank)‡	170 (115)	381 (199)	<0.001
minor &/or major complication (%)	20 (11.4)	20 (18.7)	0.11
major complication (%)	9 (5.1)	7 (6.5)	0.61
wound infection (%)	1 (0.6)	5 (4.7)	0.030
C-5 radiculopathy/palsy (%)	3 (1.7)	2 (1.9)	1.00
dysphagia (%)	4 (2.3)	1 (0.9)	0.65

* Ant = anterior; Pst = posterior.

† Values are presented as the mean ± SD.

‡ The p value for comparison of surgical estimated blood loss is based on ranked values, because these data were not normally distributed.

0.65). Although the rate of dysphagia did not differ significantly these procedures, it was significantly higher for combined anterior-posterior procedures (21.1%, $p < 0.001$). In patients in whom an anterior-only approach was used, there was no significant association between patient age and the occurrence of dysphagia ($p = 0.92$).

Discussion

This study provides rates of perioperative and delayed complications associated with the surgical treatment of CSM, based on a prospective, multicenter, externally monitored clinical study of more than 300 patients. The overall perioperative complication rate was 15.6%, and the overall perioperative minor and major complication rates were 11.6% and 7.0%, respectively. A low rate of neurological complications was observed, and the vast majority of the reported complications are treatable and without long-term impact. The overall delayed complication rate was 4.4%, and the overall delayed minor and major complication rates were 2.5% and 2.2%, respectively. This study also demonstrates that the factors associated with perioperative complications are predominantly surgical factors, including blood loss, duration of surgery, and performance of combined anterior-posterior procedures.

In the present study, the incidence of C-5 radiculopathy/palsy was 1.7%. This rate is lower than that in previous reports that have focused on this specific complication.[11,14,15] Imagama et al.[15] reported an incidence of C-5 palsy of 2.3% in 1858 patients treated with cervical laminoplasty. Ikenaga et al.[14] noted a 3.2% incidence of postoperative C-5 radiculopathy in 563 patients treated with anterior decompression for cervical myelopathy. Hashimoto and associates[11] reported an 8.5% incidence of C-5 palsy in 199 patients who underwent anterior decompression for cervical degenerative disease. Each of these studies was primarily focused on the assessment of postoperative C-5 radiculopathy, and the lower rate of this complication in the present study, despite the prospective design, may relate to the lack of appreciation of more subtle cases of C-5 radiculopathy. Instead, the present study focused on clinically apparent and significant cases. Consistent with prior reports, in the present study postoperative C-5 radiculopathy occurred in association with both posterior- and anterior-only procedures, and there was no significant difference in the rates based on surgical approach.

The rates of dysphagia and dysphonia following anterior cervical surgery are highly dependent on the magnitude and duration of symptoms required for the condition to be considered abnormal. Reported rates of dysphagia following anterior cervical discectomy and fusion range from 0% to 24%.[5,10,13,21,23,24,26,27,29,30] The rate of dysphagia in the present study (3%) is on the lower end of the reported range, and this may reflect the lack of specific screening for cases with mild severity or a brief duration in the present study. Instead, the present study focused on clinically apparent and significant forms of this complication. It is interesting to note the remarkably high rate of dysphagia with combined anterior-posterior procedures in the present study (21.3%); however, it is important to recognize that this rate is based on only 19 patients. Although we do not have a clear explanation for this high rate, it is possible that patients requiring combined anterior and posterior procedures had greater disease severity than those treated with anterior- or posterior-only approaches. In the present study, procedures including a posterior approach had a significantly higher rate of infection than anterior-only procedures. This is consistent with prior studies that have suggested that, compared with posterior spinal fusions, anterior spinal fusions have lower overall rates of postoperative infection.[25]

The only patient factor assessed that had a significant association with the occurrence of complications was patient age. No associations with complications were identified for comorbidity score, BMI, CSM severity, or smoking status. This assessment was confined to perioperative complications, and the greatest impact of some patient factors may be expected to manifest beyond the perioperative period, such as development of pseudarthrosis due to smoking. However, the overall rate of delayed complications was only approximately 5%, and no clear association between smoking and pseudarthrosis could be demonstrated.

It is interesting to note that rates of complications were not significantly associated with either the surgical approach used (anterior-only vs posterior-only) or the specific surgical procedures performed. However, there was a trend, which narrowly missed significance, for posterior approaches to be associated with higher rates of complications. Anterior fusions and posterior fusions had similar rates of minor and major complications, and whether the procedure included a laminoplasty or corpectomy did not significantly impact the overall rate of complications.

Multivariate assessments of factors associated with the occurrence of complications identified patient age, operative time, and use of combined anterior-posterior procedures in the best-fit models. That older patient age is associated with a greater risk of complications in general is not unexpected, since older age may reflect a lower tolerance of surgical procedures and older patients may have more

substantial degenerative spinal pathology. The incorporation of operative time into the best-fit model for occurrence of any complication (minor or major) likely reflects its role as a general surrogate of case complexity. The use of combined anterior-posterior procedures was incorporated into the best-fit model for the occurrence of major complications, which suggests that use of single-approach procedures, when feasible, may help to minimize morbidity.

Strengths of the present study include the prospective multicenter design with standardized collection of complications, including both perioperative and delayed complications. In addition, external monitoring was performed to ensure that the data were accurate, reliable, and complete. Limitations of this study include the lack of specific objective assessment of dysphonia and dysphagia, which may result in an underestimation of these complications. Other limitations include the lack of standardization of surgical treatment and the lack of central criteria for the determination of fusion.

Conclusions

The data derived from the present study provide benchmark rates for perioperative and delayed complications associated with the surgical treatment of CSM and demonstrate a low rate of neurological complications, with the vast majority of complications being treatable and without a long-term impact. Increased risks of complications were not associated with anterior versus posterior approaches or with specific surgical procedures (for example, fusion, corpectomy, and laminoplasty). Multivariate factors associated with the occurrence of complications included older patient age, increased operative time, and use of combined anterior-posterior procedures.

Disclosure

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