Review Article

Cukurova Anestezi ve Cerrahi Bilimler Dergisi

Severe Neurological and Systemic Adverse Events Following Cervical Epidural Steroid Injection: A Structured Review of Reported Clinical Cases, Anatomical Considerations, Pathophysiology, and Clinical Implications

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Abstract

Objective: To map out the clinical spectrum, timing, mechanisms, management, and outcomes of reported severe neurological and systemic adverse events following cervical epidural steroid injections, and to correlate the reported events to the technical approaches, safety measures and the used steroid categories. **Methods:** This study was designed as a case-based systematic review and narrative synthesis. Thirty-two published case reports were included based on a pre-defined eligibility criteria. Synthesis was conducted in accordance with PRISMA guidelines and the Synthesis Without Meta-analysis (SWiM) framework. **Results:** In Cervical Transforaminal epidural steroid injections' subgroup (N = 9 cases), non-ischemic spinal cord and nerve root injury represents the vast majority (N=5/9 cases, 55.6%), followed by vascular/ischemic neurological injury (N=3/9 cases, 33.3%) and hemorrhagic complications (N=1/9 case, 11.1%). In cervical Interlaminar epidural injections' subgroup (N = 14 cases) in total. The non-ischemic cord or nerve injury accounted for 5/14 cases (35.7%), air-related complications (e.g., pneumocephalus) 3/14 cases (21.4%), autonomic or systemic reactions 3/14 cases (21.4%), hemorrhagic complications (epidural hematoma) 2/14 cases (14.3%), and vascular/ischemic neurological injury 1/14 case (7.1%). **Conclusion:** Although overall procedural complication' incidences for CESIs are low, reported adverse events are frequently severe and occasionally fatal. Com-plication profiles are strongly route-dependent. In cervical transforaminal epidural ster-oid injections, events are primarily driven by direct nerve injury, intra-arterial entry and ischemic mechanisms. In interlaminar cervical epidural injections, events are predominantly posterior neuroaxially co-related e.g. dural puncture, air injection, venous trauma or direct mechanical spinal cord trauma.

Keywords: Cervical epidural steroid injection, Neurological complications, Systematic review, Safety profile.

1. Introduction

Cervical epidural steroid injections (CESIs) are widely used as interventional pain management procedures for cervical radicular pains. In 1900-1901 the cocaine was firstly injected epidurally by Sicard &Cathelin for pain reduction and control [1]. The hydrocortisone was firstly used in 1952 by Rebecchi and Cabra and applied epidurally for reducing sciatica induced pain [2, 3]. The cervical epidural steroids are firstly injected by Dogglotti in 1933 [10]. Cervical radicular pain originates from nerve-root inflammation, disc herniation, spondylosis, foraminal narrowing, or spinal canal stenosis. In refractory cases that do not respond adequately to conservative analgesic and rehabilitative approaches, epidural steroid injection is widely considered.

CESIs are commonly performed through two major routes: the cervical transforaminal epidural steroid injection (CTFESI) and the cervical interlaminar epidural steroid injection (CILESI). The transforaminal route delivers medication near the targeted exiting nerve root and dorsal root ganglion, whereas the interlaminar route provides broader posterior epidural access and may allow wider range of spread across extended spinal levels [5, 13]. Reviewing the previous literature has showed that clinical efficacy may not differ markedly between the two techniques, however ,the anatomical risk may be higher in the transforaminal route due to proximity to the neurovascular structures e.g. the vertebral artery course within the transvers foramina of the upper 6 cervical vertebrae, cervical nerves and the dorsal root ganglion [4,5,7].

The injectate typically consists of corticosteroid, local anesthetic, or both. Corticosteroids reduce inflammation, stabilize neural membranes and may suppress ectopic neural discharge [6, 8, 11]. Steroids used for epidural injections are commonly described as particulate and non-particulate subcategories [6, 9]. Particulate steroid preparations such as methylprednisolone and triamcinolone, may have longer local effects, but may be associated with concern for embolic injury if inadvertently injected intra-arterially. Non-particulate group especially dexamethasone, are generally favored in cervical transforaminal injections to reduce embolic risk [15-17, 29]. Although the overall occurrence of major complications appears rare in routine practice, some reported events are sometimes life-threatening or fatal. In this study we highlighted the reported complications and correlated it technically, pharmacologically and anatomically aiming at showing the correct way to the pain managers toward getting higher levels of safety and efficacy. The patients' medical history and co- morbidities can open the way to some undesirable effects, so suitable precautions should be considered earlier. The well-trained physicians, the correct technique practicing, suitable drugs, real time guidance and the awareness of the patient's co- morbidities limit the undesirable and negative outcomes [17].

2. Methods

This study was designed as a case-based systematic review and descriptive synthesis of reported cases of complications after CESIs. The literature was reviewed for published case reports and case series from 2007 to 2026. Thirty-Two reported cases were extracted from 30 Literature obtained from scientific data bases as PubMed/MEDLINE, Embase, Cochrane CENTRAL, Scopus, Web of Science, trial registries and detailed in the appendix (Table. 9).

Exclusion criteria: Case reports describing complications of epidural injections performed outside the cervical region (e.g., lumbar, thoracic, or caudal epidural injections) were excluded. Non-epidural cervical procedures (e.g., facet joint injections, medial branch blocks, or trigger point injections without epidural extension) were also excluded.

Eligibility criteria include:

Study Design & Publication Type: Case reports, case series, and observational studies reporting clinical complications following cervical epidural steroid injections (CESIs) published in the indexed scientific journals.

Population / Target Group: Human patients receiving cervical epidural injections (interlaminar or transforaminal) for cervical radiculopathy, disc herniation, or spinal pathology.

Intervention / Technique: Cervical epidural steroid injections (CESIs) performed via either Interlaminar (IL) or Transforaminal (TF) approach.

Outcome Measures: Explicit reporting of adverse events, complications (e.g., neurological, vascular/ischemic, hemorrhagic, infectious, air-related, or autonomic/systemic reactions), onset timing, cervical level involved and clinical outcome.

Extracted variables include Literature's name & year of publication, Steroids' injection route, steroid category, complications' category, complications' time of onset, associated co-morbidities, availability of radiological guidance, cervical level of CESIs, Complications' management outcome. The injection route was categorized as transforaminal (TF), interlaminar (IL). Complications were grouped into clinically meaningful categories as non-ischemic neurological cord or nerve injury, vascular ischemic neurological injury, air-related complication (Pneumocephalus) , hemorrhagic complications, autonomic systemic reactions and infections.

Complications Onset timing was classified as immediate or within 1 hour, within 24 hours and delayed beyond 24 hours. Complications' management outcomes were sorted into improved, persistent deficit/sequelae, critical care and death. The synthesis followed PRISMA principles and the SWiM approach for data analysis and findings' interpretations

3. Results

Table 1. Distribution of reported cases by CESIs' route

Route/technique category	N	% Of 32 reported cases
CTFESI	9	28.1%
CILESI	14	43.8%
Unclear/not reported	9	28.1%
Total	32	100.0%

Table 2. Complication categories' distribution

Complication category	CTFESI N (%)	CILESI N (%)	Total	% Of all cases
Non-ischemic neurological/cord or nerve injury	5 (55.6% within CTFESI; 15.6% of all cases)	5 (35.7% within CILESI; 15.6% of all cases)	10	43.5%
Vascular/ischemic neurological injury	3 (33.3% within CTFESI; 9.4% of all cases)	1 (7.1% within CILESI; 3.1% of all cases)	4	17.4%
Air-related complication	0 (0.0% within CTFESI; 0.0% of all cases)	3 (21.4% within CILESI; 9.4% of all cases)	3	13.0%
Hemorrhagic complication	1 (11.1% within CTFESI; 3.1% of all cases)	2 (14.3% within CILESI; 6.2% of all cases)	3	13.0%

Complication category	CTFESI N (%)	CILESI N (%)	Total	% Of all cases
Autonomic/cranial nerve/systemic reaction	0 (0.0% within CTFESI; 0.0% of all cases)	3 (21.4% within CILESI; 9.4% of all cases)	3	13.0%

Technique-based analysis suggests different complication patterns between the two cervical epidural approaches. Transforaminal injections are mainly associated with vascular and ischemic neurological complications, whereas interlaminar injections are more commonly associated with neuraxial access-related complications, including hematoma, pneumocephalus, and abnormal neurological spread. (Table 1-2)

Table 3. Correlation of CESIs' route specified complications and steroid category.

CESI route	Known steroid category	% Within known route subgroup	Complication distribution within route-steroid stratum	Clinical and anatomical interpretation
CTFESIs	Particulate steroid	3/5 (60.0%)	Vascular/ischemic neurological injury: 2/3 (66.7%); non-ischemic neurological/cord or nerve injury: 1/3 (33.3%).	This pattern is consistent with the anatomical vulnerability of the cervical neural foramen, where the needle target lies near radicular arteries, vertebral artery branches, the dorsal root ganglion, and the spinal cord vascular supply. In the presence of particulate material, inadvertent arterial entry may theoretically facilitate embolic or ischemic injury.
CTFESIs	Non-particulate steroid	2/5 (40.0%)	Non-ischemic neurological/cord or nerve injury: 2/2 (100.0%).	The occurrence of neurological injury despite non-particulate steroid use indicates that pharmacological particle reduction does not eliminate all transforaminal risks. Non-embolic mechanisms such as needle trauma, foraminal neural irritation, intravascular entry without particulate embolization, or unintended neuraxial spread remain plausible.
CILESIs	Particulate steroid	5/13 (38.5%)	Non-ischemic neurological/cord or nerve injury: 4/5 (80.0%); vascular/ischemic neurological injury: 1/5 (20.0%).	The predominance of non-ischemic neurological injury supports a neuraxial-access mechanism rather than a purely particle-mediated embolic mechanism. The cervical interlaminar route is anatomically related to the posterior epidural space, ligamentum flavum, dura, epidural venous plexus, and spinal cord proximity.
CILESIs	Non-particulate steroid	8/13 (61.5%)	Air-related complication: 3/8 (37.5%); hemorrhagic complication: 2/8 (25.0%); autonomic/cranial nerve/systemic reaction: 2/8 (25.0%); non-ischemic neurological/cord or nerve injury: 1/8 (12.5%).	The broad complication spectrum in this subgroup emphasizes that interlaminar complications are primarily route- and access-dependent .Dural puncture, epidural/subdural/intrathecal spread, air entry during loss-of-resistance technique; epidural venous plexus injury, hematoma, and direct neural contact are more relevant than steroid particle size alone.

Particulate steroids / CTFESI cases were mainly associated with vascular/ischemic neurological injury, whereas CILESI cases showed a broader neuraxial access-related complication spectrum. This pattern supports an anatomy-based interpretation: cervical transforaminal complications are closely linked to foraminal neurovascular anatomy and potential embolic or ischemic mechanisms, while cervical interlaminar complications are

more closely linked to posterior epidural axis, dural puncture, air entry, hematoma, abnormal spread, and direct intra thecal trauma. (Table 3)

Table 4. Correlation of the CESIs route, complication category to the Radiological guidance .

Route	Radiological guidance category	N and % Within route	Reported complication categories within this route/guidance stratum
CTFESI	Fluoroscopy/C-arm	7/9 (77.8%)	Non-ischemic neurological/cord or nerve injury: 5/7 (71.4%); Vascular/ischemic neurological injury: 2/7 (28.6%)
CTFESI	CT-guided	1/9 (11.1%)	Vascular/ischemic neurological injury: 1/1 (100.0%)
CILESI	Fluoroscopy/C-arm	7/14 (50.0%)	Autonomic/cranial nerve/systemic reaction: 3/7 (42.9%); Hemorrhagic complication: 2/7 (28.6%); Vascular/ischemic neurological injury: 1/7 (14.3%); Air-related complication: 1/7 (14.3%)
CILESI	Fluoroscopy + LOR	2/14 (14.3%)	Air-related complication: 1/2 (50.0%); non-ischemic neurological/cord or nerve injury: 1/2 (50.0%)
CILESI	LOR only/no imaging reported	3/14 (21.4%)	Non-ischemic neurological/cord or nerve injury: 2/3 (66.7%); Air-related complication: 1/3 (33.3%)

In CTFSIs, Vascular and ischemic and non-ischemic neurological events remained represented,despite availability of the radiological guidance. This ensures that radiological guidance reduces, but does not completely eliminate the anatomical risk of cervical transforaminal access, particularly in the presence of foraminal neuro vascular structures and possible intravascular entry. The CILESIs' complication pattern was dominated by neuraxial access-related events despite of LOR technique application under fluoroscopy guidance, including non-ischemic cord/nerve injury, air-related complications, hemorrhagic complications, and autonomic/systemic reactions. (Table 4)

Table 5. Complications' category and onset timing correlations.

Onset category	N (%) of total 32 cases	Complication category distribution within onset group
Immediate and within 1 hour	18/32 (56.2%)	Non-ischemic neurological/cord or nerve injury: 6/18 (33.3% within group); Vascular/ischemic neurological injury: 5 /18 (27.8% within group); Air-related complication: 4/18 (22.2% within group); Hemorrhagic complication: 2/18 (11.1% within group); Autonomic/cranial nerve/systemic reaction: 1/18 (5.6% within group)
Within 24 hours	3/32 (9.4%)	Air-related complication: 1/3 (33.3% within group); Autonomic/cranial nerve/systemic reaction: 2/3 (66.7% within group)
Delayed after 24 hours	6/32 (18.8%)	Non-ischemic neurological/cord or nerve injury: 3 (50.0% within group); Vascular/ischemic neurological injury: 1 (16.7% within group); Infectious/systemic complication: 2 (33.3% within group)

Immediate and within-one-hour complications onset shown in 18 of 32 reported cases (56.3%), which represents more than half of the reported cases, fell into the earliest clinical time window. This group contained a broad spectrum of high-acuity events, including non-ischemic neurological/cord or nerve injury, vascular/ischemic injury, air-related complications, and hemorrhagic complications. The clustering of vascular/ischemic and air-related events in the early-onset group supports the interpretation that many severe CESIs complications are compatible with procedural or near-procedural mechanisms. Delayed or variable-onset cases represented in 6 of 32 cases (18.8%) and included infectious/systemic complications, reinforcing the need to distinguish delayed pathophysiology from immediate mechanical, vascular, neuraxial, or air-related complications.(Table 5)

Table 6A. Co-morbidity categories correlated to complication categories.

Co-morbidity category	Cases in category n (% of 32)	Non-ischemic cord/ nerve	Vascular/isch-emic	Air-related
Cardiovascular/cerebrovascular & vascular-risk conditions	10 (31.2%)	3 (30.0%)	2 (20.0%)	2 (20.0%)
Metabolic/endocrine/lipid disorders	5 (15.6%)	1 (20.0%)	1 (20.0%)	1 (20.0%)
Rheumatologic/musculoskeletal/chronic pain disorders	3 (9.4%)	2 (66.7%)	0 (0.0%)	1 (33.3%)
Hematologic/oncologic systemic disease	1 (3.1%)	0 (0.0%)	0 (0.0%)	1 (100.0%)
No documented or not reported co-morbidity	19 (59.4%)	8 (42.1%)	4 (21.1%)	2 (10.5%)

Table 6B. Co-morbidity categories correlated to complication categories.

Co-morbidity category	Hemorrhagic	Autonomic/ systemic	Infectious/ systemic	Dominant pattern
Cardiovascular/cerebrovascular & vascular-risk conditions	1 (10.0%)	1 (10.0%)	1 (10.0%)	Non-ischemic cord/nerve (3/10)
Metabolic/endocrine/lipid disorders	1 (20.0%)	1 (20.0%)	0 (0.0%)	Non-ischemic cord/nerve; Vascular/ischemic; Air-related; Hemorrhagic; Autonomic/systemic (1/5)
Rheumatologic/musculoskeletal/chronic pain disorders	0 (0.0%)	0 (0.0%)	0 (0.0%)	Non-ischemic cord/nerve (2/3)
Hematologic/oncologic systemic disease	0 (0.0%)	0 (0.0%)	0 (0.0%)	Air-related (1/1)
No documented or not reported co-morbidity	2 (10.5%)	2 (10.5%)	1 (5.3%)	Non-ischemic cord/nerve (8/19)

Cardiovascular/cerebrovascular and vascular-risk co-morbidities were the most frequent documented clinical group, appearing in 10/32 reported cases. (Table6 A-B) Within this category, the reported complications were heterogeneous, but non-ischemic cord/nerve injury was the largest subgroup (3/10), followed by vascular/ischemic injury and air-related complications (2/10 each). This does not prove causality; however, it suggests that vascular-risk background may be relevant when interpreting ischemic or severe neurological events after CESIs, particularly when the transforaminal route or vascular entry is involved. Metabolic& endocrine disorders were present in 5/32 cases and were distributed across several complication types, without a single dominant pattern. Rheumatologic/musculoskeletal/chronic pain disorders were associated mainly with non-ischemic cord/nerve injury (2/32). Hematologic/oncologic systemic disease appeared in only one case and therefore cannot support inference.

Table7. Complication category and management outcome co-relation

Complication category	Total n (% of 32)	Improved completely	Major intervention/critical care	Persistent deficit/sequelae	Death
Non-ischemic neurological/cord or nerve injury	11 (34.4%)	1 (9.1%)	0 (0.0%)	5 (45.5%)	0 (0.0%)
Vascular/ischemic neurological injury	6 (18.8%)	0 (0.0%)	1 (16.7%)	1 (16.7%)	2 (33.3%)

Complication category	Total n (% of 32)	Improved completely	Major intervention/critical care	Persistent deficit/sequelae	Death
Air-related complication	5 (15.6%)	3 (60.0%)	1 (20.0%)	0 (0.0%)	0 (0.0%)
Hemorrhagic complication	4 (12.5%)	1 (25.0%)	2 (50.0%)	1 (25.0%)	0 (0.0%)
Autonomic/cranial nerve/systemic reaction	4 (12.5%)	4 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Infectious/systemic complication	2 (6.2%)	0 (0.0%)	1 (50.0%)	0 (0.0%)	0 (0.0%)

In this reported complication & management outcome analysis, non-ischemic neurological/cord or nerve injury represented the largest category, occurring in 11/32 reported cases (34.4%). (Table 7) Within this category, persistent deficit/sequelae were documented in 5/11 cases (45.5%), while 3/11 cases (27.3%) improved or recovered within this subgroup. Vascular/ischemic neurological injury accounted for 6/32 cases (18.8%) in total and showed the most severe outcome profile, including death in 2/6 cases within this subgroup (33.3%), while the persistent deficit/sequelae in 1/6 case (16.7%) within the same sub-group. Air-related complications accounted for 5/32 cases (15.6%), most of which improved and recovered, whereas hemorrhagic complications accounted for 4/32 cases (12.5%) and were associated with variable outcomes, including persistent neurological deficit. Autonomic/cranial nerve/systemic reactions accounted for 4/32 cases (12.5%) in total and were followed by improvement/recovery in all recorded cases. Infectious/systemic complications were less frequent, representing 2/32 cases (6.2%).

Table 8. CESIS complications severe sequelae, route correlation and anatomical and clinical interpretations.

Route	n (%)	Dominant reported complication pattern	Outcomes sever pattern	Anatomical-clinical interpretation
CTFESI	9/32 (28.1%)	Vascular/ischemic injury: 3/9 (33.3%); non-ischemic cord/nerve injury: 5/9 (55.6%); hemorrhagic: 1/9 (11.1%)	Includes death in 1/9 (11.1%) and persistent deficit/sequelae in 2/9 (22.2%).	The TF pattern is anatomically consistent with proximity to foraminal radicular vessels, vertebral artery-related risk, and possible intra-arterial injection/embolization mechanisms when particulate steroid is used or when vascular entry occurs.
CILESI	14/32 (43.8%)	Non-ischemic cord/nerve injury: 5/14 (35.7%); air-related: 3/14 (21.4%); autonomic/systemic: 3/14 (21.4%); hemorrhagic: 2/14 (14.3%); vascular/ischemic: 1/14 (7.1%)	Includes persistent deficit/sequelae in 4/14 (28.6%); no death recorded among ILCESIS' cases.	The IL pattern is anatomically consistent with neuraxial access-related mechanisms: narrow cervical epidural space, dural puncture, epidural/subdural/intrathecal spread, posterior epidural venous plexus injury, hematoma, pneumocephalus, and direct cord/nerve trauma.

Outcome severity also differed across route categories. In the CTFESIs subgroup, death was recorded in 1/9 cases (11.1%) and persistent deficit or sequelae in 2/9 cases (22.2%). In the CILESIs subgroup, no deaths were recorded in this sub-group, but persistent deficit or sequelae occurred in 4/14 cases (28.6%) of this sub-group. Therefore, the absence of death among reported CILESs cases should not be interpreted as absence of severe risk, because persistent neurological morbidity was documented in more than one quarter of the interlaminarily accessed cases. (Table 8)

4. Discussion

4.1. Spectrum and Severity of Reported Complications

This case-based review demonstrates that reported complications after CESIs are clinically heterogeneous (Table.2) and may range from transient symptoms to catastrophic neurological injury and death [1, 59, 60]. The most frequently represented complication category in the included cases was non ischaemic neurological injury (43,5% of all cases) including myelopathy, quadriparesis, hemiparesis, spinal cord oedema, nerve root injury, and ischemic neurological events (17,5% of all cases) as strokes and haematoma (13% of all cases) [40, 45, 47]. Air-related complications, as pneumocephalus (13% of all cases) , infections, systemic reactions and autonomic or cranial nerve manifestations were also reported [35, 42].

This spectrum is consistent with the broader safety literature. The United States Food and Drug Administration risk assessment described serious and sometimes fatal neurological events after epidural glucocorticoid injection, including paraplegia, spinal cord infarction, stroke, and death [15]. Similarly, the Anesthesia Patient Safety Foundation summarized rare but serious neurological events after epidural corticosteroid injections, including spinal cord infarction, paraplegia, quadriplegia, cortical blindness, stroke, and death [23]. Therefore, even though most cervical epidural injections are performed without major complications, the published complication literature supports the need for careful risk stratification and strict safety technique.

4.2. Technique-Related Complication Pattern

The observed technique-related complication pattern is consistent with anatomical and mechanistic expectations (Table.8). Cervical transforaminal epidural steroid injections are performed close to the exiting nerve root, radicular arteries, vertebral artery, and foraminal vascular structures [20, 21]. Accordingly catastrophic complications reported after the transforaminal approach often involve vascular ischaemic events including spinal cord infarction, brainstem infarction, cerebellar infarction, and stroke. These events have been linked to inadvertent intravascular injection, arterial injury, vasospasm, dissection, or embolization of particulate steroid material mechanisms particularly when particulate corticosteroids are used [16, 25].

The cervical interlaminar epidural injections are introduced through a posterior epidural access. Reported complications after the interlaminar approach often include dural puncture, pneumocephalus, epidural or subdural hematoma, intrathecal or intramedullary injection, direct spinal cord injury, and access-related neurological symptoms (Table 2). These events are better interpreted as neuraxial access-related complications rather than primarily embolic events [26, 27]. The International Pain and Spine Intervention Society stated that interlaminar cervical injection complications are often minor, but serious events such as intrinsic spinal cord injury and epidural hematoma have been reported, especially when anatomical constraints, bleeding risk, or sedation-related loss of patient feedback are present [28].

4.3. Complications onset timing and Clinical Interpretation

The complications onset timing analysis is clinically meaningful (Table.5). A large proportion of reported complications occurred immediately or within minutes of injection (56.2%). Acute onset may suggest intravascular injection, intrathecal or subdural spread, intramedullary injection, vasovagal reaction, direct neural trauma, air-related complications, or rapidly evolving neurological compromise [34,41]. Immediate neurological deterioration after cervical transforaminal injection is particularly concerning to vascular entry or arterial injury [49, 52]. Similarly, immediate symptoms after interlaminar injection may

suggest dural puncture, intrathecal or subdural spread, cord contact, intramedullary injection, or acute hematoma [53, 57].

Delayed onset (18.8%) should interpreted differently. Complications presenting after several hours or days may suggest evolving epidural hematoma, infection, delayed inflammatory response, systemic corticosteroid effect, or delayed air-related symptom progression [33, 46]. Published cases of pneumocephalus after cervical epidural steroid injection demonstrate that air introduced during loss-of-resistance techniques may migrate cranially and produce headache, dizziness, altered neurological symptoms, or, in severe circumstances, tension pneumocephalus physiology [26]. Therefore, the onset pattern may help guide early differential diagnosis and urgent management.

4.4. CESIs; Radiological guidance & pre-procedural measures safety co-relation:

These findings have important implications to procedural safety. Previous literature emphasizes careful pre-procedural imaging review of the spine (Table.4), technical fluoroscopic or CT imaging guidance, contrast confirmation of epidural spread, avoidance of intravascular injection, avoidance of particulate steroids in cervical transforaminal injections, avoidance of heavy sedation when patient feedback is needed, awareness of patient medical history ,co morbidities (Table .6) and strict post-procedural neurological monitoring [16,17,25]. The JAMA (Journal of The American Medical Association) safety recommendations emphasized image guidance and contrast confirmation, with real-time fluoroscopy or digital subtraction imaging for transforaminal injections before injecting potentially hazardous substances [16,17]. Recent safety-practice guidance further states that non-particulate steroid, such as dexamethasone, is the acceptable steroid for cervical transforaminal injections [24,29].

Modern cohort evidence suggests that cervical transforaminal injections performed with non-particulate steroid and contemporary safety practices may have a low rate of catastrophic complications. Beckworth and colleagues reviewed 6,241 cervical transforaminal epidural steroid injections using non-particulate steroid and reported no catastrophic complications [25]. This does not eliminate risk, but it suggests that technique, steroid selection, imaging review, and vascular-safety precautions materially influence the safety profile of the transforaminal approach. For interlaminar injections, the literature continues to emphasize lower cervical access, review of cross-sectional imaging to confirm adequate epidural space, cautious needle advancement, and avoidance of heavy sedation when neurological feedback is important [13, 17, 28].

5. Pathophysiology and Clinical Implications

The reported complications are predominantly neurological and frequently relate to vascular or neuraxial mechanisms (Table.8). Particulate steroids used in CESIs may aggregate if inadvertently introduced into the arterial circulation, potentially producing embolic sequelae such as cerebral, cerebellar, or spinal cord infarction [41, 43, 45, 49, 52, 55]. These events are more commonly noticed in case of the transforaminal approach because of its proximity to neurovascular structures. To reduce this risk, the use of non-particulate steroid and real-time imaging is recommended, especially during CTFESIs [6, 12-14.24].

Pneumocephalus may occur after dural puncture and cranial migration of air introduced during LOR (loss of resistance techniques). Small volumes of air may be absorbed spontaneously, whereas larger volumes may produce clinically significant pneumocephalus and, rarely tension pneumocephalus related complications. The use of saline rather than air for loss-of-resistance testing may reduce air-related complications [18, 19].

Vascular puncture or needle misdirection may lead to bleeding and hematoma formation. Hematoma can compress adjacent neural structures and cause radicular pain, paresthesia, myelopathy, or neurological deterioration. A careful medical history, medication

review, and assessment of anticoagulant or antiplatelet exposure are therefore essential before intervention [2, 22]. Infectious complications may relate to contamination, lack of sterile technique, or host susceptibility, and require early recognition and treatment [2, 23].

6. Anatomical Considerations

CESIs are used for cervical radicular pain management, but the two common routes have different safety-relevant anatomical hazards. The transforaminal route is close to the exiting nerve root, dorsal root ganglion, vertebral artery, and radicular and radiculo-medullary arteries therefore, its most feared complications are vascular and ischemic events [13]. The interlaminar route accesses the dorsal epidural space through the interlaminar window and ligamentum flavum, therefore its major risks are neuraxial access-related events such as dural puncture, intrathecal or intramedullary injection, epidural hematoma, pneumocephalus. [20, 21].

These anatomical distinctions explain why technique-specific safety measures are necessary. CTFESs require meticulous attention to vascular anatomy, contrast injection, and avoidance of particulate steroid. CILESIs require accurate midline or paramedian access, awareness of ligamentum flavum variation, review of canal diameter, and avoidance of deep sedation so that patient feedback can help detect early neural contact [17].

7. Limitations

The data included are based on included reported cases, not a population-based registry or a denominator-based cohort. Therefore, the results cannot be used to calculate true incidence of the overall complications occurring in the application field. The reporting bias is likely because severe and unusual complications are more likely to be published than mild or self-limited events. Some of the reported cases had incomplete information regarding medication dose, exact technique, imaging guidance, use of contrast, sedation status, anticoagulation or long-term outcome. The case-based synthesis is useful for identifying patterns and generating safety hypotheses but cannot replace prospective registry data.

8. Conclusion

Reported complications after CESIS are rare in the general clinical context but may be critically serious. The reported cases in this synthesis were mainly neurological, vascular, hemorrhagic, air-related, infectious, or systemic adverse events. The severity and mechanism of complications appear to be influenced by the technical approach, anatomical considerations, and the steroid sub-category, Safety approaches and radiological guidance.

Transforaminal approaches related to complications are mostly vascular and were often linked to proximity to the vertebral, radicular arterial systems and to the use of particulate steroid. Interlaminar complications were more commonly neuraxial access-related, including dural puncture, pneumocephalus, intramedullary injection and direct cord injury. The findings confirm that careful patient selection, accurate review of medical history, appropriate steroid selection, real-time imaging guidance, appropriate anatomical awareness of the approach applied regions and close post-procedural monitoring is strictly adherent to the safety of CESIs. Further prospective registry-based studies are required to estimate true complication rates and comparative safety between techniques.

Abbreviations: CESIs = cervical epidural steroid injections; CTFESIs = cervical transforaminal epidural steroid injections; CILESIs = cervical interlaminar epidural steroid injections; TF = transforaminal; IL = interlaminar; VA = vertebral artery; LF = ligamentum flavum; DRG = dorsal root ganglion; PDPH = post-dural puncture headache; PRISMA = Preferred

Reporting Items for Systematic Reviews and Meta-Analyses; SWiM = Synthesis without Meta-analysis; LOR = Loss of Resistance

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Appendix.

Included Reported Cases and Data Classification.

Table 9A. Included Reported Cases and Classification

No	Study/ year of publication	Technique	Steroid category	Radiological guiding	Co-Morbidities
1	Kokar et al. 2023.[29]	Transforaminal (TF)	Non-particulate steroid reported	Fluoroscopy	Not Reported

No	Study/ year of publication	Technique	Steroid category	Radiological guiding	Co-Morbidities
2	Charles J. Mazof et al. 2025 [30]	Interlaminar (IL)	Local anesthetic/other or unclear	Fluoroscopy	None
3	Chunwoo Yang et al. 2019[31]	Transforaminal (TF)	Non-particulate steroid reported	fluoroscopy	None
4	Jun Kyu Lee et al. 2015[32]	Transforaminal (TF)	Not reported	Not reported	Not reported
5	Fangyu chen.et al 2023[33]	Not reported/unclear	Non-particulate steroid reported	Not reported	
6	Stauber B.et al 2012[34]	Not reported/unclear	Local anesthetic/other or unclear	Fluoroscopy	Rheumatoid arthritis, Hypertension
7	Jun-Hui Zhang et al. 2017 [35]	Not reported/unclear	Non-particulate steroid reported	Not reported	Hypertension
8	Young Gun Cho et al. 2021[36]	Not reported/unclear	Not reported	Not reported	Hypertension, smoking, Cardiovascular problems
9	Gi-Young Park et. Al 2018[37]	Transforaminal (TF)	Not reported	C-arm guidance	Hypertension
10	Yeon-Dong Kim et al. 2015[38].	Interlaminar (IL)	Non-particulate steroid reported	Loss of Resistance (LOR) technique	Gout
11	Masoud Hashemi et al 2025[39]	Interlaminar (IL)	Non-particulate steroid reported	Fluoroscopy	Diabetes
12	Raghu Maddela et al 2014[40]	Interlaminar (IL)	Particulate/mixed steroid reported	Not reported	Hypertension, Hyperlipidemia, Arthritis
13	Connie Bao et al 2018[41]	Not reported/unclear	Particulate/mixed steroid reported	Not reported	Not reported
14	Derrick L. Barr et al 2021[42]	Not reported/unclear	Particulate/mixed steroid reported	Not Reported	Arterial fibrillations and multiple myeloma
15	Kenji Muro et al 2007[43]	Transforaminal (TF)	Particulate/mixed steroid reported	Fluoroscopy	Myocardial infarction, coronary artery disease
16	Cattien N. phan 2025[44]	Not reported/unclear	Not reported	Not reported	Dyslipidemia. Prior stroke
17	Lisa B. E. Shields 2021 case.(1) [45]	Interlaminar (IL)	Particulate/mixed steroid reported	Loss of resistance (LOR)	Hypertension, Fibromyalgia
18	Lisa B. E. Shields 2021 case (2)[45]	Interlaminar (IL)	Non-particulate steroid reported	LOR technique and Fluoroscopy	Not reported
19	Standiford Helm 2022 case (1) [46]	Interlaminar (IL)	Non-particulate steroid reported	LOR Technique	Not reported
20	Standiford Helm 2022 case (2) [46]	Interlaminar (IL)	Particulate/mixed steroid reported	Not reported	Not reported
21	Ahmad Khaled Abubaker et al 2018[47]	Not reported/unclear	Particulate/mixed steroid reported	LOR	Smoking
22	Viswanath et al. 2017[48]	Interlaminar (IL)	Non-particulate steroid reported	Fluoroscopy	Not reported
23	Deeba Ali et al. 2019[49]	Transforaminal (TF)	Not reported	CT Guided	Not Relevant
24	Molly et al. 2021[50]	Transforaminal (TF)	Particulate/mixed steroid reported	Direct real time fluoroscopy	None

No	Study/ year of publication	Technique	Steroid category	Radiological guiding	Co-Morbidities
25	Randall.W et al. 2015[51]	Interlaminar (IL)	Particulate/mixed steroid reported	Fluoroscopy/LOR technique	Not reported
26	Moon J.et al. 2017[52]	Transforaminal (TF)	Particulate/mixed steroid reported	Fluoroscopy	Not reported
27	Park et al. 2022[53]	Interlaminar (IL)	Non-particulate steroid reported	Fluoroscopy	None
28	Obeid et al 2014[54]	Transforaminal (TF)	Not reported	Fluoroscopy	Not reported
29	Li et al. 2024[55]	Interlaminar (IL)	Particulate/mixed steroid reported	Fluoroscopy	Not Reported
30	Aljuboori and Williams 2021[56]	Not reported/unclear	Not reported	Not Reported	Not Reported
31	Sunny kim et al. 2022[57]	Interlaminar (IL)	Non-particulate steroid reported	C-arm fluoroscopy	Not Reported
32	Epestein NE 2024[58]	Interlaminar (IL)	Non-particulate steroid reported	Fluoroscopy	Diabetes

Table 9B. Included Reported Cases and Classification

No	Study/ year of publication	Complication category	Complication Onset	Level of CESI	Complication Management Outcome
1	Kokar et al. 2023.[29]	Non-ischemic neurological/cord or nerve injury	Not reported	C7-T1	Treatment reported; outcome unclear
2	Charles J. Mazof et al. 2025 [30]	Autonomic/cranial nerve/systemic reaction	Not reported	C6-C7	Improved/recovered
3	Chunwoo Yang et al. 2019[31]	Non-ischemic neurological/cord or nerve injury	Not reported	C7-T1	Treatment reported; outcome unclear
4	Jun Kyu Lee et al. 2015[32]	Hemorrhagic complication	Not reported	Not Reported	Major intervention/critical care
5	Fangyu chen.et al 2023[33]	Infectious/systemic complication	Delayed (>2 days)	C7-T1	Treatment reported; outcome unclear
6	Stauber B.et al 2012[34]	Air-related complication	Immediate	C6-c7	Major intervention/critical care
7	Jun-Hui Zhang et al. 2017 [35]	Infectious/systemic complication	Delayed (>2 days)	C7-T1	Major intervention/critical care
8	Young Gun Cho et al. 2021[36]	Hemorrhagic complication	Not reported		Major intervention/critical care
9	Gi-Young Park et. Al 2018[37]	Non-ischemic neurological/cord or nerve injury	Same day to 2 days	C7	Treatment reported; outcome unclear
10	Yeon-Dong Kim et al. 2015[38].	Air-related complication	Within hours	C7-T1	Improved/recovered
11	Masoud Hashemi et al 2025[39]	Hemorrhagic complication	Within 1 hour	C7-T1	Improved/recovered
12	Raghu Maddela et al 2014[40]	Non-ischemic neurological/cord or nerve injury	Within 1 hour	C5-C6	Treatment reported; outcome unclear

No	Study/ year of publication	Complication category	Complication Onset	Level of CESI	Complication Management Outcome
13	Connie Bao et al 2018[41]	Vascular/ischemic neurological injury	Immediate	C5-C6	Death
14	Derrick L. Barr et al 2021[42]	Air-related complication	Immediate		Not reported
15	Kenji Muro et al 2007[43]	Vascular/ischemic neurological injury	Within 1 hour	C5-C6 C6-C7	Treatment reported; outcome unclear
16	Cattien N. phan 2025[44]	Vascular/ischemic neurological injury	Same day to 2 days		Major intervention/critical care
17	Lisa B. E. Shields 2021 case.(1) [45]	Non-ischemic neurological/cord or nerve injury	Immediate	C7-T1	Persistent neurological sequalae
18	Lisa B. E. Shields 2021 case (2)[45]	Air-related complication	Immediate	C7-T1	Completely resolved
19	Standiford Helm 2022 case (1) [46]	Non-ischemic neurological/cord or nerve injury	Same day to 2 days	C5-C6	Persistent deficit/sequelae
20	Standiford Helm 2022 case (2) [46]	Non-ischemic neurological/cord or nerve injury	45 minutes after intervention	C7-T1	Persistent deficit/sequelae
21	Ahmad Khaled Abubaker et al 2018[47]	Autonomic/cranial nerve/systemic reaction	Within hours	C7-T1	Improved/recovered
22	Viswanath et al. 2017[48]	Autonomic/cranial nerve/systemic reaction	Immediate	C6-C7	Improved/recovered
23	Deeba Ali et al. 2019[49]	Vascular/ischemic neurological injury	Immediate	C5, C6	Death
24	Molly et al. 2021[50]	Non-ischemic neurological/cord or nerve injury	Within 1 hour	C5-C6	Persistent deficit/sequelae
25	Randall.W et al. 2015[51]	Non-ischemic neurological/cord or nerve injury	Within 1 hour	C7-T1	Treatment reported; outcome unclear
26	Moon J.et al. 2017[52]	Vascular/ischemic neurological injury	Immediate	C6-C7	Persistent deficit/sequelae
27	Park et al. 2022[53]	Hemorrhagic complication	Immediate	C5/6	Persistent deficit/sequelae
28	Obeid et al 2014[54]	Non-ischemic neurological/cord or nerve injury	2 days after	C4-C5	Improved/recovered
29	Li et al. 2024[55]	Vascular/ischemic neurological injury	Immediate	C5-C6	Improved with little numbness
30	Aljuboori and Williams 2021[56]	Non-ischemic neurological/cord or nerve injury	Immediate		Persistent deficit/sequelae
31	Sunny kim et al. 2022[57]	Air-related complication	Immediate	C7-T1	Improved/recovered
32	Epestein NE 2024[58]	Autonomic/cranial nerve/systemic reaction	Within hours	C6-C7	Improved/recovered