

Anterior cervical spine surgery-associated complications in a retrospective case-control study

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Abstract: Anterior cervical spine procedures have been associated with satisfactory outcomes. However, the occurrence of troublesome complications, although uncommon, needs to be taken into consideration. The purpose of our study was to assess the actual incidence of anterior cervical spine procedure-associated complications and identify any predisposing factors. A total of 114 patients undergoing anterior cervical procedures over a 6-year period were included in our retrospective, case-control study. The diagnosis was cervical radiculopathy, and/or myelopathy due to degenerative disc disease, cervical spondylosis, or traumatic cervical spine injury. All our participants underwent surgical treatment, and complications were recorded. The most commonly performed procedure (79%) was anterior cervical discectomy and fusion (ACDF). Fourteen patients (12.3%) underwent anterior cervical corpectomy and interbody fusion, seven (6.1%) ACDF with plating, two (1.7%) odontoid screw fixation, and one anterior removal of osteophytes for severe Forestier's disease. Mean follow-up time was 42.5 months (range, 6–78 months). The overall complication rate was 13.2%. Specifically, we encountered adjacent intervertebral disc degeneration in 2.7% of our cases, dysphagia in 1.7%, postoperative soft tissue swelling and hematoma in 1.7%, and dural penetration in 1.7%. Additionally, esophageal perforation was observed in 0.9%, aggravation of preexisting myelopathy in 0.9%, symptomatic recurrent laryngeal nerve palsy in 0.9%, mechanical failure in 0.9%, and superficial wound infection in 0.9%. In the vast majority anterior cervical spine surgery-associated complications are minor, requiring no further intervention. Awareness, early recognition, and appropriate management, are of paramount importance for improving the patients' overall functional outcome.

Keywords: Anterior cervical spine surgery; complications; outcome

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Introduction

The anterior approach to the cervical spine constitutes a well-established surgical strategy, and one of the most commonly performed spinal procedures. Smith and Robinson (1) first described their technique for anterior

cervical spine approach, while several modifications of this original technique have also been published (2). Anterior cervical approaches allow the efficient management of a variety of spinal pathology (3). They provide relatively easy access to the vertebral column, while their surgical outcome is satisfactory in the vast majority of cases (4). It would not be

an overstatement that anterior cervical approach constitutes one of the most rewarding spinal procedures (4-12).

Despite the overall good outcome, various potential complications may occur on rare occasions (13-18). The majority of these complications are transient and self-limited, however in very rare instances, they may require a second surgical intervention, and if they remain undetected may even lead to death (17,19-27). It has been adequately demonstrated in the pertinent literature, that anterior cervical corpectomy and fusion (ACCF) procedures demonstrate higher complication rates than anterior cervical discectomy and fusions (ACDF) (27). Meticulous knowledge of all potential procedure-associated and postoperative complications is of paramount importance for their early recognition, and their proper management. Furthermore, identification of any complication-predisposing factors and situations may help avoid such complications, and in mitigating their overall clinical effect.

The purpose of our study was to evaluate the complication rate in anterior cervical spinal procedures in our institution, and identify the parameters that may predispose to their occurrence.

Methods

This is a retrospective, case-control study consisting of review of hospital charts by two residents (T.G., I.S.) separately, for any procedure-associated complications. Our study was approved by our Institutional Review Board. All the participants' data handling was performed according to the Helsinki and the Health Insurance Portability and Accountability (HIPAA) acts. No participants' informed consent was necessary for our retrospective study. The study covered a single institution, four attending neurosurgeons, over a 6-year period (January 2009 to December 2014).

All adult patients who underwent anterior spinal surgery in our institution were considered for eligibility in our study. Patients with previous anterior neck surgery for indications other than for spinal surgery were excluded. All patients underwent detailed neurological examination preoperatively, while their imaging work-up included cervical spine plain X-rays, and MRI. In specific cases, depending on the underlying pathology, the preoperative evaluation also included flexion/extension X-rays, CT scan, and EMG and nerve conduction velocity studies.

All anterior approaches were performed from the right side, under general endotracheal anesthesia, and fluoroscopic imaging. All ACDF procedures were

performed with the Smith-Robinson technique. An allograft was used in all our cases. The procedures were performed under neurophysiological monitoring with motor and somato-sensory evoked potential (MEP & SSEP), as well as spontaneous electromyography monitoring. All patients with complications formed the case group, while the remaining patients served as the control group. Every patient was routinely re-evaluated with clinical examination at 1, 6, and 12 months after their discharge, and then on a yearly basis in our outpatient clinic, while radiographic evaluation was obtained by plain X-rays at 12 months postoperatively.

The charts of 114 consecutive patients undergoing anterior cervical spine surgery were reviewed. The patient's gender and age, clinical presentation, diagnosis, type of surgery, and length of fusion were recorded and tested for their potential role as risk factors. The occurrence of any post-operative complications, their time of occurrence, the mode of treatment, and the outcome were also registered. Complications occurring during the initial 14 days were considered as perioperative, while the remaining as delayed.

We used descriptive statistics to calculate the frequency for each observed complication in terms of absolute counts and percentages. Comparisons between groups were performed with the Chi-squared test (or Fisher's exact test, if the number of observations was >6) after constructing contingency tables, and visualized by bar-plots. Continuous variables were summarized with the mean and their standard deviation, and were compared by using the Student's *t*-test and boxplots. The level of statistical significance was defined by a P value <0.05. Potential risk factors were identified by means of univariate logistic regression (Wald's P value <0.05). Odds ratios (ORs) are presented with 95% confidence intervals (CIs) and visualized with the OR plots. The predictive value of the logistic model was assessed and visualized by the area under the curve (AUC) of the receiver operating characteristics curve (ROC) of the logistic model. The statistical analysis was performed with the statistical environment R.

Results

Patients' demographic and clinical data

Our study population included 73 males and 41 females (Table 1, Figure 1). The patients' age ranged between 21 and 82 years (mean, 49.92; SD, 14.25). Their preoperative diagnoses included both pathology of traumatic and

Table 1 Patients' demographic characteristics in our study

Grouping factor	Subgroup	Total		Cases		Controls		P values
		No	%	No	%	No	%	
Age (mean, SD)		49.92, 14.25		49.64, 17.40		49.97, 13.85		0.94
Gender								0.75
	Male	73	64	10	8.8	63	55.2	
	Female	41	36	4	3.5	37	32.45	
Presentation								0.98
	Radiculopathy	23	20	3	2.63	20	17.54	
	Myelopathy	81	71	10	8.8	71	62.28	
	Instability	9	8	1	0.87	8	7.01	
	Dysphagia	1	1	0	0	1	0.87	
General diagnosis								1
	Trauma	27	24	3	2.63	24	21.05	
	Degenerative	87	76	11	9.65	76	66.67	
Specific diagnosis								0.87
	Traumatic disc herniation	13	11	1	0.87	12	10.52	
	Vertebral body fracture	11	10	2	1.75	9	7.89	
	Subluxation	3	3	0	0	3	2.63	
	Degenerative disc herniation	75	66	9	7.89	66	57.89	
	Degenerative spondylosis	11	10	2	1.75	9	7.89	
	Forestier's disease	1	1	0	0	1	0.87	
Spinal procedure		No	%					0.83
	ACDF	90	79	12	10.52	78	68.42	
	ACCF	14	12	2	1.75	12	10.52	
	ACDF-P	7	6	0	0	7	6.14	
	Odontoid screw fixation	2	2	0	0	2	1.75	
	Osteophyte resection	1	1	0	0	1	0.87	
Length of fusion								1
	Single level	71	62.28	9	7.89	62	54.38	
	Two levels	39	34.21	5	4.38	34	29.82	
	Three of more levels	4	3.50	0	0	4	3.50	

P values, Fisher's exact test; ACDF, anterior cervical discectomy and fusion; ACCF, anterior cervical corpectomy and fusion; ACDF-P, anterior cervical discectomy and fusion with plating.

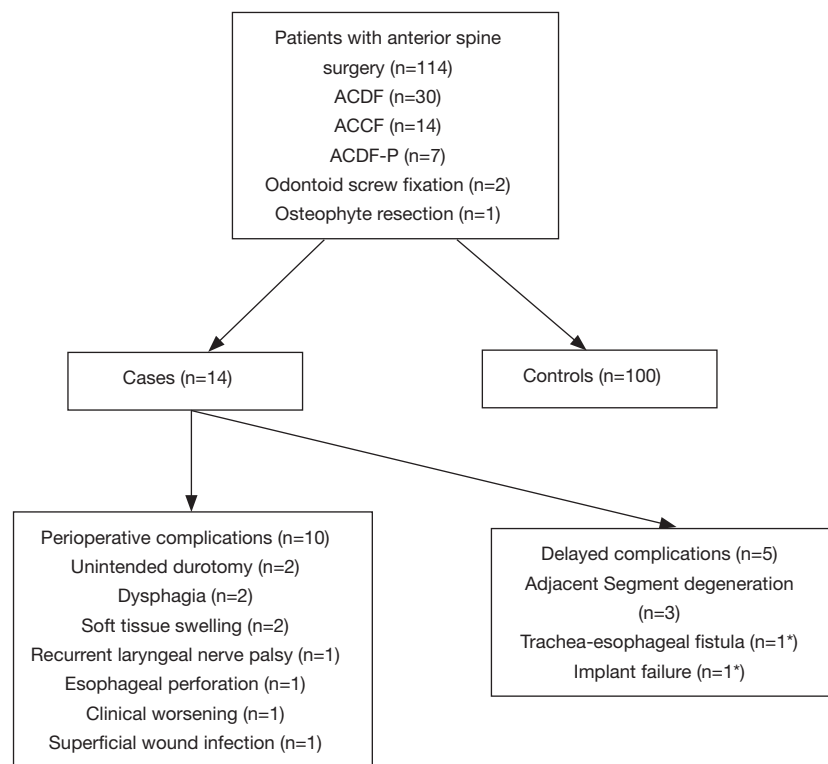


Figure 1 Patient flow chart of the current study. One hundred and fourteen patients underwent anterior cervical spine surgery in our institution over a 6-year period (January 2009 to December 2014). Complications presented in 14 patients, which formed our “Cases” group. The remaining 100 patients were used as the “Control” group. In 10 cases complications developed in the perioperative period, while the remaining 4 cases presented with 5 delayed complications. One patient developed implant failure that caused a trachea-esophageal fistula (*).

degenerative etiology. More specifically, there were 27 trauma cases suffering from subluxation, vertebral body fracture, and/or traumatic intervertebral disc herniation, with or without myelopathy. The remaining 87 patients had pathology of degenerative etiology including cervical spondylosis, intervertebral disc protrusion/extrusion, radiculopathy, myelopathy, and Forestier’s disease. ACDF was the most commonly performed procedure in our series. The operative blood loss varied between 30 and 780 mL (mean, 130 mL). Their follow up period ranged from 6 to 78 months (mean, 42.5).

Complications

Fourteen patients (12.28%) developed post-operative complications and were included in the complication group. In ten patients (71.42%) the complications occurred at the early post-operative period, while in the remaining four (28.58%) the complications occurred later (*Table 2, Figure 1*).

Perioperative complications

The patients developing perioperative complications are summarized on *Table 3* and *Figure 1*. Accidental dural penetration occurred in two patients (1.7%). In one case cerebrospinal (CSF) fistula developed postoperatively, which was treated with a lumbar drain insertion. In the other case, a lumbar drain was inserted after the completion of the procedure to prevent a CSF wound leakage. Both patients had no further consequences. Dysphagia was encountered in two patients (1.7%), and was spontaneously resolved within 7–10 days, postoperatively. Two patients (1.7%) developed a postoperative soft tissue hematoma within the first 24 postoperative hours, which presented with severe difficulty in swallowing. Both patients were closely observed, and their hematomas were spontaneously absorbed. Esophageal perforation was documented in one patient (0.9%), undergoing two-level ACDF for degenerative severe spondylosis and myelopathy. They presented with

Table 2 Summary of complications after anterior cervical spine surgery

Complication	Count	Frequency in the study sample (%)	Frequency among complications (%)
Perioperative	10	8.77	67
Dysphagia	2	1.75	13.3
Clinical worsening	1	0.88	6.67
Recurrent laryngeal nerve palsy	1	0.88	6.67
Unintended dural tear	2	1.75	13.3
Soft-tissue swelling	2	1.75	13.3
Esophageal perforation	1	0.88	6.67
Superficial wound infection	1	0.88	6.67
Delayed	5		33
ASD	3	2.63	20
Tracheo-esophageal fistula	1	0.88	6.67
Implant failure	1	0.88	6.67
Total	15	12.28	100

ASD, adjacent segment disease.

Table 3 Perioperative complications after anterior cervical spine surgery

	Gender	Age	Diagnosis	Presentation	Treatment	Length of fusion	Complication	Management	Outcome
1	Female	59	Degenerative spondylosis	Myelopathy	ACCF	Two levels	Unintended durotomy	Lumbar drain	Improved
2	Male	40	Degenerative disc herniation	Myelopathy	ACDF	Two levels	Clinical worsening	Posterior decompression	Improved
3	Male	63	Degenerative disc herniation	Radiculopathy	ACDF	Single level	Dysphagia	Conservative	Improved
4	Male	21	Vertebral body fracture	Myelopathy	ACDF	Single level	Dysphagia	Conservative	Improved
5	Male	55	Degenerative disc herniation	Myelopathy	ACDF	Two levels	Esophageal perforation	Surgical repair, antibiotics for 6 weeks, total parenteral nutrition	Improved
6	Male	74	Degenerative disc herniation	Myelopathy	ACDF	Single level	Recurrent laryngeal palsy	Conservative (methylprednizone)	Improved
7	Male	31	Degenerative disc herniation	Myelopathy	ACDF	Single level	Soft tissue swelling	Conservative	Improved
8	Female	74	Degenerative disc herniation	Myelopathy	ACDF	Single level	Soft tissue swelling	Conservative	Improved
9	Female	32	Degenerative disc herniation	Radiculopathy	ACDF	Single level	Superficial wound infection	Conservative	Improved
10	Male	66	Traumatic disc herniation	Myelopathy	ACDF	Two levels	Unintended durotomy	Lumbar drain	Improved

ACCF, anterior cervical corpectomy and fusion; ACDF, anterior cervical discectomy and fusion.

Table 4 Delayed complications after anterior cervical spine surgery

	Gender	Age	Diagnosis	Presentation	Procedure	Length of Fusion	Complication	Timing (years)	Management	Outcome
1	Male	47	Vertebral body fracture	Instability	ACCF	Two levels	Implant failure, tracheoesophageal fistula	1	Implant removal	Improved
2	Male	63	Spondylosis	Myelopathy	ACDF	Single level	ASD	3.5	ACDF	Improved
3	Male	34	Degenerative disc herniation	Myelopathy	ACDF	Single level	ASD	3	ACDF	Worsened
4	Female	36	Degenerative disc herniation	Radiculopathy	ACDF	Single level	ASD	1	ACDF	Improved

ACCF, anterior cervical corpectomy and fusion; ACDF, anterior cervical discectomy and fusion; ASD, adjacent segment disease.

progressive hoarseness, dysphagia, and low-grade fever, and was confirmed with a CT scan, which showed air in the mediastinum. The patient had a second urgent operation, in which the esophageal wall perforation was corrected with a muscular patch. The patient was placed on parenteral alimentation and antibiotics for six weeks. He was finally discharged with no other problems. Symptomatic postoperative recurrent laryngeal nerve (RLN) palsy occurred in one patient (0.9%), presenting with severe hoarseness postoperatively, and the diagnosis was confirmed by using indirect laryngoscopy. Small doses of methyl-prednisolone were given for 5 days, and the patient's symptomatology gradually resolved. In one case (0.9%) aggravation of a preexisting myelopathy was observed, with worsening of the patient's neurological condition. The patient, who initially was treated with two-level ACDF for myelopathy of degenerative etiology, had to undergo a second procedure, which was a posterior decompression. His neurological condition progressively improved after the second procedure. It is worth noting that neuro-monitoring could not assist in preventing any of the observed perioperative complications.

Delayed complications

Four patients developed delayed complications (Table 4, Figure 1). Mechanical failure of the implanted instrumentation occurred in one case (0.9%). The patient had undergone a single-level (C7) corpectomy for a traumatic vertebral body fracture and subluxation. An anterior plate was implanted, and the patient underwent

a 360° fusion in two settings. He returned approximately one year after his discharge, complaining of progressively worsening odynophagia, difficulty in swallowing, hoarseness, and low fever. His imaging work up including X-rays and CT scan demonstrated a tracheo-esophageal fistula, most probably secondary to a large neck abscess, while one of the inferior anterior cervical plate screws had been pulled out. The patient was taken to surgery to drain his abscess, and to remove the previously implanted cervical plate. He remained on antibiotics for a long period of time, and recovered with no further problems. Another patient (0.9%) developed a superficial surgical wound infection postoperatively, which was treated with oral antibiotics with no further consequences. Finally, adjacent intervertebral segment disc degeneration was documented in three patients (2.7%), who underwent a second ACDF procedure for managing their disease.

Risk factors

There were no statistically important differences between the case group and the control group in terms of the patients' gender (P=0.75), age (P=0.94), clinical presentation (P=0.98), diagnosis (P=0.87), spinal procedure (P=0.83), and length of fusion (P=1) (Table 1, Figures 2-6). The available data permitted logistic regression analysis only for the overall complications and the perioperative ones. None of the above-mentioned parameters could be considered as a risk factor for postoperative complications according to the employed logistic regression (Tables 5,6, Figures 7,8).

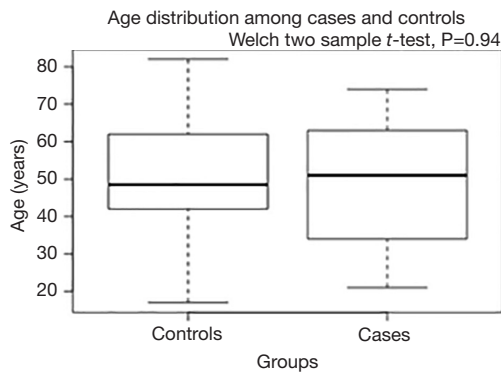


Figure 2 Boxplot of the age distribution among cases and controls. There was no statistical difference in the age distribution between the two groups, as tested by the Welch two sample *t*-test.

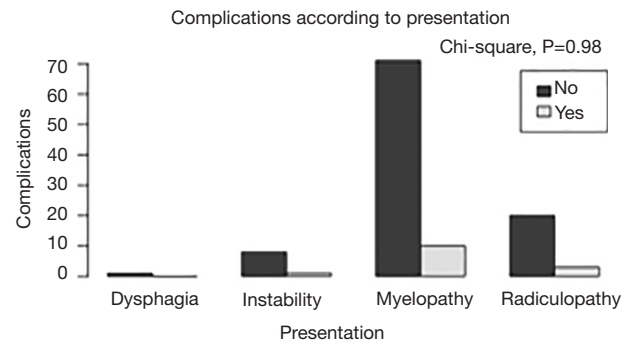


Figure 5 Bar-plot of the complications according to the primary presenting symptoms. The absolute number of complications did not differ according to the presenting symptom, as tested by the Chi-square test.

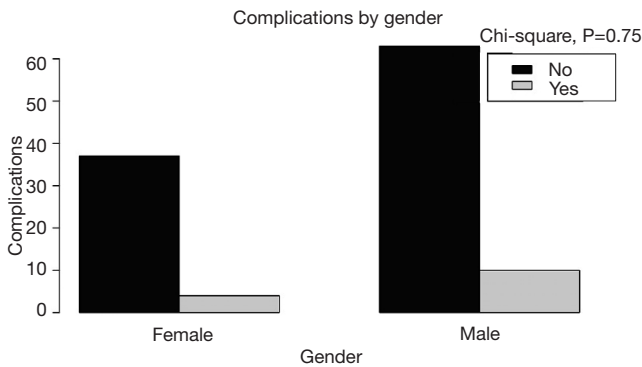


Figure 3 Bar-plot of the complications according to the gender. The absolute number of complications was not statistically different between the two genders, as tested by the Chi-square test.

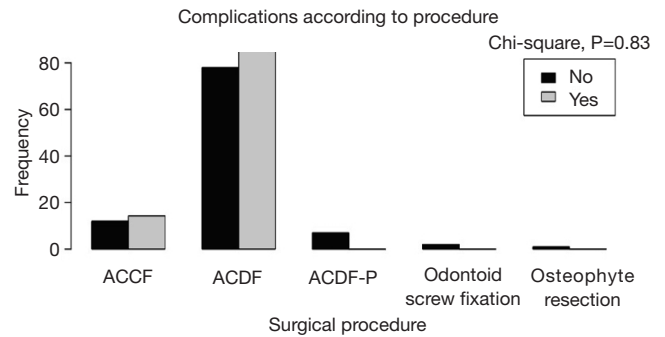


Figure 6 Bar-plot of the complications according to the surgical procedure. The absolute number of complications did not differ according to the surgical procedure, as tested by the Chi-square test. ACCF, anterior cervical corpectomy and fusion; ACDF, anterior cervical discectomy and fusion; ACDF-P, anterior cervical discectomy and fusion with plating.

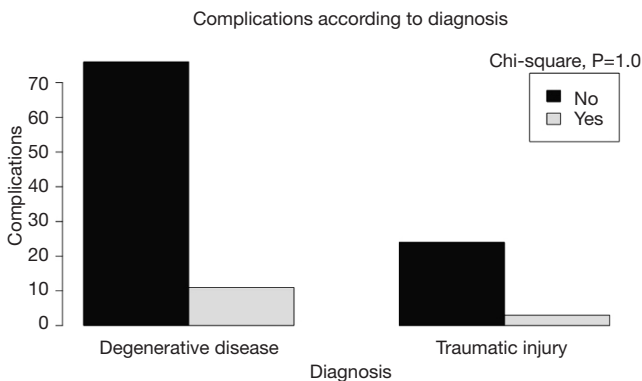


Figure 4 Bar-plot of the complications according to the crude diagnosis (traumatic *vs.* degenerative disorders). The absolute number of complications did not vary according to the patient's crude diagnosis, as tested by the Chi-square test.

Discussion

Summary of findings

The most important findings from the current study is that the cumulative incidence of postoperative complications after anterior spinal surgery is as high as 13.2%. Complications at the early postoperative period are more common and in most instances do not require surgical treatment, contrary to the delayed ones, where surgical intervention is required in most cases. Furthermore, we could not identify risk factors among the parameters tested.

Table 5 Odds ratio and 95% confidence interval for potential risk factors associated to the overall complication rate after anterior cervical spine surgery

Examined parameters	Variant	Reference	Odds ratio	95% confidence interval	Wald's test (P value)	LR-test (P value)	AIC
Gender	Male	Female	1.47	0.43, 5.02	0.540	0.532	88.53
Age		(Per year)	0.99	0.95, 1.04	0.936	0.936	88.91
Diagnosis	Trauma	Degenerative	0.87	0.22, 3.35	0.832	0.831	88.87
Presentation	Radiculopathy	Instability	1.20	0.11, 13.32	0.882	0.989	90.63
	Myelopathy	Instability	1.13	0.13, 9.98	0.915		
Procedure	ACCF	ACDF	1.08	0.21, 5.55	0.923	0.599	92.16
Length of fusion	Two levels	Single level	1.01	0.31, 3.27	0.983	0.586	89.85

AIC, akaike information criterion; ACCF, anterior cervical corpectomy and fusion; ACDF, anterior cervical discectomy and fusion.

Table 6 Odds ratio for potential risk factors associated to the perioperative complication rate after anterior cervical spine surgery

Examined parameters	Variant	Reference	Odds ratio	95% confidence interval	Wald's test (P value)	LR-test (P value)	AIC
Gender	Male	Female	1.34	0.33, 5.5	0.682	0.677	71.59
Age		(Per year)	1.01	0.96, 1.05	0.714	0.714	71.63
Diagnosis	Trauma	Degenerative	0.79	0.16, 3.97	0.775	0.770	71.683
Procedure	ACCF	ACDF	1.44	0.17, 12.37	0.737	0.727	75.72
Length of fusion	Two levels	Single level	1.24	0.33, 4.68	0.753	0.655	72.92

AIC, akaike information criterion; ACCF, anterior cervical corpectomy and fusion; ACDF, anterior cervical discectomy and fusion.

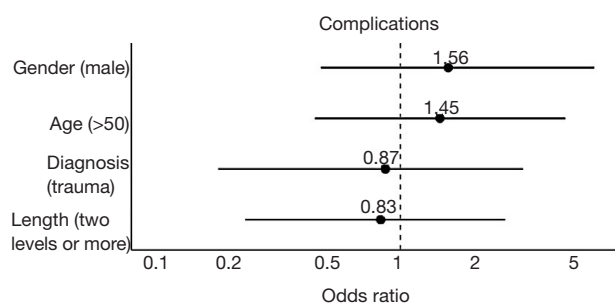


Figure 7 Odds ratio plot of risk factors for the development of complications after anterior cervical spine surgery. Males and patients older than 50 years of age have an increased tendency to develop complications. On the contrary, patients with traumatic disorders and more than two-level surgery showed decreased tendency to develop complications. However, none of these tendencies reached a statistically significant level according to the logistic regression.

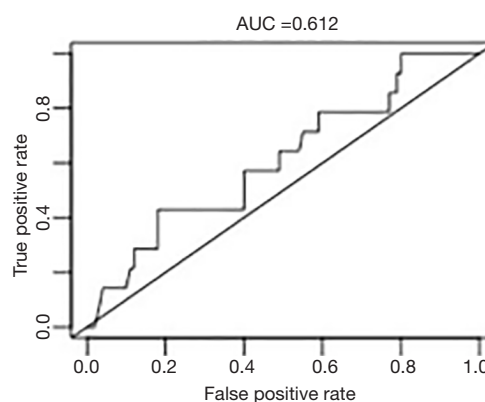


Figure 8 Receiver operating characteristic (ROC) curve of the logistic regression. The area under the curve indicates that the predictive value of the logistic model using the gender, age, diagnosis, type of surgical procedure, and length of fusion is low.

Background

Anterior cervical spine surgery-associated complications are well described in the literature, even though their reported incidence widely varies among published series. Meticulous knowledge of any potential complications is of paramount importance for their early recognition, and their proper management. Moreover, actual incidence of anterior spinal procedure complications is of importance for medico-legal purposes. Underreporting of complications may generate the false impression that anterior cervical approaches have no complications, and may establish an erroneously legal background.

The long list of complications includes infection, abscess, and hematoma formation (20,26-29). Additionally, neurovascular or adjacent organ injuries have been reported (17,20,27,29-39). Implant related complications have also been reported in the literature (20,27,40-44). The list also includes functional complications such as dysphagia, dysphonia, and difficulty in swallowing (7,45-51). Although the vast majority of these complications are of minor clinical impact, there are extremely rare occasions that the outcome of a complication may be troublesome or even fatal.

Adjacent segment disc disease

The most common complication was the occurrence of adjacent intervertebral disc degeneration in 2.7% of our cases. Although adjacent intervertebral disc degeneration is not typically listed among the ACDF complications, it is well documented that anterior cervical spine surgery with fusion significantly alter the regional biomechanics, increase the load to the adjacent intervertebral discs, and introduce stress and instability to them (52-62). However, Hilibrand and Robbins (63) raised the question of whether this adjacent segment degeneration was the result of the previous surgical intervention or may just reflect the underlying natural history of the cervical degenerative process. Matsumoto *et al.* (64) found that patients with anterior fusion had a higher rate of radiographically proven adjacent segment degeneration. Nevertheless, recently published data showed that the incidence of adjacent segment degeneration after ACDF was 12.2%, and subsequently increased to 25% after a second cervical fusion (40,43). Similarly, Bohlman *et al.* (5) concluded that 9% of their patients developed adjacent segment disease within 6 years after ACDF, and 7.4% of them required a reoperation. Likewise, Hilibrand *et al.* (65) anticipated that more than 25% of

patients undergoing ACDF will develop adjacent segment degeneration. They calculated that the annual incidence of adjacent segment degeneration is 2.9% per year (65).

Dysphagia

In the majority of the previously published series, dysphagia and dysphonia are the most common postoperative complications, with rates ranging from 1–79% (16,45). This wide variation may be partially explained by the fact that dysphagia is routinely underestimated as a complication (21,25,66). There are reports on the incidence of postoperative dysphagia based on the surgeon's interpretation or the patient's interpretation. Thus, Johns *et al.* (49) reported that the incidence of dysphagia was 11% when based on the physicians' notes, while it was 57% when the patients were surveyed. According to Dettori *et al.* (67) a patient's reported outcome has been shown to be more reliable, valid, and preferable. Dysphagia was observed in 1.7% of our patients, and this was based on patients' reports. Khaki *et al.* (48) reported 52% incidence of postoperative dysphagia in patients undergoing anterior cervical spine surgery. It has been postulated that soft tissue swelling is the most common cause of postoperative dysphagia (2,16,68-70). However, there are studies supporting the theory that soft tissue swelling is not related to the development of postoperative dysphagia (46,48). Various causes have been implicated in the development of postoperative dysphagia, including RLN palsy, pharyngeal plexus denervation, esophageal direct injury, and regional esophageal ischemia (71-75). In addition, postoperative hematoma and scar tissue formation should be ruled out, especially in cases of chronic dysphagia (76). However, the underlying pathophysiology of postoperative dysphagia remains poorly understood (77). With all the existing controversies, the low dysphagia incidence observed in our study may be related to the relative low rate of anterior cervical plate usage, the application of solely manual retraction with periodic pressure release, and the careful intraoperative soft-tissue handling. In all our cases, dysphagia was transient and required no special treatment. Although most studies reported that dysphagia decreases with time, the prevalence of chronic dysphagia is more common than previously considered (73,78-80).

Postoperative hematoma

Postoperative wound hematoma occurred in 1.7% in our

series. The reported incidence of postoperative wound hematoma among the previously published series is 0.2–2.4% (20,21,81–89). A postoperative hematoma although occurs rarely, it may potentially be a life-threatening complication. Generally, immediate recognition and evacuation of the hematoma is necessary, in order to avoid airway compromise. It is well known that the development of such a complication is more common in the acute postoperative period. It has to be emphasized however, that up to 35% of hematomas has been reported to be presented in a delayed fashion, at an average of 6 days postoperatively (28,32). Interestingly, O'Neil *et al.* (28) mentioned that in 27% of their cases a drain was in place, while in 27% of cases the hematoma formed shortly after the drain removal, raising significant questions regarding its role in preventing a postoperative hematoma. The importance of meticulous intraoperative hemostasis cannot be overemphasized. The role of a drain in preventing a hematoma formation remains to be defined.

Dural penetration

Intraoperative dural penetration was observed in 1.7% of our cases. Incidental durotomy is a rare, and potentially serious complication, which is reported with incidence varying between 0.2–0.5% (20,90). The reported incidence of meningitis secondary to CSF leak after anterior cervical spine surgery is approximately 0.2% (21). The employment of meticulous and careful, microscopic dissection during the posterior longitudinal ligament (PLL) opening, especially in chronic-standing disc extrusion cases, and/or in cases of ossified PLL is of paramount importance. Intraoperative recognition of the dural violation allows the proper management of any potential CSF leaks, and thus minimizes the risk of any postoperative infections.

Esophageal perforation

Esophageal perforation occurred in 0.9% of our cases. The overall incidence ranges between 0 and 3.4% (3,91–95). Fountas *et al.* (20) reported an incidence of 0.3% while Zhong *et al.* (33) reported 0.45%. Although the majority of patients suffering esophageal perforation have a good prognosis, this complication is still associated with mortality rates up to 16% (96). Interestingly, perforation of the esophagus after a previous anterior cervical procedure may occur as late as 10 years after surgery (36). Optimal treatment of esophageal perforation remains controversial.

There are reports supporting a conservative management (19,97–100). However, the most preferable therapeutic strategy is immediate surgical repair (3,91,93,95,101–105). The importance of intraoperative or early recognition of this complication cannot be overemphasized. The risk of any esophageal injuries is higher in patients with previous neck surgeries, or neck irradiation.

Neurological complications

Worsening of preexisting myelopathy may occur in any spinal procedures. Its incidence in our series was 0.9%. Fountas *et al.* (20) have reported aggravation of preexisting myelopathy secondary to spinal cord contusion in 0.2% of their cases. It is well established that patients with pre-existing myelopathy have significantly higher incidence of procedure-associated complications (13.4%) and mortality rates (0.6%) compared with patients without myelopathy (6.3% and 0.1%, respectively) (29). Careful microscopic surgical technique and the employment of intraoperative electrophysiological monitoring may minimize the risk of worsening the patient's preoperative neurological condition.

RLN palsy

Another common complication is RLN palsy. There are studies showing that RLN palsy is underreported (71,106). Dysphonia and/or hoarseness are the most common clinical expression of unilateral vocal paralysis, while bilateral RLN palsy can lead to respiratory insufficiency (23,107,108). In our series, the incidence of symptomatic RLN palsy was documented in 0.9% of our patients. It is documented that the incidence of spontaneous, asymptomatic, preoperative RLN palsy is approximately 1.6% (109,110). Jung *et al.* (111) noticed that the incidence of clinically symptomatic RLN palsy among patients undergoing anterior cervical spine surgery was 8.3% in the early postoperative period, while another 10.8% of their patients remained asymptomatic despite the presence of RLN paresis or paralysis. Similarly, Fountas *et al.* (20) reported 3.1% postoperative clinically symptomatic RLN palsy in their series. Contrariwise, Starmer *et al.* (50) found that postoperative vocal fold paralysis after anterior cervical disc surgery was only 0.1%. By anatomical point of view, the right RLN is more vulnerable to injury (112). Therefore a left-sided approach may be advantageous. Although the pathophysiology of RLN palsy remains ill defined, the avoidance of excessive mechanical retraction may

minimize the risk of postoperative RLN paresis or palsy.

Implant failure

Implant and/or graft failure is another complication associated with anterior cervical spine surgery. The incidence of screw pullout was 0.9%, in our series. Cloward (113) provided one of the first reports on graft migration. Since then, mechanical failure and/or screw migration have been reported (41,42,97,114-116). Initial malposition or suboptimal position is the most common reason for mechanical fatigue, and eventual failure of the implant.

Surgical wound infection

Superficial or deep wound infections are included among the anterior cervical surgery complications. In our series, only 0.9% developed superficial wound infection. It has been demonstrated that the incidence of postoperative infections is strongly associated with the patients' age. Veeravagu *et al.* (7) found that younger age was associated with increased risk of infection. They also found that postoperative surgical wound infection was the most common cause for readmission (7). The presence of co-morbidity may also increase the risk of a postoperative surgical wound infection (7). Boakye *et al.* (29), mentioned that patients aged 65–84 years were eight times more likely to have an adverse outcome. Likewise, Lovecchio *et al.* (26) also reported that certain preoperative factors, such as patient age over 65 and preoperative hospital stay more than 24 hours, conferred a significantly higher likelihood of a complication.

Cumulative complication rate

The cumulative complication rate in our series was 13.2%, while no deaths occurred. Fountas *et al.* (20), reported that the overall morbidity rate in their ACDF series was 19.3%, while the mortality rate was 0.1%. Similarly, Veeravagu *et al.* (7), estimated that the overall mortality at 2 years was 0.1% in the single level ACDF procedures, and 0.18% among their multilevel cases. Additionally, the complication rate was 2.1% for single level ACDFs, with overall complications more common in multilevel procedure. They also reported annual incidence of revision surgery in single and multilevel cases of 2.9% per year and 3.4% per year, respectively (7). Bilbao *et al.* (27) reported a complication rate of 25% in patients undergoing cervical spondylotic corpectomies. Extensive corpectomy procedures seem to be

associated with higher complication rates (27).

Study limitations

It has to be emphasized that our study carries significant limitations and weaknesses. First of all, the current study is a retrospective one, thus carrying all biases of retrospective studies. Additionally, the limited size of our clinical series may compromise the statistical power of our results. Another potential problem is the inclusion of different type of anterior cervical spine procedures. However, the purpose of our study was to provide data of all anterior cervical spine procedures, and not only of a specific type, since many of the observed complications are associated with the anterior approach itself.

Conclusions

Anterior cervical spine procedures have been associated with quite satisfactory outcome in the vast majority of cases. However, the occurrence of troublesome complications, although rare, needs to be taken into consideration. We could not identify any modifiable preoperative risk factors to prevent any perioperative and/or delayed complications. Awareness, early recognition and appropriate management are of paramount importance for improving the outcome of these patients and their quality of life. Moreover, avoidance or mitigation of any complications may decrease the length of hospital stay, the number of hospitalre-admissions, thus significantly decreasing the overall health cost.

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Footnote

Conflicts of Interest: The authors have no conflict of interest to declare.

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