

Carotid Artery Injury in Anterior Cervical Spine Surgery: Multicenter Cohort Study and Literature Review

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Abstract

Study Design: Retrospective study and literature review.

Objective: To provide more comprehensive data about carotid artery injury (CAI) or cerebrovascular accident (CVA) related to anterior cervical spine surgery.

Methods: We conducted a retrospective, multicenter, case series study involving 21 high-volume surgical centers from the AOSpine North America Clinical Research Network. Medical records of 17 625 patients who went through cervical spine surgery (levels from C2 to C7) between January 1, 2005, and December 31, 2011, were analyzed. Also, we performed a literature review using Medline and PubMed databases. The following terms were used alone, and in combination, to search for relevant articles: cervical, spine, surgery, complication, iatrogenic, carotid artery, injury, cerebrovascular accident, CVA, and carotid stenosis.

Results: Among 17 625 patients that were analyzed, no cases were reported to experienced CAI or CVA after cervical spine surgery. Nevertheless, in our PubMed search we found 157 articles, but only 5 articles matched our study objective criteria; 2 cases were reported to present CAI and 3 cases presented CVA.

Conclusions: CAI and CVA related to anterior cervical spine surgeries are extremely rare. We were not able to find neither in our retrospective study nor in our literature research a correlation between the type or length of anterior cervical spine procedure with CVA or CAI complications. However, surgeons should be aware of the possibility of vascular complications and minimize intraoperative direct vascular manipulations or retraction. Preoperative screening for underlying vascular pathology and risk factors is also important.

Keywords

carotid artery injury, cerebrovascular accidents, anterior cervical spine

Introduction

Cervical spine surgery incorporates different anterior and posterior techniques that aim to treat a wide variety of pathologies. Most of these pathologies can be approached anteriorly by a series of modifications of the technique first described by Smith and Robinson in 1958.¹ Since then, lateral traction of vascular structures of the neck was identified as a potential complication, and it was recommended by Smith and Robinson to perform carotid artery retraction during these surgeries in 10-minute intervals to avoid prolonged carotid artery-sheath compression.¹ However, recent studies have not been able to provide a direct

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correlation between carotid traction and reduction of carotid blood flow.² Additionally, vascular complications related to continuous retraction of the carotid artery sheath during anterior cervical approach have been reported as rare and anecdotal.^{3,4}

In general, anterior cervical spine surgery is considered safe and well established, with minimal risks for perioperative vascular complications.⁵ Complications associated with vascular injury during anterior cervical procedures have not been extensively reported in the literature.⁶

In order to provide more comprehensive data on the vascular complications related to cervical spine surgery, we performed a much larger retrospective study of 17 625 patients by analyzing the results of the Anterior Cervical Spine Surgery–Retrospective Study, a multicenter study on carotid artery injury (CAI) or cerebrovascular accident (CVA) due to carotid artery retraction, following cervical spine surgery in patients with no previous history of vascular disease.

In addition, we provide a systematic review of literature on CAI and CVA complications related to anterior cervical surgery.

Methods

We conducted a retrospective, multicenter, case series study involving 21 high-volume surgical centers from the AOSpine North America Clinical Research Network, selected for their excellence in spine care, clinical research infrastructure, and experience. Medical records of 17 625 patients who went through cervical spine surgery (levels from C2 to C7) between January 1, 2005, and December 31, 2011, were reviewed to identify the occurrence of 21 predefined treatment complications. The complications included reintubation requiring evacuation, esophageal perforation, epidural hematoma, C5 palsy, recurrent laryngeal nerve palsy, superior laryngeal nerve palsy, hypoglossal or glossopharyngeal nerve palsy, dural tear, brachial plexopathy, blindness, graft extrusion, misplaced screws requiring reoperation, anterior cervical infection, CAI or cerebrovascular accident, vertebral artery injuries, Horner's syndrome, thoracic duct injury, tetraplegia, intraoperative death, revision of arthroplasty, and pseudomeningocele.

Trained research staff at each site extracted the data from medical records, surgical charts, radiology imaging, narratives, and other source documents for the patients who experienced one or more of the complications from the list. Data was transcribed into study-specific paper case report forms. Copies of case report forms were transferred to the AOSpine North America Clinical Research Network Methodological Core for processing, cleaning, and data entry.

Descriptive statistics were provided for baseline patient characteristics. A paired *t* test was used to analyze changes in clinical outcomes at follow-up compared to preoperative status.

Separate articles were prepared to present and discuss various complications of this large study. Among the 21 predefined treatment complications, this article focuses on iatrogenic CAI or CVA as a complication of anterior cervical surgery.

In addition, we performed a systematic review of the literature to provide comprehensive data on previously reported cases of CAI and stroke following cervical spine surgery, their mechanism of occurrence, and their management.

This review was conducted using Medline and PubMed databases. The following terms were used alone, and in combination, to search for relevant articles: cervical, spine, surgery, complication, iatrogenic, carotid artery, injury, cerebrovascular accident, CVA, and carotid stenosis.

To reflect the current trends in cervical spine surgery, the most recent literature within the past 15 years was reviewed and rigorously analyzed. We included studies only reporting on iatrogenic carotid artery injuries following lower cervical spine surgery in adults aged 18 years and older, within the first 30 days following surgery. Articles reporting CAI after anterior cervical surgery and/or CVA due to CAI were also included. The patients with a previously known history of vascular disease such as atherosclerosis and vessel dissection were excluded. Those cases that had vertebral artery injury after a posterior cervical approach and those cases that presented CAI as a consequence of direct trauma prior to surgery were also excluded.

Results

Databases of 21 high-volume surgical centers from the AOSpine North America Clinical Research Network were reviewed. Among 17 625 patients who received anterior cervical spine surgery (levels from C2 to C7) from January 1, 2005, to December 31, 2011, no cases were reported with CAI or CVA due to CAI.

The systematic review of the literature conducted using Medline and PubMed databases submitting the keywords found a total of 157 articles. After meticulous assessment of all articles, relevant articles were selected, analyzed, and presented. There were only 5 articles considered relevant, reporting on anterior cervical spine surgery complications with the previously described inclusion criteria: 1 case was associated with carotid artery dissection,⁷ 1 case was associated with CAI,⁸ and 3 cases were associated with cerebrovascular accidents due to prolonged carotid artery retraction.^{3,4,9} Details of these 5 studies are summarized in Table 1.

Because of the extraordinary low incidence, we decided to include 2 historical articles that have been cited multiple times and yet considered relevant for our research.^{3,8}

Discussion

Cerebrovascular complications related to anterior cervical surgery are very rare, and our extensive study suggests that the incidence rate could be lower than what we found, 1:17 625.

This research was part of a multicenter cohort study in which every complication associated with cervical spine procedures was registered and analyzed separately.

In addition, from our literature analysis, we included 2 articles that did not fit into the research time frame. They were

Table 1. Summary of Reported Cases With Iatrogenic CAI and CVA Following Cervical Spine Surgery.

Study	Type of Complication	Type of Surgery	Patient Demographics	Operative Time	Timing of Symptoms	Clinical Presentation	Imaging Findings	Treatment	Final Outcome
Loret et al ⁷	Carotid artery dissection	Right-sided approach	Female, 41 years	3 hours	5 hours	Hemiplegia, facial palsy	Stroke	Heparin, aspirin, stent placement, thrombectomy, rehabilitation >6 months	Overall improvement but residual spasticity
Radhakrishnan et al ⁹	CVA	C4-C5/C5-C6 arthroplasty Right-sided approach	Male, 50 years	>2 hours	3 hours	Hemiparesia, facial palsy, seizure 48 hours postoperative	Stroke, atherosclerotic vessel	N/A	N/A
Yeh et al ⁴	CVA	C5-C6 ACDF Left-sided approach	Male, 76 years	3 hours	N/A; immediate postoperative period	Decreased level of consciousness, reintubation	Stroke, no carotid artery thrombosis	Dopamine, norepinephrine, hyperventilation, osmotherapy	Death POD 7
Chozick et al ³	Carotid artery thrombosis	C3 to C6 ACDF (revision surgery) Right-sided approach	Male, 74 years	3 hours	>72 hours	Hemiplegia, facial palsy	Stroke, carotid artery thrombosis in an atherosclerotic vessel	Rehabilitation >8 months	Improvement in coordination, insufficiency in walking
Lesoin et al ⁸	Carotid artery injury	C4-C5 corpectomies N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Abbreviations: ACDF, anterior cervical discectomy and fusion; CAI, carotid artery injury; CVA, cerebrovascular accident; POD, postoperative day.

considered historically important and a reference in understanding the low incidence of CAI in iatrogenic anterior cervical complication procedures.^{3,8}

The first of these articles was a large series of cases that have also reported a low incidence of CVA or CAI. Lesoin et al,⁸ in over 20 years of practice, reported a single case of iatrogenic CAI in 1000 patients who underwent operation for the treatment of cervical myelopathy. This low incidence of iatrogenic CAI during anterior cervical surgery could be explained because of the surgical anatomy per se. The carotid artery is covered by connective tissue and thus it is unlikely to be damaged by retractor blade insertion or during blunt dissection of the neck.

Chozick et al,³ the second article, reported a lethal stroke associated with prolonged retraction of the carotid artery, following an anterior cervical discectomy, foraminotomy, and fusion procedure. Furthermore, during cervical corpectomy or cervical discectomy, prolonged carotid artery retraction has been associated with CVA in a few cases.^{3,4,9} Yeh et al⁴ reported a case in which an extensive right hemispheric infarct occurred 72 hours after anterior cervical corpectomy of C4.

Last, Radhakrishnan et al⁹ presented a case of postoperative stroke following anterior cervical discectomy that involved carotid artery manipulation. However, the CVA complication was attributed to intraoperative hypotension, which was believed to be caused by a continuation of antihypertensive medication rather than carotid retraction. Recent publications have shown that during anterior cervical discectomies that last between 2 and 6.5 hours, the reduction in cross-sectional area of the carotid artery ranges from 39% to 80%. Despite the prolonged surgical time and the changes in cross-sectional area, no patient experienced an ischemic cerebral event.²

It is important to note the role that stroke risk factors may have played in the occurrence of these reported complications, specially, gender, history of untreated hypertension, smoking, and episodes of intraoperative hypotension.⁹ Thus, preoperative screening for risk factors is needed to avoid complications in anterior cervical surgical approaches. Associated vascular occlusive pathology or thrombosis predisposition must also be accounted for.

Empirical indirect methods aimed at measuring the carotid blood flow during or after surgery, like superficial temporal artery palpation, are not recommended since a postoperative stroke was reported and no changes were detected on temporal artery pulse pressure.³ On the contrary, the same authors recommended specific imaging studies such as preoperative Doppler ultrasound, as this may be helpful in determining underlying pathology.³

Technical details of anterior cervical surgery should also be taken into consideration. Proper retractor placement below the longus coli muscle just enough to provide effective exposure is recommended.⁴

Finally, we would like to address the recommendations found in the literature to decrease or avoid CAI during anterior cervical spine surgery:

1. If a long operative time is expected, such as for a multi-level corpectomy, it may be advisable to release the

retractor blade intermittently, in order to restore adequate ICA flow.⁶

2. Spine surgeons should be familiar with carotid artery manipulation related to surgical complications, including the mechanisms involved and proper management, due to the potential risk of severe disability or patient mortality. Standardizing the approaches and techniques may reduce the risk of these iatrogenic injuries and their consequences, and a correct management strategy for these complications should be known in advance in order to reduce patient morbidity and mortality.

Study Limitations

Our study had several limitations. Even though we conducted an extensive research on over 17 625 patients, iatrogenic CVA or CAI complications may be underreported and these types of complications may occur later or symptoms may be mild and remain undetected.

Conclusion

Given the broad range of cervical spine pathologies that are currently being treated by anterior cervical approaches, a detailed overview of CAI and its consequences is of great interest to spine surgeons.

After this extensive clinical data and literature review, we can also conclude that factors for perioperative stroke related to anterior cervical spine surgery are fairly similar to those for nonsurgical strokes in the general population and no assessment or direct correlation can be made in relation to the type or length of the surgery. Prospective data collection that looks specifically for signs and symptoms of vascular injuries would be necessary to provide greater understanding of the etiology, frequency, and mechanisms of occurrence for iatrogenic CAI and CVA. This could help in taking better preventive and reparative measures to minimize morbidity and mortality.

Last, surgeons should be aware of the possibility of vascular complications and minimize intraoperative direct vascular manipulations or retraction. Preoperative screening for underlying vascular pathology and risk factors is also important.

Authors' Note

This study was ethically approved by the institutional ethics committees at all participating sites.

Declaration of Conflicting Interests

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