Vertebral artery injuries in cervical spine surgery

Clinical Study

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Abstract

BACKGROUND CONTEXT: Vertebral artery injuries (VAIs) are rare but serious complications of cervical spine surgery, with the potential to cause catastrophic bleeding, permanent neurologic impairment, and even death. The present literature regarding incidence of this complication largely comprises a single surgeon or small multicenter case series.

PURPOSE: We sought to gather a large sample of high-volume surgeons to adequately characterize the incidence and risk factors for VAI, management strategies used, and patient outcomes after VAI.

STUDY DESIGN: The study was constructed as a cross-sectional study comprising all cervical spine patients operated on by the members of the international Cervical Spine Research Society (CSRS).

PATIENT SAMPLE: All patients who have undergone cervical spine surgery by a current member of CSRS as of the spring of 2012.

OUTCOME MEASURES: For each surgeon surveyed, we collected self-reported measures to include the number of cervical cases performed in the surgeon’s career, the number of VAIs encountered, the stage of the case during which the injury occurred, the management strategies used, and the overall patient outcome after injury.

METHODS: An anonymous 10-question web-based survey was distributed to the members of the CSRS. Statistical analysis was performed using Student t tests for numerical outcomes and chi-squared analysis for categorical variables.

RESULTS: One hundred forty-one CSRS members (of 195 total, 72%) responded to the survey, accounting for a total of 163,324 cervical spine surgeries performed. The overall incidence of VAI was 0.07% (111/163,324). Posterior instrumentation of the upper cervical spine (32.4%), anterior corpectomy (23.4%), and posterior exposure of the cervical spine (11.7%) were the most common stages of the case to result in an injury to the vertebral artery. Discectomy (9%) and anterior exposure of the spine (7.2%) were also common time points for an arterial injury. One-fifth (22/111) of all VAI involved an anomalous course of the vertebral artery. The most common management of VAI was by direct tamponade. The outcomes of VAIs included no permanent sequelae in 90% of patients, permanent neurologic sequelae in 5.5%, and death in 4.5%. Surgeons at academic and private centers had nearly identical rates of VAI. However, surgeons who had performed 300 or fewer cervical spine surgeries in their career had a VAI incidence of 0.33% compared with 0.06% in those with greater than 300 lifetime cases (p=0.028).

CONCLUSIONS: The overall incidence of VAI during cervical spine surgery reported from this survey was 0.07%. Less experienced surgeons had a higher rate of VAI compared with their more
Introduction

Vertebral artery injury (VAI) is a rare but serious complication of cervical spine surgery, with the potential to cause catastrophic bleeding, permanent neurologic impairment, and even death.

The vertebral artery is at risk during both anterior and posterior procedures of the cervical spine and can be injured during exposure, decompression, or instrumentation. Anomalies in the course of the artery can increase the likelihood of injury, particularly if they are not appreciated preoperatively. Up to 13.4% of vertebral arteries enter the cervical spine at a level other than C6 [1]. Curylo et al. [2] reported that 2.7% of cadaver specimens studied had a tortuous vertebral artery course, while Eskander et al. found 7.6% of cervical spine magnetic resonance images revealed midline migration of the artery [3].

The highest reported rates of VAI are associated with anterior cervical surgery at 0.2% to 0.5% [4–6] and with posterior C1–C2 transarticular fixation for atlantoaxial instability at 0% to 8.2% [7–9]. These reports are primarily from a single surgeon or smaller multicenter case series with as few as 41 patients. Given how infrequently VAI occurs, it is difficult to identify the true incidence with smaller sample sizes. The purpose of this study was to gather a large sample of high-volume surgeons to attempt to clarify the incidence and risk factors for VAI.

Materials and methods

An anonymous 10-question survey was sent out to all of the Cervical Spine Research Society (CSRS) members. The questionnaire asked each surgeon to record the total number of cervical spine cases performed in their career and how many VAI they had encountered as the primary surgeon. Specific details were then elicited for each incidence of VAI, including how many years in practice at the time of injury, the stage of the case during which the injury occurred, whether there was an anomalous artery involved, management strategies of the arterial injury, and patient outcomes.

Stages of the case when the injury occurred were divided into exposure, decompression, or instrumentation. Exposures were noted to be anterior or posterior. Decompression methods were documented as anterior foraminotomy, anterior release, anterior corpectomy, posterior foraminotomy, or posterior laminectomy. Instrumentation options were divided anatomically into anterior upper cervical (C1–C2), anterior subaxial, posterior upper cervical (Occiput–C2), or posterior subaxial.

Management included as many of the following options as were used by the surgeon: tamponade, decrease blood pressure, increase blood pressure, blood transfusion, intravenous fluids, calling a partner, calling a vascular surgeon, calling interventional radiology, artery ligation, arterial repair, arterial stent, embolization, insertion of a screw, and use of electrocautery. Patient outcomes were noted as no harm, temporary neurologic deficit, permanent neurologic deficit, cerebellar infarct, and death.

Statistical analysis to analyze varying rates of VAI among groups of surgeons for continuous variables was performed using Student t test. Chi-squared tests were performed for categorical variables. Statistical significance was defined as a p value of <.05. All statistical analysis was performed using SPSS version 20.0 (IBM, Chicago, IL, USA).

Results

Demographics

One hundred forty-one CSRS members (of 195 total, 72%) responded to the survey. Seventy percent of respondents worked in an academic center, 15% worked in a private practice model that included the training of residents and/or fellows, and 15% were in a purely private practice model. There were an equally proportionate number of cases from each practice setting. The average surgeon responding performed just over 1,158 cervical spine surgeries (range, 10–5,000) in their career for a total of 163,324 cervical spine surgeries included in our analysis.

Arterial injury

A total of 111 VAI were reported for an overall incidence of 0.07%. Sixty-eight (48.8%) surgeons admitted encountering at least one VAI in their career, whereas 73 surgeons had never encountered a VAI. The average number of VAI per surgeon was 0.78 (range, 0–6) (Fig. 1). The average career volume for those who had encountered a VAI was 1,359 cervical cases compared with 971 for those without a VAI in their career. The individual surgeon rate of VAI ranged from 0% to 3.8% (average, 0.148%). The average VAI rate of surgeons involved with resident/fellow teaching and those in a purely private practice setting were identical, at 0.148% (p=.998). The VAI rate for surgeons who had performed 300 or fewer cases in their career was 0.528% (range, 0–3.8%) compared with 0.074% (range, 0–0.6%) for the 118 surgeons who had performed more than 300 cases (p=.028). The mean career year for VAI occurrence was
10.2 (range, 1–25). One-fifth (22/111) of all VAIs involved an anomalous course of the vertebral artery.

Timing of injury

One-fifth (22/111) of all VAIs occurred during the surgical approach (Fig. 2). The posterior exposure accounted for 11.7% (13/111) of VAI and the anterior exposure (Smith-Robinson) accounted for 7.2% (8/111). One surgeon reported encountering a VAI during a lateral exposure.

Decompression accounted for 49 of the 111 VAIs (44%). Twenty-six (23.4%) injuries occurred during corpectomy, 10 (9%) during discectomy, 6 (5.4%) during laminectomy, 4 (3.6%) during anterior foraminotomy, 2 (1.8%) during posterior foraminotomy, and 1 (0.9%) during anterior release.

Instrumentation accounted for 36% of all VAIs (40/111). Thirty-six (32.4%) occurred during posterior upper cervical instrumentation and four injuries (3.6%) occurred during instrumentation in the anterior upper cervical spine (defined as C1–C2). There were no VAIs during anterior or posterior instrumentation of the subaxial (C3–C7) cervical spine. Fig. 3 lists all causes of VAI in order of prevalence.

Management and outcomes

The survey had multiple management selections available, making one-to-one correlation with each VAI impossible. Of the options available to the 68 surgeons who
reported at least one VAI, definitive management solutions were selected in 98 instances. Direct tamponade was the most common definitive management selection chosen by 76.4% (52/68) of surgeons. Artery ligation was used by 29.4% of surgeons (20 times), arterial repair by 13.2% (9 times), embolization by 11.7% (8 times), insertion of a screw by 7.4% (5 times), and stenting by 5.9% (4 times). Assistance from interventional radiology was selected by 27.9% of surgeons (19 times) and vascular surgery assistance was used by 13.2% (9 times).

Patient outcomes were reported in 110 of 111 cases (99%). No sequelae (96) and temporary neurologic sequelae (3) accounted for 90% of outcomes (99/110). Cerebellar infarct occurred in six (5.5%) patients, and five deaths were reported for a fatality rate of 4.5% (Fig. 4).

Discussion

Vertebral artery injury during cervical spine surgery is a rare but potentially devastating complication. It can occur during any cervical spine surgery, but rates reported in the literature vary depending on the procedure and approach used. Two large series have evaluated the risk of VAI after anterior cervical spine surgery and found a rate of 0.3% to 0.5%. Golfinos et al. [4] evaluated 1,215 cases and documented four VAIs, whereas Smith et al. [5] found six VAIs in 1,195 consecutive cases.

More recently, Neo et al. [6] compiled the largest series to date with 5,641 cervical spine cases. This was a retrospective review that looked at VAI rates at multiple centers in Japan, including both spine surgeons and generalists who performed spine surgery. Their numbers showed an overall VAI rate of 0.14% (8/5,641) for all cervical spine surgeries. This rate broke down to 0.04% for spine surgeons and 0.21% for nonspine orthopedists. Anterior cervical spine surgery specifically had a slightly higher VAI incidence of 0.18%. Similar to many other literature reports, they reported much higher rates of VAI with Magerl screw or transarticular C1–C2 fixation. Their overall Magerl screw VAI rate was 1.3%, with 0.94% for spine surgeons and 2.3% for nonspine surgeons. This was lower than previous reports of rates as high as 8.2% [8] and was attributed to a change to a safer technique with an aiming device described by the same primary author in 2005 [9].

Our article evaluates a survey of the career experience of 141 CSRS members. These 141 surgeons represented a 72% response rate from the entire CSRS membership and reported on a total of 163,324 cervical spine cases performed during their careers. A total of 111 VAIs were documented for an overall rate of 0.07%. Although these numbers are estimates and subject to recall bias, this represents by far the largest collection of cervical spine cases on record looking at VAI. Given the gravity of VAI, it was presumed that such instances would remain fresh in the surgeons’ memory long after the event. The rate of 0.07% is lower than the 0.14% reported by Neo et al., but is in line with their rate of 0.04% for the spine-only surgeons in their cohort.

Our survey respondents consisted of 70% surgeons who worked in an academic center, 15% who worked in private practice but were involved in the training of residents and/or fellows, and 15% in a purely private practice model with no teaching responsibilities. Comparing those surgeons with teaching responsibilities to those without, we found no difference in the individual surgeon rates of VAI with both groups averaging 0.148% (p = .998). The overall rate of VAI based on practice setting was also not statistically different, with teaching settings having a rate of 0.07% (97/139,610), compared with 0.06% (14/23,714) in a purely private practice model (p = .568).

Post hoc analysis did show, however, that surgeon experience may play a role in the incidence of VAI. Surgeons who had performed 300 or fewer cervical cases reported an average surgeon VAI rate of 0.528% compared with 0.074% of those having performed more than 300 cervical cases (p = .028). Furthermore, the 23 surgeons who reported 300 or fewer cervical cases accounted for 15 VAIs, for an overall rate of 0.33% (15/4,441). The 118 surgeons with more than 300 cases accounted for 96 VAIs, for an overall rate of 0.06% (96/158,787). Using chi-squared analysis, this equates to an odds ratio of VAI, by a less experienced surgeon, of 5.6 (95% confidence interval, 3.1–9.9).

The average VAI occurrence was at career year 10.2 that however argues against VAI being purely an error of surgical inexperience. Fig. 5 illustrates a scatter plot of the career years when VAIs occurred. Although there is a downward slope toward later career years, there are also fewer surgeons who have reached each successive year of practice and therefore, a smaller denominator in the calculation of VAI risk. Unfortunately, we did not have data on how many years our survey respondents had been in practice for comparison with the incidence of VAI. Additionally, the methodology of our survey is open to potential
Reported outcomes in the literature after VAI vary widely, with rates of brain ischemia and death varying from 0% to 33% after VAI [3–7,10,11]. These reports consist of relatively small numbers of cases of VAI (range, 4–15), and many factors can affect the ultimate outcome, including artery dominance, amount of injury to the vessel, management strategies and timing, and individual variation in tolerance to ischemia. This makes the true incidence of neurologic sequelae and death after VAI very difficult to determine accurately. In our survey consisting of 110 reported outcomes after VAI, we found no harm or only temporary neurologic deficit in 90% (99/110). Cerebellar infarct occurred in six (5.5%) patients, and five deaths were reported for a fatality rate of 4.5%.

Strengths of the study include the broad scope with the large case numbers and a strong response rate from an elite global association of cervical spine surgeons.

Limitations of the study include the fact that the case numbers are estimates and the VAI data are subject to recall and reporting bias. However, given that an intraoperative VAI is an event that is not easily forgotten, we would expect few cases to have been omitted from memory lapse alone. With VAIIs being such rare events, incidence is difficult to calculate on such a large scale with more precise measurement techniques. Another limitation, as discussed above, is that the use of a survey is always subject to respondent’s interpretation of questions, possibly coding answers in a different fashion than they were intended. Also because of the setup of the survey, there was not an opportunity for one-to-one correlation between VAI, management strategy, and patient outcome. In cases where surgeons had more than one VAI and only chose one patient outcome, we extrapolated that outcome to account for each of the VAIIs reported by that surgeon.

Conclusion

The incidence of VAI during cervical spine surgery reported from this survey was 0.07%. Less experienced surgeons had a higher rate of VAI compared with their more experienced peers. Particular attention to avoiding VAI should be spent during the highest risk portions of the case that included posterior instrumentation of the upper cervical spine, anterior corpectomy, and posterior exposure of the cervical spine. The results of VAI are highly variable resulting in no permanent harm most of the time; however, this can be a serious injury that may lead to permanent neurologic injury or death.

References


