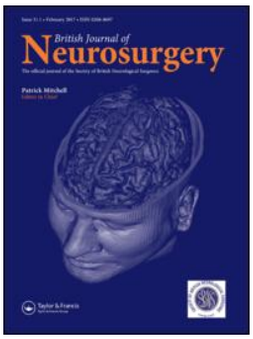

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ORIGINAL ARTICLE

Safety for cervical corpectomy and diskectomy: univariate and multivariate analysis on predictors for prolonged ICU stay after anterior spinal fusion

David Y. C. Chan[a], Wai K. Mak[a], David T. F. Sun[a], Richard C. Y. Mok[a], Amelia Y. Ng[b], Patricia K.Y. Kan[b], George K. C. Wong[a], Danny T. M. Chan[a] and Wai S. Poon[a]

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ABSTRACT

Aim: Cervical anterior spinal fusion (ASF) with corpectomy has risks of catastrophic acute complications such as airway obstruction requiring re-intubation. Our team has adopted a management plan for all cervical corpectomy patients to be admitted to the intensive care unit (ICU) after the operations for overnight observation. Some of these patients were kept intubated after the operations and transferred to the ICU. This study aims to review the outcome of this practice and to identify independent predictors associated with a prolonged ICU stay.

Methods: We reviewed consecutive patients with cervical ASF from January 2010 to June 2018. The primary outcome was the ICU length of stay. Univariate and multivariate analyses were conducted to identify independent risk factors associated with a prolonged ICU stay. In total, 103 patients had ASF during the study period. ICU length of stay for elective ASF was 1.01 day (SD 0.373 days) and was significantly shorter than that for emergency ASF (13.29 days, SD 12.57 days) ($p < 0.001$). 79.6% (82/103) of the ASF patients were extubated in the operating theatre after surgery. Significantly more corpectomy patients (33.3%) versus ACDF patients (15.1%) were kept intubated to the ICU after the operation ($p = 0.037$). None required reintubation in the ICU. 90.9% (80/88) of the elective ASF can be discharged from the ICU within 24 hours and only 3.41% (3/88) of the elective ASF had prolonged post-operative stay in the ICU (≥48 hours).

Results: For prolonged postoperative ICU stay (≥48 hours), ICU admission airway status of ASF patients who were either extubated in the OT or kept intubated to ICU had no significant association ($p = 0.903$). Univariate and multivariate analysis had identified emergency admissions ($p = 0.043$) and the presence of postoperative neurological deficits ($p = 0.031$) as independent predictors associated with a prolonged postoperative ICU stay.

Conclusion: In conclusion, cervical corpectomy and ASF were safe with minimal acute complications.

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KEYWORDS
Corpectomy; anterior cervical discectomy; anterior cervical fusion; neurosurgical intensive care

Introduction

Anterior cervical spinal surgery with corpectomy is a more demanding procedure with risks of catastrophic acute complications such as airway obstruction. Unplanned re-intubation, emergency cricothyroidotomy or emergency tracheostomy were considered as airway emergencies. Our unit has adopted a management plan for all cervical corpectomy patients to be admitted to the intensive care unit (ICU) after the operation for overnight observation. Some of these patients were kept intubated after the operations and transferred to the ICU. The study aims to review the outcome of this practice by analyzing the length of stay in ICU and to review the rate of acute postoperative complications.

Methods

We retrospectively reviewed consecutive patients with cervical anterior spinal fusion (ASF) under the care of the Division of Neurosurgery, Prince of Wales Hospital, Hong Kong, from January 2010 to June 2018. Data were prospectively collected in the Neurosurgery traumatic brain injury registry and spine registry. Data were anonymized and were analyzed retrospectively. Inclusion criteria for analysis including all consecutive patients aged 16 or above and were discharged from Prince of Wales Hospital during the period from January 2010 to June 2018. Exclusion criteria including patients with head injury with admission Abbreviated Injury Scale (AIS) greater than 4. Patients who received single staged anterior and posterior cervical spine operations in one single general anaesthesia and patients with cervical disc replacement (CDR) were also excluded. The primary outcome was to compare the length of stay (LOS) in the intensive care unit (ICU) including the duration of cervical corpectomy versus anterior cervical discectomy and fusion (ACDF) respectively. Univariate and multivariate analyses were conducted to identify independent risk factors associated with a prolonged ICU stay. Airway complications including unplanned re-intubation, emergency

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Table 1. Chi-square cross table showing a significantly higher proportion of corpectomy patients were keep intubated postoperatively upon transferal from the operating theatre (OT) to the intensive care unit (ICU).

Airway status upon postoperative ICU Admission	Airway protection with Endotracheal tube *in situ* from the Operating Theatre (OT) to ICU	Extubation in OT before transferal to ICU	Total	*p* Value
Types of anterior cervical spine surgery				
Corpectomy	33.3% (10)	66.7% (20)	30	0.037
Anterior cervical diskectomy and fusion (ACDF)	15.1% (11)	84.9% (62)	73	
Total	21	82	103	

OT: operating theatre; ICU: intensive care unit.

cricothyroidotomy or emergency tracheostomy were evaluated. For the surgical technique, all the cases had anterior cervical surgery via the right-sided approach. Other complications including hoarseness of voice, dysphagia, reoperation rates, neurological deficits, and death were analyzed.

Statistical analysis

Univariate and multivariate analysis were performed to identify independent factors associated with prolonged stay in the ICU. Variables considered in the statistical analysis including gender, age, mechanism of injury, presence of spinal fracture, emergency or elective admission, types of anterior cervical spinal operations, airway status upon ICU admission and presence of postoperative complications. Statistical analysis was performed with the Chi-square test, Fisher's exact test and unpaired *t*-test. Univariate analysis was performed with the general linear model. Multivariate analysis was performed with logistic regression. The corresponding odds ratio with a 95% confidence interval was included with significance set at 5%. Statistical analysis was performed with the Statistical Package for the Social Sciences for Microsoft Windows Version 25.0.0. (IBM SPSS Inc, Chicago, IL, USA).

Ethics approval was obtained from the Institutional Review Board of the study center: The Joint Chinese University of Hong Kong – New Territories East Cluster Clinical Research Ethics Committee. Informed consent was exempt given the retrospective nature of the study.

Table 2. Levels and number of corpectomy and anterior cervical diskectomy and fusion.

Operative level(s)	Number
Corpectomy	30
1-Level corpectomy	28
C3	2
C4	8
C5	6
C6	11
C7	1
2-Level corpectomy	2
C4, C5	1
C5, C6	1
Anterior cervical diskectomy and fusion (ACDF)	73
1-Level ACDF	51
C3/4	17
C4/5	13
C5/6	19
C6/7	2
2-Level ACDF	18
C3/4 C4/5	6
C4/5 C5/6	6
C4/5 C6/7	1
C5/6 C6/7	5
3-Level ACDF	4
C3/4 C4/5 C5/6	4
Operated level	
C3/4	27
C4/5	30
C5/6	34
C6/7	8
The total operated level of ACDF	99

ACDF: anterior cervical diskectomy and fusion.

Results

In total 103 patients had ASF during the study period. The average age was 56 years old (19–86 years old). There were 23 females and 80 males. Out of the 103 patients, 30 (29.1%) had cervical corpectomy performed (Table 1). 73 (70.9%) had anterior cervical diskectomy and fusion (ACDF) (Table 2).

The average ICU length of stay (LOS) after elective cervical corpectomy was 1.182 days (SD 0.480 days). It is comparable to post-operative ICU stay for elective ACDF, which was 0.9661 days ($p = 0.0680$) (Table 3). The average postoperative ICU stay for emergency cervical ASF was up to 13.29 days (SD 12.57) and it was significantly longer than the duration for elective ASF ($p < 0.001$) (Table 3).

79.6% (82/103) of the ASF patients were directly extubated in the operating theatre after surgery. Significantly more corpectomy patients (33.3%) versus ACDF patients (15.1%) were kept intubated to the ICU after the operation ($p = 0.037$). 77.67% (80/103) of the ASF patients can be discharged from the ICU within 24 hours after the operation. A majority (86.4%, 89/103) of the ASF patients can be discharged from the ICU within 48 hours. 90.9% (80/88) of the elective ASF can be discharged from the ICU within 24 hours and only 3.41% (3/88) of the elective ASF had prolonged post-operative stay in the ICU (≥48 hours) (Table 4).

None required reintubation in the ICU. None required emergency cricothyroidotomy nor emergency tracheostomy during the post-operative period.

Eighty-five patients (82.5%) had neurological improvement after the operation. For the acute complications, 12 (11.6%) developed transient hoarseness of voice (<1 week). 91.7% (11/12) recovered within 1 week (Figure 1) and all subsequently recovered within 3 months (Figure 2). None required re-intubation within 48 hours. 1 patient (0.97%) had epidural abscess requiring re-operation on postoperative Day 8.

For prolonged postoperative ICU stay (≥48 hours), operative procedures with either corpectomy ($p = 0.116$) or diskectomy ($p = 0.109$) had no significant association. ICU admission airway status of ASF patients who were either extubated in the OT or kept intubated after the operation upon admission to ICU had no significant association with prolonged postoperative ICU stay ($p = 0.903$). Univariate analysis and multivariate logistic regression had identified emergency admission ($p = 0.043$) and presence of

Table 3. Average hospital length of stay for elective cervical corpectomy and anterior cervical diskectomy and fusion (ACDF).

Elective OT LOS	Elective corpectomy (30 patients with 32 corpectomy level)	Elective ACDF (73 patients with 99 diskectomy level)	*p* Value
Average OT duration	337 mins (275 mins−430 mins)	170 mins (119 mins−315 mins)	<0.0001
Average ICU LOS (days)	1.182 (SD 0.480)	0.9661 (SD 0.470)	0.0680
Average general ward LOS (days)	6.727 (SD 3.314)	6.271 (SD 4.866)	0.2983
Average total LOS in acute hospital (days)	8.091 (SD 2.859)	7.271 (SD 3.658)	0.1759

ACDF: anterior cervical diskectomy and fusion; ICU: intensive care unit; LOS: length of stay.

Table 4. Average hospital length of stay for elective versus emergency cervical anterior spinal fusion.

Types of admission	Emergency (15)	Elective (88)	*p* Value
Average ICU LOS (days)	13.29 (SD 12.57)	1.01 (SD 0.373)	<0.001*
Average HDU LOS (days)	3.43 (SD 5.52)	0.01 (SD 0.894)	<0.001*
Average general ward LOS (days)	14.46 (SD 7.85)	6.4 (SD 4.531)	<0.001*
Average total LOS in acute hospital (days)	28.94 (SD 15.01)	7.49 (SD 5.012)	<0.001*

ICU: Intensive care unit; HDU: high dependency unit; LOS: length of stay; SD: standard deviation.
*The *p* value it less than 0.05 and hence it's statistically significant.

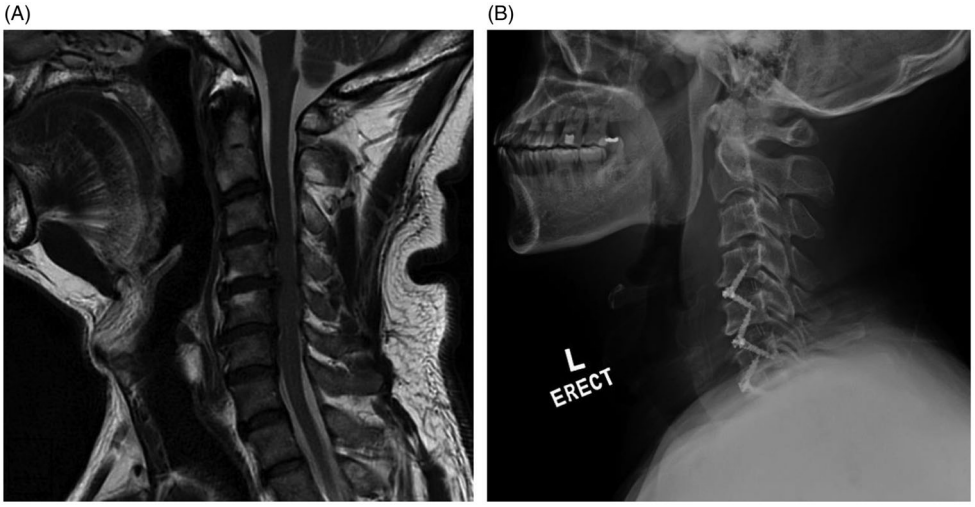

Figure 1. Plain lateral radiograph of the cervical spine of a 61-year-old man who had undergone C4/5 C5/6 C6/7 anterior cervical diskectomy and fusion (ACDF). He was kept intubated to the ICU after the operation. As compared to the preoperative magnetic resonance image (MRI) scan (A), the postoperative day 1 radiograph (B) had shown significant pre-vertebral swelling. He was extubated in the ICU the same day on post-op Day 0. He had transient hoarseness of voice but no airway obstruction. His length of stay in the ICU was one day and was discharged home the next day on post-op Day 1. His symptoms including hoarseness of voice completely resolved in one week.

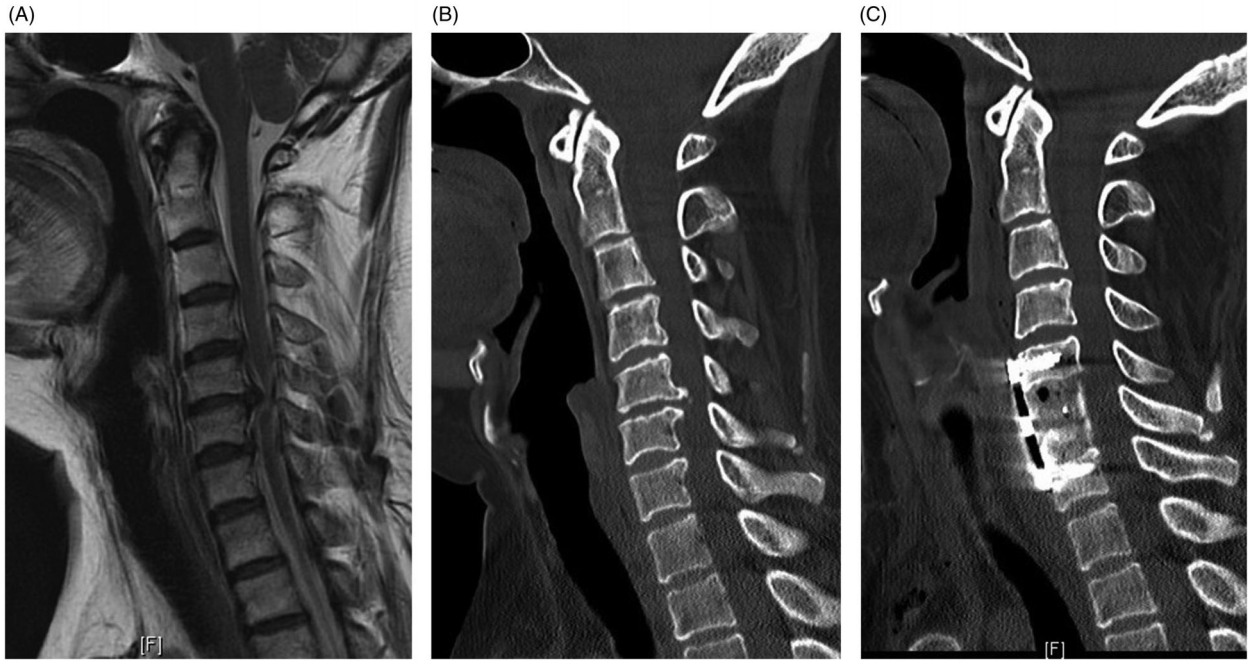

Figure 2. Preoperative T2 sagittal magnetic resonance imaging (A) and plain computed tomography (B) of the cervical spine of a 50-year-old lady showing C5/6 cervical stenosis with a prolapsed disc and posterior osteophytes. She had hoarseness of voice after the operation and postoperative day 1 radiograph (C) had shown significant pre-vertebral swelling. Her symptoms subsequently resolved and did not require reintubation. Her length of stay in the ICU was one day and was discharged to the general ward the next day.

Table 5. Univariate analysis of factor associated with prolonged ICU length of stay (≥48 hours).

	Discharged from ICU within 48 hours after OT (%)	Prolonged postoperative ICU Length of Stay ≥48 hours (%)	*p* Value
Patient's demographics			
Age	56.9 years old (22–86 years old)	55.9 years old (19–73 years old)	0.826
Gender			0.031
Male	66 (82.5)	14 (17.5)	
Female	23 (25.8)	0 (0)	
Etiology			
Degenerative	60 (96.8)	2 (3.2)	0.119
Trauma	29 (70.7)	12 (29.2)	0.425
Mechanism of injury			
Low energy trauma – low fall (<2 meter)	28 (84.8)	5 (15.2)	0.108
High energy trauma – MVA or fell from height (>2 meter)	1 (12.5)	7 (87.5)	0.028
Level of pathology			0.078
High cervical (C2–C4)	41 (80.4)	10 (19.6)	
Low cervical (C5–C7)	48 (92.3)	4 (76.9)	
Presence of C-spine Fracture			<0.001
Yes	5 (35.7)	9 (64.3)	
No	84 (94.4)	5 (5.6)	
Types of admission			<0.001
Emergency admission	4 (26.7)	11 (73.3)	
Elective admission	85 (96.6)	3 (3.4)	
Anterior cervical spine surgery			
Corpectomy	25 (83.3)	5 (16.7)	0.109
ACDF Total	64 (87.7)	9 (12.3)	0.116
1-Level ACDF	46 (90.2)	5 (9.8)	0.659
2-Level ACDF	16 (88.9)	2 (11.1)	0.073
3-Level ACDF	2 (50)	2 (50)	0.052
Airway status upon ICU admission after OT			0.903
Extubation in OT	76 (92.7)	6 (7.3)	
Airway protection with Endotracheal tube *in situ* from OT to ICU	13 (61.9)	8 (38.1)	
Post-operative complications			
Neck swelling/neck hematoma			0.025
Yes	0 (0)	1 (100)	
No	88 (87.1)	13 (12.9)	
Postoperative new neurological deficit			0.010
Yes	4 (50)	4 (50)	
No	85 (89.5)	10 (10.5)	
Hoarseness of voice (Transient: <1 week)			0.597
Yes	12 (100)	0 (0)	
No	76 (84.4)	14 (15.6)	
Hoarseness of voice (>1 week)			0.690
Yes	1 (100)	0 (0)	
No	88 (86.3)	14 (13.7)	

ACDF: anterior cervical discectomy and fusion; ICU: intensive care unit; MVA: motor vehicle accident; OT: operating theatre.

postoperative neurological deficit ($p = 0.031$) as independent predictors associated with a prolonged postoperative ICU stay.

Discussion

Catastrophic acute post-operative complications such as airway obstruction[1] or laryngeal edema[2] were recognized concerns for cervical corpectomy and anterior spinal fusion.[3] The rate of post-operative hematoma requiring re-operations ranging from 2.4% to 5.6%.[4] For the airway management after anterior cervical spine surgery, in general, operating surgeons preferred direct extubation in the operating theatre. On the other hand, some of these patients were kept intubated after the operations and transferred to the ICU as determined by the anaesthetists. There were concerns with this practice which might potentially prolonged ICU stay after the operations. The aim of the study is to review the outcome of this practice by analyzing the length of stay in ICU. Overall, there was a literature gap and most articles did not specifically report the length of stay in ICU, which had significant clinical relevance in terms of resource allocation and costs.

Currently, there was no established standard of practice for post-operative care after anterior cervical spine surgery. There were potential controversies including the need for post-operative ICU beds and whether or not to cancel elective corpectomy operations when ICU beds were not available. Outpatient ACDF is now increasing in frequency[5] and is potentially a feasible option in selected cases.[6] However, Arshi et al had reported that ambulatory ACDF had higher peri-operative complications as analyzed from a nationwide database with more than ten thousand patients.[7] At the same time, a more conservative post-operative airway management protocol was proposed to keep the patient intubated overnight if there was the presence of any risk factors.[8] For the timing of the acute complications, Lied et al identified 94.4% (17/18) of the immediate to early complications occurred within 6 hours after the operations.[9] All five potentially life-threatening neck hematomas were detected within 6 hours in their series.[9] In view of these, our unit has adopted a management plan for all cervical corpectomy patients to be admitted to the intensive care unit (ICU) after

Table 6. Multivariate logistic regression analysis of factors associated with prolonged ICU length of stay (≥48 hours) after cervical anterior spinal fusion.

Factors	OR	95% CI	*p* Value
Age	0.924	0.799–1.069	0.289
Gender	0.001	–	0.997
Etiology/mechanism of injury	21.48	0.064–7264	0.302
Presence of C-spine fracture	0.001	–	0.396
Emergency admission	116.97	17.54–780.2	0.043*
Corpectomy	0.817	0.001–5744	0.964
ACDF	1.302	0.012–142.1	0.912
Remained intubated to ICU after OT	9.472	0.020–4595	0.476
Post-operative airway complications including neck swelling or hoarseness of voice	0.062	0.001–2.708	0.149
Post-operative new neurological deficit	15.49	1.282–187.2	0.031*

ACDF: anterior cervical discectomy and fusion; ICU: intensive care unit; OT: operating theatre.
*The *p* value it less than 0.05 and hence it's statistically significant.

the operations for overnight observation. Pharmacologically, there was no significantly effective agent to tackle airway edema including intravenous steroids.[10] A univariate analysis identified long operating time (more than 5 hours) and estimated blood loss greater than 300mL as significant surgical factors associated with prolonged intubation or reintubation after anterior cervical spine surgery.[11] It was important for our study to show that ICU admission airway status of ASF patients who were either extubated in the OT or kept intubated after the operation upon admission to ICU had no significant association with prolonged postoperative ICU stay ($p = 0.903$). In fact, one of the safest ways to avoid airway complications after multilevel anterior cervical surgery was to maintain intubation overnight and to use a fiberoptic laryngoscopy to assess the airway the next day.[12] Good communication with the anaesthetists was crucial and the majority of the patients can be extubated after overnight intubation to reduce risks of postoperative airway emergencies.[13]

There has been a debate concerning post-operative care for ACDF. The spectrum of the post-operative management ranged from day admission with same-day discharge[9] to routine ICU admissions such as our centre. With our current study showing the safety and the overall low complication rates for ASF (none required reintubation in the ICU), it is an opportunity to review this practice. From Table 5, all five 1-level ACDF prolonged ICU stay were emergency cases. All 46 elective single-level ACDF can be discharged from ICU after overnight observation. Based on the findings from this study, we do not recommend routine post-operative ICU admission for single-level elective ACDF. The arrangement of ICU bed shall be reviewed on a case to case basis. Factors such as multi-level surgery, corpectomy, or emergency operations shall be considered. This can relieve the demand on ICU beds while ensuring patients' safety and treatment outcomes.

Conclusion

Cervical Corpectomy and anterior spinal fusion were safe with minimal acute airway complications. The average postoperative ICU stay was 1 day for elective cervical ASF. The majority (90.9%) of the elective ASF can be discharged from the ICU within 24 hours. Emergency admission ($p = 0.043$) and presence of postoperative neurological deficit ($p = 0.031$) were independent predictors associated with a prolonged postoperative ICU stay (Table 6). None required unplanned re-intubation nor emergency tracheostomy.

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Disclosure statement

The authors report no conflict of interest. The authors alone are responsible for the content and writing of the article. There is no financial disclosure. The authors confirm that this research meets the ethical guidelines, including adherence to the legal requirements of the study country.

Previous presentation

Part of the paper was previously presented as an oral presentation on December 7, 2018, at the 25th Annual Scientific Meeting of the Hong Kong Neurosurgical Society in Hong Kong.

Author contributions

DYC and WKM were the lead investigators and contributed to the conception and design of the study. DYC, WKM, DTS and RCM contributed to the conducting of the study including data collection and data entry. DYC and RCM contributed to data analysis. DYC, WKM, DTS, RCM, AYN, WSP, GKW and DTC contributed to data interpretation and writing of the paper. DTS, WSP, GKW and DTC contributed to administrative support and study supervision. All authors contributed to revising the paper critically for important intellectual content and final appraisal for publication.

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References

1. Sagi HC, Beutler W, Carroll E, Connolly PJ. Airway complications associated with surgery on the anterior cervical spine. *Spine (Phila Pa 1976)* 2002;27:949–53.
2. Palumbo MA, Aidlen JP, Daniels AH, Bianco A, Caiati JM. Airway compromise due to laryngopharyngeal edema after anterior cervical spine surgery. *J Clin Anesth* 2013; 25:66–72.
3. Fountas KN, Kapsalaki EZ, Nikolakakos LG, *et al.* Anterior cervical discectomy and fusion associated complications. *Spine (Phila Pa 1976)* 2007;32:2310–7.
4. Epstein NE. A review of complication rates for anterior cervical diskectomy and fusion (ACDF). *Surg Neurol Int* 2019; 10:100.
5. Purger DA, Pendharkar AV, Ho AL, *et al.* Outpatient vs inpatient anterior cervical discectomy and fusion: a population-level analysis of outcomes and cost. *Neurosurgery* 2018;82:454–64.
6. Helseth Ø, Lie dB, Halvorsen CM, Ekseth K, Helseth E. Outpatient cervical and lumbar spine surgery is feasible and safe: a consecutive single center series of 1449 patients. *Neurosurgery* 2015; 76:728–37.
7. Arshi A, Wang C, Park HY, *et al.* Ambulatory anterior cervical discectomy and fusion is associated with a higher risk of revision surgery and perioperative complications: an analysis of a large nationwide database. *Spine J* 2018; 18:1180–7.
8. Kim M, Choi I, Park JH, Jeon SR, Rhim SC, Roh SW. Airway management protocol after anterior cervical spine surgery: analysis of the results of risk factors associated with airway complication. *Spine (Phila Pa 1976)* 2017; 42:E1058–66.
9. Lie dB, Sundseth J, Helseth E. Immediate (0-6 h), early (6-72 h) and late (>72 h) complications after anterior cervical discectomy with fusion for cervical disc degeneration; discharge six hours after operation is feasible. *Acta Neurochir (Wien)* 2008;150:111–8.
10. Emery SE, Akhavan S, Miller P, *et al.* Steroids and risk factors for airway compromise in multilevel cervical corpectomy patients: a prospective, randomized, double-blind study. *Spine (Phila Pa 1976)* 2009;34:229–32.
11. Kim M, Rhim SC, Roh SW, Jeon SR. Analysis of the risk factors associated with prolonged intubation or reintubation after anterior cervical spine surgery. *J Korean Med Sci* 2018; 33:e77.
12. Epstein NE, Hollingsworth R, Nardi D, Singer J. Can airway complications following multilevel anterior cervical surgery be avoided? *J Neurosurg* 2001; 94:185–8.
13. Kwon B, Yoo JU, Furey CG, Rowbottom J, Emery SE. Risk factors for delayed extubation after single-stage, multi-level anterior cervical decompression and posterior fusion. *J Spinal Disord Tech* 2006;19:389–93.