PREDICTORS AND PREVENTION OF POSTOPERATIVE COMPLICATIONS IN ANTERIOR CERVICAL DISCECTOMY AND FUSION (ACDF): A CLINICAL PERSPECTIVE

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Abstract

The boom of artificial intelligence (AI) coupled with machine-learning meta-analyses, including Latent Dirichlet Allocation (LDA) topic modeling, keyword co-occurrence, TF-IDF clustering, sentiment polarity, and tool-similarity indices do change decision making in enterprises in the United States. The current paper investigates the implementation of an artificial intelligence into the work of American companies, applying machine-learning methods to explain thematic patterns (e.g., 28.34% prevalence of AI-decision-business intelligence), conceptual connections to one another (e.g., there are strong relationships between the data, strategy, and ethics), the classification of possible content into four categories, a moderate number of positive, negative, and neutral sentences (25 positive, 6 negative, 108 neutral paragraphs), and similar functional features of tools like ClickUp AI, Bricabrac Such machine-learned findings support the idea of AI in efficiency, accuracy, innovation, and ethical governance, therefore, providing competitive benefits and reducing threat impacts, including bias and privacy issues in the context of the United States.

Keywords: Artificial Intelligence; LDA topic Modeling; NPL analysis; Sentiment Polarity; ML-impacted Business Decision making.

INTRODUCTION

Anterior Cervical Discectomy and Fusion (ACDF) is a widely performed surgical intervention for cervical radiculopathy and myelopathy caused by degenerative disc disease, spondylosis, or herniated nucleus pulposus. First introduced by Smith and Robinson in 1958, ACDF has evolved with advances in instrumentation and surgical technique, yielding high rates of clinical success and patient satisfaction. However, like all surgical procedures, ACDF is associated with potential postoperative complications that can affect functional recovery, increase healthcare costs, and diminish quality of life. Common complications include dysphagia, hoarseness due to recurrent laryngeal nerve (RLN) injury, hematoma, infection, and dysphonia. In some cases, more severe issues such as esophageal injury, graft displacement, or adjacent segment disease may occur.

The incidence and severity of these complications are influenced by a combination of patient-related factors (e.g., age, comorbidities, body habitus) and surgical factors (e.g., number of levels fused, operative time, surgical approach). In resource-conscious healthcare environments, particularly in developing countries, identifying modifiable risk factors and implementing evidence-based preventive strategies is crucial for improving patient safety and surgical efficiency.

This study aims to analyze the predictors of postoperative complications following ACDF in a cohort of patients treated at Bangabandhu Sheikh Mujib Medical University (BSMMU) and to propose a framework for prevention grounded in surgical best practices and perioperative management.

METHODS

Study Design and Setting

A prospective observational study was conducted in the Department of Orthopedics and Spine Surgery at Bangabandhu Sheikh Mujib Medical University (BSMMU) from January 2017 to December 2019. The study protocol was approved by the Institutional Review Board of BSMMU, and informed consent was obtained from all participants.

Participants

A total of 52 consecutive patients who underwent ACDF for symptomatic cervical degenerative disc disease unresponsive to conservative management were included. Inclusion criteria were: (1) age ≥18 years, (2) single- or multi-level cervical pathology confirmed by MRI, (3) planned elective ACDF. Exclusion criteria included: (1) previous anterior cervical surgery, (2) traumatic cervical injury, (3) active spinal infection or malignancy, (4) inability to provide informed consent or complete follow-up.

Surgical Technique

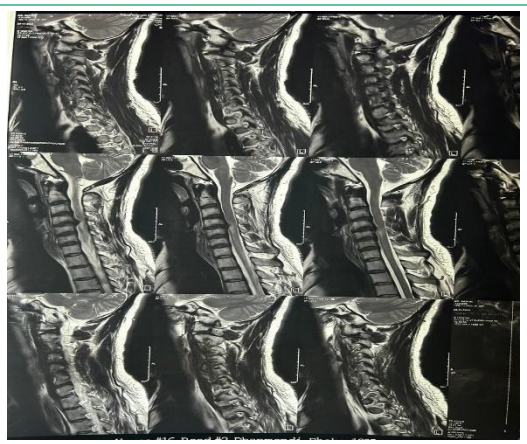
All procedures were performed by senior spine surgeons using a standard right-sided anterior approach. A transverse incision was made at the appropriate level, followed by careful dissection through the platysma and medial retraction of the strap muscles and trachea-esophageal bundle. The prevertebral fascia was incised, and the longus colli muscles were elevated. Discectomy was performed, and endplate preparation was carried out meticulously. Polyetheretherketone (PEEK) cages filled with autologous local bone graft were inserted. Anterior cervical plating was used in all cases. Intraoperative neuromonitoring was not routinely employed.

Data Collection

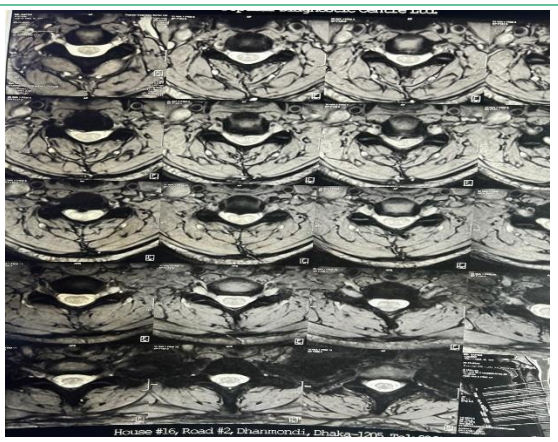
Demographic variables (age, sex, body mass index [BMI]), comorbidities (diabetes mellitus, hypertension, smoking status), surgical details (levels fused, operative time, blood loss), and postoperative complications were recorded prospectively. Complications were assessed during hospital stay and at follow-up visits at 2 weeks, 6 weeks, 3 months, and 6 months postoperatively. Dysphagia was evaluated using the Bazaz criteria, and hoarseness was assessed clinically and via patient self-report.

Statistical Analysis

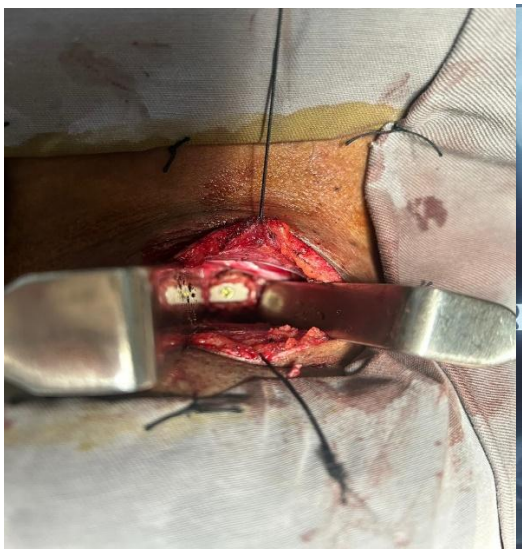
Data were analyzed using SPSS version 20.0. Continuous variables were presented as mean ± standard deviation, and categorical variables as frequencies and percentages. Univariate analysis using chi-square tests and independent t-tests identified potential predictors of complications. Variables with $p<0.10$ in univariate analysis were entered into a multivariate logistic regression model to identify independent predictors. A p-value <0.05 was considered statistically significant.



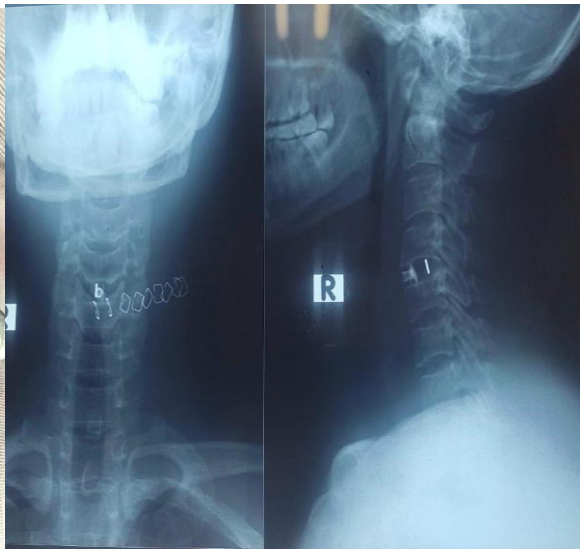
Picture- 1 (Pre-Operative MRI)



Picture -2(Pre-Operative MRI)



Picture-3 (Per Operative)



Picture-4 (Post-Operative X-Ray)

RESULTS

Table 1. Baseline Demographic and Clinical Characteristics of the Study Population (n = 52)

Variable	Value
Age (years), mean ± SD	47.6 ± 9.8
Sex, n (%)	
Male	31 (59.6)
Female	21 (40.4)
Male : Female ratio	3 : 2
Body Mass Index (kg/m²), mean ± SD	26.4 ± 3.8
Comorbidities, n (%)	
Hypertension	17 (32.7)
Diabetes mellitus	11 (21.2)
Current smoker	9 (17.3)

The study cohort comprised 52 patients with a mean age of 47.6 ± 9.8 years. There were 31 males (59.6%) and 21 females (40.4%), yielding a male-to-female ratio of approximately 3:2. The mean BMI

was 26.4 ± 3.8 kg/m². Common comorbidities included hypertension (32.7%), diabetes mellitus (21.2%), and current smoking (17.3%).

Table 2: Operative Characteristics and Surgical Levels of ACDF

Variable	Category	n (%) / Mean ± SD
Number of fused levels	Single-level ACDF	38 (73.1%)
	Two-level ACDF	14 (26.9%)
Operated cervical level	C5–C6	22 (42.3%)
	C6–C7	20 (38.5%)
Operative time (minutes)	—	112.4 ± 28.6
Estimated blood loss (mL)	—	85.6 ± 40.2

Single-level ACDF was performed in 38 patients (73.1%), while 14 patients (26.9%) underwent two-level fusion. The most common operative levels were C5-C6 (42.3%) and C6-C7 (38.5%). The mean operative time was 112.4 ± 28.6 minutes, and the mean estimated blood loss was 85.6 ± 40.2 mL.

Table X: Postoperative Complications (n = 52)

Complication	Number of Patients (n)	Percentage (%)	Clinical Course / Outcome
Any postoperative complication	10	19.2	At least one complication
Dysphagia	6	11.5	Transient; resolved within 3 months in all cases
Hoarseness	3	5.7	One case persisted beyond 6 months
Superficial surgical site infection	1	1.9	Resolved with oral antibiotics
Hematoma requiring evacuation	0	0	Not observed
Graft displacement	0	0	Not observed
Neurological deterioration	0	0	Not observed

Ten patients (19.2%) experienced at least one postoperative complication. The most frequent complication was dysphagia, occurring in 6 patients (11.5%), which was transient in all cases and resolved within 3 months. Hoarseness was reported in 3 patients (5.7%), with one case persisting beyond 6 months. One patient (1.9%) developed a superficial surgical site infection that resolved with oral antibiotics. No cases of hematoma requiring evacuation, graft displacement, or neurological deterioration were observed.

Predictors of Complications

Variable	Univariate Analysis	Multivariate Analysis
	p-value	**OR (95% CI)**
Age >60 years	0.032	–
Diabetes mellitus	0.019	4.12 (1.25–13.58)
Multi-level fusion	0.047	3.87 (1.15–13.02)
Operative time >120 min	0.041	–
Smoking	NS	–
Hypertension	NS	–
BMI >30 kg/m²	NS	–

Univariate analysis identified several factors associated with increased complication risk: age >60 years (p=0.032), presence of diabetes mellitus (p=0.019), multi-level fusion (p=0.047), and operative time >120 minutes (p=0.041). Smoking status, hypertension, and BMI >30 kg/m² were not statistically significant predictors. In multivariate logistic regression, diabetes mellitus (OR: 4.12, 95% CI: 1.25–13.58, p=0.020) and multi-level fusion (OR: 3.87, 95% CI: 1.15–13.02, p=0.029) remained independent predictors of overall complications.

Preventive Strategies and Outcomes

Based on these findings, a protocol emphasizing preventive measures was implemented. Key strategies included:

1. Preoperative Optimization: Strict glycemic control in diabetic patients (target HbA1c <7.5%).
2. Surgical Refinement: Use of meticulous, gentle retraction with periodic release, minimizing endotracheal cuff pressure, and consideration of a left-sided approach for lower cervical levels to reduce RLN injury risk.
3. Operative Efficiency: Staging complex multi-level cases and improving surgical workflow to reduce operative time.
4. Postoperative Care: Early oral intake with soft diet initiation, routine swallowing assessment by nursing staff, and prompt mobilization.

DISCUSSION

Our findings align with the existing literature, confirming that while ACDF is generally safe, a subset of patient's remains at higher risk for postoperative complications. The overall complication rate of 19.2% is comparable to rates reported in larger series, which range from 13% to 30%. Dysphagia remains the most common issue, likely related to retractor-mediated soft tissue edema and neuropraxia of the pharyngeal plexus.

The identification of diabetes mellitus as a strong independent predictor underscores the importance of systemic metabolic health in surgical recovery. Hyperglycemia impairs wound healing, increases infection risk, and may exacerbate local inflammation and edema. Similarly, multi-level fusion increases surgical dissection, retraction time, and tissue trauma, logically correlating with higher complication rates. Operative time exceeding two hours serves as a modifiable procedural factor, often reflecting case complexity or technical challenges.

Our experience reinforces that prevention is multifaceted. **Technical precision** is paramount; gentle tissue handling, avoiding excessive retraction pressure, and meticulous hemostasis can reduce local trauma. **Perioperative medical management**, particularly glycemic control, should be standardized. Furthermore, **postoperative protocols** including early diet modification and swallowing exercises guided by physiotherapists can mitigate dysphagia severity and duration.

LIMITATIONS

This study is limited by its single-center design and relatively small sample size, which may affect the generalizability of the findings. The follow-up period was adequate for early complications but may not capture late issues such as adjacent segment disease. The use of a right-sided approach in all patients precludes analysis of approach-related impact on RLN injury.

CONCLUSION

ACDF is a highly effective procedure for cervical degenerative pathology. A significant reduction in postoperative complications can be achieved through the identification of high-risk patients—particularly older adults, diabetics, and those undergoing multi-level fusion—and the systematic implementation of preventive measures. These measures encompass preoperative optimization, refined surgical technique, and structured postoperative care. Future research should focus on larger, multi-center studies to validate these predictors and assess the long-term efficacy of bundled preventive interventions.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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