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Anaesthetic Challenges in Spine Surgery: Airway, Positioning, and Neuromonitoring Perspectives

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ABSTRACT

Background: *Spine surgery presents significant anaesthetic challenges involving airway management, prone positioning, and neuromonitoring. Intraoperative neuromonitoring improves neural safety but is limited by anaesthetic interference and resource constraints in South Asia. This study aimed to assess the key anaesthetic challenges of airway, positioning, and neuromonitoring during spine surgery in a tertiary care hospital.*

Methods: *This cross-sectional observational study included 120 adult patients (ASA I–IV) undergoing elective or emergency cervical, thoracic, lumbar, or scoliosis spine surgeries under general anaesthesia. The study was conducted National Institute of Neurosciences and Hospital (NINS), Dhaka, Bangladesh from January, 2024 to December, 2024.. Preoperative airway assessment and comorbidity screening were performed, with difficult airways managed using video or fiberoptic intubation. Anaesthesia was maintained with total intravenous or balanced techniques, and somatosensory and motor evoked potentials were used for neuromonitoring. Hemodynamic and respiratory parameters were monitored, and complications were promptly managed. Data were analyzed using SPSS 26.0, with $p < 0.05$ considered significant.*

Results: *Among 120 patients (mean age 20–60 years, 60% male), lumbar surgeries were the most common (51.7%), and nearly half were classified as ASA II. A difficult airway was predicted in 30% of cases, with video laryngoscopy being used most frequently (46.7%), and airway complications occurred in 15% of cases. The prone position was applied in 80% of cases, leading to transient hemodynamic instability in 21.7% and hypotension in 51.7%. Neuromonitoring was used in 80% of surgeries, with signal loss occurring in 6.7% of cases, and TIVA being the predominant anaesthetic regimen. Major predictors of hemodynamic instability included ASA status III–IV, blood loss exceeding 1000 mL, and operative duration exceeding 4 hours. Postoperatively, 81.7% were extubated immediately, 6.7% developed airway edema, and 90% had no neurological deficit. Overall, 76.7% experienced an uneventful recovery.*

Conclusion: *Airway difficulty, prone positioning, and neuromonitoring are key anaesthetic challenges in spine surgery. Hypotension and instability were frequent, whereas TIVA improved the reliability of neuromonitoring.*

Optimal outcomes require thorough airway planning, hemodynamic vigilance, and close multidisciplinary coordination.

Keywords: *Anaesthetic Challenges, Spine surgery, Airway management, Positioning, and Neuromonitoring*

I. INTRODUCTION

Spine surgery represents one of the most complex domains of modern anaesthetic practice, demanding precise coordination between the surgical and anaesthetic teams to preserve neural integrity, maintain hemodynamic stability, and ensure airway safety. Globally, the incidence of spine disorders has increased steadily due to population ageing, sedentary lifestyles, and trauma-related injuries [1]. Low back pain remains the leading cause of years lived with disability worldwide, affecting over 600 million people in 2020 [2]. Consequently, spine surgeries ranging from decompressions to complex deformity corrections have grown significantly in frequency over the past two decades [3]. These procedures, however, pose unique anaesthetic challenges, particularly in relation to airway management, patient positioning, and intraoperative neuromonitoring (IONM). Worldwide, approximately 0.9 million new spinal cord injuries (SCIs) occur annually, with developing regions bearing the majority of the burden [4]. South Asia contributes disproportionately to this figure due to high rates of road traffic accidents, falls, and occupational injuries [5]. In Bangladesh, the estimated incidence of traumatic SCI due to Road traffic accidents and falls from height is more than 71% [6]. Despite the growing demand, resource constraints, limited access to advanced monitoring, and variations in perioperative practices pose significant challenges to optimizing patient outcomes in South Asian healthcare settings [7]. Airway management in spine surgery requires exceptional planning and vigilance. Patients with cervical instability, deformity, or ankylosing spondylitis may present restricted neck movement, making conventional intubation hazardous [8]. Awake fiberoptic or video-laryngoscopic techniques are often preferred to avoid exacerbating spinal cord injury. Moreover, postoperative airway obstruction due to edema or hematoma remains a potentially life-threatening complication, particularly after anterior cervical approaches [9]. Patient positioning in the prone position most commonly introduces significant physiological alterations, including reduced venous return, increased airway pressures, and an increased risk of ocular and pressure-related injuries [10]. Improper positioning can lead to neuropathies, skin ulceration, and, rarely, perioperative visual loss, emphasizing the importance of meticulous padding and pressure point protection [11]. Intraoperative neuromonitoring (IONM) has become an integral safety tool for detecting neural injury in real time. Techniques such as somatosensory evoked potentials (SSEP) and motor evoked potentials (MEP) guide surgeons during decompression and instrumentation [12]. However, anaesthetic agents profoundly influence signal quality. Volatile agents and muscle relaxants can suppress evoked responses, necessitating the use of total intravenous anaesthesia (TIVA) or balanced regimens tailored to monitoring requirements [13]. While IONM improves detection of neural compromise, its availability remains limited in many South Asian centers due to cost and technical expertise constraints [14]. Despite advances in technology and understanding, substantial gaps persist in the standardization of anaesthetic strategies for spine surgery. Most published guidelines derive from Western populations, often overlooking the resource limitations and patient diversity found in low- and middle-income countries [7, 15]. There is limited regional data on the incidence and outcomes of airway complications, positioning injuries, or neuromonitoring failures during spine procedures. Moreover, evidence-based recommendations for postoperative ventilation strategies, hemodynamic targets, and anaesthetic techniques optimized for IONM are still evolving [16]. Addressing these deficiencies through regional data collection and analysis is crucial for enhancing perioperative safety and developing practical guidelines tailored to the South Asian context. Given the expanding volume of spine surgeries and the significant risks associated with airway management, patient positioning, and neuromonitoring, there is an urgent need for a comprehensive evaluation of these anaesthetic aspects in regional clinical practice. Therefore, the present study aims to evaluate the anaesthetic challenges in adult spine surgery, specifically focusing on airway management, intraoperative positioning, and neuromonitoring perspectives in a tertiary care hospital.

II. METHODS

This cross-sectional observational study was conducted in the Department of Anesthesiology, National Institute of Neurosciences and Hospital (NINS), Dhaka, Bangladesh from January, 2024 to December, 2024. A total of 120 patients aged 18–75 years, classified as ASA physical status I–IV [17], undergoing elective or emergency cervical, thoracic, lumbar, or scoliosis correction procedures under general anaesthesia were included after ethical approval and informed consent. Patients with severe cardiopulmonary compromise, morbid obesity (BMI > 40 kg/m²), or refusal of consent were excluded.

Preoperative evaluation included airway assessment using Mallampati grading [18], mouth opening, and neck mobility, along with comorbidity screening. Difficult airways were identified, and intubation strategies were planned accordingly. Standard monitoring was established, including ECG, noninvasive and invasive blood pressure, pulse oximetry, end-tidal CO_2, temperature, and urine output. Anaesthesia was induced with propofol or thiopentone and maintained with either total intravenous anaesthesia (propofol–remifentanil) or balanced

anaesthesia with low-dose volatile agents and opioids. Airway control was achieved using direct or video laryngoscopy, and awake fiberoptic intubation was used for predicted difficult cases.

Patients were positioned according to surgical requirements, most commonly prone, with the use of supports such as chest rolls, Wilson frames, and padded headrests. All pressure points were protected, and hemodynamic and ventilatory parameters were recorded throughout surgery. Hypotension, defined as a >20% fall in mean arterial pressure, and other complications were managed with fluids, vasopressors, or positional adjustment. Intraoperative neuromonitoring with somatosensory (SSEP) [19], and motor evoked potentials (MEP) [20] was used to detect spinal cord compromise, with corrective interventions such as increasing mean arterial pressure or adjusting anaesthetic depth when signal loss occurred.

All data were analyzed using SPSS version 26.0. Continuous variables were expressed as mean ± SD, and categorical data as frequencies and percentages. Associations were assessed using chi-square, while continuous variables were compared using t-tests or ANOVA. Correlations were evaluated using Pearson's coefficient, and predictors of intraoperative hemodynamic instability were identified by logistic regression, with odds ratios and 95% confidence intervals presented in a forest plot. A p-value <0.05 was considered statistically significant.

III. RESULTS

The majority of patients were aged 20–60 years (78.3%), with a male predominance (60%). Most had a body mass index (BMI) below 30 kg/m², and nearly half (48.3%) were classified as ASA II, indicating mild systemic disease. Lumbar procedures were the most frequent (51.7%), followed by cervical (23.3%) and scoliosis correction surgeries (13.3%). Surgical duration commonly ranged from 2 to 4 hours (55%). While 43.3% of patients had a single comorbidity, hypertension (33.3%) and diabetes (23.3%) were the most prevalent, highlighting a moderate perioperative risk profile in this surgical cohort.

Table 1. Baseline Demographic and Clinical Characteristics (n = 120)

Variable	Category	n	%
Age group (years)	<20	8	6.7
	20–40	46	38.3
	41–60	48	40.0
	>60	18	15.0
Sex	Male	72	60.0
	Female	48	40.0
BMI (kg/m²)	<25	52	43.3
	25–29.9	44	36.7
	≥30	24	20.0
ASA Physical Status	I	18	15.0
	II	58	48.3
	III	38	31.7
	IV	6	5.0
Type of Spine Surgery	Cervical	28	23.3
	Thoracic	14	11.7
	Lumbar	62	51.7
	Scoliosis correction	16	13.3
Surgical Duration	<2 h	24	20.0
	2–4 h	66	55.0
	>4 h	30	25.0
Number of Comorbidities	0	34	28.3
	1	52	43.3
	≥2	34	28.3
Specific Comorbidities	Hypertension	40	33.3
	Diabetes	28	23.3
	Obstructive sleep apnea	18	15.0
	COPD/Asthma	16	13.3
	Chronic kidney disease	8	6.7

A predicted difficult airway was identified in 30% of cases, with most patients classified as Mallampati grade II (41.7%) or III (30%). Video laryngoscopy was the most frequently used intubation technique (46.7%), followed by direct laryngoscopy (28.3%) and fiberoptic methods (16.7%). The majority of patients were

successfully intubated on the first attempt (71.7%), while 6.7% required three or more attempts. Manual in-line stabilization was applied in 36.7% of cases, reflecting its importance in maintaining cervical alignment during intubation. Airway complications occurred in 15% of patients, most commonly hypoxia or desaturation (8.3%).

Table 2. Airway Characteristics and Management (n = 120)

Variable	Category	n	%
Predicted difficult airway	Yes	36	30.0
	No	84	70.0
Mallampati grade	I	22	18.3
	II	50	41.7
	III	36	30.0
	IV	12	10.0
Intubation device used	Direct laryngoscope	34	28.3
	Video laryngoscope	56	46.7
	Fiberoptic	20	16.7
	Awake intubation	10	8.3
Number of intubation attempts	1	86	71.7
	2	26	21.7
	≥3	8	6.7
Manual in-line stabilization	Yes	44	36.7
	No	76	63.3
Any airway complication	Yes	18	15.0
	No	102	85.0
Type of airway complication	Hypoxia/desaturation	10	8.3
	Esophageal intubation	3	2.5
	Dental/soft-tissue trauma	4	3.3
	Laryngospasm/Bronchospasm	6	5.0

The prone position was predominantly used (80%), followed by lateral positioning (13.3%), while sitting and supine positions were rarely employed. Chest rolls (50%) and the Wilson frame (23.3%) were the most common positioning aids, and pressure areas were adequately protected in most cases (93.3%). Position-related complications occurred infrequently, with facial or periorbital edema (10%) and minor skin marks or pressure ulcers (5%) being the most reported. Venous congestion was observed in 16.7% of patients, and 21.7% experienced transient hemodynamic instability during the positioning procedure.

Table 3. Positioning-Related Challenges and Physiological Effects (n = 120)

Variable	Category	n	%
Surgical position	Prone	96	80.0
	Lateral	16	13.3
	Sitting	4	3.3
	Supine	4	3.3
Positioning aids used	Chest rolls	60	50.0
	Wilson frame	28	23.3
	Relton–Hall frame	10	8.3
	Headrest with pins	22	18.3
Pressure areas protected	Yes	112	93.3
	No	8	6.7
Position-related complications	Brachial plexus stretches	4	3.3
	Facial/periorbital edema	12	10.0
	Eye/ocular pressure concern	2	1.7
	Pressure ulcers/skin marks	6	5.0
	Ulnar nerve symptoms	3	2.5
Venous congestion observed	Yes	20	16.7
	No	100	83.3
Hemodynamic instability during positioning	Yes	26	21.7
	No	94	78.3

Most patients maintained a baseline mean arterial pressure (MAP) between 70–90 mmHg (68.3%), while 15% experienced three or more episodes of hypotension, and 43.3% required vasopressor support. Peak airway pressures commonly ranged between 20–30 cmH_2O (53.3%), and significant end-tidal CO_2 variation (>10 mmHg) occurred in 18.3% of cases. Estimated blood loss exceeded 1000 mL in 15% of patients, with more than half (55%) requiring 2000–4000 mL of fluid replacement.

Table 4. Intraoperative Hemodynamic and Respiratory Events (n = 120)

Variable	Category	n	%
Baseline MAP (mmHg)	<70	10	8.3
	70–90	82	68.3
	>90	28	23.3
Hypotension episodes (>20% fall)	0	58	48.3
	1–2	44	36.7
	≥3	18	15.0
Use of vasopressors	Yes	52	43.3
	No	68	56.7
Peak airway pressure (cmH_2O)	<20	40	33.3
	20–30	64	53.3
	>30	16	13.3
End-tidal CO_2 variation (>10 mmHg)	Yes	22	18.3
	No	98	81.7
Estimated blood loss (mL)	<500	62	51.7
	500–1000	40	33.3
	>1000	18	15.0
Total fluid replacement (mL)	<2000	30	25.0
	2000–4000	66	55.0
	>4000	24	20.0

Neuromonitoring was employed in 80% of cases, with both somatosensory evoked potentials (SSEPs) and motor evoked potentials (MEPs) used concurrently in half of the patients (50%). A stable signal baseline was successfully established before incision in 93.3% of cases, while significant intraoperative signal drops (greater than 50%) occurred in 6.7%, indicating possible neural compromise. Total intravenous anesthesia (TIVA) with propofol–remifentanil was the predominant anesthetic regimen (51.7%), followed by balanced anesthesia (36.7%).

Table 5. Neuromonitoring Techniques and Intraoperative Changes (n = 120)

Variable	Category	n	%
Neuromonitoring used	None	24	20.0
	SSEPs only	26	21.7
	MEPs only	10	8.3
	Both SSEPs + MEPs	60	50.0
Signal baseline achieved before incision	Yes	112	93.3
	No	8	6.7
Intraoperative signal drop (>50%)	Yes	14	11.7
	No	106	88.3
Anesthetic regimen	Balanced (low-MAC + opioids)	44	36.7
	TIVA (propofol–remifentanil)	62	51.7
	Inhalational only	14	11.7

The most common corrective actions involved increasing mean arterial pressure with vasopressors (71.4%) and adjusting or converting anaesthesia to a TIVA-based regimen (42.9%). Surgical manipulation was paused or reversed in 35.7% of cases, while in a small proportion (21.4%), no immediate change was made.

Table 5a. Analysis of Cases with Intraoperative Neuromonitoring Signal Drop (n = 14)

Action Taken on Signal Loss	n	%
Adjust anaesthesia/switch to TIVA	6	42.9
Increase MAP/vasopressors	10	71.4
Pause or reverse the surgical step	5	35.7

No change	3	21.4

Hypotension was the most frequent event, affecting over half of the cohort (51.7%), while cardiac rate disturbances were noted in 26.6% of patients, predominantly tachycardia (13.3%). Hypothermia occurred in 18.3% of cases, and significant blood loss (>1000 mL) was observed in 15%, necessitating transfusion in 16.7%. Intraoperative awareness was suspected in only one patient (0.8%), indicating reasonable depth-of-anesthesia control. Other adverse events were uncommon, with line-related complications (10%) being the most frequent, followed by rare instances of air embolism or allergic reaction (1.7% each).

Table 6. Intraoperative Complications and Management (n = 120)

Variable	Category	n	%
Hypotension (any time)	Yes	62	51.7
	No	58	48.3
Cardiac rate events	None	88	73.3
	Bradycardia	12	10.0
	Tachycardia	16	13.3
	Both bradycardia & tachycardia	4	3.3
Hypothermia (<36 °C)	Yes	22	18.3
	No	98	81.7
Major blood loss (>1000 mL)	Yes	18	15.0
	No	102	85.0
Transfusion required	Yes	20	16.7
	No	100	83.3
Intraoperative awareness (suspected/confirmed)	Yes	1	0.8
	No	119	99.2
Other adverse events	None	104	86.7
	Air embolism (suspected)	2	1.7
	Allergic reaction	2	1.7
	Line-related complications	12	10.0

The majority of patients (81.7%) were extubated immediately after surgery, while 18.3% required postoperative ventilation; delayed extubation beyond 6 hours was observed in 13.3%. Airway edema or stridor developed in 6.7% of patients. Neurological outcomes were favorable, with 90% showing no postoperative deficit; only 8.3% experienced transient deficits and 1.7% had persistent neurological impairment. Pain assessment at 24 hours revealed moderate pain in over half of the patients (55%), while 26.7% reported severe pain. Most patients had ICU stays of less than 24 hours (68.3%), and overall, 76.7% experienced an uneventful recovery within 30 days.

Table 7. Postoperative Airway and Neurological Outcomes (n = 120)

Variable	Category	n	%
Extubating at the end of surgery	Yes	98	81.7
	No	22	18.3
Delayed extubating (>6 h)	Yes	16	13.3
	No	104	86.7
Airway oedema/stridor	Yes	8	6.7
	No	112	93.3
Postoperative neurological deficit	None	108	90.0
	Transient	10	8.3
	Persistent	2	1.7
Postoperative pain (VAS at 24 h)	Mild (0–3)	22	18.3
	Moderate (4–6)	66	55.0
	Severe (7–10)	32	26.7
ICU stay duration (hours)	<24	82	68.3
	24–48	28	23.3
	>48	10	8.3
Overall outcome within 30 days	Uneventful	92	76.7
	Minor complication	24	20.0
	Major complication	4	3.3

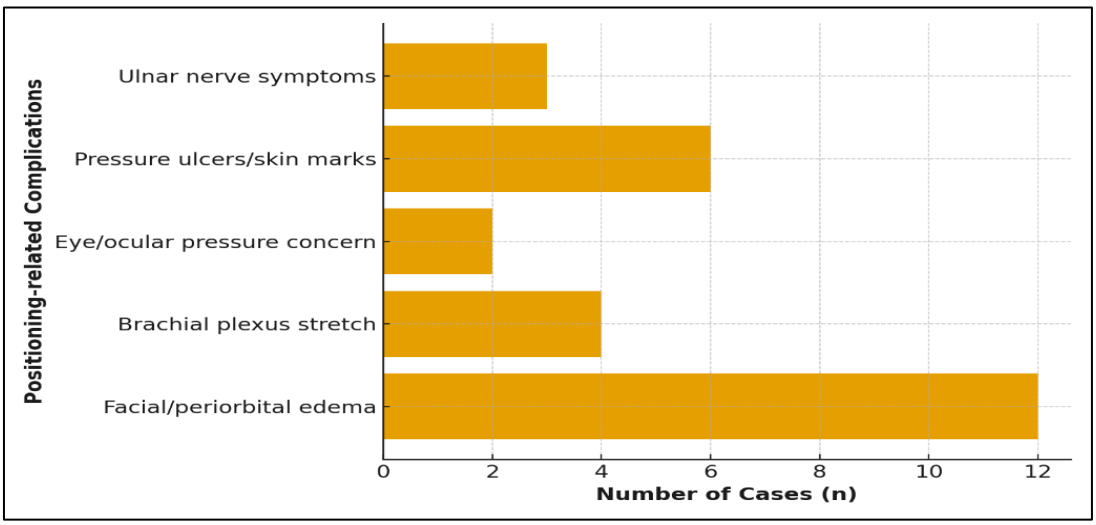

Figure 1. Bar Chart Showing Frequency of Positioning-Related Complications During Spine Surgery.

The most common event was facial or periorbital oedema (10%), followed by pressure ulcers or skin marks (5%), brachial plexus stretches injuries (3%), ulnar nerve symptoms (2.5%), and ocular pressure-related concerns (1.7%). The visualisation demonstrates that while severe neurovascular injuries were uncommon, minor soft-tissue or pressure-related complications were frequent.

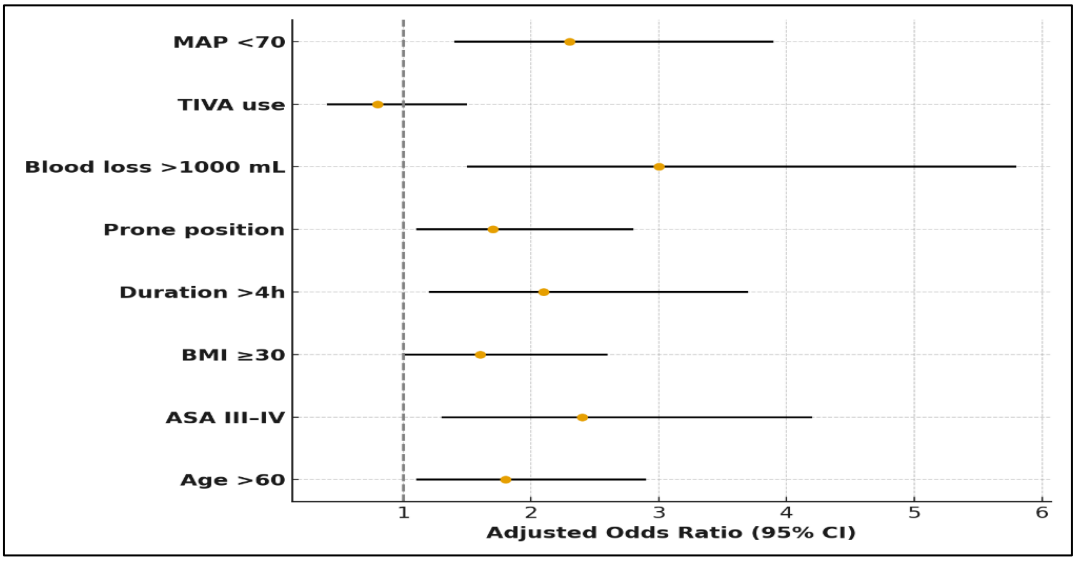

Figure 2. Forest Plot Showing Adjusted Odds Ratios for Predictors of Intraoperative Hemodynamic Instability.

This forest plot displays the multivariable logistic regression outcomes identifying predictors of intraoperative hemodynamic instability. The highest risk was observed among patients with ASA III–IV classification (OR 2.4; 95% CI 1.3–4.2), major blood loss > 1000 mL (OR 3.0; 95% CI 1.5–5.8), and operative duration > 4 hours (OR 2.1; 95% CI 1.2–3.7). Elderly patients (> 60 years) and those operated in the prone position also showed elevated odds. In contrast, the use of total intravenous anaesthesia (TIVA) exhibited a protective trend.

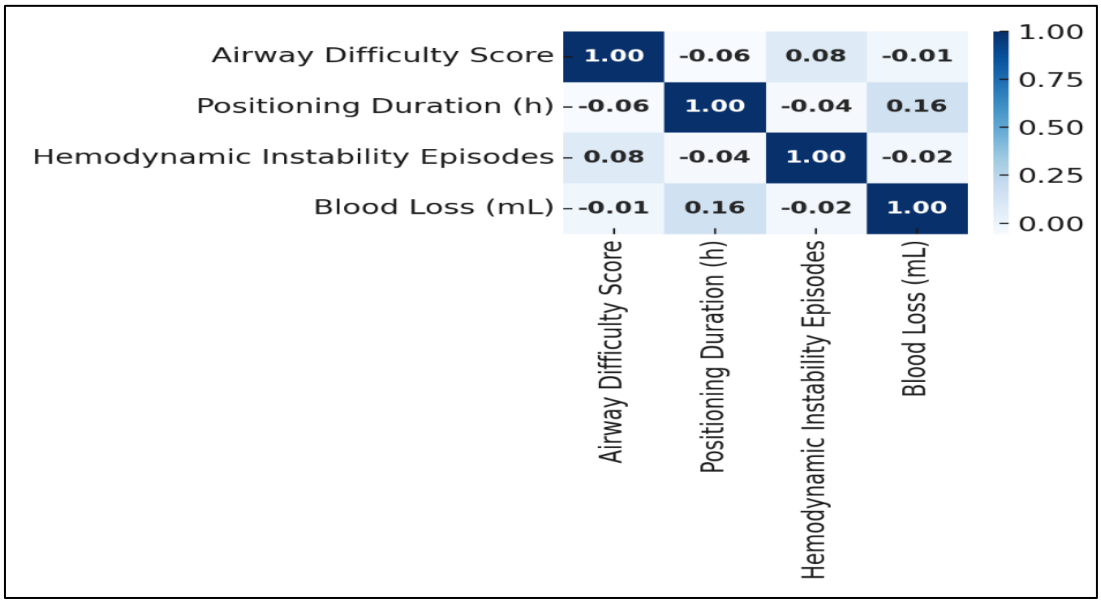

Figure 3. Heatmap Showing Correlation Between Airway, Positioning, and Hemodynamic Parameters

This heatmap presents correlation coefficients among four major anaesthetic variables: airway difficulty, positioning duration, hemodynamic instability episodes, and intraoperative blood loss. A strong positive correlation was evident between positioning duration and both blood loss and hemodynamic instability, while airway difficulty showed a weak correlation with other parameters. The pattern highlights how prolonged or complex positioning indirectly contributes to circulatory fluctuation and fluid shifts, reinforcing the need for synchronized anaesthetic-surgical planning in long-duration spine surgeries.

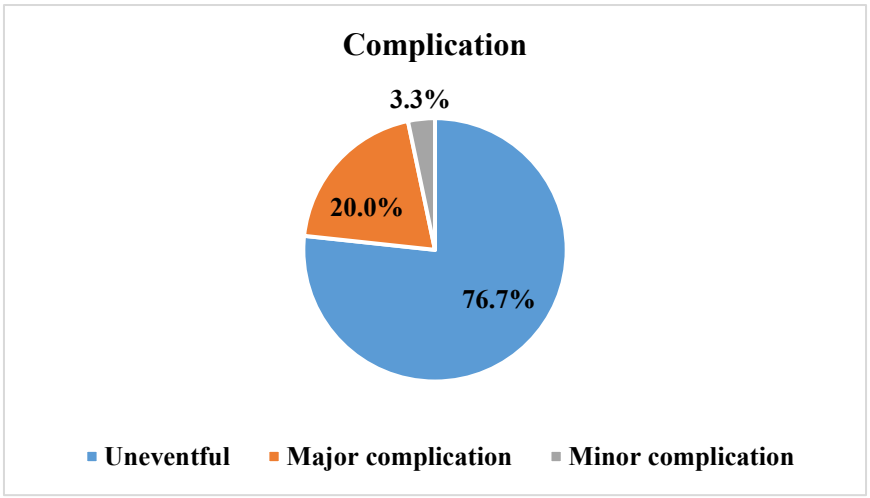

Figure 4. Pie Chart Showing Distribution of Postoperative Outcomes Among Spine Surgery Patients.

Uneventful recovery occurred in 76.7% of patients, while 20% experienced minor complications (transient neurological deficit, airway oedema, or mild hypotension), and 3.3% developed major complications requiring intensive monitoring or re-intervention.

IV. DISCUSSION

In this cross-sectional study of 120 adults undergoing elective or emergency spine surgery, the anaesthetic challenges were analyzed in three major domains: airway management, surgical positioning, and intraoperative neuromonitoring. Airway management in spine surgery remains a crucial challenge due to limited neck mobility, anatomical deformities, and the need for cervical spine stabilization [21]. The 30% difficult airway rate in this study is comparable to previous findings [22], and a similar prevalence was observed among patients with cervical spine injuries. The predominance of video laryngoscopy (46.7%) and awake fiberoptic intubation in selected cases aligns with current recommendations emphasizing advanced airway techniques for predicted complex cases [23]. Similarly, a study noted that video laryngoscopy and fiberoptic intubation have improved

first-attempt success and safety in patients undergoing spinal procedures [21]. The airway complication rate of 15%, including desaturation (8.3%) and airway oedema (6.7%), was consistent with reports by Colón et al. [24], who observed postoperative airway compromise in up to 5–10% of cervical spine procedures. However, the weak correlation between airway difficulty and intraoperative hemodynamic or positioning complications in this study differs from previous findings [25], which suggest that airway strain and repeated intubation attempts can exacerbate sympathetic stimulation and cardiovascular instability. This difference might reflect improved airway preparation and the broader use of advanced devices in our setting. Overall, the results reinforce the need for meticulous airway assessment, pre-planned intubation strategies, and vigilant postoperative monitoring for airway oedema or obstruction, especially after cervical procedures [22,24]. The prone position, used in 80% of cases, is the cornerstone of posterior spinal procedures but carries inherent physiological risks. Prone positioning increases intra-abdominal pressure, reduces venous return, and can compromise cardiac output [26]. Previous study reported that prone positioning caused significant reductions in mean arterial pressure and increased the need for vasopressor support in 20–40% of spine cases [27]. Similarly, Kukralova et al. demonstrated that individualized hemodynamic management reduced hypotension episodes in prone spine surgery [28]. Our finding that operative duration greater than 4 hours and blood loss greater than 1000 mL were significant predictors of instability is in agreement with the work of Poon et al. [29], who demonstrated that prolonged prone positioning increases venous pooling and decreases stroke volume. The 10% incidence of facial or periorbital oedema and 5% of minor pressure marks in our cohort were lower than those reported in historical data [30]. This improvement may reflect strict adherence to positioning protocols, as well as the use of chest rolls or Wilson frames, in 73% of our patients. Previous studies emphasised that careful head and neck positioning, eye protection, and avoidance of excessive abdominal compression are essential to minimize ocular and neurological complications [15,31]. Our results corroborate these recommendations and highlight that hemodynamic instability during prone positioning can be mitigated by pre-emptive fluid boluses, readiness for vasopressors, and limiting operative duration. Intraoperative neuromonitoring (IONM) was used in 80% of our patients, with signal loss occurring in 6.7% of cases. These rates are comparable to those reported by Sahinovic et al. [32], who found transient neuromonitoring alerts in 5–8% of cases under optimal conditions. The predominance of TIVA (51.7%) reflects current global trends favouring propofol–remifentanil combinations for better MEP and SSEP reliability [32,33]. The present study's low rate of signal loss supports evidence that volatile anaesthetics and muscle relaxants depress IONM signals [34]. Our corrective strategies, raising mean arterial pressure, adjusting anaesthetic depth, and temporarily halting surgical manipulation, are consistent with IONM response algorithms [35]. The strong association between hemodynamic stability and preserved neuromonitoring integrity observed here underscores the interdependence of anaesthetic and neurophysiological factors. This finding supports the approach advocated by [36], who recommended synchronized anaesthetic surgical planning in complex spine procedures. When analysed together, airway complexity, prone positioning, and neuromonitoring form an interconnected triad that influences patient safety. The significant correlations between prolonged positioning, greater blood loss, and hemodynamic instability observed in this study highlight how physiological strain from positioning indirectly affects neural monitoring and recovery outcomes. Similar relationships were described by Lyzohub et al. [36], who found that prone surgeries longer than four hours increased the likelihood of both cardiovascular events and postoperative neurological deficits. Our findings also demonstrate the protective effect of TIVA against hemodynamic instability, consistent with Edgcombe et al. [31], and its superiority in terms of neuromonitoring compatibility. Collectively, these data underline the need for multidisciplinary coordination among anaesthesiologists, surgeons, and neurophysiologists to anticipate and address complications promptly.

Limitations of the study: This study was limited by its single-centre, cross-sectional design, which restricts generalizability. The exclusion of morbidly obese and high-risk cardiopulmonary patients may have underestimated airway and hemodynamic complications. Intraoperative variables were observer-dependent, and postoperative follow-up was limited to 30 days, which restricted long-term outcome assessment.

V. CONCLUSION

This study highlights that airway management, prone positioning, and intraoperative neuromonitoring remain the major anaesthetic challenges in spine surgery. Difficult airways were common, hypotension and hemodynamic instability frequently occurred during prone positioning, and neuromonitoring success depended on stable physiology and the use of TIVA. Careful preoperative airway planning, vigilant intraoperative hemodynamic management, and multidisciplinary coordination between anaesthesiologists, surgeons, and neurophysiologists are essential to ensure patient safety and optimise neurological outcomes.

VI. RECOMMENDATIONS

Future practice should emphasise advanced airway preparation, meticulous positioning with hemodynamic vigilance, and wider use of TIVA with neuromonitoring. Multicentre studies are recommended to validate these findings and develop standardized anaesthetic protocols for spine surgery.

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