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Presented by James Demetrious, DC, DABCO

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James Demetrious, DC, DABCO

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- Diplomate, International Academy of Neuromusculoskeletal Medicine

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- Many Contributions to **NCMIC Examiner** and **Podcast**

Educator
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- NCMIC Speakers' Bureau for>10 years
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Editorial
- Editorial Reviewer for journals *Spine*, *Annals of Internal Medicine*, and *Clinical Anatomy*
- Former Managing Editor of *Journal of Chiropractic Orthopedists*

Honors
- Academy of Chiropractic Orthopedists Distinguished Service and Fellow Awards
- American College of Chiropractic Orthopedists Outstanding Achievement Award

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Why Grand Rounds?

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Cellular and Molecular Life Sciences (2023) 80:366
https://doi.org/10.1007/s00018-023-05013-1
Cellular and Molecular Life Sciences
REVIEW

Unraveling the lymphatic system in the spinal cord meninges: a critical element in protecting the central nervous system

Sriharsha Gonuguntla[1] · Jasmin Herz[1]

Received: 22 August 2023 / Revised: 18 October 2023 / Accepted: 20 October 2023 / Published online: 20 November 2023

Abstract
The lymphatic vasculature plays a crucial role in fluid clearance and immune responses in peripheral organs by connecting them to distal lymph nodes. Recently, attention has been drawn to the lymphatic vessel network surrounding the brain's border tissue (Aspelund et al. in J Exp Med 212:991–999, 2015. https://doi.org/10.1084/jem.20142290; Louveau et al. in Nat Neurosci 21:1380–1391, 2018. https://doi.org/10.1038/s41593-018-0227-9), which guides immune cells in mediating protection against tumors (Song et al. in Nature 577:689–694, 2020. https://doi.org/10.1038/s41586-019-1912-x) and pathogens Li et al. (Nat Neurosci 25:577–587, 2022. https://doi.org/10.1038/s41593-022-01063-z) while also contributing to autoimmunity (Louveau et al. 2018) and neurodegeneration (Da Mesquita et al. in Nature 560:185–191, 2018. https://doi.org/10.1038/s41586-018-0368-8). New studies have highlighted the integral involvement of meningeal lymphatic vessels in neuropathology. However, our limited understanding of spinal cord meningeal lymphatics and immunity hinders efforts to protect and heal the spinal cord from infections, injury, and other immune-mediated diseases. This review aims to provide a comprehensive overview of the state of spinal cord meningeal immunity, highlighting its unique immunologically relevant anatomy, discussing immune cells and lymphatic vasculature, and exploring the potential impact of injuries and inflammatory disorders on this intricate environment.

Keywords Spinal cord meninges · Lymphatic vessels · Immune surveillance · Neuroimmunology · Macrophages · Spinal cord injury

Introduction

The spinal cord is vital in connecting the brain with the body. It extends throughout the entire length of the torso and functions as a relay station, transmitting sensory information from the body and sending motor commands back to initiate actions. While many spinal cord injuries (SCI) may not directly damage neurons, they often disrupt descending pathways, leading to impaired communication between the brain and different regions of the spinal cord. Compression caused by a tumor or abscess in the lumbosacral spinal cord, for example, can interfere with the intricate control mechanisms involved in walking, ultimately risking paralysis. Damage can result from external physical impact such as falls, vehicle accidents, and degenerative disc disease but also from infection or inflammation such as tuberculosis. It is essential to note that each case is unique, and the extent and progression of the spinal cord trauma can vary depending on the incident but also the individual's age and circumstances. One of the most formidable challenges in spinal cord injury rehabilitation lies in enhancing the neurological status of patients, necessitating innovative approaches to promote recovery and restore function. Numerous medical, surgical, and cell-based therapies have been translated from preclinical studies into clinical trials [1]. Some of these innovative strategies have succeeded in bridging disconnected neurons [2] or facilitating repair, and have even paused progression by fine-tuning the immune system. Over the last 2 decades, researchers have explored how to orchestrate protective immunity at the injury site, utilizing approaches

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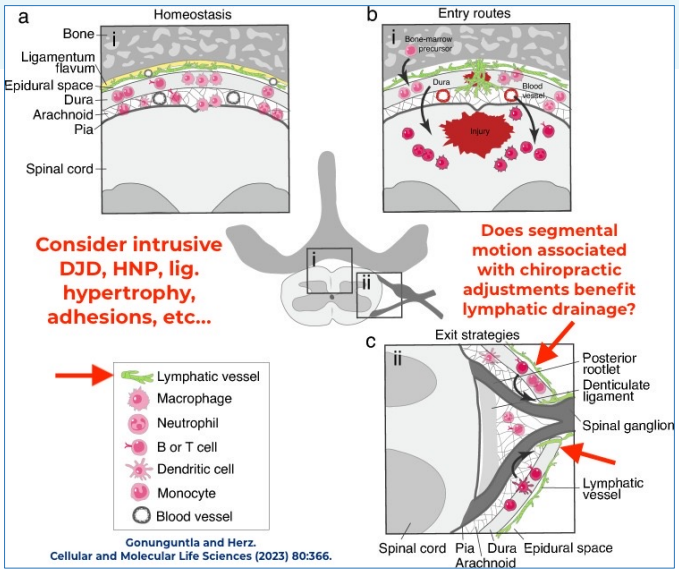

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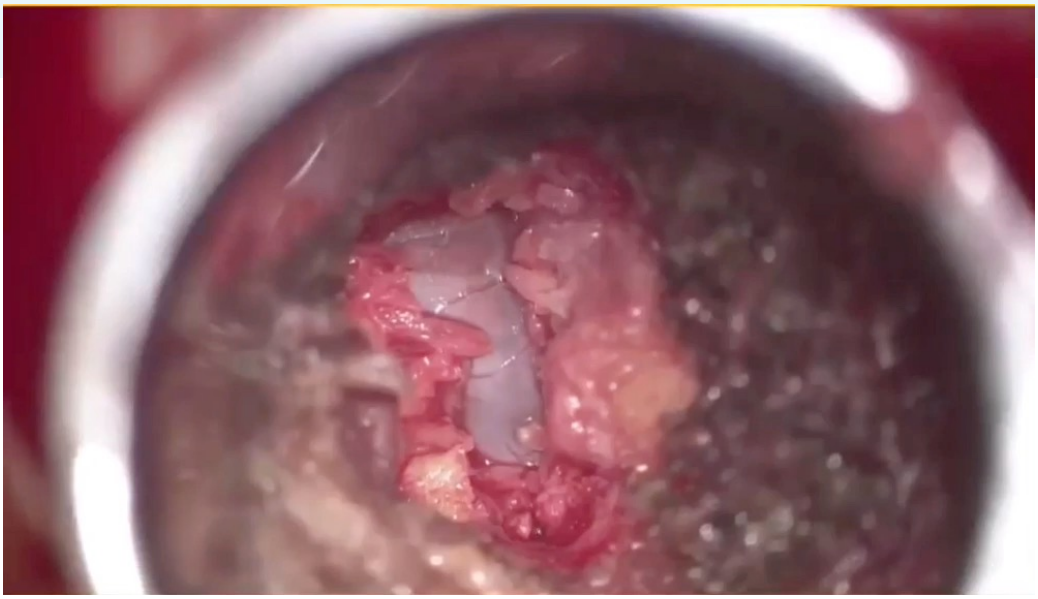

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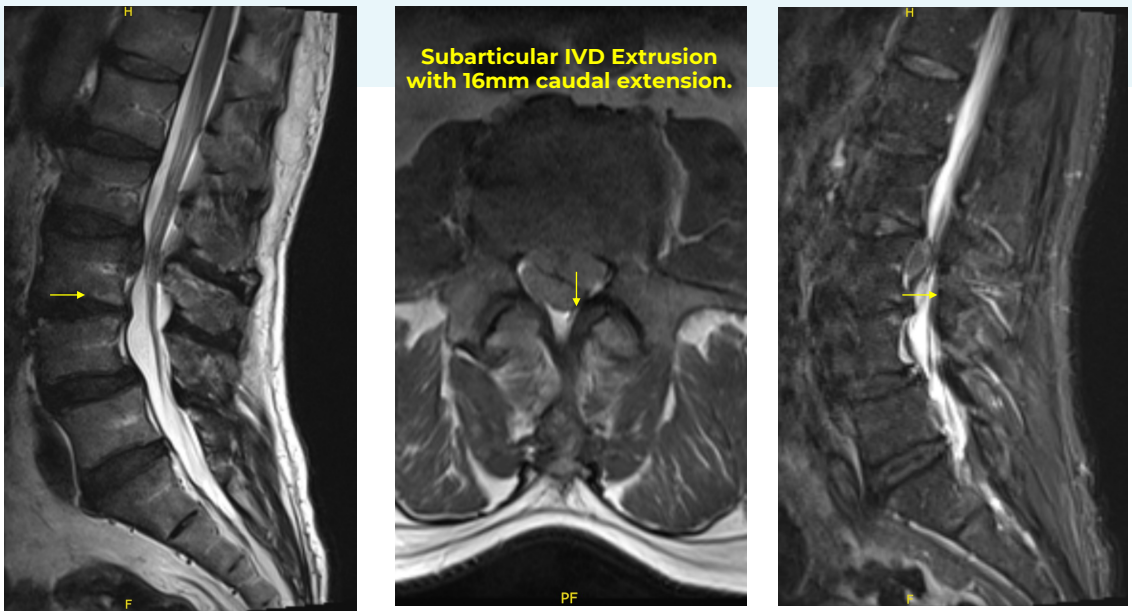
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Subarticular IVD Extrusion with 16mm caudal extension.
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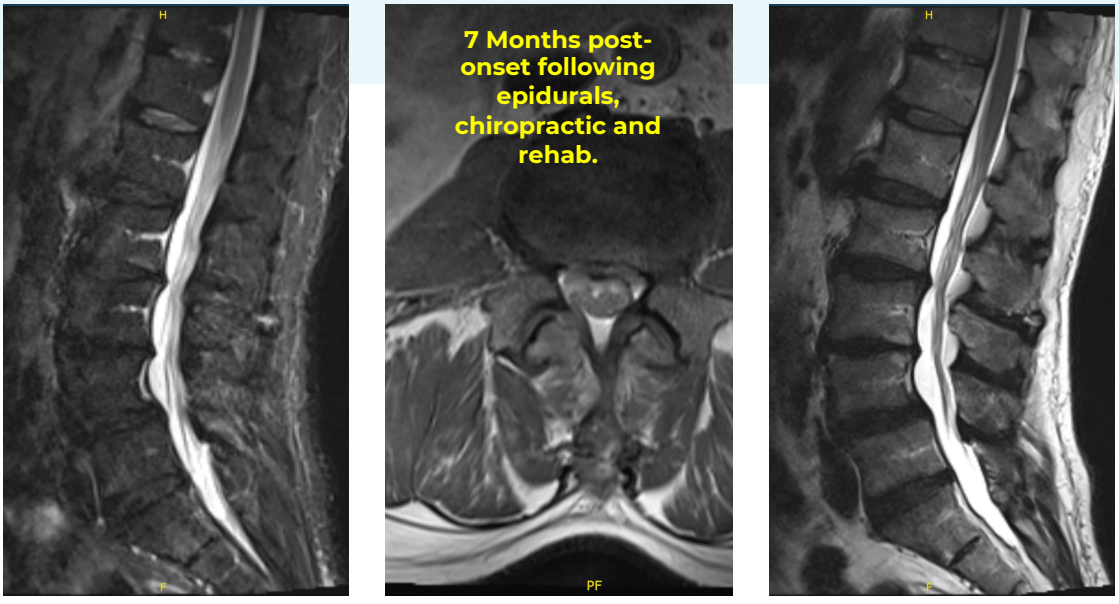
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7 Months post-onset following epidurals, chiropractic and rehab.
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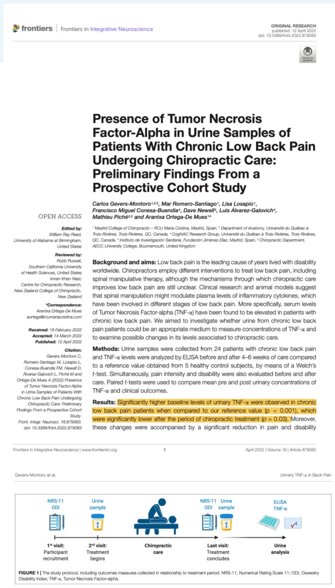

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ORIGINAL RESEARCH
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Presence of Tumor Necrosis Factor-Alpha in Urine Samples of Patients With Chronic Low Back Pain Undergoing Chiropractic Care: Preliminary Findings From a Prospective Cohort Study

Carlos Gevers-Montoro[1,2,3], Mar Romero-Santiago[1], Lisa Losapio[1], Francisco Miguel Conesa-Buendía[4], Dave Newell[5], Luis Álvarez-Galovich[4], Mathieu Piché[2,3] and Arantxa Ortega-De Mues[1]*

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Background and aims: Low back pain is the leading cause of years lived with disability worldwide. Chiropractors employ different interventions to treat low back pain, including spinal manipulative therapy, although the mechanisms through which chiropractic care improves low back pain are still unclear. Clinical research and animal models suggest that spinal manipulation might modulate plasma levels of inflammatory cytokines, which have been involved in different stages of low back pain. More specifically, serum levels of Tumor Necrosis Factor-alpha (TNF-α) have been found to be elevated in patients with chronic low back pain. We aimed to investigate whether urine from chronic low back pain patients could be an appropriate medium to measure concentrations of TNF-α and to examine possible changes in its levels associated to chiropractic care.

Methods: Urine samples were collected from 24 patients with chronic low back pain and TNF-α levels were analyzed by ELISA before and after 4–6 weeks of care compared to a reference value obtained from 5 healthy control subjects, by means of a Welch's *t*-test. Simultaneously, pain intensity and disability were also evaluated before and after care. Paired *t*-tests were used to compare mean pre and post urinary concentrations of TNF-α and clinical outcomes.

Results: Significantly higher baseline levels of urinary TNF-α were observed in chronic low back pain patients when compared to our reference value ($p < 0.001$), which were significantly lower after the period of chiropractic treatment ($p = 0.03$). Moreover, these changes were accompanied by a significant reduction in pain and disability

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Gevers-Montoro et al. Urinary TNF-α in Back Pain

NRS-11 ODI | Urine sample | NRS-11 ODI | Urine sample | ELISA TNF-α
1st visit: Participant recruitment | 2nd visit: Treatment begins | Chiropractic care | Last visit: Treatment concludes | Urine analysis

FIGURE 1 | The study protocol, including outcomes measures collected in relationship to treatment period. NRS-11, Numerical Rating Scale 11; ODI, Oswestry Disability Index; TNF-α, Tumor Necrosis Factor-alpha.

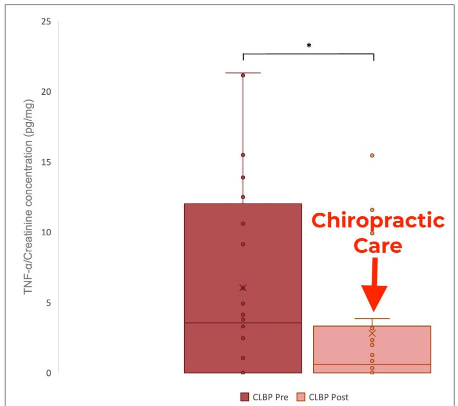

FIGURE 2 | Urinary TNF-α levels in chronic low back pain (CLBP) patients, pre- and post-treatment. For each sample, the urinary concentrations of TNF-α (pg/ml) and creatinine (mg/dl) were assessed. The ratio of urinary TNF-α to urinary creatinine in pg/mg was calculated to correct changes in urine volume. The middle line represents the median and the *x* represents the mean. The upper and the lower lines of the box represent the first and third quartile respectively and the whiskers include all individual data points within 1.5 times the interquartile range. $^{*}p < 0,05$.

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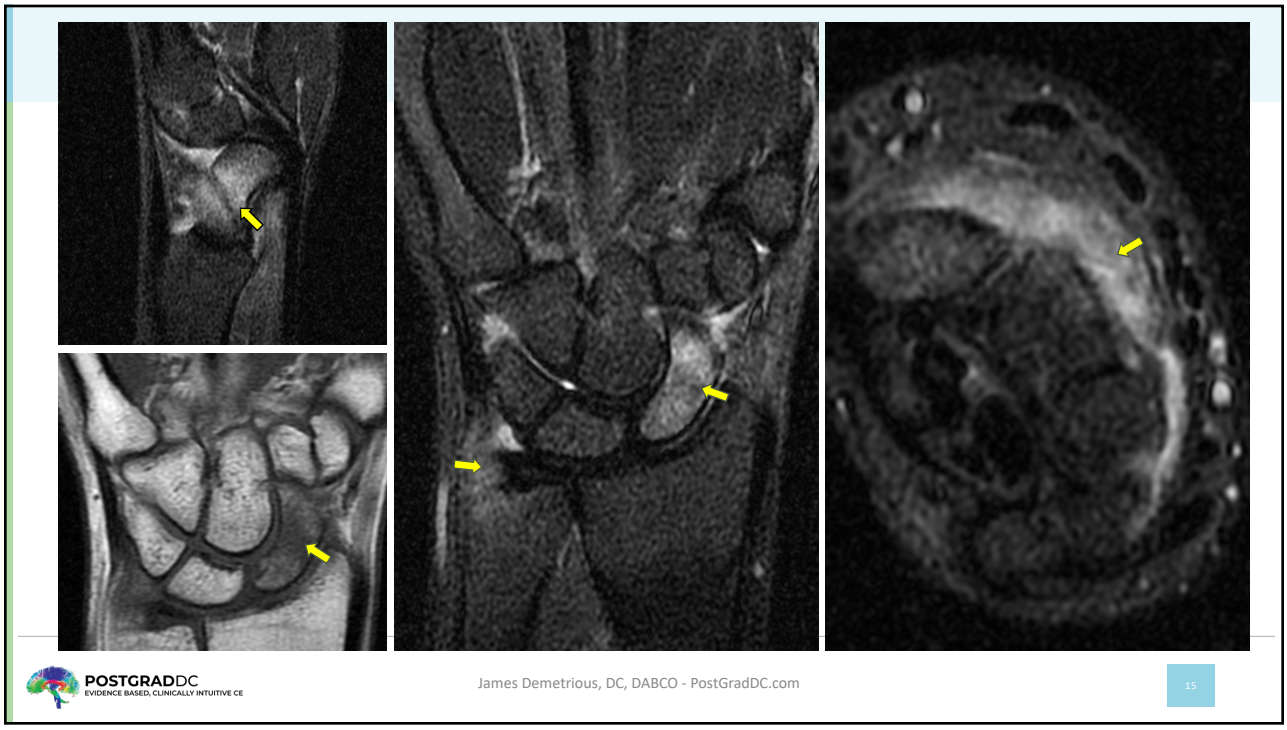
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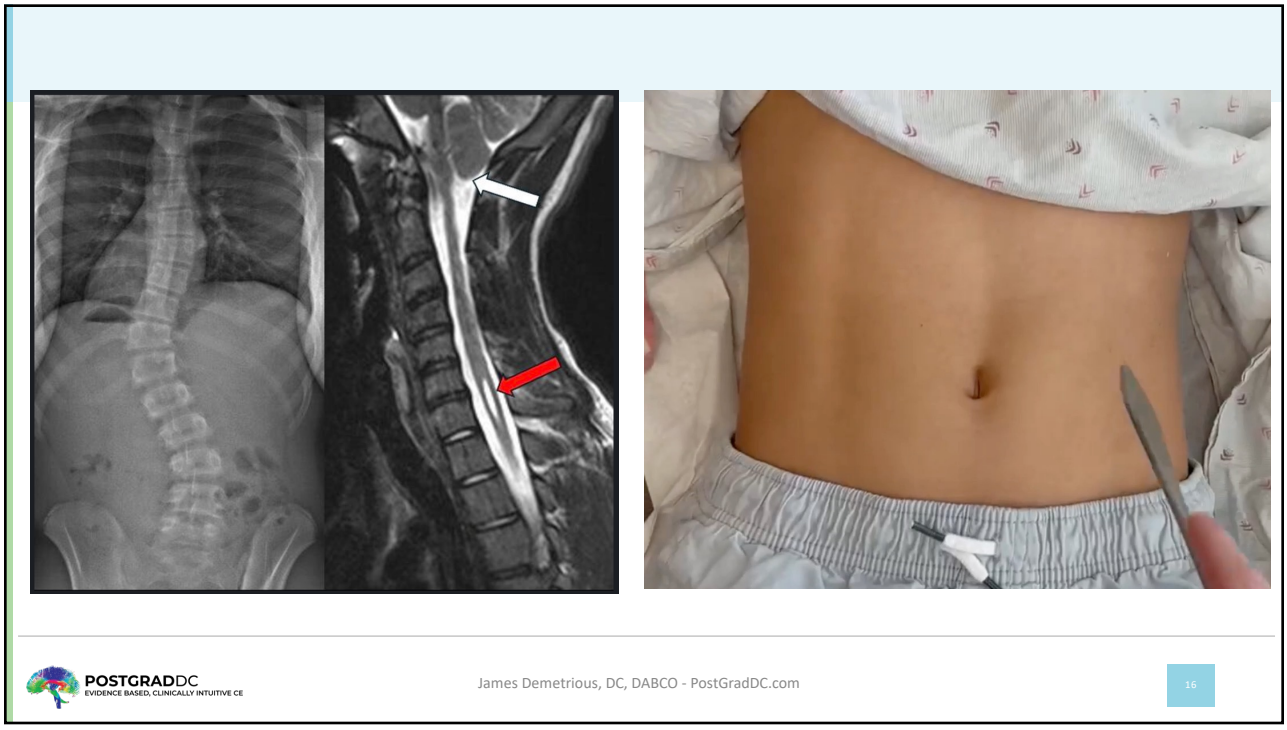
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European Spine Journal
https://doi.org/10.1007/s00586-024-08581-3

ORIGINAL ARTICLE

Patterns of initial treatment and subsequent care escalation among medicare beneficiaries with neck pain: a retrospective cohort study

Brian R. Anderson[1] · Todd A. MacKenzie[2] · Jon D. Lurie[2] · Leah Grout[3] · James M. Whedon[3]

Received: 1 July 2024 / Revised: 6 October 2024 / Accepted: 18 November 2024

Abstract

Purpose To compare long-term care escalation encounters among three care patterns for new episodes of neck pain among Medicare beneficiaries.

Methods We examined Medicare claims spanning a four-year period for beneficiaries with new episodes of neck pain beginning in 2019. All patients were continuously enrolled under Medicare parts A, B, and D and aged 65–99 years. We calculated the cumulative frequency and propensity- weighted rate ratios for escalated care encounters across three distinct, index-visit related neck pain treatment cohorts: 1) Spinal manipulative therapy; 2) Primary care without prescription analgesics within 7 days; 3) Primary care with prescription analgesics within 7 days.

Results When compared to the primary care without analgesics cohort, the spinal manipulative therapy cohort was associated with a 64% lower rate (RR 0.36, 95% CI 0.35,0.37) for long-term care escalation encounters, while the primary care with prescription analgesics cohort was associated with an 8% higher rate (RR 1.08; 95% CI 1.05,1.10).

Conclusion Initial spinal manipulative therapy was associated with a significant reduction in downstream care escalation encounters among Medicare beneficiaries with new episodes of neck pain. Our study contributes to a growing body of evidence supporting the integration of non-pharmacological care strategies for neck pain management.

Keywords Neck pain · Spinal manipulation · Prescription drugs · Primary care physicians · Health care utilization

Introduction

The prevalence of neck pain (NP) among adults over the age of 65 in the United States (US) is reported to be 9.7% [1], impacting approximately 3.9 million older adults and peaking between the ages of 70–74 years. Healthcare spending related to neck pain has increased at a rate six times faster than its prevalence, suggesting a rise in the use of high-cost care options such as injection procedures and fusion surgeries. [2–4].

Medicare is a federal health insurance program primarily serving Americans aged 65 and over, providing coverage for inpatient (Part A) and outpatient (Part B) care. In 2021, around 64 million beneficiaries were enrolled in Medicare Parts A and B, with approximately 49 million also opting for prescription drug coverage (Part D). [5] Spinal Manipulative Therapy (SMT) is the only chiropractic service covered by Medicare, and chiropractors perform 97% of all SMT procedures reimbursed by the program [6]. Over a 10-year period, chiropractic users in the U.S. averaged 8.3 visits annually, with an average cost of $87 USD per visit, resulting in total yearly expenditures of $721 USD per user [7].

Most studies on pain management among Medicare beneficiaries have focused on low back pain. Therefore, there is a critical need for more research on non-pharmacological management of NP, particularly in light of new clinical practice guidelines [8]. Such guidelines discourage the initial use of prescription drugs and emphasize non-pharmacological therapies such as SMT [9]. Physicians may also prescribe

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Original Research

APTA American Physical Therapy Association | OXFORD

First Provider Seen for an Acute Episode of Low Back Pain Influences Subsequent Health Care Utilization

Christopher G. Bise, PT, DPT, PhD[1,2,*], Michael Schneider, DC, PhD[1], Janet Freburger, PT, PhD[1], G. Kelley Fitzgerald, PT, PhD[1], Galen Switzer, PhD[3,4], Garry Smyda, BS[2], Pamela Peele, PhD[2,5], Anthony Delitto, PT, PhD[1,6]

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Table 2. Episode Length and Costs of Care[a]

	Portal of Entry						
	Emergency Department	Primary Care	Surgery	Specialty Care	Chiropractic	Physical Therapy	Other
N	2895 (9.7%)	15,199 (51.0%)	2475 (8.3%)	2692 (9.0%)	4971 (16.7%)	1226 (4.1%)	348 (1.2%)
Episode length (mean, 95% CI), d	58.23 (55.64–60.83)	75.77 (74.37–77.16)	74.57 (71.21–77.93)	110.62 (105.49–115.76)	79.03 (75.66–82.41)	61.81 (57.86–65.75)	82.29 (72.90–91.68)
Episode length (median, IQR), d	35 (10,79)	49 (20, 97)	49 (21, 97)	68 (30, 136)	35 (10, 93)	37 (18, 77)	53 (23, 108)
LBP-related spending (mean, 95% CI)	$3,382.02 ($3,102.06–$3,661.99)	$2,912.22 ($2,789.01–$3,035.44)	$4,346.25 ($3,870.92–$4,821.47)	$2,048.57 ($1,863.05–$2,234.09)	$992.37 ($913.11–$1071.64)	$1,925.34 ($1,689.64–$2,161.04)	$4,030.24 ($2,687.91–$5,372.56)
Low back costs (median)	$950.1	$793.74	$981.7	$865.77	$431.7	$851.83	$812.64
Total cost of care (mean, 95% CI)	$20,028.23 ($18,902.67–$21,153.80)	$16,609.48 ($16,163.41–$17,055.56)	$17,825.38 ($16,794.17–$18,856.60)	$17,300.99 ($16,247.62–$18,354.36)	$7,761.63 ($7,305.72–$8,217.54)	$11,612.13 ($10,586.49–$12,637.78)	$20,294.55 ($16,588.91–$24,000.19)
Total cost of care (median)	$9,412.01	$7,836.44	$8,144.52	$8,346.22	$3,334.08	$5,716.24	$8,385.46

[a]IQR = interquartile range; LBP = low back pain.

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Forensic Science International: Reports 11 (2025) 100400

Contents lists available at ScienceDirect

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journal homepage: www.sciencedirect.com/journal/forensic-science-international-reports

Causal analysis of vertebral artery dissection and fatal stroke following chiropractic cervical spine manipulation

Steven P. Brown *

Private Practice

ARTICLE INFO

Keywords:
Forensic analysis
Dissection
Chiropractic
Manipulation
Stroke

ABSTRACT

A 34-year-old female suffered a fatal stroke 7.5 h after cervical spine manipulation (CSM) performed by a chiropractic physician. Imaging noted vertebral artery dissection (VAD), basilar artery occlusion, and thromboembolic stroke. The medical examiner opined that CSM caused the VAD which embolized to cause the fatal stroke. However, causation of VAD by CSM is not supported by the research.

We utilized an intuitive approach to causation analysis to determine the cause of the VAD and the stroke. Causation of the VAD and the stroke by CSM could not be established as more likely than not. The malpractice case was settled by bringing allegations of misdiagnosis and failure to diagnose and refer the VAD to medical emergency.

We conclude that in the absence of convincing evidence that CSM could cause VAD, forensic professionals should consider VAD as a presenting symptom prior to CSM in such cases. Adherence to the standard of care for the chiropractic profession with attention to differential diagnosis could prevent such cases.

Case presentation

Case information was taken from publicly available documents in the 11/24/2020 Appendix of Declarations and Evidence in Support of Plaintiff's Opposition to Defendant's Motion for Summary Adjudication [1]. These documents include the declaration of the plaintiff chiropractic expert, transcript of the deposition of the defendant, chiropractic records, hospital records, and a certified copy of the autopsy report. Background information was taken from publicly available investigative journalism and media coverage of this case [2,3].

The decedent was a 34-year-old female professional model who presented to a chiropractic physician for diagnosis and treatment on 1/29/2016. Her height was five feet and weight 110 pounds with a body mass index (BMI) of 21.5.

She reported a five-day history of sudden onset, worsening, severe, constant, dull, left suboccipital neck pain and left occipital headache. Pain level 8/10. She also reported nausea. Symptoms were not relieved by anything and affected all her daily activities.

The chiropractor documented that her symptoms began with a neck injury five days earlier on a 1/25/2016 photo shoot. Symptoms occurred when the photographer asked her to hold a pose for a long time that involved arching her back and leaning her neck to the side [2]. The decedent's hair and makeup assistant, personal assistant, and the father of her daughter all confirmed this neck injury. On 1/29/2016 she posted on Twitter that, "Pinched a nerve in my neck on a Photoshoot and got adjusted this morning."

Physical examination findings included cervical spine range of motion (ROM) decreased with pain. Palpation revealed very tender muscle spasm noted in the left cervical spine. Segmental dysfunction noted at C2, C3, C4, C5, and C7. Cervical Distraction relieved the patient's neck pain. Cervical/Jackson Compression was negative. No vital signs or neurological examination were performed. No imaging was ordered or considered. No differential diagnosis was formulated. The chiropractor diagnosed migraine and cervicalgia. Treatment consisted of cervical spine manipulation (CSM), therapeutic ultrasound and therapeutic exercises.

The decedent returned on 2/1/2016. The chiropractor documented a 50 % improvement with increased cervical spine ROM. Pain level was documented as 5/10. Physical examination findings included decreased cervical spine ROM with mild-moderate spasm and mild pain. No vital signs, orthopedic examination, or neurological examination were performed. Diagnosis was again migraine and neck pain. However, an additional diagnosis of torticollis was documented. Treatment consisted of CSM, muscle stimulation, and therapeutic ultrasound.

The chiropractor did not document the time of the second chiropractic visit. However, the decedent's personal assistant said she talked to the decedent not long after she got home from the chiropractic office around 10:00am [2]. There was no record of the decedent's activities from 10:00am to 5:30pm.

At 5:30pm, emergency department records document that the decedent suddenly developed slurred speech, vertigo, and left-sided weakness of the arm and leg. She called a friend who transported her to the emergency department.

At the ED, she initially showed significant improvement with IV tissue plasminogen activator (tPA) treatment. At 8:45pm, Head & Neck CTA (computed tomography angiography) noted bilateral V3 segment VAD and basilar artery occlusion. Prior to DSA (digital subtraction angiography), when she was sat up to evaluate for hemodynamic instability, she started having speech difficulty again. During the DSA procedure, bilateral VADs were noted with left worse

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January 24, 2025 PostGradDC No Comments

Chiropractic Standard of Care

Written by: James Demetrious, DC, DABCO

Board Certified Chiropractic Orthopedist

Ensuring Patient Safety and Efficacy

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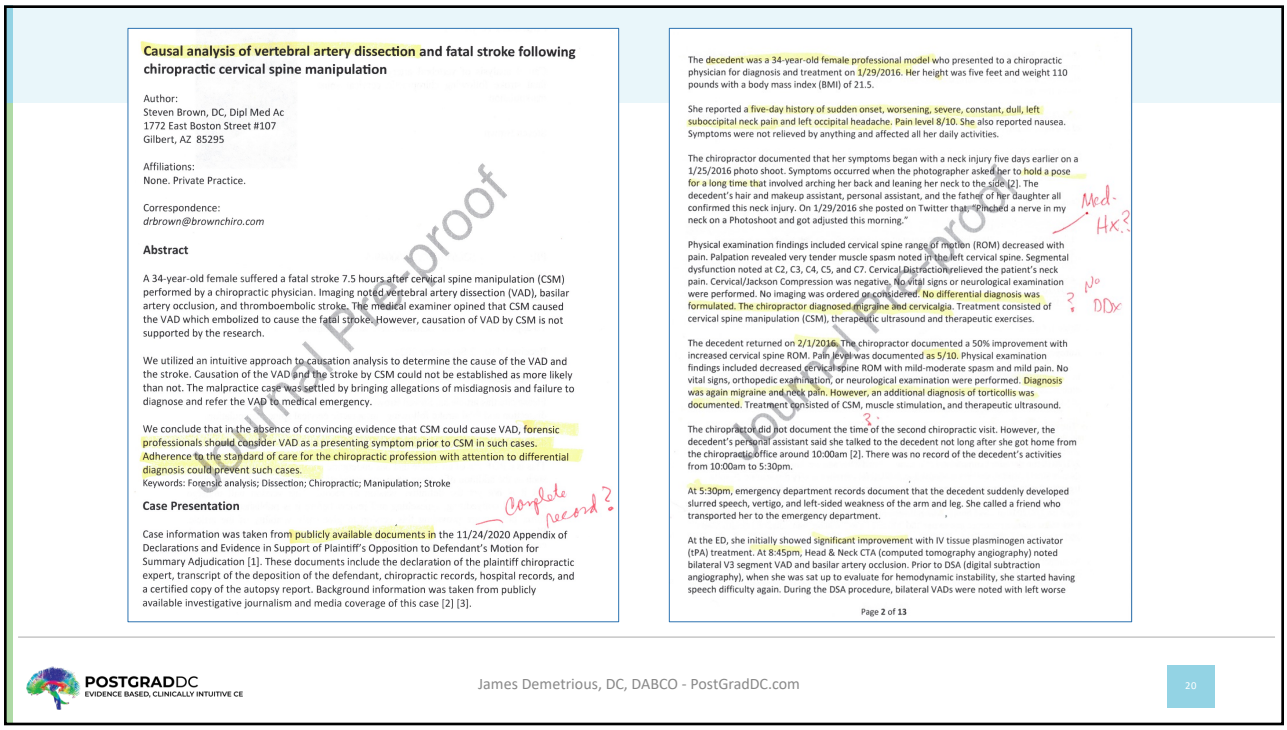

Causal analysis of vertebral artery dissection and fatal stroke following chiropractic cervical spine manipulation

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Abstract

A 34-year-old female suffered a fatal stroke 7.5 hours after cervical spine manipulation (CSM) performed by a chiropractic physician. Imaging noted vertebral artery dissection (VAD), basilar artery occlusion, and thromboembolic stroke. The medical examiner opined that CSM caused the VAD which embolized to cause the fatal stroke. However, causation of VAD by CSM is not supported by the research.

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Keywords: Forensic analysis; Dissection; Chiropractic; Manipulation; Stroke

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She reported a five-day history of sudden onset, worsening, severe, constant, dull, left suboccipital neck pain and left occipital headache. Pain level 8/10. She also reported nausea. Symptoms were not relieved by anything and affected all her daily activities.

The chiropractor documented that her symptoms began with a neck injury five days earlier on a 1/25/2016 photo shoot. Symptoms occurred when the photographer asked her to hold a pose for a long time that involved arching her back and leaning her neck to the side [2]. The decedent's hair and makeup assistant, personal assistant, and the father of her daughter all confirmed this neck injury. On 1/29/2016 she posted on Twitter that, "Pinched a nerve in my neck on a Photoshoot and got adjusted this morning."

Physical examination findings included cervical spine range of motion (ROM) decreased with pain. Palpation revealed very tender muscle spasm noted in the left cervical spine. Segmental dysfunction noted at C2, C3, C4, C5, and C7. Cervical Distraction relieved the patient's neck pain. Cervical/Jackson Compression was negative. No vital signs or neurological examination were performed. No imaging was ordered or considered. No differential diagnosis was formulated. The chiropractor diagnosed migraine and cervicalgia. Treatment consisted of cervical spine manipulation (CSM), therapeutic ultrasound and therapeutic exercises.

The decedent returned on 2/1/2016. The chiropractor documented a 50% improvement with increased cervical spine ROM. Pain level was documented as 5/10. Physical examination findings included decreased cervical spine ROM with mild-moderate spasm and mild pain. No vital signs, orthopedic examination, or neurological examination were performed. Diagnosis was again migraine and neck pain. However, an additional diagnosis of torticollis was documented. Treatment consisted of CSM, muscle stimulation, and therapeutic ultrasound.

The chiropractor did not document the time of the second chiropractic visit. However, the decedent's personal assistant said she talked to the decedent not long after she got home from the chiropractic office around 10:00am [2]. There was no record of the decedent's activities from 10:00am to 5:30pm.

At 5:30pm, emergency department records document that the decedent suddenly developed slurred speech, vertigo, and left-sided weakness of the arm and leg. She called a friend who transported her to the emergency department.

At the ED, she initially showed significant improvement with IV tissue plasminogen activator (tPA) treatment. At 8:45pm, Head & Neck CTA (computed tomography angiography) noted bilateral V3 segment VAD and basilar artery occlusion. Prior to DSA (digital subtraction angiography), when she was sat up to evaluate for hemodynamic instability, she started having speech difficulty again. During the DSA procedure, bilateral VADs were noted with left worse

Complete record?

Med-Hx?

No DDx?

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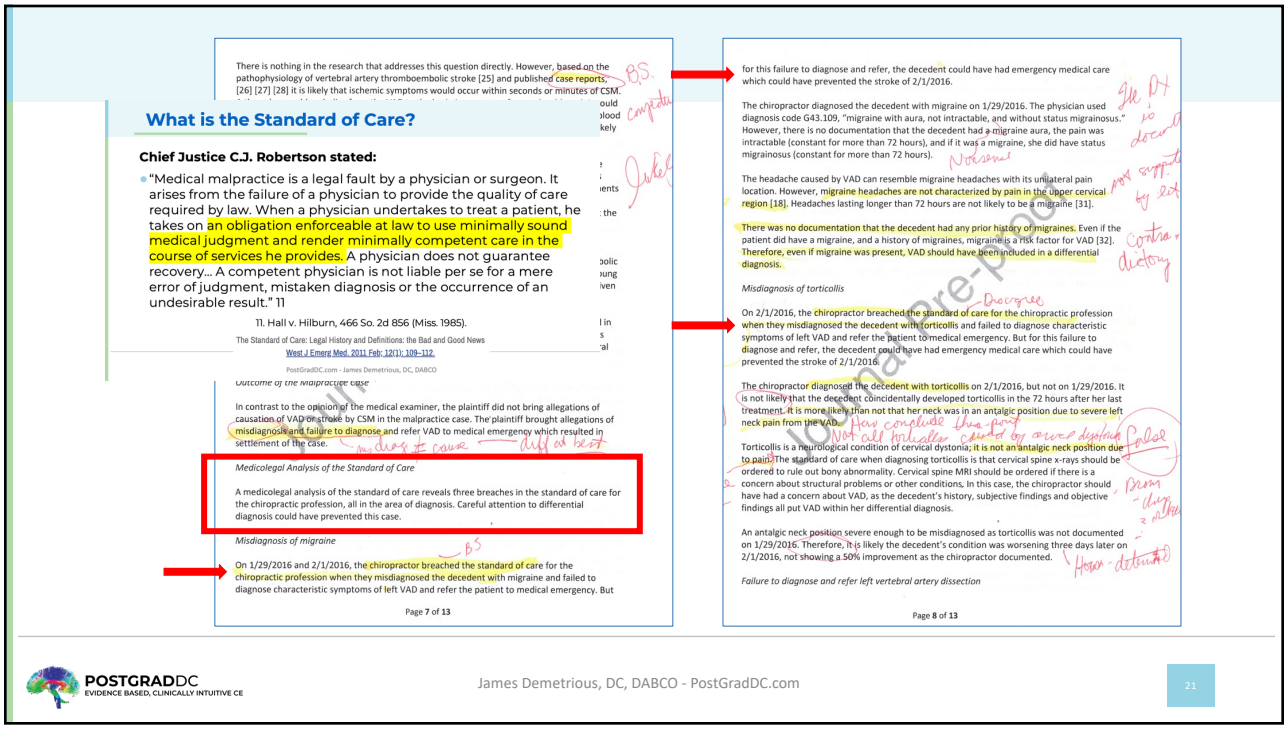

What is the Standard of Care?

Chief Justice C.J. Robertson stated:

- "Medical malpractice is a legal fault by a physician or surgeon. It arises from the failure of a physician to provide the quality of care required by law. When a physician undertakes to treat a patient, he takes on an obligation enforceable at law to use minimally sound medical judgment and render minimally competent care in the course of services he provides. A physician does not guarantee recovery... A competent physician is not liable per se for a mere error of judgment, mistaken diagnosis or the occurrence of an undesirable result." 11

11. Hall v. Hilburn, 466 So. 2d 856 (Miss. 1985).

The Standard of Care: Legal History and Definitions: the Bad and Good News
West J Emerg Med. 2011 Feb; 12(1): 109–112.
PostGradDC.com - James Demetrious, DC, DABCO

There is nothing in the research that addresses this question directly. However, based on the pathophysiology of vertebral artery thromboembolic stroke [25] and published case reports, [26] [27] [28] it is likely that ischemic symptoms would occur within seconds or minutes of CSM.

Outcome of the malpractice case

In contrast to the opinion of the medical examiner, the plaintiff did not bring allegations of causation of VAD or stroke by CSM in the malpractice case. The plaintiff brought allegations of misdiagnosis and failure to diagnose and refer VAD to medical emergency which resulted in settlement of the case.

Medicolegal Analysis of the Standard of Care

A medicolegal analysis of the standard of care reveals three breaches in the standard of care for the chiropractic profession, all in the area of diagnosis. Careful attention to differential diagnosis could have prevented this case.

Misdiagnosis of migraine

On 1/29/2016 and 2/1/2016, the chiropractor breached the standard of care for the chiropractic profession when they misdiagnosed the decedent with migraine and failed to diagnose characteristic symptoms of left VAD and refer the patient to medical emergency. But

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for this failure to diagnose and refer, the decedent could have had emergency medical care which could have prevented the stroke of 2/1/2016.

The chiropractor diagnosed the decedent with migraine on 1/29/2016. The physician used diagnosis code G43.109, "migraine with aura, not intractable, and without status migrainosus." However, there is no documentation that the decedent had a migraine aura, the pain was intractable (constant for more than 72 hours), and if it was a migraine, she did have status migrainosus (constant for more than 72 hours).

The headache caused by VAD can resemble migraine headaches with its unilateral pain location. However, migraine headaches are not characterized by pain in the upper cervical region [18]. Headaches lasting longer than 72 hours are not likely to be a migraine [31].

There was no documentation that the decedent had any prior history of migraines. Even if the patient did have a migraine, and a history of migraines, migraine is a risk factor for VAD [32]. Therefore, even if migraine was present, VAD should have been included in a differential diagnosis.

Misdiagnosis of torticollis

On 2/1/2016, the chiropractor breached the standard of care for the chiropractic profession when they misdiagnosed the decedent with torticollis and failed to diagnose characteristic symptoms of left VAD and refer the patient to medical emergency. But for this failure to diagnose and refer, the decedent could have had emergency medical care which could have prevented the stroke of 2/1/2016.

The chiropractor diagnosed the decedent with torticollis on 2/1/2016, but not on 1/29/2016. It is not likely that the decedent coincidentally developed torticollis in the 72 hours after her last treatment. It is more likely than not that her neck was in an antalgic position due to severe left neck pain from the VAD.

Torticollis is a neurological condition of cervical dystonia; it is not an antalgic neck position due to pain. The standard of care when diagnosing torticollis is that cervical spine x-rays should be ordered to rule out bony abnormality. Cervical spine MRI should be ordered if there is a concern about structural problems or other conditions, In this case, the chiropractor should have had a concern about VAD, as the decedent's history, subjective findings and objective findings all put VAD within her differential diagnosis.

An antalgic neck position severe enough to be misdiagnosed as torticollis was not documented on 1/29/2016. Therefore, it is likely the decedent's condition was worsening three days later on 2/1/2016, not showing a 50% improvement as the chiropractor documented.

Failure to diagnose and refer left vertebral artery dissection

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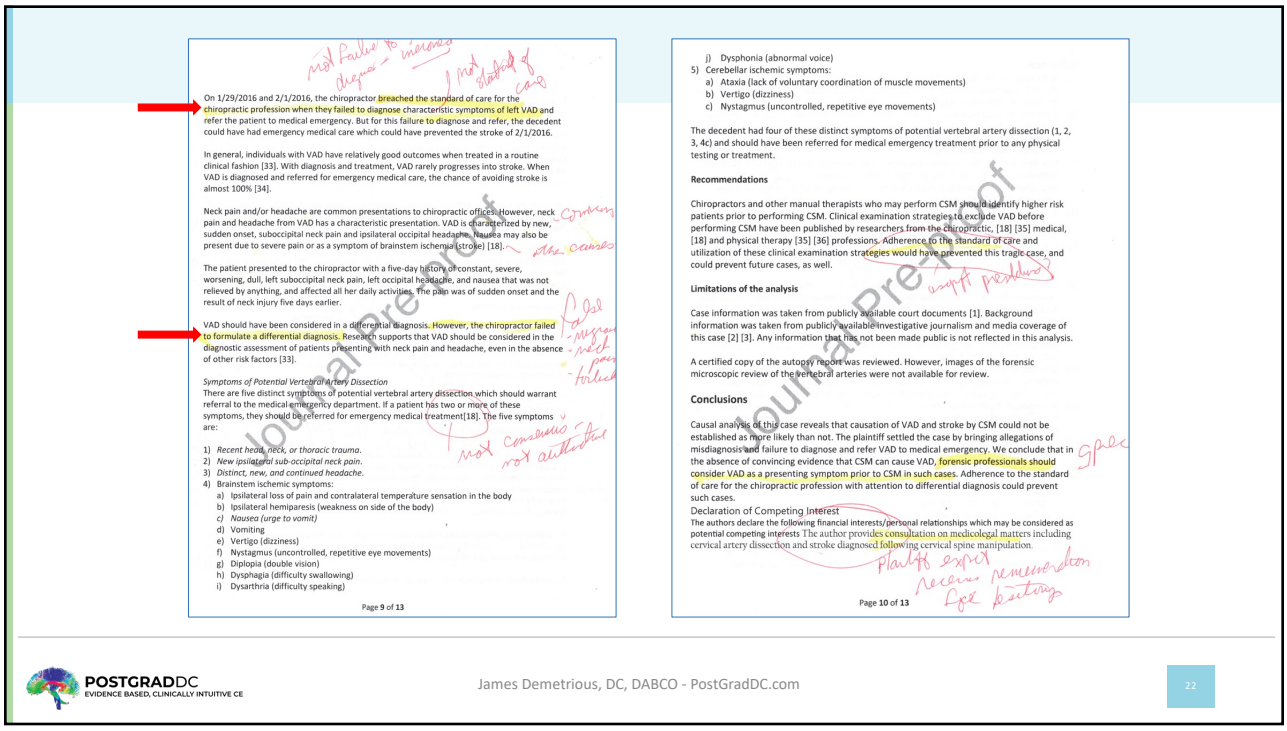

On 1/29/2016 and 2/1/2016, the chiropractor breached the standard of care for the chiropractic profession when they failed to diagnose characteristic symptoms of left VAD and refer the patient to medical emergency. But for this failure to diagnose and refer, the decedent could have had emergency medical care which could have prevented the stroke of 2/1/2016.

In general, individuals with VAD have relatively good outcomes when treated in a routine clinical fashion [33]. With diagnosis and treatment, VAD rarely progresses into stroke. When VAD is diagnosed and referred for emergency medical care, the chance of avoiding stroke is almost 100% [34].

Neck pain and/or headache are common presentations to chiropractic offices. However, neck pain and headache from VAD has a characteristic presentation. VAD is characterized by new, sudden onset, suboccipital neck pain and ipsilateral occipital headache. Nausea may also be present due to severe pain or as a symptom of brainstem ischemia (stroke) [18].

The patient presented to the chiropractor with a five-day history of constant, severe, worsening, dull, left suboccipital neck pain, left occipital headache, and nausea that was not relieved by anything, and affected all her daily activities. The pain was of sudden onset and the result of neck injury five days earlier.

VAD should have been considered in a differential diagnosis. However, the chiropractor failed to formulate a differential diagnosis. Research supports that VAD should be considered in the diagnostic assessment of patients presenting with neck pain and headache, even in the absence of other risk factors [33].

Symptoms of Potential Vertebral Artery Dissection

There are five distinct symptoms of potential vertebral artery dissection which should warrant referral to the medical emergency department. If a patient has two or more of these symptoms, they should be referred for emergency medical treatment[18]. The five symptoms are:

1) *Recent head, neck, or thoracic trauma.*
2) *New ipsilateral sub-occipital neck pain.*
3) *Distinct, new, and continued headache.*
4) Brainstem ischemic symptoms:
   a) Ipsilateral loss of pain and contralateral temperature sensation in the body
   b) Ipsilateral hemiparesis (weakness on side of the body)
   c) *Nausea (urge to vomit)*
   d) Vomiting
   e) Vertigo (dizziness)
   f) Nystagmus (uncontrolled, repetitive eye movements)
   g) Diplopia (double vision)
   h) Dysphagia (difficulty swallowing)
   i) Dysarthria (difficulty speaking)
   j) Dysphonia (abnormal voice)
5) Cerebellar ischemic symptoms:
   a) Ataxia (lack of voluntary coordination of muscle movements)
   b) Vertigo (dizziness)
   c) Nystagmus (uncontrolled, repetitive eye movements)

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The decedent had four of these distinct symptoms of potential vertebral artery dissection (1, 2, 3, 4c) and should have been referred for medical emergency treatment prior to any physical testing or treatment.

Recommendations

Chiropractors and other manual therapists who may perform CSM should identify higher risk patients prior to performing CSM. Clinical examination strategies to exclude VAD before performing CSM have been published by researchers from the chiropractic, [18] [35] medical, [18] and physical therapy [35] [36] professions. Adherence to the standard of care and utilization of these clinical examination strategies would have prevented this tragic case, and could prevent future cases, as well.

Limitations of the analysis

Case information was taken from publicly available court documents [1]. Background information was taken from publicly available investigative journalism and media coverage of this case [2] [3]. Any information that has not been made public is not reflected in this analysis.

A certified copy of the autopsy report was reviewed. However, images of the forensic microscopic review of the vertebral arteries were not available for review.

Conclusions

Causal analysis of this case reveals that causation of VAD and stroke by CSM could not be established as more likely than not. The plaintiff settled the case by bringing allegations of misdiagnosis and failure to diagnose and refer VAD to medical emergency. We conclude that in the absence of convincing evidence that CSM can cause VAD, forensic professionals should consider VAD as a presenting symptom prior to CSM in such cases. Adherence to the standard of care for the chiropractic profession with attention to differential diagnosis could prevent such cases.

Declaration of Competing Interest
The authors declare the following financial interests/personal relationships which may be considered as potential competing interests The author provides consultation on medicolegal matters including cervical artery dissection and stroke diagnosed following cervical spine manipulation.

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Systemic lupus erythematosus is associated with an increased risk of cervical artery dissection

Robert J. Trager[1,2,3✉], Benjamin P. Lynn[4], Anthony N. Baumann[5,6] & Eric Chun-Pu Chu[7]

Limited evidence suggests that autoimmune diseases are associated with an increased risk of cervical artery dissection (CeAD). We hypothesized individuals with systemic lupus erythematosus (SLE) would have an increased risk of CeAD following SLE diagnosis compared to matched non-lupus controls. We queried a de-identified United States electronic medical records network (TriNetX, Inc.) for individuals aged 18 and older from 2012 to 2020, for two cohorts: (1) SLE and (2) non-lupus controls, excluding those with prior CeAD. We used propensity matching to control for confounding variables and calculated the risk ratio (RR) for CeAD occurring over four years' follow-up, secondarily exploring cumulative incidence. After matching, both cohorts contained 77,008 patients, who were mostly female (89%). The incidence and risk of CeAD was significantly greater among those with SLE compared to matched non-lupus controls (.95% CI) (0.08% vs. 0.04%; RR = 2.33 [1.49,3.66]; $P < 0.0001$). These findings support the hypothesis that SLE is a risk factor for CeAD. Additional research is needed to identify the mechanisms that may underly the SLE-CeAD association and examine the potential association between other autoimmune diseases and CeAD.

Systemic lupus erythematosus (SLE) is a chronic, multisystem autoimmune disorder involving the production of autoantibodies which lead to inflammation and tissue damage[1]. Limited research has suggested that autoimmune diseases, such as SLE, may be a risk factor for spontaneous cervical artery dissection (CeAD)[2–5], a condition involving a tear and hematoma within the wall of the vertebral or carotid artery[6]. The incidence of SLE increases during adolescence, reaching up to 10 per 100,000 person-years in adults[7]. CeAD has an incidence of 8.9 per 100,000 person-years and accounts for 15–25% of strokes in adults under age 50[8].

Specific etiologies of CeAD are recognized including trauma[9] and iatrogenic causes such as spine surgery[9]. Several risk factors for CeAD have also been identified, albeit with varying degrees of certainty. Better-established risk factors include fibromuscular dysplasia and other genetic conditions affecting collagen[10–13], hypertension[11,12], migraine without aura[11], pregnancy[13,15], and respiratory infections[16–19] (apart from coronavirus disease 2019[20]). Others potential risk factors like diabetes mellitus[11,21], autoimmune thyroiditis[18], hypolipidemia[11,12], fluoroquinolones[22], oral contraceptives[16,23,24], alcohol intake[11,25,26], and tobacco use[11] have conflicting or only preliminary evidence to date. Additionally, socioeconomic factors may influence whether patients undergo testing to identify CeAD[9,27], highlighting the need for carefully designed studies to examine these risk factors.

Case-control studies have also revealed heightened inflammatory markers in individuals with CeAD compared to non-CeAD controls. Notably, elevations in C-reactive protein, erythrocyte sedimentation rate, and white blood cell counts have been observed[28–30]. While these findings suggest a potential underlying inflammatory mechanism for CeAD, the mediating factors remain unclear. Accordingly, some researchers have suggested that autoimmune disease may play a role, given these conditions can induce inflammation[31]. For example, one case-control study involving 215 CeAD cases found that 12.6% of individuals with CeAD had an autoimmune disease, compared to only 0.9% of age- and sex-matched population controls[3]. Therefore, while a direct link between specific autoimmune diseases and CeAD is yet to be confirmed, prior research indicates that further investigation into this relationship is warranted.

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https://doi.org/10.1038/s41598-025-85655-2

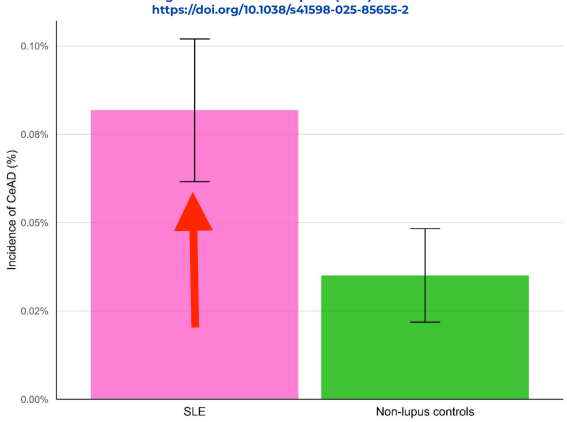

Fig. 1. Total incidence of cervical artery dissection (CeAD) over the four-year follow-up window. Incidences of CeAD are shown for the systemic lupus erythematosus cohort (SLE; pink) and non-lupus controls (green). Brackets indicate 95% confidence intervals.

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Validation of a diagnostic support tool for early recognition of cervical arterial dissection in primary care

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Diagnosis

ABSTRACT

Background: Cervical arterial dissection (CeAD) is a leading cause of stroke in young adults with an early presentation often mimicking musculoskeletal pain. Currently, no validated tests exist and CAD may be missed. A diagnostic support tool could help guide urgent referral for imaging, when to monitor, or when safe to proceed with treatment, and ultimately help stroke prevention.
Objectives: To validate a 4-criteria diagnostic support tool for early recognition of CeAD in primary care, to refine tool descriptors as needed, and propose optimal cut-offs for clinical application.
Design: Prospective observational study
Method: Participants with radiologically confirmed CeAD and controls without CeAD were identified from adults >18 years presenting to a tertiary metropolitan hospital with initial diagnosis of headache or neck pain. All were scored with criteria out of7 (acute onset pain [2], recent trauma/infection [1], neurological features [2], age <55 years [2]). Diagnostic values were calculated to determine cut offs and the tool was refined based on the analysis.
Results: Thirty participants with CeAD and 261 controls with non-CeAD causes of headache and neck pain were included. The diagnostic support tool was an 'excellent' predictor of CeAD (AUC 0.83) but demonstrated poor specificity. Refining the tool to 'acute/sudden onset' [1], 'unusual/unfamiliar headache/neck pain' [1], recent trauma/infection [1] and neurological features ≥2 [1], scored out of 4, showed 100 % sensitivity and 74 % specificity to detect CeAD at a cut-off of 3/4 (AUC 0.87).
Conclusions: The refined tool shows acceptable clinical utility at a cut-off ≥3, where referral for vascular imaging is recommended. Further validation in Emergency and primary care is needed.

1. Introduction

Spontaneous Cervical Artery Dissection (CeAD), including dissection of the internal carotid artery (ICAD) or vertebral artery (VAD) is a leading cause of ischaemic stroke in young and middle-aged adults with an annual incidence of 2–3 cases per 100,000 [1–3]. However, this may be an underestimate of the true incidence of CeAD as patients with subtle and transient symptoms may go undiagnosed [4,5]. Incidental findings on imaging suggest CeAD may occur asymptomatically [8]. CeAD causing stroke is a rare but potentially catastrophic adverse event reported in association with cervical musculoskeletal therapies which is a major concern to practitioners, though correlation between exposure and outcome is questioned [6,7]. The clinical dilemma is the early presenting features of CeAD, typically headache and neck pain, may mimic migraine or a musculoskeletal presentation prior to overt neurological features arising days or weeks later [8]. There are two major concerns for practitioners, firstly misdiagnosis of an evolving dissection event delaying medical management to prevent stroke and secondly, that patients may seek musculoskeletal treatment of their neck pain or headache which could exacerbate an underlying dissection, risking potential ischaemic sequelae. There have been calls in the international community for research to direct practice [7,9,10].

Delays in diagnosis and misdiagnosis of CeAD in emergency departments have also been noted by Liberman et al. [11], affecting 1 in 30 cases, particularly when patients present with headache, highlighting the urgent need for diagnostic criteria to aid stroke prevention. Hashimoto et al. [12] proposed criteria for use in an emergency department including unilateral, worsening headache and no improvement with

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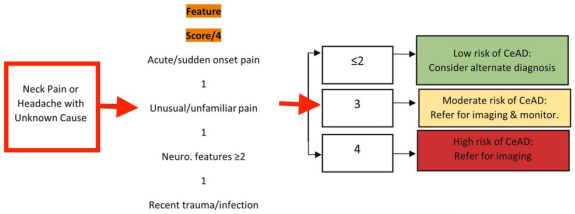

Fig. 2. Flow chart representing stratification of cases using the refined tool.

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Qualified? Meh...

Demetrious *Chiropractic & Manual Therapies* (2018) 26:22
https://doi.org/10.1186/s12998-018-0193-z

Chiropractic & Manual Therapies

HYPOTHESIS Open Access

Spontaneous cervical artery dissection: a fluoroquinolone induced connective tissue disorder?

James S. Demetrious

Dr. Demetrious was the first person to ever publish that medication can weaken the cervical arteries and cause strokes. His hypothesis has been initially confirmed by three independent researchers. Much work to be done.

> Eur J Neurol. 2019 Jul;26(7):1028-1031. doi: 10.1111/ene.13917. Epub 2019 Mar 5.

Use of fluoroquinolones and the risk of spontaneous cervical artery dissection

E Del Zotto [1], A Pezzini [1 2]

Case Reports > Intern Med. 2021 Sep 1;60(17):2863-2865.
doi: 10.2169/internalmedicine.6736-20. Epub 2021 Mar 22.

Vertebral Artery Dissection after Exposure to Levofloxacin: A Report of Two Cases

Taku Harada [1 2], Yukinori Harada [2], Taro Shimizu [2]

Archives of Cardiovascular Diseases Supplements
Volume 15, Issue 1, January 2023, Pages 112-113

Fluoroquinolone use preceding medium-size artery dissection: A case series

L. Wang [1], B. Oehmichen [1], B. Pariente [1], N. Mohamedi [1], C. Cheng [1], G. Détriché [1], A. Galloula [1], L. Khider [1], A. Lillo Le Louet [1], E. Messas [1], L. Amar [1], G. Goudot [1], T. Mirault [1]

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- Dr. Schneider received his PhD in Rehabilitation Science from the University of Pittsburgh in 2008 and his DC degree from Palmer College of Chiropractic in 1982.
- He has been a Principal Investigator and/or Co-Investigator on numerous NIH-funded research studies and has authored over 100 peer-reviewed publications.
- He has also served as an expert witness in malpractice cases involving chiropractors accused of causing vertebral artery dissections.
- Most recently, he was appointed as the inaugural director of the new Doctor of Chiropractic program at the University of Pittsburgh.

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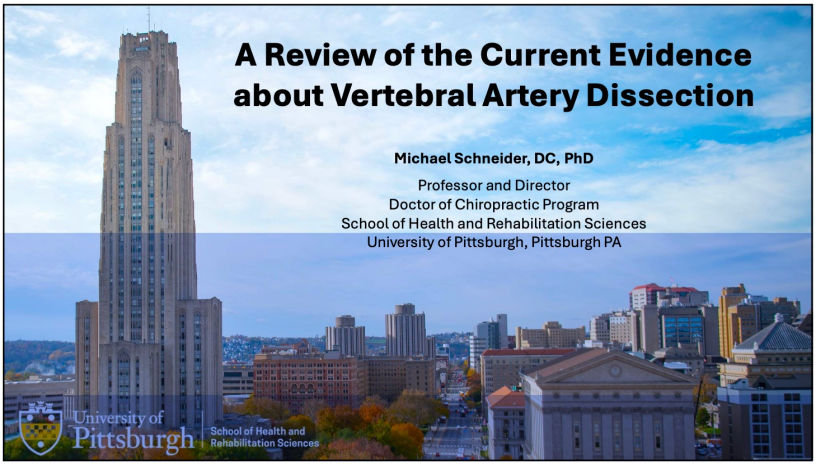
Dr. Schneider…



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