

Total Intravenous Anesthesia Versus Volatile Anesthetic Maintenance for ACDF Surgeries- An Observational Study

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ABSTRACT

Background: Anterior Cervical Discectomy and Fusion (ACDF) is a common spinal surgery aimed at relieving nerve root or spinal cord compression in the cervical spine. The choice of anesthetic technique plays a pivotal role in ensuring optimal surgical conditions, neurological monitoring, and postoperative recovery. While volatile anesthetics are traditionally used, Total Intravenous Anesthesia (TIVA) is emerging as a preferred alternative due to its favorable hemodynamic and neurophysiological profile.

Objective: To compare the perioperative outcomes of TIVA versus volatile anesthesia in patients undergoing ACDF surgery, with specific focus on intubation/extubation quality, hemodynamic stability, and intraoperative neuromonitoring compatibility.

Methods: An observational study was conducted at a tertiary care institute analyzing data from 14 patients who underwent ACDF between July 2022 and March 2025. Of these, 8 received TIVA (dexmedetomidine/propofol-based) and 6 underwent volatile anesthesia. Data were collected in adherence to STROBE guidelines. Key parameters included intubation/extubation quality, Modified Observer Assessment Sedation Score (MOASS), and incidence of peri-extubation events.

Results: The TIVA group exhibited smoother extubation with no incidences of coughing, tachycardia, or hypertension, although extubation was marginally delayed. No statistically significant difference was observed in MOASS between the groups. Literature review and supporting studies suggest that TIVA allows better Preservation of Motor Evoked Potentials (MEPs), improved hemodynamic stability, reduced Postoperative Nausea and Vomiting (PONV), and minimal environmental impact.

Conclusion: TIVA appears to offer significant advantages over volatile anesthesia in ACDF surgeries, particularly in preserving intraoperative neurophysiological signals, providing hemodynamic stability, and facilitating safer airway management and recovery. While volatile agents remain widely used, a tailored approach considering patient risk factors and surgical demands may favour TIVA as the anesthetic of choice in select ACDF cases.

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Received: July 31, 2025; **Accepted:** August 12, 2025; **Published:** August 14, 2025

Keywords: Anterior Cervical Discectomy, Fusion, Total Intravenous Anesthesia, Volatile Anesthetics, Intraoperative Monitoring

Introduction

Anterior Cervical Discectomy and Fusion (ACDF) is a common surgical procedure used to treat conditions affecting the cervical spine, such as herniated discs, degenerative disc disease, or spinal stenosis. This surgery is performed to relieve spinal cord or nerve root pressure, which can cause pain, numbness, or weakness in the neck, shoulders, and arms. The procedure involves removing the intervertebral disc through an incision in anterior aspect of neck. Once the disc is removed (discectomy), the empty space is filled with a bone graft or spacer, and the adjacent vertebrae are fused together to provide stability (fusion). ACDF is widely recognized

for its effectiveness in alleviating symptoms and restoring function in patients with cervical spine disorders.

Volatile anesthesia is commonly used in spine surgeries, due to its ease in administration and titration of anesthetic depth. However, there are several drawbacks and risks, especially in complex surgeries like ACDF, because sevoflurane / isoflurane, can cause vasodilation, leading to a drop in spinal cord blood flow. This is a serious concern in ACDF surgery, where precise spinal cord monitoring is necessitates optimal spinal cord perfusion. Significant hypotension impairs blood flow to the spinal cord and it potentially leads to neurological complications. Volatile anesthetics also depress the respiratory system. Therefore in ACDF surgery, where the airway may be compromised due to post-surgical hematoma and edema, extubating without a respiratory

gas analyzer becomes a challenge.

Volatile anesthetics also affect evoked potential signals, especially motor evoked potentials (MEP). Therefore, their use can reduce the accuracy of intraoperative neurological assessments thereby increasing the risk of undetected intra-operative nerve damage. Total Intravenous Anesthesia (TIVA) is a technique that involves use of intravenous agents, such as propofol, dexmedetomidine to maintain anesthesia throughout the surgical procedure, without the use of volatile anesthetics. TIVA provides more predictable hemodynamic control because intravenous agents are less likely to cause significant vasodilation or hypotension. In surgeries like ACDF, maintaining stable blood pressure is crucial for ensuring adequate spinal cord perfusion, especially when there is a risk of ischemia during surgery.

In ACDF surgery, Motor Evoked Potentials (MEP) are often used to assess the integrity of the spinal cord and nerves during surgery. Volatile anesthetics can interfere with these monitoring techniques, potentially making it difficult to accurately detect intraoperative neural damage. TIVA, however, has a minimal effect on these signals, allowing for more reliable intraoperative monitoring of the spinal cord, which can be critical for preventing neurological injury.

The more predictable respiratory control with TIVA makes it easier for the anesthesia team to manage the airway, especially given that the patient's neck will be in a position that may make intubation more challenging. In conjunction to this debate of using TIVA or volatile anesthetics for ACDF surgery, we conducted an observational study of patients operated at our institute, in order to generate our hospital anesthetic database for such cases.

Methodology

In adherence to the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines of EQUATOR network, we conducted an observational study based on data collected of ACDF surgeries conducted by the neurosurgeons as well as by the orthopedicians at our institute. This data was entered in the excel spreadsheet. 14 patients operated between July 2022 to March 2025 were included in the dataset. 8 patients underwent ACDF surgery in TIVA (dexmedetomidine / propofol based), while 6 underwent ACDF surgery under volatile anesthetics. The parameters recorded assessed the quality of intubation and quality of extubation in both the groups (Figure 1).

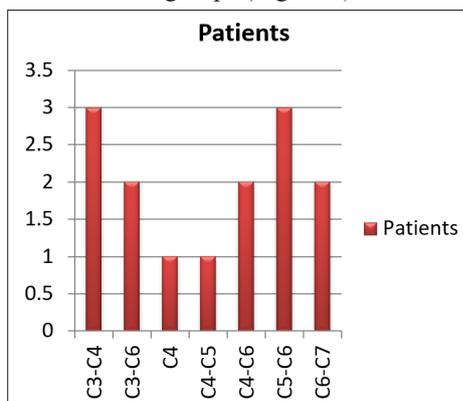


Figure 1: Patient Profile as Per the level of the Lesion

Results

We used Welch's t-test for unequal variances and Fisher's exact test for categorical comparisons. A value of $p < 0.05$ was accepted as statistically significant. Although the time to extubation was

clinically delayed in the TIVA group, there was no incidence of coughing, hypertension or tachycardia in the TIVA group. The Modified Observer Assessment Sedation Score (MOASS) showed no significant difference between the two groups (Tables 1,2,3).

Table 1: Quality of Intubation in Study Population

Quality of intubation	
Intubation attempt	First in all
Laryngoscopy duration (in seconds)	17.33 + 4.1096
Desaturation during laryngoscopy	No in all
Capnography confirmation	Yes in all
RSI required	No in all
Adverse Event at Intubation	None
Heart rate during Intubation (beats/min)	94.16 + 9.227
Mean arterial pressure during Intubation (mmHg)	87.66 + 6.446

Table 2: Comparison of Observed Parameters Between the Two Groups

Parameter	TIVA (n = 8)	Volatile (n = 6)	p-value
Time to extubation (min)	8.6 ± 0.53	6.9 ± 0.16	0.00003
Response to command (min)	9.7 ± 2.6	8.1 ± 6.1	0.52
HR at extubation (bpm)	86.3 ± 4.8	96.7 ± 8.2	0.01
MAP at extubation (mmHg)	94.1 ± 3.5	103.6 ± 5.7	0.0028
MOASS at 15 min	4.33 ± 0.47	4.81 ± 0.31	0.044
MOASS at 60 min	4.83 ± 0.37	4.83 ± 0.37	1
Incidence of Cough	0/8	2/8	0.14

Table 3: Outcome After Surgery

Patient	Preoperative power	Postoperative power
1	3/5 all limbs	4/5 all limbs
2	3/5 UL and 0/5 LL	3/5 UL and 2/5 LL
3	5/5 all limbs	5/5 all limbs
4	2/5 Lt.UL, 3/5 Rt.UL and 1/5 LL	2/5 Lt.UL, 3/5 Rt.UL and 1/5 LL
5	5/5 all limbs	5/5 all limbs
6	5/5 all limbs	5/5 all limbs
7	3/5 UL and 5/5 LL	4/5 UL and M 5/5 LL
8	0/5 all limbs	0/5 all limbs
9	3/5 UL and 5/5 LL	3/5 UL and 5/5 LL
10	3/5 Lt.UL, 2/5 Rt.UL and 0/5 LL	3/5 Lt.UL 1/5 Rt.UL and 0/5 LL
11	5/5 UL and 2/5 LL	5/5 UL and 3/5 LL
12	3/5 Lt.UL 5/5 Rt.UL and 5/5 LL	5/5 all limbs
13	0/5 all limbs	0/5 all limbs
14	3/5 all limbs	4/5 all limbs

Discussion

TIVA has gained popularity for ACDF due to its potential benefits over traditional volatile anesthetic techniques, particularly in terms

of hemodynamic stability, neurological monitoring, recovery time, and patient outcomes. ACDF surgery, particularly when performed for conditions such as cervical degenerative disc disease or herniated discs, often requires precise control of blood pressure and heart rate to ensure adequate spinal cord perfusion. Fluctuations in hemodynamics, especially hypotension, can reduce spinal cord blood flow and increase the risk of neurological injury. Lin et al. found that TIVA provided more stable intraoperative blood pressure compared to volatile agents, which were associated with greater variability and risk of hypotension [1]. Sharma et al. used dexmedetomidine even during anesthetic induction for spine surgeries. They observed optimal postoperative neurocognitive tests after this anesthetic protocol with the integrated dexmedetomidine algorithm [2,3]. Therefore predictable hemodynamic response associated with TIVA enhances the safety profile for ACDF surgery by maintaining optimal perfusion pressure to the spinal cord, reducing the risk of intraoperative neurological complications.

ACDF Surgery often Employs Somatosensory Evoked Potentials (SSEPs) and motor evoked potentials (MEPs), to detect potential damage to the spinal cord or nerves during surgery. The use of volatile anesthetics can interfere with these monitoring modalities, which may lead to false-positive or false-negative results and potentially missed injuries. Nakahari et al. conducted a study comparing the effects of TIVA versus volatile anesthesia on MEP signals in ACDF surgery. They found that TIVA produced more stable and reliable MEP responses, allowing for more accurate intraoperative monitoring of spinal cord function [4]. The ability of TIVA to preserve neurophysiological monitoring makes it a preferred choice in ACDF surgery, especially in cases where spinal cord integrity is of paramount importance.

A key advantage of TIVA is its rapid onset and offset of action, which facilitates expedited recovery times and shorter extubation periods. In ACDF, early extubation and recovery are crucial to reducing the risk of complications such as respiratory infections or atelectasis, which may arise from prolonged mechanical ventilation. According to a study by Kim et al., patients undergoing ACDF surgery with TIVA had significantly shorter extubation times compared to those receiving volatile anesthetics. TIVA also led to quicker postoperative awakening and higher rates of early ambulation [5].

Postoperative Nausea and Vomiting (PONV) is a common and distressing side effect of anesthesia, especially with volatile anesthetics. This complication can delay recovery, prolong hospitalization, and affect patient satisfaction, especially in spinal surgeries like ACDF, where pain management is a critical concern. Aijima et al. found that patients undergoing surgery with TIVA had a significantly lower incidence of PONV compared to those receiving volatile anesthesia. TIVA, with propofol as the main anesthetic agent, was associated with reduced nausea and vomiting in the first 24 hours after surgery [6].

The usage of etomidate for anesthetic induction, has not been found to be detrimental in the setting of neurotrauma [7]. However, we did not find any evidence of using etomidate infusion as a TIVA agent during ACDF surgery in our literature review. Volatile anesthetics are potent greenhouse gases with a significant environmental footprint. In contrast, TIVA uses intravenous agents, which do not contribute to atmospheric pollution. Khalil et al. have highlighted the environmental benefits of TIVA, noting that it is a greener option compared to volatile anesthetics [8]. This is increasingly relevant in hospitals and surgical centers with a focus on sustainability.

Regional cerebral oximetry is increasingly being used for neuromonitoring in neurological lesions [9]. However, recent interest has surged in usage of regional oximetry (rSO₂) using optodes during spine surgeries as well [10]. Murniece et al. observed decrease in rSO₂ by more than 20% from baseline values in patients undergoing spine surgery. For a decrease of 50% they even initiated a NIRS protocol. The patients with desaturation episodes had longer medium time of the operation (114 ± 35 versus 200 ± 98 min, p = 0.01). Receiver operating characteristic curve analysis showed blood loss to be a strong predictor for possible cerebral desaturation [11].

In the observational study of usage of oximetry during elective major spine surgery, conducted by Meng et al., the authors observed that Multiple Muscular tissue oxygenation (SmtO₂) indices were associated with composite complications (p < 0.05). No cerebral oxygenation (SctO₂) indices were associated with complications. SmtO₂ standard deviation, AUC, and AUC weighted, and SctO₂ standard deviation, were associated with LOH (univariate analysis, P < 0.05). They concluded that muscular tissue oxygenation has a stronger association with length of hospital stay and post-surgical complications than cerebral tissue oxygenation after major spine surgery [12].

Speaking of postoperative neurocritical complications, it is noteworthy that even posterior reversible encephalopathy (PRES) has been reported following spine surgery. Although, traditionally PRES has been reported with neurological illnesses like Guillain Barre Syndrome [13]. However, Matusuo et al. observed PRES after L5-S1 discectomy [14]. Also, Zimering et al. observed PRES in a patient with C5-C6 subluxation with spinal cord compression who underwent anterior and posterior cervical spine fusion and decompression [15]. This patient developed status epilepticus immediately after the surgery. Neuroimaging confirmed the diagnosis of PRES which took two weeks to resolve.

Conclusion

TIVA offers several advantages for ACDF surgery, including better hemodynamic stability, fewer postoperative complications like nausea, and the ability to more effectively monitor spinal cord function. It also provides a safer, quicker recovery and avoids the environmental impact of volatile agents. For patients with certain risk factors, such as older age or comorbid conditions, TIVA might be the preferred choice of anesthesia, contributing to both better intraoperative control and postoperative outcomes.

While volatile anesthesia remains a standard and generally safe option for ACDF surgery, it's essential for the anesthesiologist and surgical team to balance its benefits with these potential drawbacks. Careful monitoring, a well-managed anesthetic plan, and consideration of alternative or adjunct anesthesia techniques (like total intravenous anesthesia or regional blocks) may help mitigate some of these risks and improve outcomes for patients.

Declaration: The authors certify that they have obtained all appropriate patient consent.

Conflicts of Interest: The authors declare no competing interests.

Sources of funding: None

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