Dysphagia after anterior cervical spine surgery: a systematic review of potential preventative measures

Andrei F. Joaquim, MD, PhD\textsuperscript{a}, Jozef Murar, MD\textsuperscript{b}, Jason W. Savage, MD\textsuperscript{b}, Alpesh A. Patel, MD, FACS\textsuperscript{b,*}

\textsuperscript{a}Department of Neurosurgery, State University of Campinas (UNICAMP), 13083-970 Campinas, SP, Brazil
\textsuperscript{b}Department of Orthopaedic Surgery, Northwestern University Feinberg School of Medicine, 676 N St Clair St, Suite 1350, Chicago, IL 60611, USA

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Abstract

BACKGROUND CONTEXT: Anterior cervical spine surgery is one of the most common spinal procedures performed around the world, but dysphagia is a frequent postoperative complication. Many factors have been associated with an increased risk of swallowing difficulties, including multilevel surgery, revision surgery, and female gender.

PURPOSE: The objective of this study was to review and define potential preventative measures that can decrease the incidence of dysphagia after anterior cervical spine surgery.

STUDY DESIGN: This was a systematic literature review.

METHODS: A systematic review in the Medline database was performed. Articles related to dysphagia after anterior cervical spine surgery and potential preventative measures were included.

RESULTS: Twenty articles met all inclusion and exclusion criteria. These articles reported several potential preventative measures to avoid postoperative dysphagia. Preoperative measures include performing tracheal exercises before the surgical procedure. Intraoperative measures can be summarized as avoiding a prolonged operative time and the use of recombinant human bone morphogenetic protein in routine anterior cervical spine surgery, using small and smoother cervical plates, using anchored spacers instead of plates, application of steroid before wound closure, performing arthroplasty instead of anterior cervical fusion for one-level disease, decreasing tracheal cuff pressure during medial retraction, using specific retractors, and changing the dissection plan.

CONCLUSIONS: Current literature supports several preventative measures that may decrease the incidence of postoperative dysphagia. Although the evidence is limited and weak, most of these measures did not appear to increase other complications and can be easily incorporated into a surgical practice, especially in patients who are at high risk for postoperative dysphagia.

Keywords: Dysphagia; Anterior cervical surgery; Preventative measures; Complications; Swallowing; Anterior cervical approach

Introduction

Anterior cervical spine surgery (ACSS) is a common procedure performed to treat many spine conditions, such as trauma and degenerative spinal disease. Many studies have reported that one of the most common complications after ACSS is dysphagia [1–3]. The reported incidence of dysphagia is widely variable and is likely due to the

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* Corresponding author. Department of Orthopaedic Surgery, Northwestern University Feinberg School of Medicine, 676 N St Clair St Suite 1350, Chicago, IL 60611, USA. Tel.: 312-695-6800.
E-mail address: alpesh2@gmail.com (A.A. Patel)
heterogeneity of the existing literature. However, an incidence of up to 71% has been reported in well-designed prospective studies that assess the dysphagia rate after surgery [4]. Several risk factors have been associated with an increase in postoperative dysphagia incidence, including multilevel surgery, revision procedures, female gender, older age, and involvement of C4–C5 and C5–C6 levels [5,6]. The objective of this study was to review potential measures that could be used to decrease the incidence and intensity of postoperative dysphagia after ACSS.

Material and methods


The search produced a total of 451 published articles. Abstracts were reviewed and included if dysphagia was a reported patient outcome measure and if the study investigated perioperative measures to reduce dysphagia after ACSS. Only articles written in English language (or translated text) were included. Exclusion criteria included case reports, literature reviews, and cadaveric or experimental studies in animals. Twenty-one articles were eligible after abstract screening and were fully reviewed. Of those, 20 articles were included based on the purpose of our review and our inclusion criteria. The articles selected were then classified according to evidence-based medicine criteria proposed by Wright et al. [7].

Results

The 20 articles that met all inclusion and exclusion criteria are summarized in Table 1, and the preventative measures proposed are described in Table 2. The following articles are described in the following:

Preoperative measures

Tracheal/esophageal traction exercise preoperative treatment

Chen et al. [8] proposed a preoperative exercise to improve the compliance of the trachea and the esophagus before ACSS. Chen et al. labeled the exercise as tracheal/esophageal traction exercise (TTE), which consisted of maneuvers that softly and gradually pushed off the thyroid cartilage at least 1 cm across the anterior midline of the neck. The TTE was performed twice per day, 15 counts each time, for 3 days, starting 4 days before the surgery. A total of 52 patients underwent TTE and 50 patients were the control group. The dysphagia was assessed using the Bazaz dysphagia score. One week postoperatively, the Bazaz dysphagia scores for patients with two- to four-level fusions in the TTE group were significantly better than those in the control group (p = .000 for the second- and third-level fusions and p = .013 for the fourth-level fusion). The same was observed at 3 weeks postoperatively, the two- to four-level fusion patients in the TTE group had better Bazaz scores than those in the control group (p = .000 for the second- and third-level fusions and p = .004 for the fourth-level fusion; Level II of Evidence).

Intraoperative measures

Avoiding a prolonged operative time

Rihn et al. [4] performed a prospective study to determine the incidence and severity of postoperative dysphagia after anterior cervical discectomy and fusion (ACDF). Thirty-eight patients who underwent one- or two-level ACDF were followed and compared with a control group of 56 patients who underwent posterior lumbar decompression. They observed a correlation between operative time and the severity of dysphagia after 12 weeks (p = .04; Level II of Evidence).

Bone morphogenetic proteins

Bone morphogenetic proteins (BMPs) have previously been shown to increase complications after ACSS. Bone morphogenetic proteins are characterized by osteoinductive properties, which make them a useful adjuvant in arthrodesis procedures to enhance bone fusion. They are commercially available in two forms: recombinant human BMP-2 (rhBMP-2) and BMP7 [9]. In our study, four articles relating the use of BMP and dysphagia after cervical spine procedures were found.

Tumialán et al. [10] reported the results of a retrospective review of 200 patients who underwent single or multilevel ACDF with titanium plate fixation and polyetheretherketone spacers filled with recombinant rhBMP-2 impregnated in a Type I collagen sponge to achieve fusion. After a mean of 16.7 months of follow-up (ranging from 8 to 36 months), good to excellent results were reported in 85% of the cases based on Odom criteria, with fusion obtained in 100% of patients. However, 14 patients (7%) had significant clinical dysphagia and four (2%) required reoperation for hematoma or seroma after surgery (Level IV of Evidence).

Buttermann [11] performed a prospective nonrandomized study of 66 patients who underwent a one- to three-level ACDF with iliac-crest bone autograft (36 patients) compared with a group of patients using BMP and allograft (30 patients). Although clinical and radiologic outcomes were similar between the groups, 15 patients (50%)

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<td>Buttermann [11], Level II</td>
<td>To compare the use of BMP plus bone allograft vs. iliac bone autograft in ACDF patients</td>
<td>Prospective nonrandomized study: 66 patients 1- to 3-level ACDF with either iliac-crest bone autograft or BMP allograft (0.9 mg BMP per level)</td>
<td>Both groups of patients had similar improvement in all outcome scales and neurologic recovery over the follow-up period</td>
<td>15 Patients (50%) with BMP had neck swelling (new-onset dysphagia) vs. 5 (14%) of the ACDF group. When considering patients operated for 2 levels, 10 (63%) of the 16 had neck swelling compared with 3 (16%) of 9 patients in the ACDF group. No statistical differences regarding pseudarthrosis between the groups. BMP allograft use was associated with higher costs and slightly shorter surgery time</td>
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<td>Chen et al [8], Level II</td>
<td>To investigate whether a new preoperative TTE treatment has an effect on postoperative dysphagia after anterior cervical spine surgery</td>
<td>Compared the neck disability index, VAS scores for arm and neck pain, and Bazaz dysphagia scores of 2 randomized groups. One group received TTE (52 patients) treatment for 3 consecutive days before surgery, whereas the control group did not (50 patients)</td>
<td>First week after operation: Bazaz dysphagia scores for patients with second- to fourth-level fusions in the TTE group were significantly better than those in the control group ($p=.000$ for second- and third-level fusions and $p=.013$ for fourth-level fusion). Also at 3 wk after surgery, the second- to fourth-level fusion patients in the TTE group had better Bazaz scores than those in the control group ($p=.000$ for second- and third-level fusions and $p=.004$ for fourth-level fusion)</td>
<td>Dysphagia could be reduced in patients with multiple-level fusion after anterior cervical spine surgery by preoperative TTE treatment. The baseline demographic characteristics of both groups were evaluated; no significant difference was observed between the characteristics in the TTE group and the control group</td>
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<td>Chin et al. [18], Level II</td>
<td>To determine whether patients with cervical plates protruding off the vertebral body more prominently than preexisting osteophytes had higher rates of dysphagia, suggesting a mechanical role</td>
<td>Osteophyte heights measured on the preoperative radiographs of 63 patients. After surgery (2-mm plate), the distance of the plate from the vertebral body was measured and compared with preoperative osteophyte heights. Group 1: 30 patients who had cervical plates protrude less than or equal to the height of the tallest preoperative osteophyte. Group 2: 34 patients who had plates protrude greater than the height of the tallest preoperative osteophyte</td>
<td>Five of 30 Group 1 patients had dysphagia ($&gt;1$ mo). Six of 34 Group 2 patients had dysphagia. There was no difference between Groups 1 and 2 in rate of dysphagia ($\beta=0.90$)</td>
<td>Long-term postoperative dysphagia in Group 1 patients and the lack of a difference in rates of dysphagia between Group 1 and Group 2 made it improbable plate thickness of 2 mm or prominence between 3 and 7 mm consistently played roles in dysphagia. Preoperative osteophyte height did not predict which patients developed postoperative dysphagia. Plates at the C3 and shorter constructs trended to have higher rates of dysphagia.</td>
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Fengbin et al. [25], Level II

To compare the degree of dysphagia between the lateral (LEO) and the medial (MEO) dissection to the omohyoid muscle

80 Patients were enrolled and divided into the MEO and LEO groups. Two-level ACDF—right-sided Smith-Robinson approach. Follow-up was obtained 1, 3, 6, and 12 wk and 6 mo after surgery. Dysphagia was assessed using a 14-item questionnaire from the SWAL-QOL survey.

There were no differences between the MEO and LEO groups with respect to general characteristics. Overall, the SWAL-QOL scores were not different between the 2 groups at any of the follow-up time points. When the level of surgery was taken into consideration, the early postoperative SWAL-QOL scores were significantly lower in the C3–C4 subgroup when the MEO approach was used. Conversely, the SWAL-QOL scores were significantly lower in the C6–C7 subgroup when the LEO approach was used.

The findings from this study suggest that the LEO approach should be selected if the level of surgery involves C3–C4. For C6–C7 surgery, however, a left-sided MEO approach should be used. Depending on surgeon’s preference, either approach can be used if both cervical levels are involved.

Finemberg et al. [9], 2013, Level III

A nationwide population-based database was analyzed to identify the incidence of complications and mortality associated with bone morphogenetic protein (BMP) utilization in cervical spine fusion surgery.

Data from the Nationwide Inpatient Sample was obtained for each year from 2002 to 2009. Patients undergoing anterior cervical fusion (ACF) or posterior cervical fusion (PCF) for diagnoses of cervical myelopathy and/or radiculopathy were identified and separated into cohorts 1–2 level and 3+ level fusions) and incidence of dysphagia was identified as well as use of BMP.

Overall complication rates were significantly greater when BMP was used in ACFs (p<.0005) because of a significantly higher rate of dysphagia (37.2 vs. 22.5 per 1,000 cases; p<.0005). BMP was used more frequently in 1–2 level ACFs with dysphagia (9.4 vs. 7.2% of cases). Independent predictors of dysphagia included age (>65 y), male gender, 3+ level fusion, BMP utilization, and preoperative comorbidities.

The study found “off-label” use of BMP as an adjunct to cervical fusions was associated with increased rates of dysphagia in ACFs and increased costs for all cervical fusions. The study did not measure long-term outcomes after discharge; however the impact of increased in-hospital costs, LOS, and incidence of dysphagia with utilization of BMP should be considered before its use in cervical fusions.

Hofstetter et al. [21], Level III

To study clinical and radiologic outcomes after ACDF using a zero-profile anchored spacer (LDR) compared with a standard interposition graft with anterior plating.

Retrospective cohort study. 70 patients: 35 patients underwent ACDF with anterior plating and the remaining patients received an LDR device. Dysphagia occurring in the immediate postoperative period and lasting for >3 mo was recorded.

Both the zero-profile anchored spacer and a standard interposition graft with anterior plating resulted in improvement of neurologic outcome at a mean follow-up time of 13.9 mo. Fusion rates were found to be similar between ACDF with anterior plating (96.0%) and LDR (95.2%).

7 Patients (20%) with ACDF and plating complained about swallowing difficulties beyond 3 mo compared with only 1 patient with the LDR device (p=.027). The severity of dysphagia was mild in all but 2 patients. Both patients with moderate and severe swallowing difficulties had undergone ACDF with anterior plating.

The use of a smaller and smoother profile plate such as the Zephyr does reduce the incidence of dysphagia.

Lee et al. [19], Level II

To compare the incidence, prevalence, and rate of improvement of dysphagia in 156 Consecutive patients undergoing anterior cervical spine surgery with plate fixation. Compared the Atlantis plate group had higher incidences of dysphagia than the Zephyr group at all time points.

The use of a smaller and smoother profile plate such as the Zephyr does reduce the incidence of dysphagia.

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<td>patients undergoing anterior cervical spine surgery with 2 different anterior instrumentation designs</td>
<td>incidence of dysphagia between the two different plate groups: the Atlantis plate has thicker and wider plate dimensions than the Zephir plate. Dysphagia evaluations were performed prospectively by telephone interviews at 1, 2, 6, 12, and 24 mo after the procedure. Risk factors were compared between the groups and were not statistically different.</td>
<td>except at the 2-mo follow-up point. The Atlantis plate group had a 14% incidence of dysphagia at 2 y compared with the Zephir group, which had a 0% incidence at 2 y (p&lt;.04). For primary surgeries, there was a higher incidence of dysphagia at all time points in the Atlantis group compared with the Zephir group (58% vs. 43%, 35% vs. 30%, 22% vs. 10%, 17% vs. 0%, and 13% vs. 0% at 1, 2, 6, 12, and 24 mo, respectively) (p&lt;.04 at 1 y). A regression analysis was performed.</td>
<td>dysphagia compared with a slightly larger and less smooth plate such as the Atlantis. The resulting formulas predict that the permanent rate of dysphagia for the Atlantis group is 13.6% and for the Zephir group is 3.58%.</td>
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<td>Lee et al. [26], Level II</td>
<td>To analyze the effect of local retropharyngeal steroid to reduce prevertebral soft-tissue swelling (PSTS) after ACDF</td>
<td>Fifty 1–2 level ACDF cases enrolled. 25 Cases as the steroid group (mixture of triamcinolone and morcellized collagen sponge) applied to the retropharyngeal space before wound closure. 25 Cases—control group—no steroid. Measured the PSTS ratio to vertebral body from C3 to C7 and PSTS index Simple lateral radiographs were taken preoperatively, immediately after operation, and postoperatively at 2 d, 4 d, 2 wk, and last follow-up. The changes in odynophagia, radiologic union, Neck Disability Index were analyzed.</td>
<td>The PSTS ratio of the steroid group was significantly lower on C3 and C4 immediately after operation, on C3, C4, C5, and C6 at 2 d postoperatively, on C3, C4, and C5 at 4 d postoperatively. The differences of PSTSI (the steroid: control group) maintained at 58.2:74.3% (p=.004) immediately after operation, 57.9:84.1% (p=.000) at 2 d, 56.3:82.9% (p=.000) at 4 d, 44.9:51.4% (p=.037) at 2 wk. The mean VAS score for odynophagia was significantly lower in the steroid group until 2 wk postoperatively (p=.000). The last follow-up showed no significant difference in the radiologic and clinical outcome.</td>
<td>The use of rhBMP-2 in patients undergoing 2-level ACDF significantly increases the severity of dysphagia (dysphagia score) without affecting the overall incidence of dysphagia. However, there is no statistically significant difference in the incidence or severity of dysphagia between patients undergoing 3- or 4-level ACDF treated with PEEK/rhBMP-2 and those treated with only allograft. The use of rhBMP-2...</td>
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<td>Lu et al. [12], Level III</td>
<td>Comparing the dysphagia rates of patients who have undergone multilevel ACDF using allograft spacers with those who underwent ACDF using polyetheretherketone (PEEK) cages filled with rhBMP2</td>
<td>Group 1 (BMP group)—100 patients—multilevel ACDF with PEEK cages filled with rhBMP-2 and instrumented with a cervical plate. Group 2 (allograft group)—control cohort of 50 patients who underwent multilevel ACDF with allograft spacers and anterior plate fixation. Patient demographics were not significantly different between the groups.</td>
<td>Complication rate: 13% in the BMP group compared with 8% in the allograft group (p&lt;.005). There was no significant difference in overall dysphagia incidence between the BMP group and the allograft group (40% vs. 44%, respectively; p&gt;.05). There was a significant difference in the severity of dysphagia (SWAL-QOL dysphagia scoring system) between the 2 groups: 0.757 for the BMP group vs. 0.596</td>
<td>The use of rhBMP-2 in patients undergoing 2-level ACDF significantly increases the severity of dysphagia (dysphagia score) without affecting the overall incidence of dysphagia. However, there is no statistically significant difference in the incidence or severity of dysphagia between patients undergoing 3- or 4-level ACDF treated with PEEK/rhBMP-2 and those treated with only allograft. The use of rhBMP-2...</td>
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for the allograft group (p<.005). There was no pseudarthrosis in Group 1 (the BMP group) compared with a 16% pseudarthrosis rate in Group 2 (the allograft group; p<.05). There was a weak correlation between the total rhBMP-2 dose and the dysphagia score (Kendall tau rank correlation coefficient 0.166, p=.046).

McAfee et al. [13], 2010, Level I

The dysphagia data for both PCM and ACDF patients were reviewed from 5 centers to (1) compare the severity of dysphagia, (2) compare the postoperative incidence of dysphagia, and (3) compare the resolution of perioperative dysphagia.

Patients with 1-level symptomatic cervical radiculopathy and/or myelopathy for progressive neurologic symptoms were randomized to undergo anterior decompression and PCM arthroplasty (N=151) or ACDF (control) (N=100). Patients self-reported dysphagia severity using the Bazaz scale preoperatively and at follow-up.

Both PCM and ACDF groups exhibited an initial postoperative problem with swallowing, but the PCM group continued to improve with time, whereas the ACDF only improved minimally. The PCM treatments indicated significantly lower incidence of dysphagia at 3 and 12 mo postoperatively compared with ACDF controls (p<.05). An increase in dysphagia severity at either the 6-wk or 3-mo follow-up visit was reported in 35 (42%) PCM and 29 (64%) ACDF subjects. Long-term resolution of these symptoms was noted in 74% (26/35) of the PCM subjects as compared with 41.4% (12/29) of the ACDF subjects (p=.015).

Mendonza-Lattes et al. [15], Level II

To explore the relationship between intraoperative intraesophageal pressure due to surgical retraction, esophageal mucosal blood flow at the level of surgery, and postoperative dysphagia.

17 Patients scheduled for anterior cervical arthrodesis—intraaluminal pressure in the upper esophageal sphincter was measured (mm Hg) with a custom-made manometer probe and mucosal perfusion was measured at the level of surgery with a laser Doppler flow meter. The type of retraction chosen by the surgeon was noted. Postoperatively, the patients were evaluated for dysphagia with the use of the MD Anderson Dysphagia Inventory.

4/11 Patients who had dynamic retraction and 5/6 patients who had static retraction during surgery had postoperative dysphagia. The patients with dysphagia had a significantly higher average intraluminal pressure (60.8±54.3 compared with 54.4±51.8 mm Hg; p<.0001) and significantly lower average mucosal perfusion (26.1±18.1 compared with 40.8±26.2 tissue perfusion units; p<.0001) in comparison with the asymptomatic patients.

Patients with dysphagia after anterior cervical arthrodesis were exposed to higher intraoperative esophageal pressure and decreased esophageal mucosal blood flow during surgical retraction compared with patients without dysphagia. In this small series, dynamic retraction seemed to be associated with a lower prevalence of postoperative dysphagia.

Miao et al. [22], Level II

To analyze the primary efficacy and safety of a new zero-profile implant named Zero-P in ACDF in a Chinese population.

89 Patients enrolled with cervical degenerative disc disease—prospectively treated by ACDF. 39 Patients had Zero-P implanted in

At 2, 6, and 12 mo follow-up, the JOA scores significantly increased and the VAS scores decreased correspondently compared with the asymptomatic patients.

The incidence of postoperative dysphagia and the long-term resolution of the dysphagia were greatly improved in the PCM group compared with the instrumented ACDF control group.

The primary clinical and radiographic efficacy of Zero-P used in ACDF was satisfactory. The device could improve and...
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<td>Papavero et al. [16], Level II</td>
<td>To investigate whether postoperative swallowing disturbances correlate with the amount of intraoperative retraction of the pharynx/esophagus wall measured during the procedure</td>
<td>An on-line pressure transducer between the retractor and pharynx/esophagus recorded the episophageal pressure in 92 patients. In 31 patients, a transducer was additionally inserted into the pharynx/esophagus to measure the endoesophageal pressure. The patients rated swallowing difficulty during the first postoperative 5 d using a 10-point score. A control group of 32 lumbar surgery patients was also evaluated.</td>
<td>Mean episophageal pressure after retractor opening was 76.3 mm Hg, and mean endoesophageal pressure was 16.3 mm Hg. An adjustment to 75% and 76%, respectively, of the initial value occurred within the first hour. 49.3% complained of swallowing disturbances—67.4% of women and only 36.2% of the men. No correlation between the amount of retraction and postoperative dysphagia was observed.</td>
<td>A correlation between intraoperative pharynx/esophagus retraction and postoperative swallowing disturbances could not be confirmed. The cause of the prevalence of the female gender is unknown. The absence of impaired deglutition in the control group suggests that a local phenomenon must be causative of swallowing disturbances after ACDF.</td>
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<td>Pattavilakom and Seex [17], Level II</td>
<td>To compare the conventional Cloward-style retractor (CRS) with the SRS (Seex retractor system) in a prospective randomized clinical trial</td>
<td>26 Patients were randomized to either the CRS or SRS before 1- or 2-level anterior cervical decompression and fusion. The pressure beneath the medial retractor blade was recorded with a thin pressure transducer strip. Postoperative sore throat, dysphagia, and dysphonia were assessed after 1, 7, and 28 d.</td>
<td>Complication rates were low with a trend favoring SRS that was not statistically different. Average retraction pressure with SRS was 1.9 mm Hg and with CRS was 5.6 mm Hg (p&lt;.001 on F test; p=.002 on 2-tailed t test). Mean average peak retraction pressure with the SRS was 3.4 mm Hg and with the CRS was 20 mm Hg (p&lt;.001 on F test; p=.005 on 2-tailed t test).</td>
<td>The new retractor was considered safe, and statistically similar complication rates were observed with the 2 systems. The SRS generated significantly less retraction pressure compared with the CRS. This difference can be explained by the different principles governing the function of these retractors.</td>
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<td>Qi et al. [20], Level III</td>
<td>To compare the clinical outcome and complications, including dysphagia, after anterior cervical fusion for the treatment of cervical spondylosis using either a zero-profile (Zero-P; Synthes) implant or an anterior cervical plate and cage</td>
<td>A total of 83 patients underwent fusion using a Zero-P and 107 patients underwent fusion using a plate and cage.</td>
<td>All patients in both groups had significant symptomatic and neurologic improvement. There was a higher incidence of dysphagia in the plate and cage group on the day after surgery and at 2 mo postoperatively. The mean SWAL-QOL score took longer to recover in the plate and cage group, leading to a statistically significant symptomatic and neurologic improvement.</td>
<td>Compared with the traditional anterior cervical plate and cage, the Zero-P implant was considered safe and convenient procedure giving good results in patients with symptomatic cervical spondylosis with a reduced incidence of dysphagia postoperatively.</td>
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Mean episophageal pressure after retractor opening was 76.3 mm Hg, and mean endoesophageal pressure was 16.3 mm Hg. An adjustment to 75% and 76%, respectively, of the initial value occurred within the first hour. 49.3% complained of swallowing disturbances—67.4% of women and only 36.2% of the men. No correlation between the amount of retraction and postoperative dysphagia was observed. A correlation between intraoperative pharynx/esophagus retraction and postoperative swallowing disturbances could not be confirmed. The cause of the prevalence of the female gender is unknown. The absence of impaired deglutition in the control group suggests that a local phenomenon must be causative of swallowing disturbances after ACDF.
Ratnaraj et al. [14], Level II

To determine whether the incidence of postoperative sore throat, hoarseness, and dysphagia associated with anterior spine surgery is reduced by maintaining endotracheal tube cuff pressure (ETCP) at 20 mm Hg during the period of neck retraction.

51 Patients scheduled for anterior cervical spine surgery were enrolled. After intubation, ETCP was adjusted to 20 mm Hg in all patients. After placement of neck retractors, ETCP was measured. Patients were randomized to a control (no adjustment—23 patients) or treatment group (ETCP adjusted to 20 mm Hg—27 patients). A blinded observer questioned the patients about the presence of sore throat, dysphagia, and hoarseness at 1 h, 24 h, and 1 wk postoperatively.

Rihn et al. [4], Level II

To determine the incidence and severity of dysphagia after ACDF using lumbar decompression patients as a control group and determine which factors were associated with increased postoperative dysphagia.

Prospective study to determine the incidence and severity of postoperative dysphagia after ACDF. Thirty-eight patients who underwent 1 or 2 levels ACDF were followed and compared with a control group of 56 patients who underwent posterior lumbar decompression.

Tumialán et al. [10], Level IV

To demonstrate the safety and efficacy of ACDF performed using titanium plates and PEEK spacers filled with rhBMP-2 impregnated in a Type I collagen sponge to achieve fusion.

Retrospectively reviewed 200 patients who underwent a single- or multilevel ACDF with titanium plate fixation and PEEK spacer filled with a collagen sponge impregnated with low-dose rhBMP-2.

significant difference in the degree of dysphagia between the groups at 2 mo (p = .011). All patients achieved fusion, and no graft migration or nonunion was observed.

The results of this study suggest the following 3 predictors of postoperative throat discomfort after anterior cervical spine surgery in which neck retraction is performed: increased ETCP during neck retraction (sore throat), neck retraction time (dysphagia), and female sex (sore throat and hoarseness). The simple maneuver of decreasing ETCP to 20 mm Hg may be helpful in improving patient comfort after anterior cervical spine surgery.

A single-level ACDF was performed in 96 patients, 2-level ACDF in 62 patients, 3-level ACDF in 36 patients, and 4-level ACDF in 6 patients. Long-term follow-up was available for 193 patients. Fourteen patients (7%) in this series experienced clinically significant dysphagia, and 4 (2%) required repeated operation for hematoma or seroma. In single- and 2-level fusions in which the total dose of rhBMP-2 was 0.7–1.05 and 1.4–2.10 mg, respectively, the resulting incidence of dysphagia was 1% and 3.2%, respectively. In 3- and 4-level fusions, in which the total dose of rhBMP-2 was 2.7–3.45 mg, the resulting incidence of dysphagia was 3% and 5.7%, respectively. Incidence of symptomatic dysphagia may be decreased with a lower dose of rhBMP-2 that is placed only within the PEEK spacer.
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<td>Vanek et al. [23], Level II</td>
<td>To compare clinical and radiologic efficacy of anterior cervical microdiscectomy and fusion done by the newly designed low-profile interbody spacer in cases of symptomatic cervical spine spondylosis</td>
<td>Prospective study of 77 patients undergoing anterior cervical interbody fusion of 1 or 2 motion segments from C3 to C7. Zero-P spacer was used in 44 patients (55 segments), and in 33 cases (41 segments), a stabilization was done using interbody spacer and dynamic anterior cervical plate.</td>
<td>dose of rhBMP-2 ranged from 2.1 to 3.15 and 2.8 to 4.2 mg, respectively, the incidence of dysphagia was 19.4% and 66%, respectively.</td>
<td>There was no significant difference in NDI values, presence of dysphagia (p=.308), and CobbC values during follow-up (p=.051) between both groups. A significant difference in the first 2 values of CobbS was found (p&lt;.001), but the next course of CobbS changes showed no difference in either group. There was not any difference in the radiologic stability during follow-up, and no revision surgery was done. The results of the presented study confirm biomechanical assumptions associated with the Zero-P spacer. Implantation of this new cage results in setting required biomechanical conditions in the treated segment, which are comparable to those when the segment is treated with a dynamic plate. However, the potential of the mentioned implant to reduce the incidence of postoperative dysphagia was not proven on this sample of patients.</td>
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<td>Yang et al. [24], Level III</td>
<td>To compare the clinical outcomes and radiologic changes of 3- and 4-level ACDF with stand-alone anchored spacers and with traditional anterior plates</td>
<td>51 Consecutive patients with cervical spondylotic myelopathy who underwent 3- or 4-level ACDF were divided into 2 groups: Group A (N=23) received anchored spacers and Group B (N=28) received an anterior plate.</td>
<td>Solid fusion was achieved in all patients. No significant difference existed between multilevel ACDF with stand-alone anchored implants and with an anterior cervical plate in achieving clinical symptomatic improvement, and lordotic curvature improvement. The dysphagia rate of Group A at 2-mo follow-up was significantly lower than that of Group B (p=.04) Swallowing Quality of Life of Group A at 48 h and 2 mo postoperatively was significantly higher than that of Group B. The thickness of the prevertebral soft tissue at 48 h and 2 mo postoperatively was significantly lower in Group A than in Group B.</td>
<td>Compared with using an anterior plate, ACDF with a stand-alone anchored spacer achieved a similar clinical outcome with less irritation to the prevertebral soft tissue and a lower dysphagia rate in the first 2 mo.</td>
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BMP, bone morphogenetic protein; ACDF, anterior cervical discectomy and fusion; TTE, tracheal/esophageal traction exercise; LOS, length of stay; rhBMP, recombinant human bone morphogenetic protein; PCM, porous coated motion; VAS, visual analog scale; JOA, Japanese Orthopaedic Association; NDI, Neck Disability Index; Cobb C, Cobb angle measured between the lower end plate of the second cervical vertebra and the lower end of the seventh cervical vertebra; Cobb S, Cobb angle of the treated segments.
receiving BMP experienced neck swelling and dysphagia compared with five patients (14%) in the iliac-crest group. Among patients who underwent a two-level fusion (25 patients total), the BMP group had 10 (63%) of 16 patients with dysphagia compared with three (16%) of nine patients. These results suggested a potential role of BMP in the development of dysphagia (Level II of Evidence).

Lu et al. [12] reported their experience in a retrospective study of 150 patients who underwent multilevel ACDF, divided into two groups: Group 1—patients who had a polyetheretherketone interbody spacer filled with rhBMP-2 and Group 2—patients with an allograft interbody spacer without rhBMP-2. The demographic characteristics between groups were similar. The complication rate in the BMP group was 13% compared with 8% in the allograft group (p<.005). The incidence of dysphagia was not statistically significant between groups (40% in the BMP vs. 44% in the allograft; p>.05), but the severity of dysphagia using the SWAL-QOL dysphagia scoring system was more pronounced in the BMP group than in the allograft group, 0.757 and 0.596, respectively (p<.0005). When subgroup analysis was performed, Lu et al. reported that the use of rhBMP-2 increased the severity of dysphagia in patients who underwent two-level ACDF (p<.005) but showed no difference between groups when three- or four-level ACDF cases were compared. There were no cases of pseudarthrosis in Group 1 (BMP) compared with a 16% pseudarthrosis rate in Group 2 (allograft; p<.05). The authors concluded that rhBMP-2 increased the severity of dysphagia in two levels ACDF but concurrently demonstrated that rhBMP-2 decreases the risk of pseudarthrosis (Level III of Evidence).

Fineberg et al. [9] performed a retrospective analysis of a nationwide inpatient database, from 2002 to 2009, seeking to identify the incidence of complications and mortality associated with “off-label” BMP use in cervical spine surgery. In a total of 213,421 anterior cervical spine procedures, the incidence of BMP use was 0.3% in 2002, 10.8% in 2007, and 8.5% in 2009. The complication rates when BMP was used for ACDF were 59.6 per 1,000 versus 39.8 per 1,000 when no BMP was used (p<.0005). The complication rates were elevated because of the increased incidence of dysphagia (37.2 with BMP vs. 22.5 per 1,000; p<.0005). The authors recommended that BMP use in ACDF procedures should be carefully monitored for complications of dysphagia in the early postoperative period (Level III of Evidence).

Cervical arthroplasty versus anterior cervical discectomy with plating

McAfee et al. [13] performed a five-center, prospective, randomized controlled study of 251 consecutive patients who underwent either a one-level cervical disc replacement or a one-level ACDF and compared the incidence, severity, and time for resolution of dysphagia using the Bazaz dysphagia scoring system. Arthroplasty was performed in 151 patients and ACDF in 100 patients. The Bazaz results demonstrate that both groups exhibited an initial postoperative problem with swallowing. However, patients who underwent porous coated motion (PCM) improved faster than patients who underwent ACDF. The incidence of dysphagia at 6 weeks and 3, 12, and 24 months postoperatively was lower (p<.05) in the PCM group compared with the ACDF group. Long-term resolution of these symptoms was noted in 74% (26 of 35) of the PCM subjects compared with 41.4% (12 of 29) of the ACDF subjects (p=.015). The authors’ conclusion was that the incidence and long-term resolution of postoperative dysphagia were greatly improved in the PCM group compared with the instrumented ACDF control group. Of note, the choice between arthroplasty and ACDF should not be performed based on the incidence of postoperative dysphagia incidence (Level I of Evidence).

Endotracheal tube cuff pressures and esophagus retraction

Ratnaraj et al. [14] evaluated whether the reduction of the endotracheal tube cuff pressure (ETCP) during anterior cervical exposure and tracheoesophageal retraction was associated with postoperative dysphagia. They studied 51 patients who underwent ACSS. After intubation, all patients had their ETCP adjusted to 20 mm Hg. After retractors were placed, the ETCP was measured again and patients were randomized to a control group (no adjustment—23 patients) or a treatment group (ETCP readjusted to 20 mm Hg—27 patients). Incidence of sore throat, dysphagia, and hoarseness was evaluated at 1 and 24 hours and 1 week postoperatively. There were no differences between the groups 1 hour postoperatively. However, at 24 hours, 51% of patients in the treatment group complained of sore throat compared with 74% of patients in the control group (p<.05); 65% of the women experienced sore throat compared with 35% of the men (p<.05). At 24 hours, longer retraction time also correlated with development of dysphagia (p<.05; r²=0.61). The authors concluded that an increased ETCP during neck retraction and a prolonged time of retraction result in worsening of postoperative dysphagia. They also suggested that decreasing the ETCP to 20 mm Hg may be helpful in improving patient comfort postoperatively (Level II of Evidence).
Mendonca-Lattes et al. [15] studied the relationship between intraoesophageal pressure secondary to surgical retraction as well as esophageal mucosa flow during surgery and their association with postoperative dysphagia. They evaluated 17 patients and measured their intraluminal pressure in the upper esophageal sphincter using a custom-made manometer. Mucosal perfusion was also measured at the level of surgery using a laser Doppler flow meter. The type of retraction used by the assistant surgeon was also registered (dynamic in 11 cases and static in 6). Dysphagia was assessed using the MD Anderson Dysphagia Inventory. Four of 11 patients with dynamic retraction and five of six patients with static retraction had postoperative dysphagia. They reported that patients with dysphagia had a significantly higher average intraluminal pressure (60.8±54.3 mm Hg compared with 54.4±51.8 mm Hg; p<.0001), as well as significantly lower mucosal perfusion (26.1±18.1 compared with 40.8±26.2 tissue perfusion units; p<.0001) in comparison with the asymptomatic patients (Level II of Evidence).

Papavero et al. [16] used an on-lay pressure transducer to investigate whether the pressure between the retractor and the pharynx/esophagus correlated with postoperative swallowing problems in 92 patients. Thirty-one patients also had an additional manometer inserted into the pharynx and esophagus to measure the endoesophageal pressure. The mean epiesophageal pressure after retractor opening was 76.3 mm Hg, and the mean endoesophageal pressure was 16.3 mm Hg. An adjustment to 75% and 76%, respectively, of the initial value occurred within the first hour. The authors reported that there was no correlation between the amount of retraction and postoperative dysphagia in their series (Level II of Evidence).

Pattavilakom and Seex [17] compared the conventional Cloward-style retractor (CRS) with a new Seex retractor system (SRS) in a prospective randomized trial to evaluate postoperative swallowing problems after one- or two-level ACDF. The pressure beneath the medial retractor blade was recorded with a thin pressure transducer strip. Although complication rates were low and favored the SRS, there was no statistical difference between the groups. The SRS had an average retraction pressure of 1.9 mm Hg compared with 5.6 mm Hg with CRS (p<.001 on F test; p=.002 on two-tailed t test). Mean average peak retraction pressure was 3.4 mm Hg with the SRS and 20 mm Hg with the CRS (p<.001 on F test; p=.005 on two-tailed t test). The authors concluded that the new retractor system reduces retraction pressure based on different principles of retraction, although its benefits were not clinically demonstrated (Level II of Evidence).

Plate thickness and design

Chin et al. [18] investigated the effect of plate thickness on dysphagia. The authors identified plate prominence and compared it with preexisting osteophytes to determine the effect of the plate on postoperative dysphagia. Osteophyte heights on radiographs were measured preoperatively in 63 patients who underwent ACDF using a 2-mm plate. Postoperatively, the distance of the plate from the vertebral body was measured and the patients were divided into two groups. In Group 1, there were 30 patients with cervical plates protruding less than or equal to the height of the tallest preoperative osteophyte. Group 2 had 34 patients with plates protruding greater than the height of the tallest preoperative osteophyte. There was no difference between groups in the rate of dysphagia (5 of 30 patients in Group 1 vs. 6 of 34 patients in Group 2—β=0.90). The authors concluded that postoperative plate prominence, relative to preoperative osteophyte height, did not predict postoperative dysphagia (Level II of Evidence).

Lee et al. [19] compared the incidence, prevalence, and rate of improvement of dysphagia in 156 patients undergoing ACSS with two different plates with different dimensions. One plate (Atlantis; Medtronic, Memphis, TN, USA) has thicker and wider plate dimensions compared with the other plate (Zephir; Medtronic, Memphis, TN, USA). The dysphagia status was assessed prospectively by telephone interviews. The Atlantis group had higher incidences of dysphagia than the Zephir group at all time points except at 2 months. At 2 years, the incidence of dysphagia in the thicker Atlantis plate was 14% compared with 0% with the thinner Zephir plate (p<.04). The authors concluded that the use of a smaller profile plate can reduce the incidence of dysphagia (Level II of Evidence).

Qi et al. [20] compared postoperative complications, including dysphagia, in a group of patients who underwent anterior cervical spine procedures using a zero-profile implant (Zero-P; Synthes, Paoli, PA, USA) compared with a group of patients who underwent a fusion using a plate and an interbody device. Eighty-three patients underwent fusion with the Zero-P compared with 107 patients with a plate and an interbody device. Both groups had a similar neurologic improvement, but there was a higher incidence of dysphagia in the plate and interbody device group 1 day and 2 months postoperatively. The authors concluded that the zero-profile implant was safe to use and reduced the incidence of dysphagia postoperatively (Level III of Evidence).

Hofstetter et al. [21] performed a retrospective cohort study looking at clinical and radiographic outcomes, including dysphagia, of 70 consecutive patients, 35 who underwent ACDF using a zero-profile anchored spacer compared with 35 who underwent ACDF with a standard interposition graft with anterior plating. Dysphagia that occurred in the immediate postoperative period and lasted for more than 3 months was recorded. Both groups had similar neurologic outcomes and fusion rates, but seven patients (20%) with standard grafting and plating complained of swallowing difficulty beyond 3 months compared with only one in the zero-profile group (p=.027). Evaluation of postoperative radiographs also demonstrated there was significantly more swelling in the prevertebral space in the standard group compared with the zero-profile group.
Dissection plan—lateral or medial to the omohyoid muscle

Fengbin et al. [25] performed a randomized prospective study looking at the incidence of dysphagia between two variations of the Smith-Robinson surgical approach to the anterior spine used for ACDF. Eighty patients undergoing two-level ACSSs were randomized to two surgical groups: 40 patients underwent cervical dissection lateral (LEO) to the omohyoid muscle and 40 patients underwent cervical dissection medial (MEO) to the omohyoid muscle. Both groups were similar in general characteristics and did not have significant differences in dysphagia scores at any follow-up time points as assessed with the SWAL-QOL questionnaire. However, when the level of surgery was taken into consideration, early postoperative SWAL-QOL scores were significantly lower in the C3–C4 subgroup when the MEO approach was used. Conversely, the SWAL-QOL scores were significantly lower in the C6–C7 subgroup when the LEO approach was used. The authors suggested that either approach can be used if both cervical levels are involved; however, they suggest using the LEO approach if surgery involves C3–C4 and the MEO approach for C6–C7 (Level II of Evidence).

Steroid in the retropharyngeal region

Lee et al. [26] analyzed the effect of steroids in the reduction of retropharyngeal prevertebral soft-tissue swelling (PSTS) and dysphagia symptoms after ACDF. Fifty patients who underwent ACDF involving one or two levels were randomized into two groups. The steroid group consisted of 25 patients who received a mixture of triamcinolone and morcellized collagen sponge in the retropharyngeal space before wound closure. The control group consisted of 25 patients who did not receive any steroid. Prevertebral soft-tissue swelling was measured on lateral X-rays taken pre- and postoperatively.

The steroid group was found to have significantly lower PSTS ratio on C3 and C4 immediately after operation, on C3, C4, C5, and C6 at 2 days postoperatively, and on C3, C4, and C5 at 4 days postoperatively. The mean visual analog scale for odynophagia was significantly lower in the steroid group until 2 weeks postoperatively (p=.000). At the last follow-up, there were no differences in the radiologic and clinical outcomes. The authors concluded that using retropharyngeal local steroid significantly reduced PSTS and odynophagia after ACDF without additional complications in the early postoperative period when PSTS-related complications are the highest (Level II of Evidence).

Discussion

Many risk factors are associated with postoperative dysphagia after ACSS. The incidence varies from 1.7% to as high as 71%, probably due to differences in study designs and definition/measurements of dysphagia after ACSS [4,27]. Fortunately, most of the times, symptoms are mild and transitory, decreasing over the weeks, although 12% to 14% of the patients can present persistent dysphagia even after 1 year [27]. The most probable explanation for dysphagia after ACSS is that it is a multifactorial phenomenon, explained by esophageal retraction, direct cervical plate stimulating the esophagus, prevertebral swelling, among others [27].

Although not included in the purpose of our review, combined cervical approaches (anterior and posterior) can have higher risks of postoperative dysphagia compared with isolated anterior approaches [28]. The role of the posterior cervical approach in the incidence of dysphagia is still debated. Chen et al. reported the results of 30
consecutive patients who underwent same-day anteroposterior cervical approaches. Postoperative dysphagia was detected in 13 patients (43.3%), and risk factors for dysphagia were multilevel surgery (5.1 vs. 4.0—mean numbers of anterior levels surgically treated in patients with and without dysphagia, respectively, p = .004). All the 13 patients with dysphagia had surgery above C4 compared with 58.8% of the patients without dysphagia (p = .010). The last risk factor reported by the authors was greater correction of C2–C7 lordosis after surgery in the dysphagia group (p = .020), probably because lordosis can direct stretching the esophagus and/or compress the posterior pharyngeal wall in the anterior surface of the spine. We can also infer that greater correction of cervical kyphosis is associated with more levels of anterior discectomy and a longer operative time, potential confounding factors. Interestingly, the authors did not have an increase in the incidence of dysphagia with plating. Some known risk factors for postoperative ACSS dysphagia, such as female gender and revision surgery (probably due to a more difficult soft-tissue dissection increasing tissue damage), are not potential targets for preventative measures for decrease in the incidence of dysphagia after surgery, for obvious reasons [5,29]. However, our review pointed some potential measures that can be used to reduce postoperative dysphagia after ACSS in different clinical scenarios:

**Preoperative traction exercises**

Preoperative TTE may improve the compliance of the trachea and esophagus, which can decrease dysphagia in multilevel fusions [8]. The TTEs should be performed twice a day, 15 counts each time, for 3 days, starting at least 4 days before the surgery. This measure can be used specially in situations associated with an increased risk, such as multilevel or revision surgeries.

**Avoid a prolonged operative time**

A prolonged operative time was the only variable that correlates with the severity of dysphagia after 12 weeks in the prospective series reported by Rihn et al. [4]. Other variables such as gender, age, and body mass index did not have correlation with the symptoms. For instance, in complex cervical cases in which a long operative time is predicted, senior surgeons would probably have less dysphagia after surgery than fellows or residents.

**Avoid routine use of rhBMP**

There is evidence that the use of BMP can increase the incidence and intensity of postoperative dysphagia after ACSSs [9–11]. One of the potential mechanisms that can lead to dysphagia after BMP use is an increase in the incidence of swelling after ACSS [30,31]. BMP should, therefore, not be used in the anterior cervical spine. Exceptions, such as revision surgery or patient who may be at high risk for pseudarthrosis, can be considered for BMP use but a thorough risk-benefit discussion should be performed with careful inpatient monitoring of patients postoperatively.

**Endotracheal tube cuff pressure**

Reduction of ETCPs after the placement of neck retractors can decrease intensity of dysphagia after ACSS because ischemic changes in tracheal mucosa can be responsible for postoperative sore throat and dysphagia [14,15]. However, one study reported no relation between pressure in the esophagus and dysphagia [16]. Although further studies are needed, current reduction of cuff pressures can be easily incorporated to the anesthesiologist team without increase in patients’ complications.

**Cervical retractors**

Changing the type of the cervical retractors used during ACSS can potentially decrease the incidence of dysphagia. Dynamic retraction as opposed to static self-retaining retraction may reduce dysphagia by preventing prolonged pressure and ischemia. A self-retaining retractor left in place during the whole procedure is probably going to put more pressure on the trachea and esophagus than small retractors just placed when exposure is need and moved frequently, resulting in more soft-tissue swelling.

**Cervical plate choice**

Choosing a low-profile, small, and smooth cervical plate may influence the incidence of dysphagia after ACSS [5]. The relationship between the plate directly posterior to the esophagus may affect esophagus motility. Although the cervical plate may play a role in postoperative dysphagia, our literature review obtained controversial results about this issue, with one study suggesting that plate prominence did not correlate to postoperative dysphagia [18], whereas others suggesting that low-profile plates had a lower incidence of symptoms. Better-designed studies are necessary to clarify this issue [19].

**Anchored spacer**

Using an anchored spacer (“zero-profile”) implant instead of plating may decrease postoperative dysphagia [20–24]. The potential mechanisms to decrease dysphagia in such cases include decreasing esophageal injury, hematoma, and scar formation around the anterior plate [32]. However, one prospective study did not show benefits regarding dysphagia using this new system [23]. Similar to cervical plating, Level I studies are necessary to clarify the benefits of an anchored spacer in dysphagia incidence.

**Surgical approach**

Changing the surgical plan according to the operative level to one that is lateral to the omohyoid muscle at C3–C4...
and medial to this muscle at C6–7 may decrease the incidence of postoperative dysphagia [25]. Lateral dissection to the omohyoid at C3–C4 can decrease injury to internal branches of the superior laryngeal nerve, which can decrease the incidence of postoperative dysphagia. Critically evaluating this information, many surgeons divided the omohyoid muscle during ACSS, after complications related to its ligation are not reported. Further studies addressing the surgical approach and dysphagia severity are necessary before solid conclusions.

Local steroid delivery

Application of a steroid injection in the retropharyngeal region after wound closure may decrease soft-tissue swelling and inflammatory response, both of which could decrease esophageal inflammation and the incidence of postoperative dysphagia [26]. However, although ACSS has a low incidence of infection compared with posterior approach, an additional risk can be added to the procedure with steroid use and surgeons should be attempt to that. The use of local steroid can be considered especially in patients with high risk for develop dysphagia, such as women, multilevel or revision surgeries, or an expected long operative time.

As conclusion, this review identified many potential preventative measures that may decrease the intensity or incidence of postoperative dysphagia after ACSS. Most of these measures do not appear to have a risk of additional complications and can therefore be safely incorporated into surgical practice, especially in high-risk patients. Although the evidence is limited and weak, our review also suggests directions for future research to help decrease dysphagia-related problems after ACSS.

References


