Cervical Manipulation Leading to Cerebellar Stroke in a Pilot

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BACKGROUND: Stroke is a decidedly devastating event for any patient, but particularly for a military aviator in a single-seat aircraft. Incidence of acute ischemic infarct in men ages 25 to 29 ranges from 3.4 to 5.6/100,000. The neurological sequelae of stroke can have a lasting and profound impact on an aviator's career. Literature review revealed a relatively small number of cases where stroke was attributable to cervical manipulation.

CASE REPORT: A 29-yr-old male jet pilot with a 2-wk history of cervicalgia following a mountain bike ride performed self-manipulation of his neck at home following a visit to a chiropractor. He sustained an immediate onset of euphoria, nausea, dysarthria, vertigo, diplopia, and occipital headache, and was transported via ambulance to the nearest emergency department. The patient's MRI/MRA imaging revealed a dissection of his right vertebral artery, as well as bilateral cerebellar infarcts. During the course of the following months, the patient's residual symptoms included neck pain, headaches, disequilibrium, and quadrantanopia.

DISCUSSION: The ability to recognize the symptoms of stroke and seek treatment in a timely manner are paramount and can drastically reduce the potential for permanent deficit. The evaluation of residual sequelae in military aviators who fly single-seat aircraft is of particular interest to aerospace medicine physicians when it comes time to return a pilot to flight duties. Additionally, the link between cervical manipulation and vertebral artery dissection leading to stroke remains equivocal, and further research is warranted.

KEYWORDS: infarct, dissection, posterior circulation, vertebral artery.

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Acute ischemic stroke accounts for 85% of all strokes, with the remainder being hemorrhagic.[8] Within this subcategory, the Oxford (or Bamford) Stroke Classification system is often used to classify acute ischemic stroke based on clinical signs and symptoms into lacunar, partial anterior circulation, total anterior circulation, and posterior circulation stroke.[2] This stratification assists clinicians in predicting the region affected, extent of the stroke, underlying etiology, and prognosis.[2]

Roughly 20% of acute ischemic infarcts involve the posterior (vertebrobasilar) circulation.[12] Typical symptomology involves vertigo, dizziness, nausea, emesis, headache, double vision, other visual deficits, gait disturbances, hypoesthesias, and weakness involving bilateral regions of the body. The most common signs upon physical examination are gait and limb ataxia, dysarthria, oculomotor palsies, hemiparesis, and oropharyngeal dysfunction (see **Table I**). Major risk factors for cerebellar stroke in young adults are hypertension, diabetes, tobacco use, hyperlipidemia, and atrial fibrillation, among others.[14] The most common etiologies of ischemic stroke are atherosclerosis, embolic phenomena, coagulopathies, dissection, vasculitides, and systemic hypoperfusion syndromes.[14]

In this case study, the patient progressed from neck pain to vertebral artery dissection to bilateral cerebellar infarcts in the setting of manual cervical manipulation. A literature review revealed that cases of vertebral artery dissection and subsequent stroke secondary to cervical manipulation are relatively small in number and often not well reported. Wynd et al.[16] reported that within 43 articles studied, 901 cases of cervical artery dissection were noted and, of these, 707 were associated with subsequent stroke due to recent cervical manipulative

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Table I. Risk Factors, Symptoms, and Signs of Cerebellar Stroke.[8,10]

RISK FACTORS	SYMPTOMS	SIGNS
Hypertension	Vertigo/Disequilibrium	Ataxia
Tobacco use	Nausea/vomiting	Dysdiadochokinesia
History of stroke	Gait disturbance	Dysarthria
Atrial fibrillation	Headache	Hemiparesis
Diabetes	Dysarthria	Facial palsy
Dyslipidemia	Tinnitus	Anisocoria
History of cardiac disease	Diplopia	Conjugate deviation
History of migraine		Horner's syndrome
Headaches		Upward gaze palsy
		Loss of light reflex
		Oropharyngeal dysfunction

therapy. The most common type of stroke within this meta-analysis was ischemic (92%).

Interestingly, the link between vertebral artery dissection and cervical manipulation remains contested within the scientific community. Cervical manipulation performed by chiropractors typically involves high-velocity, low-amplitude manual thrusts to the spinal facet joints that extend slightly beyond their physiological range of motion.[1] The anatomical location of the vertebral arteries places them at increased risk for mechanical trauma during such manipulation. The vertebral arteries arise from the subclavian artery and enter the vertebral column at the transverse foramen of C6.[1] From there, they ascend through the transverse foramina of C6-C2 and emerge from the transverse process of the axis (C2) before sweeping laterally to pass through the transverse foreman of the atlas (C1). Finally, they pass around the posterior border of the lateral mass of the atlas and through the atlanto-occiptal membrane to continue cephalad, where they join together at the lower border of the pons to form the basilar artery. Segment III is most commonly affected due to the tortuosity of the vessels as they pass posterolaterally around the posterior arch of C1 and, subsequently, between the atlas and foramen magnum.[1]

In one study by Thomas et al.,[13] patients with stroke secondary to dissection were compared to patients with strokes of another etiology. Of the dissection patients, 64% reported a recent episode of mechanical trauma, including cervical manipulative therapy. The authors subsequently concluded that a significant association exists between mild mechanical head trauma and craniocervical arterial dissection. Another paper by Quinn et al.[11] described the case of a female patient who suffered a cervical arterial dissection following a turbulent flight aboard a commercial airliner. The proposed primary etiological factor precipitating the dissection was transient excessive g force, another form of mechanical head trauma. In contrast, a more recent study by Biller et al.[4] analyzed current biomechanical evidence collected from a wide spectrum of clinical practice settings and suggested that the link between cervical manipulative therapy and cervical artery dissections could not be classified as causative.

In the context of the subpopulation that this case report draws from, it is important to recognize that neck pain is a common chief complaint among aviators within the tactical jet community. Frequently, the cervicalgia symptoms of these patients who present to their flight surgeon or primary care physician are attributed to sustained, high-G dynamic flight involving repetitive axial cervical rotation. Data presented in one anonymous survey revealed that 72% of fighter pilots experienced neck pain in relation to flying and, specifically, 93% were related to neck rotation.[15] These patients are frequently treated with a combination of nonsteroidal anti-inflammatory agents, muscle relaxers, and chiropractic therapy. While the majority of these patients make a full recovery to their previous functional status, it remains of paramount importance to pay special attention to the evaluation of young patients with worsening neck pain and new onset neurological symptoms. The incidence of craniocervical dissection and stroke is relatively low; however, these are diagnoses which cannot afford to be missed.

CASE REPORT

A 29-yr-old active duty Caucasian male jet pilot initially presented to an aviation medicine clinic with a chief complaint of neck pain and posterior headaches following a mountain bike ride 5 d prior. He rated his neck pain as a 5 out of 10 on the pain scale and described the quality of his pain as dull and aching. His pain was located over his left cervical region, with intermittent radiation down into his thoracic region and posterior left arm. Past medical history was significant for ocular migraines diagnosed during childhood, treated occasionally with nonsteroidal anti-inflammatory drugs and acetaminophen. The pilot had never suffered from migraine headaches during flight secondary to high-G dynamic maneuvering. Additionally, no medical waivers for flight status had been granted. The patient's history and physical exam findings that day were consistent with cervicalgia and he was treated with naproxen, cyclobenzaprine, and referred to a chiropractor. Imaging of the neck was not performed at this time.

The pilot attempted to manipulate his own neck for relief of stiffness 2 wk later and approximately 4 h after completing a chiropractic therapy session. He placed his right palm underneath his right chin, and forcefully rotated his head and neck to the left sharply. After feeling a cracking sensation, the patient noticed the immediate sensation of euphoria, followed within 5 s by the acute onset of severe neck pain, nausea, emesis, dysarthria, vertigo, horizontal diplopia, and occipital headache. He was able to dial 911, but unable to communicate his symptoms or location. After crawling on his hands and knees from his apartment into the nearby street due to severe disequilibrium, he attempted to wave down a passing vehicle for assistance. Within minutes, an ambulance arrived and transported him to the nearest emergency department.

Upon arrival, the pilot's initial vital signs were as follows: blood pressure 189/108, heart rate 91, respiratory rate 14, and temperature 98.8. Physical examination revealed a multitude of neurological deficits, namely right beating nystagmus of 5 to 6 beats in duration, shortened ability to maintain a sharpened

Romberg pause, ataxia, impaired rapid alternating movements, and dysarthria. A CT scan and MRI of his brain revealed a 3.1 × 1.3 cm ischemic infarct within the right posterior cerebellar hemisphere and multiple punctate infarcts within the left medial cerebellar tonsil suggestive of embolic phenomenon. An MRA revealed marked narrowing of the left vertebral artery between the C1 and C2 vertebral levels, consistent with a dissection. The patient's case was discussed by the emergency room physician, neurologist, intensivist, and radiologist, who collectively decided not to administer thrombolytic therapy or antihypertensive medication at the time. This complex decision was due primarily to the remaining possibility of an undiagnosed hemorrhagic event within his neck or brain, in addition to continuing to meet the exclusion criteria of elevated systolic blood pressure greater than 185 mmHg.

The pilot was subsequently admitted to the stroke unit under the care of the Neurology and Neurosurgery services, and placed on an intravenous Heparin drip. No surgical intervention was indicated. His blood pressure normalized during the following 24 h without medical intervention. Over the course of his 3-d admission, his ataxia, nausea, emesis, and dysarthria resolved. Upon discharge, his disequilibrium, nausea, posterior headache, neck pain, and horizontal diplopia remained. His Heparin therapy was transitioned to oral Coumadin via a Lovenox bridge and he was enrolled in a Coumadin clinic for maintenance of his anticoagulant therapy.

During the course of the following weeks, the pilot was issued a grounding notice and evaluated on an outpatient basis by multiple specialists, including critical care, internal medicine, neurology, and neuro-ophthalmology. His Coumadin therapy was discontinued after 4 mo and he was started on aspirin 81 mg daily, tizanidine 4 mg as needed for his residual headaches, and amitriptyline 25 mg at bedtime for neck pain. Additionally, he was enrolled in physical therapy and vestibular therapy.

Approximately 4 mo following his initial infarcts, the pilot underwent an extensive re-evaluation which included neuroimaging and repeat ophthalmological clinical testing. By this point all of the patient's residual symptoms had resolved, with the exception of a newly discovered left inferior homonymous quadrantanopia which was demonstrated on multiple Humphrey visual field exams. This defect did not have a corresponding anatomical lesion in his brain and it was unclear if it represented sequelae from his infarct or a preexisting condition. Follow-up MRI imaging revealed a small amount of encephalomalcia within the posterior right cerebellar hemisphere and multiple tiny foci within the left cerebellar tonsil, consistent with his previous infarcts. MR angiogram demonstrated complete patency of the posterior circulation vasculature.

After a full year had passed since his dissection and subsequent stroke, all medications were discontinued and an aeromedical waiver package was submitted on behalf of the pilot. He was permanently disqualified from single-seat military aircraft primarily due to his residual visual field deficit, but was subsequently returned to flight status with the limitation of flying only multipilot platforms.

DISCUSSION

Worldwide, stroke is the second most common cause of mortality and the third most common cause of disability.[2] Incidence of acute ischemic infarct in men ages 25 to 29 ranges from 3.4 to 5.6/100,000.[10] Although rare, vertebral artery dissection and stroke sequelae in an aviator can have devastating implications. In the acute operational setting, in-flight incapacitation can have a deadly outcome. Sequelae can result in temporary flight duty restriction or even career ending grounding. The aeromedical standards within both the civilian and military aviation communities are firm and well-founded based on previous mishap data. Thus, the number of military pilots who have suffered a stroke and been returned to active flight status as pilot-in-command is expectedly very low.[7] In previous cases, boards composed of various aeromedical subspecialists have been called upon to make such determinations.

The patient in this case underwent a long postinfarct treatment course involving medications, specialist evaluations, and vestibular therapy. He underwent a mandatory 1-yr grounding period per the Naval Aerospace Medical Institute's recommendation, during which he was evaluated in person by neurologists and ophthalmologists at the Navy's Operational Medical Institute. While he was left with a residual quadrantanopia, his other symptoms resolved. Literature review revealed a study conducted by Albuquerque et al.,[1] which found that of 13 patients who had received cervical manipulative therapy and suffered vertebral artery dissection, 31% (4/13) were left permanently disabled or died as result of their arterial injuries. Data analyzed from Savitz et al.[12] revealed a 3.6% poststroke mortality rate along with an 18% residual major disability rate among posterior circulation infarct patients within 30 d. Factors that affect the outcome of cerebellar stroke include the presence of arterial lesions, the severity of neurological signs, the mechanism of ischemia, and the location of the infarction.[12] Phenomena known to specifically increase the risk of a poor outcome are basilar artery involvement, cardiac embolism, and involvement of multiple intracranial territories.[12]

Case reports of cervical manipulative therapy leading to vertebral artery dissection and subsequent stroke are relatively few in number, and causation between the two has been historically difficult to establish. Haynes et al.[6] found that although evidence is lacking for such a relationship, it is also absent for no association. In a more robust analysis of 983 patients by Bejot et al.,[3] the association between multiple cervical artery dissections and cervical manipulation was confirmed and attributed to mechanical trauma of the arterial wall subsequent to rotational manipulation. While the study included a large sample size, a partly retrospective recruitment of patients may have biased the assessment of risk factors. Additionally, a selection bias was present due to patients with severe short-term outcomes potentially not being included in the study. In a similar observational study by Engelter et al.,[5] prior cervical trauma was more prevalent in patients who had sustained cervical artery dissections compared to patients who suffered ischemic strokes due to etiologies other than vessel dissections. Their data suggested a

clear association between cervical artery dissection and cervical manipulation therapy, with a statistically significant *P*-value of < 0.001. This particular study was the largest to date addressing the significance of this relationship and, additionally, utilized the same universal questionnaire for all patients in order to reduce the likelihood of bias. An interesting potential limitation of the study was the inability to identify cervical artery dissection which may have already been in progress prior to manipulation therapy.

To date, current data and retrospective case reports still do not provide enough conclusive evidence to provide a clinical practice guideline to osteopathic physicians and chiropractors who perform cervical manipulation. Detailed and timely reporting of such incidents is paramount to furthering the understudying of the relationship between these two phenomena. From a clinical standpoint, the acceptable level of risk associated with a therapeutic intervention such as cervical manipulative therapy must be balanced against evidence of therapeutic efficacy.[9] Interestingly, the U.S. Navy currently does not have a standing policy which restricts aviators from engaging in chiropractic cervical manipulation.

Although neck pain is ubiquitous in ejection seat aviators, careful attention should be paid to patients within this subset presenting with new-onset neck pain and corresponding neurological symptoms. Given the potential for devastating residual deficits, serial physical examination and specialist re-evaluation at appropriately timed intervals following a stroke are crucial. In the military aviation environment, an aviator's flight surgeon is the provider who most closely observes and interacts with him or her on a regular basis, and is best equipped to monitor the patient in the long term. Given this unique relationship, aviation medicine physicians should pay careful attention to tracking the presence of any neurological sequelae, as these deficits will play a primary role in the determination of an aviator's continued flight status. Residual deficits that fail to resolve should be brought to the attention of an appropriate specialist for thorough investigation. In this distinctive operational setting, taking care of the patient and enabling a potential return to flight status are synonymous.

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