

Plausible Mechanisms by which Cervical Spine Manipulation Can Cause Immediate Stroke



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Plausible Mechanisms of Causation of Immediate Stroke by Cervical Spine Manipulation: A Narrative Review

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Steven P. Brown¹

1. Integrative/Complementary Medicine, Brown Chiropractic & Acupuncture, PC, Gilbert, USA

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Abstract

It has been proposed that cervical spine manipulation (CSM) can cause dissection in healthy cervical arteries, with resultant immediate stroke. However, research does not support a causal association between CSM and cervical artery dissection (CAD) in healthy cervical arteries. The objective of this study was to review the literature to identify plausible mechanisms of causation of immediate stroke by CSM. Immediate stroke is defined as a stroke occurring within seconds or minutes of CSM. Our review found plausible thromboembolic and thrombotic mechanisms of causation of immediate stroke by CSM in the literature. The common premise of these mechanisms is CAD being present before CSM, not occurring as a result of CSM. These mechanisms of causation have clinical and medicolegal implications for physicians performing CSM.

- **Part 1**
- Biography & Case Review
- **Part 2**
- Plausible Mechanisms of Causation
- **Hour 3**
- Clinical & Medicolegal Implications

Introduction & Background

Terminology

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It has been proposed that cervical spine manipulation (CSM) can cause dissection in healthy cervical arteries, with resultant immediate stroke. However, research does not support a causal association between CSM and cervical artery dissection (CAD) in healthy cervical arteries. The objective of this study was to review the literature to identify plausible mechanisms of causation of immediate stroke by CSM. Immediate stroke is defined as a stroke occurring within seconds or minutes of CSM. Our review found plausible thromboembolic and thrombotic mechanisms of causation of immediate stroke by CSM in the literature. The common premise of these mechanisms is CAD being present before CSM, not occurring as a result of CSM. These mechanisms of causation have clinical and medicolegal implications for physicians performing CSM.

- **Plausible** (Biological plausibility)
- A plausible causal association is a relationship between a putative cause and an outcome that is consistent with existing knowledge.
- **Immediate Stroke** (Temporality)
- Within seconds or minutes.

Introduction & Background

Possibility v. Plausibility

- **Possibility**
- Refers to the potential for something to happen or exist.
- It indicates that an event or situation can occur, but it does not provide any indication of how likely it is.
- **Plausibility**
- Refers to the degree to which a statement or hypothesis is credible or believable.
- It suggests that something not only can happen but also is reasonable and likely based on available evidence.

Plausible Mechanisms of Causation of Stroke

Abstract

- It has been proposed that CSM can cause CAD, with immediate stroke. However, research does not support a causal association of CSM & CAD.
- **The objective of this study was to review the literature for plausible mechanisms of causation of immediate stroke by CSM.**
- Two plausible mechanisms of causation were found. The common premise is CAD being present before CSM, not caused by CSM.
- These mechanisms of causation have clinical and medicolegal implications for physicians performing CSM.

Plausible Mechanisms of Causation of Stroke

Literature Search: Methods

- **Databases Searched**
 - 1. PubMed
 - 2. Index to Chiropractic Literature
- **Search Terms:** *chiropractic, stroke, dissection, “cervical spine manipulation”, “vertebral artery”, “internal carotid artery”*
- **Inclusion/Exclusion Criteria**
 - Included peer reviewed & academic studies that proposed a plausible mechanism of causation of immediate stroke by CSM.
 - Excluded studies proposing CSM may cause stroke by vasospasm, hemostasis, subclinical endothelial injury, or turbulent flow.

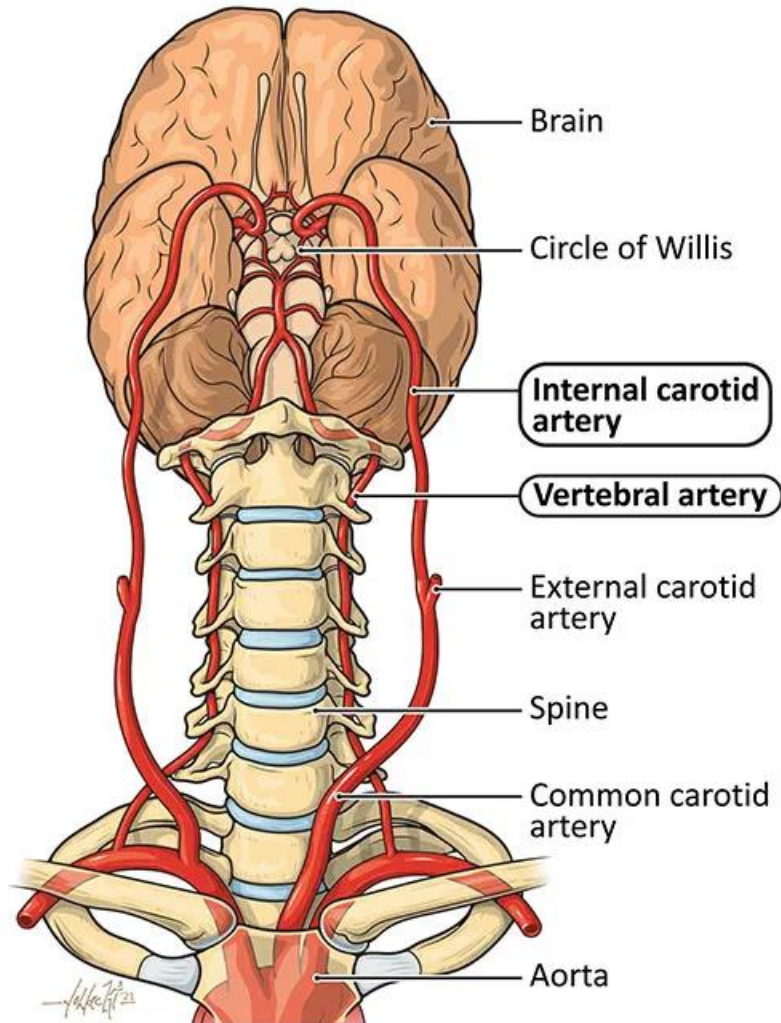
Plausible Mechanisms of Causation of Stroke

Vascular Flow Studies

- **Yelverton C**, et al. Changes in Vertebral Artery Blood Flow in Different Head Positions and Post-Cervical Manipulative Therapy. JMPT. **2020**
- **Al-Obaidi SM**, et al. Changes in Vertebral Artery Hemodynamics Associated With McKenzie Therapeutic Cervical Movements: An Exploration Using Duplex Ultrasound Imaging. JMPT. **2019**
- **Moser N**, et al. Effect of cervical manipulation on vertebral artery and cerebral hemodynamics in patients with chronic neck pain: a crossover randomized controlled trial. BMJ Open. **2019**
- **Kranenburg HAR**, et al. Effects of Head and Neck Positions on Blood Flow in the Vertebral, Internal Carotid, and Intracranial Arteries: A Systematic Review. JOSPT. **2019**
- **Thomas LC**, et al. The effect of end-range cervical rotation on vertebral and internal carotid arterial blood flow and cerebral inflow: A sub analysis of an MRI study. Man Ther. **2015**
- **Quesnele JJ**, et al. Changes in vertebral artery blood flow following various head positions and cervical spine manipulation. JMPT. **2014**
- **Thomas LC**, et al. Effect of selected manual therapy interventions for mechanical neck pain on vertebral and internal carotid arterial blood flow and cerebral inflow. Phys Ther. **2013**
- **Licht PB**, et al. Vertebral artery flow and spinal manipulation: a randomized, controlled and observer-blinded study. JMPT. **1998**

Introduction & Background

The Cervical Arteries



Terminology

The cervical arteries are:

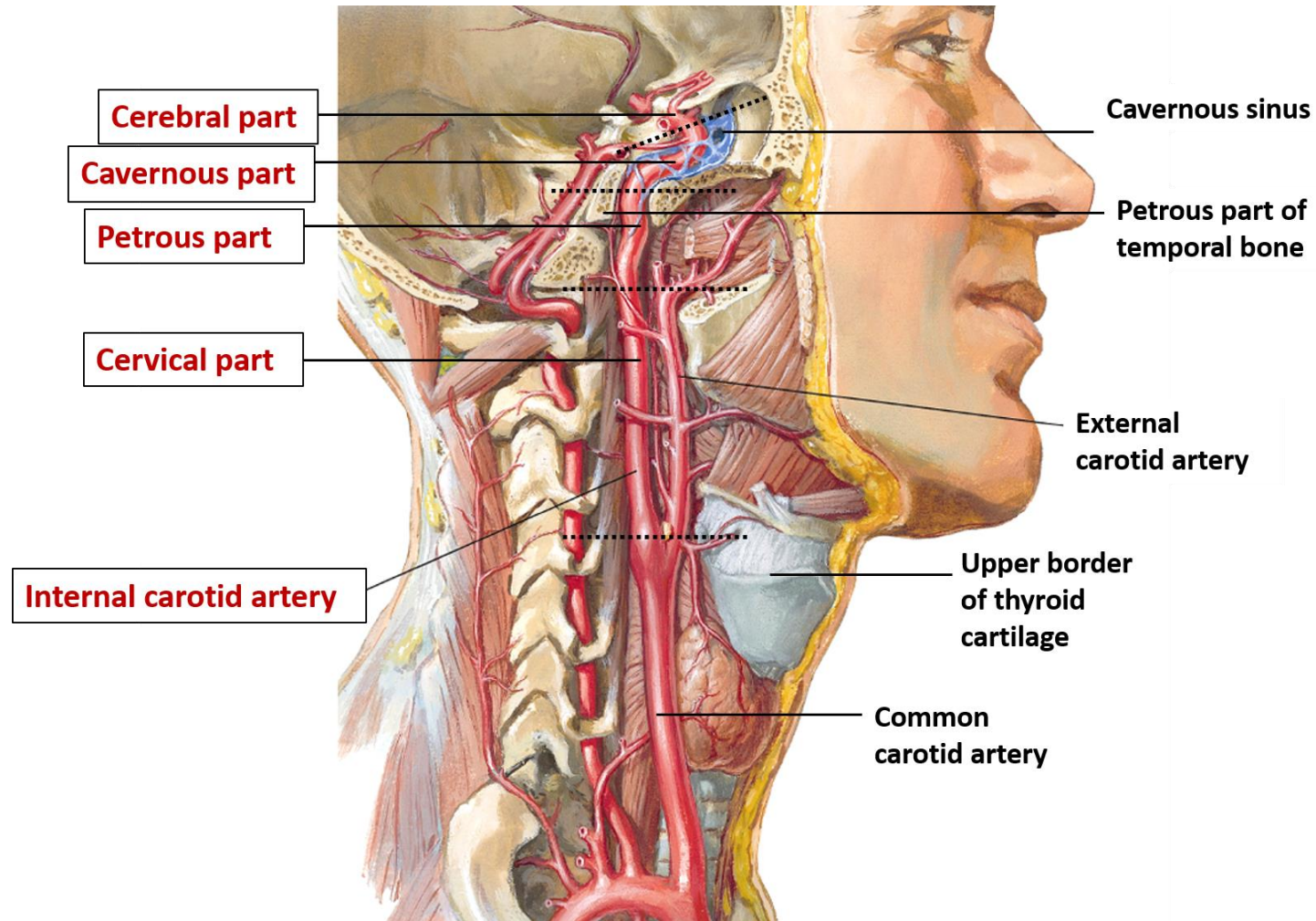
1. Vertebral Artery

- V4: Intracranial segment
- V3: C2-C0 Extradural segment
- V2: C6-C2 Foraminal segment
- V1: Pre-foraminal segment

2. Internal Carotid Artery

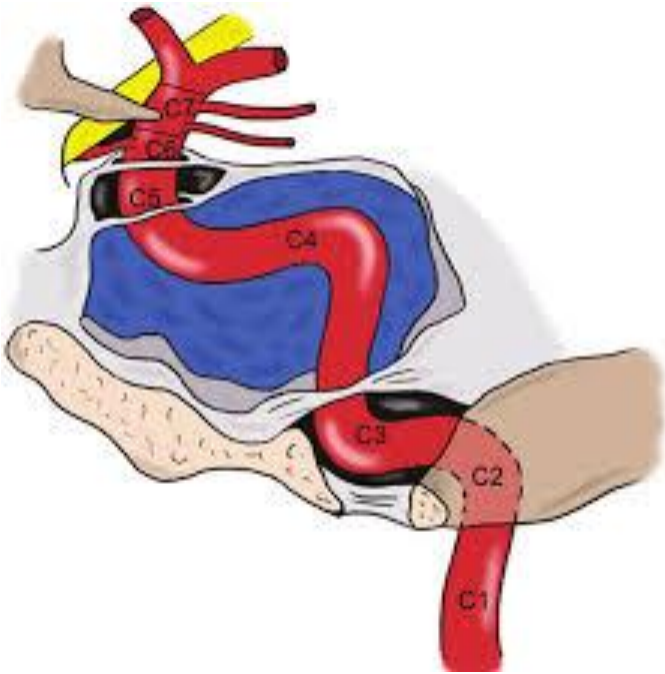
Introduction & Background

Internal Carotid Artery



Introduction & Background

Internal Carotid Artery Segments/Portions



C7: Communicating/Terminal segment
(Cerebral/Supraclinoid portion)

C6: Ophthalmic/Supraclinoid segment
(Cerebral/Supraclinoid portion)

C5: Clinoid segment

C4: Cavernous segment (Cavernous portion)

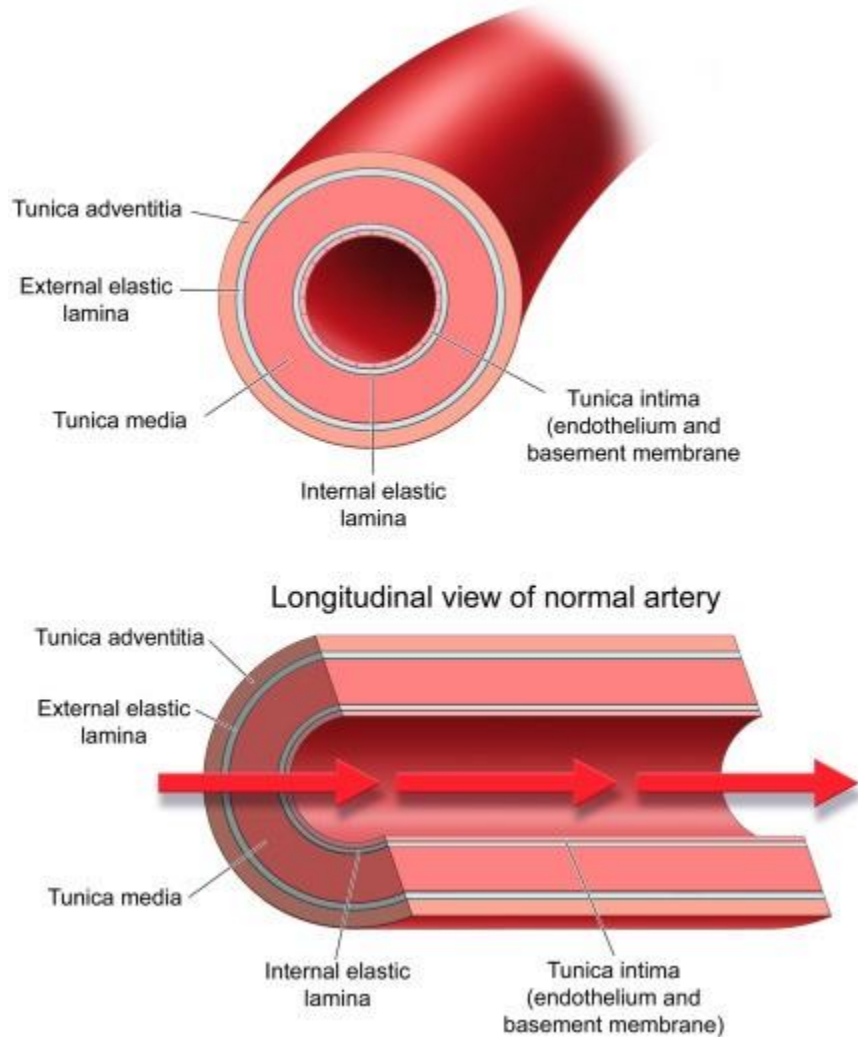
C3: Lacerum segment (Petrous portion)

C2: Petrous segment (Petrous portion)

C1: Cervical segment (Cervical portion)

Introduction & Background

Arterial Wall Anatomy

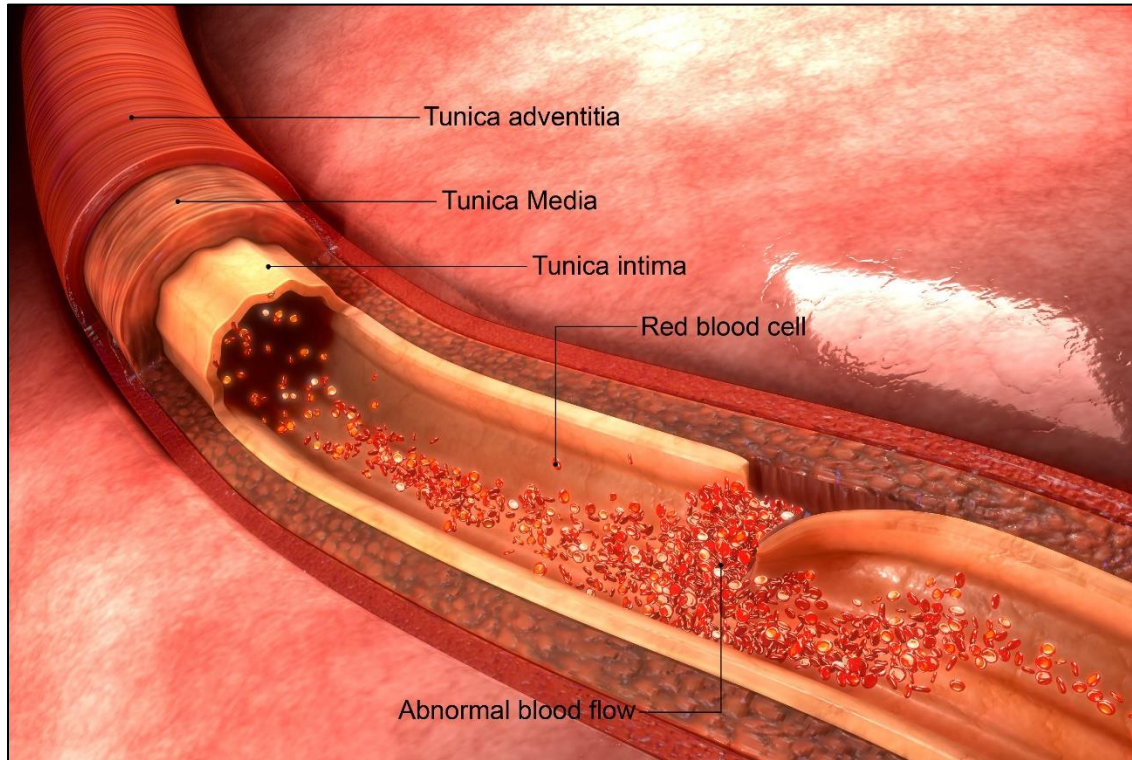


Extracranial Cervical Arteries

1. Tunica intima
2. Internal elastic lamina
3. Tunica media
4. External elastic lamina
5. Tunica adventitia

Introduction & Background

Cervical Artery Dissection



Cervical Artery Dissection

- A flap-like tear of the tunica intima
- Forms a thrombus
- Rare. More common in ICA.

Etiology

1. Spontaneous: Arteriopathy
2. Traumatic: MVC, sports injury

Introduction & Background

TIA & Stroke



- **Stroke (Cerebral Infarction)**
- Symptomatic focal cerebral ischemic events
- Minor, moderate, severe, or fatal
- May or may not be detected or detectable with modern imaging techniques
- TIAs are minor ischemic strokes
- Easton JD, Johnston SC.
- **Time to Retire the Concept of Transient Ischemic Attack**
- JAMA. March 2022.

Introduction & Background

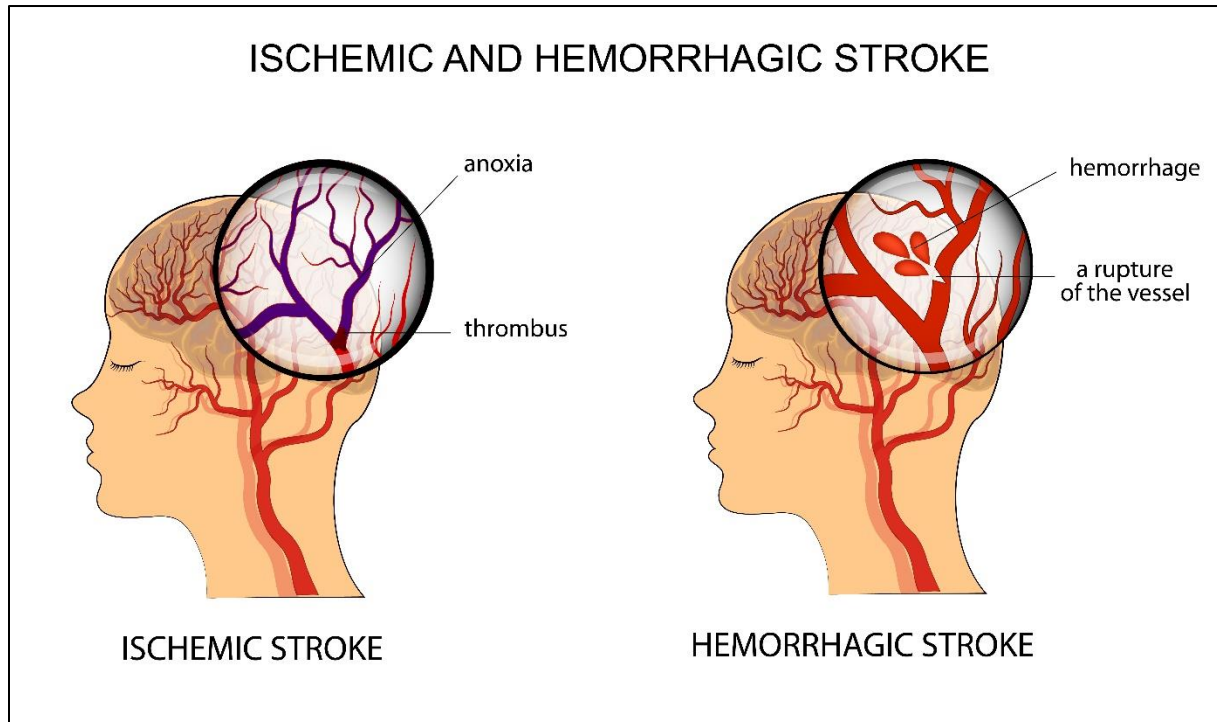
Vertebrobasilar Artery Insufficiency (VBAI)



- Vertebrobasilar insufficiency [VBI] is no different from posterior circulation TIA [stroke].
- We therefore argue that the term vertebrobasilar insufficiency is redundant.
- Chandratheva A, Werring D, Kaski D.
- **Vertebrobasilar insufficiency: an insufficient term that should be retired.**
- Pract Neurol. November 2020.

Introduction & Background

Stroke



Ischemic Stroke

Decrease in blood supply to the brain causing an ischemic (anoxic) event.

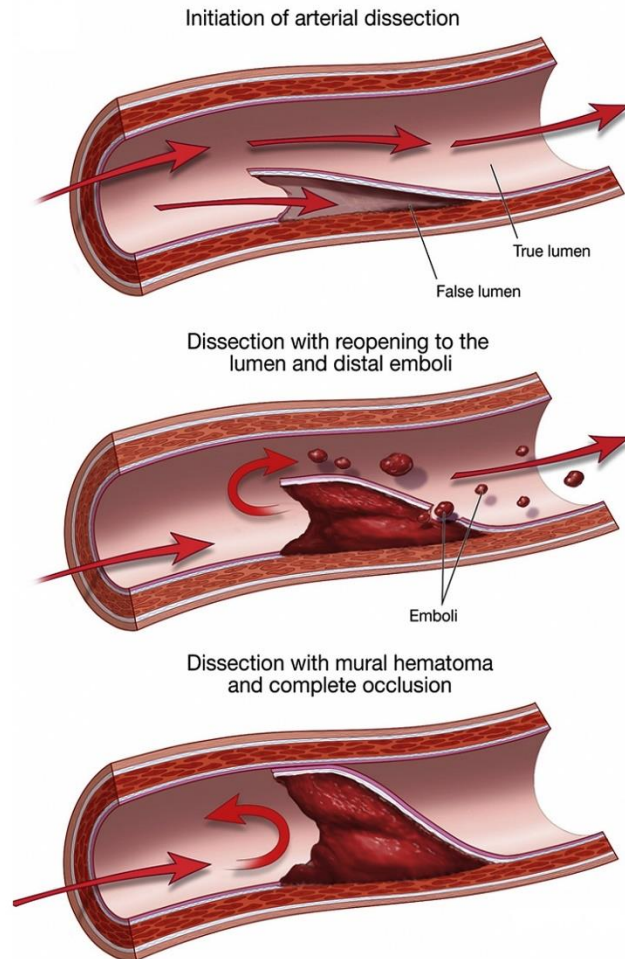
1. Thromboembolic mechanism
2. Thrombotic mechanism

Hemorrhagic Stroke

Bleeding into the brain by a rupture of a blood vessel.

Introduction & Background

Stroke



Ischemic Stroke

- Decrease in blood supply to the brain causing an ischemic event.

1. Thromboembolic mechanism
2. Thrombotic mechanism

Evidence for Causation of Dissection by CSM

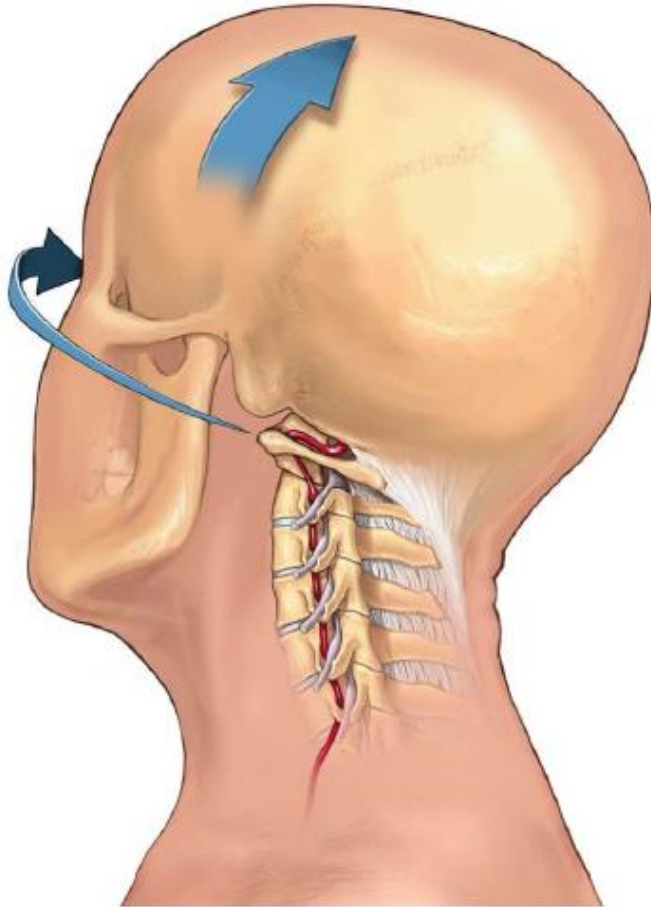
2011 Albuquerque Case Series



- “Chiropractic manipulation of the cervical spine can produce dissections of the cranial and cervical arteries.”
- Albuquerque FC, et al.
- **Craniocervical arterial dissections as sequelae of chiropractic manipulation: patterns of injury and management.**
- J Neurosurg. December 2011.

Evidence for Causation of Dissection by CSM

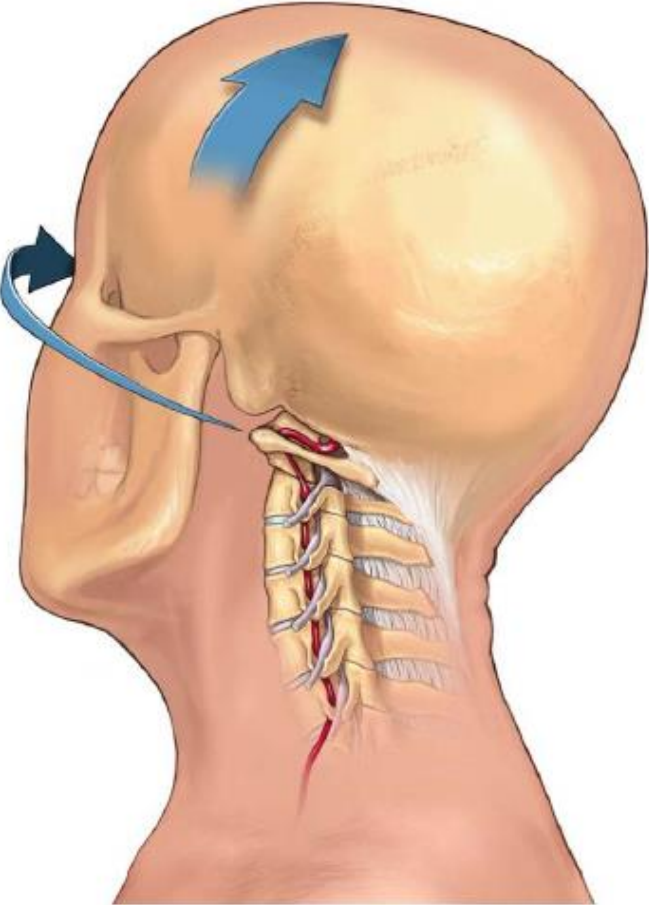
Alleged Mechanism of CSM & VA Dissection



- Rotation & extension of the neck predispose the VA (**V3 segment**) to dissection by stretching the vessel against either C1 or posterior OCC-C1 membrane, which the VA penetrates as it courses superiorly into the skull.
- Biller J, Sacco RL, Albuquerque FC, AHA Stroke Council, et al.
- **Cervical arterial dissections & association with cervical manipulative therapy.**
- Stroke. October 2014.

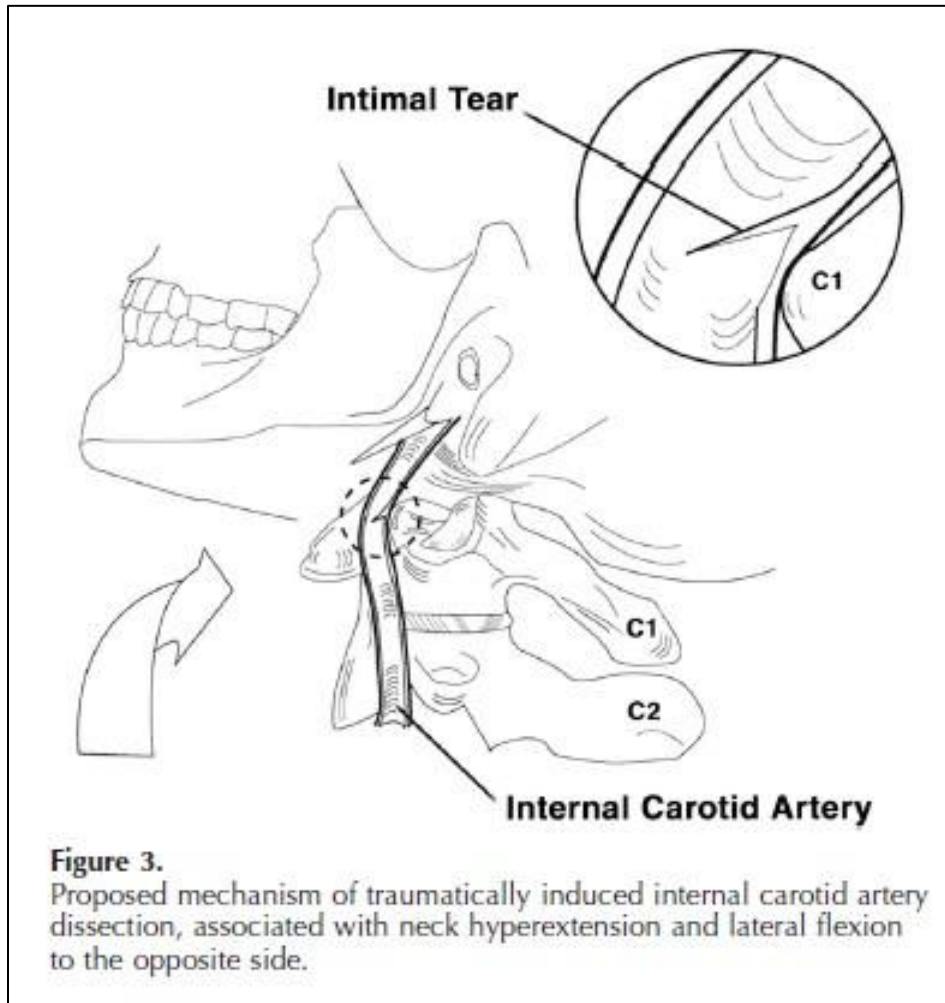
Evidence for Causation of Dissection by CSM

Alleged Mechanism of CSM & VA Dissection



Evidence for Causation of Dissection by CSM

Alleged Mechanism of CSM & ICA Dissection



- “The ICA [**C1 segment**] may potentially be injured during CSM. With extension & lateral flexion of the head, the artery becomes fixed in place, abutting the upper cervical vertebrae.”
- Biller J, et al. **Cervical arterial dissections & association with cervical manipulative therapy.** Stroke. October 2014.
- Haneline MT, Croft AC, et al. **Association of internal carotid artery dissection and chiropractic manipulation.** Neurologist. January 2003.

No Evidence for Causation of Dissection by CSM

2008 Cassidy

- “The increased risks of VBA stroke associated with chiropractic and PCP visits is likely due to patients with headache and neck pain from VBA dissection seeking care before their stroke.
- Cassidy JD, et al.
- **Risk of vertebrobasilar stroke and chiropractic care: results of a population-based case-control and case-crossover study.**
- Spine. February 2008.



No Evidence for Causation of Dissection by CSM

2013 Symons & Herzog



- Summary of four biomechanical cadaver studies demonstrating that strains to the cervical arteries during CSM are typically less than **50%** of strains obtained during normal ROM testing, and **far less** than failure strains.
- Symons B, Herzog W.
- **Cervical artery dissection: a biomechanical perspective.**
- J Can Chiropr Assoc. December 2013.

No Evidence for Causation of Dissection by CSM

Biomechanical Cadaver Studies

- **Gorrell LM, Herzog W, et al.** Vertebral arteries do not experience tensile force during manual cervical spine manipulation applied to human cadavers. JMPT. **2023**
- **Gorrell LM, Herzog W, et al.** Kinematics of the head and associated vertebral artery length changes during high-velocity, low-amplitude cervical spine manipulation. Chiropr Man Therap. **2022**
- **Herzog W, et al.** Internal Carotid Artery Strains During High-Speed, Low-Amplitude Spinal Manipulations of the Neck. JMPT. **2015**
- **Piper SL, Herzog et al. W.** Quantifying strain in the vertebral artery with simultaneous motion analysis of the head and neck: a preliminary investigation. Clin Biomech. **2014**
- **Symons B, Herzog W.** Cervical artery dissection: a biomechanical perspective. JCCA. **2013**
- **Herzog W, et al.** Vertebral artery strains during high-speed, low amplitude cervical spinal manipulation. J Electromyogr Kinesiol. **2012**
- **Wuest S, Herzog W, et al.** Preliminary report: biomechanics of vertebral artery segments C1-C6 during cervical spinal manipulation. JMPT. **2010**
- **Symons BP, Herzog W.** Internal forces sustained by the vertebral artery during spinal manipulative therapy. JMPT. **2002**

No Evidence for Causation of Dissection by CSM

2014 Achalandobaso

- “Neither cervical manipulation nor thoracic manipulation did produce significant changes in the CPK, LDH, CRP, troponin-I, myoglobin, NSE, or aldolase blood levels.”
- “Our data suggest that the mechanical strain produced by SM seems to be innocuous to the joints and surrounding tissues in healthy subjects.”
- Achalandabaso A, et al.
- **Tissue damage markers after a spinal manipulation in healthy subjects: a preliminary report of a randomized controlled trial.**
- Disease Markers. 2014.

No Evidence for Causation of Dissection by CSM

2014 Biller



- Current biomechanical evidence is insufficient to establish the claim that CMT causes CD.
- Practitioners should strongly consider VAD as a presenting symptom prior to CSM.
- Biller J, et al.
- **Cervical arterial dissections & association with cervical manipulative therapy.**
- Stroke. October 2014.

No Evidence for Causation of Dissection by CSM

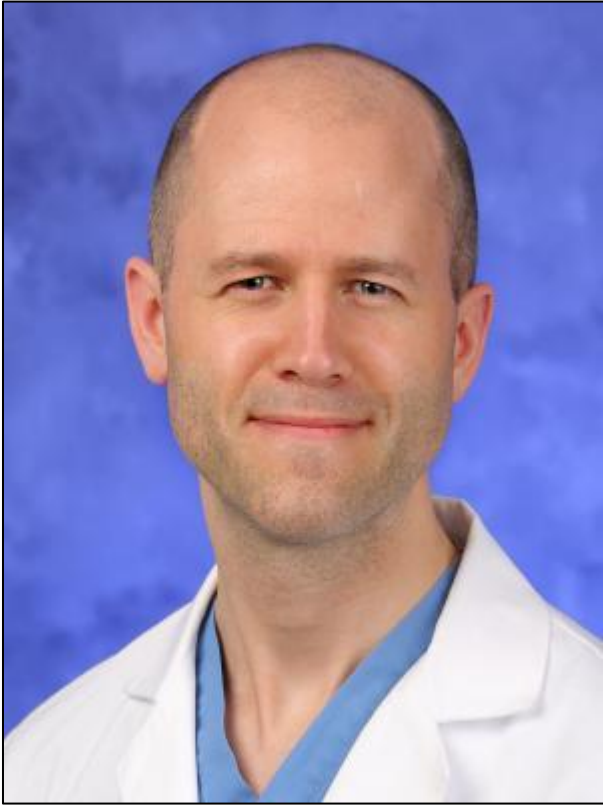
2014 Biller



- Authored by **11 MDs** and **1 DC**.
- Co-authored by Felipe Albuquerque, MD.
- Published on behalf of the AHA Stroke Council.
- Endorsed by the American Association of Neurological Surgeons.
- Endorsed by the Congress of Neurological Surgeons.
- Published in the journal *Stroke*.

No Evidence for Causation of Dissection by CSM

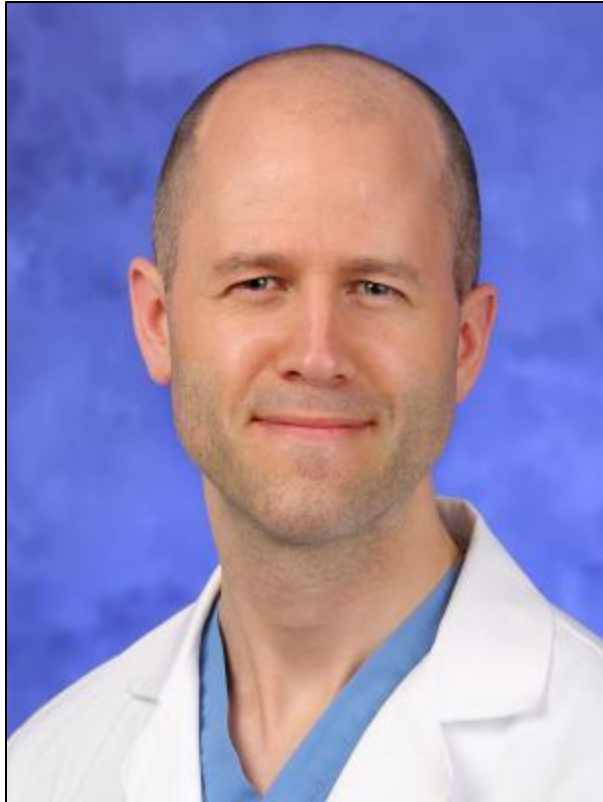
2016 Church



- “There is no convincing evidence to support a causal link between chiropractic manipulation and CAD.”
- “...the known association of neck pain both with CAD and with CSM may explain the relationship between CSM and CAD.”
- Church EW, et al.
- **Systematic Review & Meta-analysis of Chiropractic Care & Cervical Artery Dissection: No Evidence for Causation.**
- Cureus. February 2016.

No Evidence for Causation of Dissection by CSM

2016 Church



- Authored by **six neurosurgeons** from the Department of Neurosurgery at Penn State Hershey Medical Center.
- No chiropractic researchers involved.
- Published in *Cureus Journal of Medical Science*.

No Evidence for Causation of Dissection by CSM

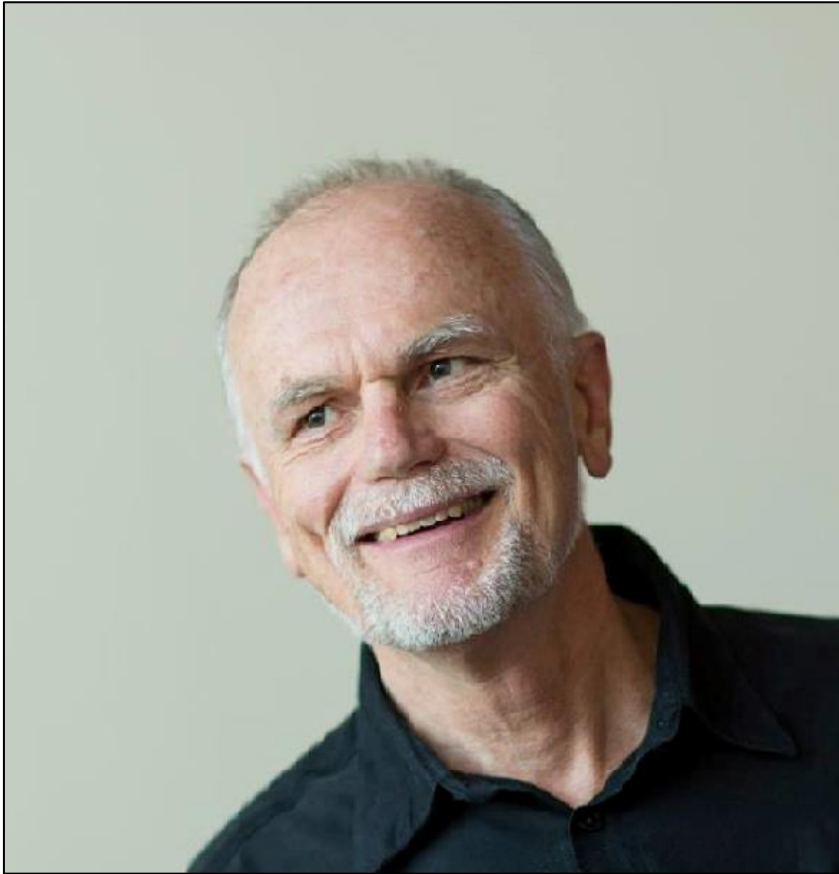
2017 Cassidy

- “Associations between chiropractic and PCP visits and stroke were similar and likely due to patients with early dissection-related symptoms seeking care *prior to* developing their strokes.”
- Cassidy JD, et al.
- **Risk of Carotid Stroke after Chiropractic Care: A Population-Based Case-Crossover Study.**
- J Stroke Cerebrovascular Disease. April 2017.



No Evidence for Causation of Dissection by CSM

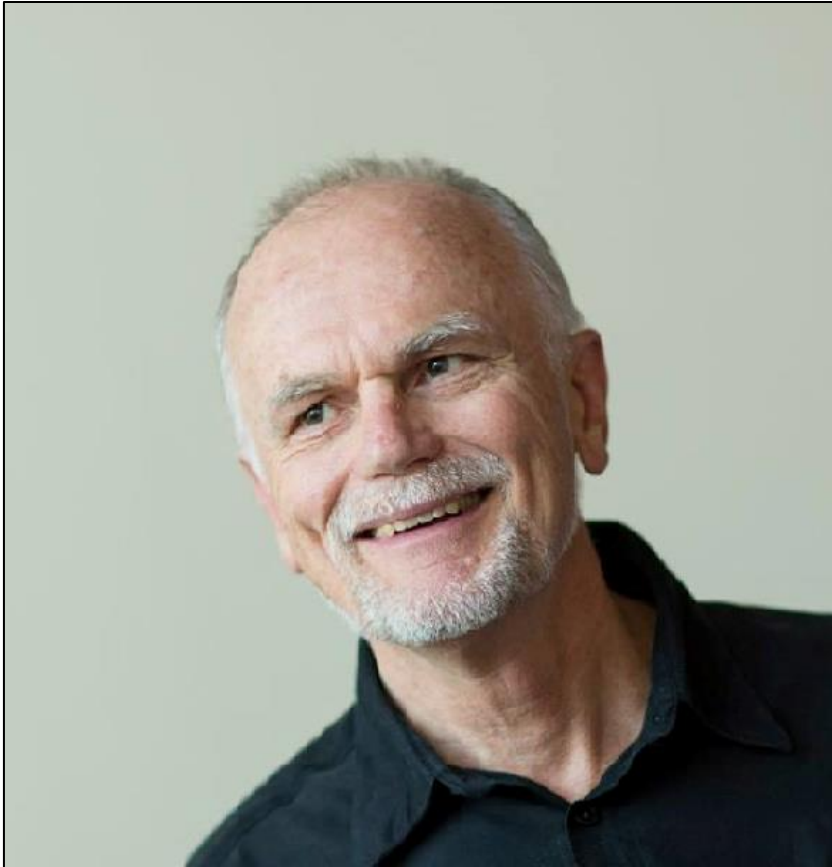
2022 Whedon



- “Our findings strongly suggest that CeAD patients are likely seeking out care for neck pain and related symptoms from either a CSM provider, medical provider or both in the period leading up to their diagnosis of CeAD rather than having a specific risk for CeAD imparted by receipt of CSM in this population.”
- Whedon JM, et al.
- **Association between cervical artery dissection and spinal manipulative therapy - a medicare claims analysis.**
- BMC Geriatr. November 2022,

No Evidence for Causation of Dissection by CSM

2023 Whedon



- “Our findings therefore strongly suggest that the association between CSM and CeAD is not causal in nature. It is more likely that in the period leading up to their diagnosis of CeAD, patients with neck pain and related symptoms seek out care from a CSM provider, a medical provider or both, rather than having a specific risk for CeAD imparted by receipt of CSM.”
- Whedon, et al.
- **The association between CAD and spinal manipulation among US adults.**
- Eur Spine J. October 2023.

No Evidence for Causation of Dissection by CSM

2023 Gorrell & Herzog



- “During cervical spine manipulations (using cervical spine extension and rotation), arterial length changes remained below that slack length, suggesting that VA elongated but were not stretched during the manipulation.”
- Gorrell LM, Herzog W, et al.
- **Vertebral arteries do not experience tensile force during manual cervical spine manipulation applied to human cadavers.**
- J Man Manip Ther. August 2023.

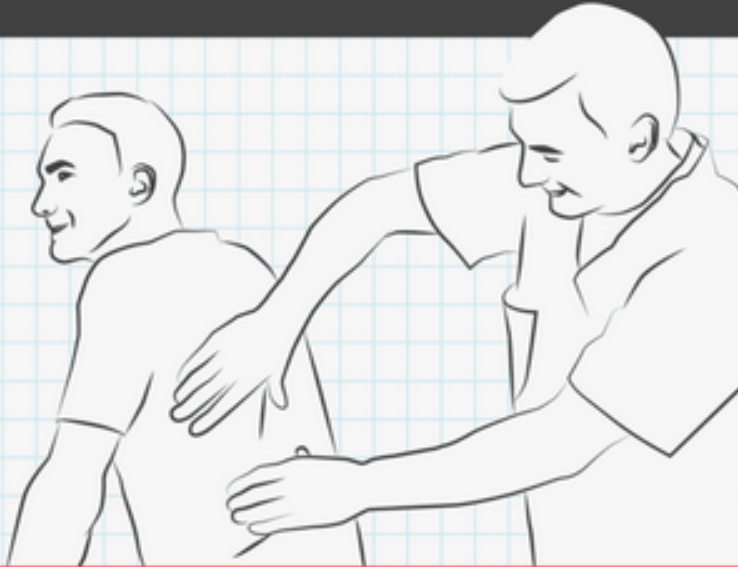
No Evidence for Causation of Dissection by CSM

Cervical Artery Dissection vs. Stroke

- Church EW, et al. **Systematic Review and Meta-analysis of Chiropractic Care and Cervical Artery Dissection: No Evidence for Causation.**
- Cureus. February 2016.
- Whedon JM, et al. **Association between cervical artery dissection and spinal manipulative therapy -a medicare claims analysis.**
- BMC Geriatrics. November 2022.
- Whedon JM, et al. **The association between cervical artery dissection and spinal manipulation among US adults.**
- European Spine Journal. October 2023.

CHIROPRACTIC STATISTICS

How many people
in the US see a
chiropractor?



Compiled by: TheGoodBody.com

[+THE GOOD BODY](http://THEGOODBODY)

Chiropractic Statistics (Top Picks)

- More than 35 million people in the US visit a chiropractor annually.
- One million chiropractic adjustments are performed every day across America.

- *thegoodbody.com*
- One million chiropractic adjustments are performed every day across America.

Incidence of Immediate Stroke after CSM

2001 Haldeman Case Series (CCPA Data)



- **1:8.06 million** chiropractic office visits.
- Every **8.06** business days.
- **30** times per year.
- **2.5 TIMES PER MONTH.**
- Haldeman S, et al.
- **Arterial dissections following cervical manipulation: the chiropractic experience.**
- *CMAJ*. October 2001.

Incidence of Immediate Stroke after CSM

2023 Chu Study



- Chu identified patients with SMT-related AEs from January 2017 through August 2022, a period of over five years.
- “There were no cases of stroke, transient ischemic attack, vertebral or carotid artery dissection, cauda equina syndrome, or spinal fracture.”
- “In this study, severe SMT-related AEs were reassuringly very rare.”

Incidence of Immediate Stroke after CSM

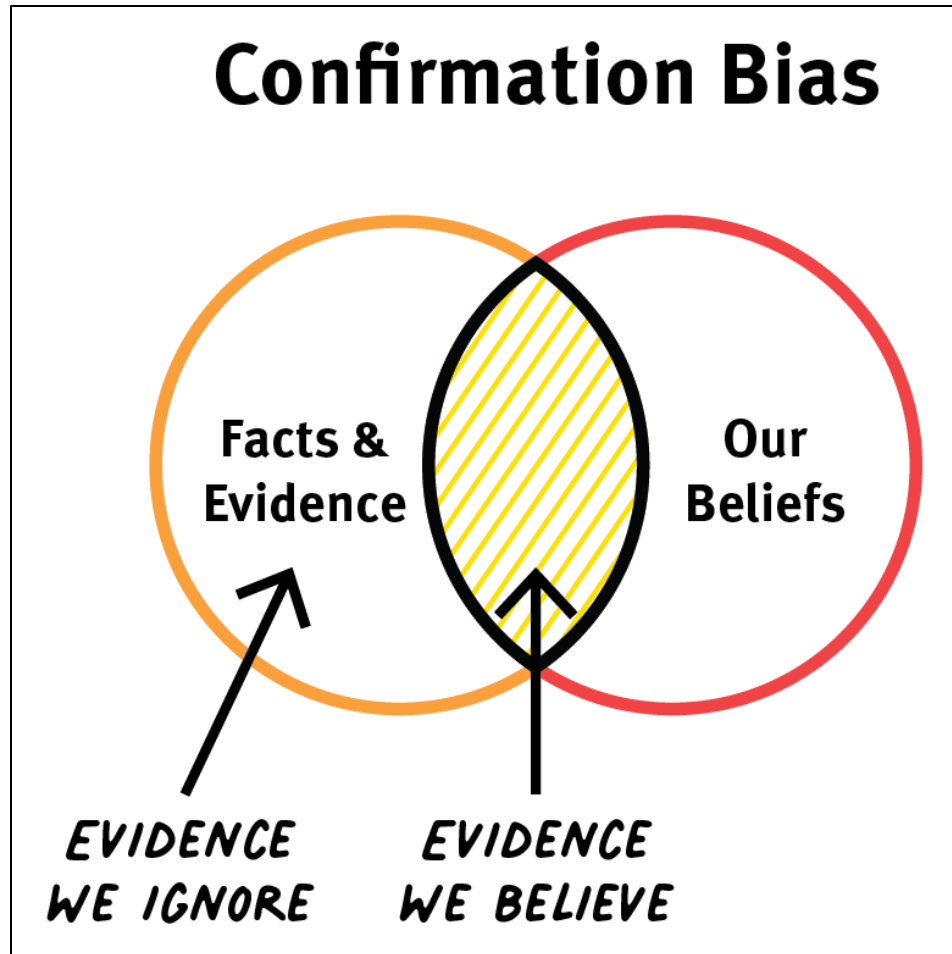
2023 Chu Study



- **Hong Kong**
- Population 7,333,200 (2022)
- 315 registered DCs (2023)
- **960,140 manipulations over 5+ years**
- Chu EC, Trager RJ, et al.
- **A retrospective analysis of the incidence of severe adverse events among recipients of chiropractic spinal manipulative therapy.**
- *Sci Rep.* January 2023.

Plausible Mechanisms of Causation of Stroke

Literature Search: Minimizing Risk of Bias



- Risk of bias minimized by analysis of studies challenging the proposed mechanisms of a causal relationship between CSM and immediate stroke.
- One contrary study was found.

Plausible Mechanisms of Causation of Stroke

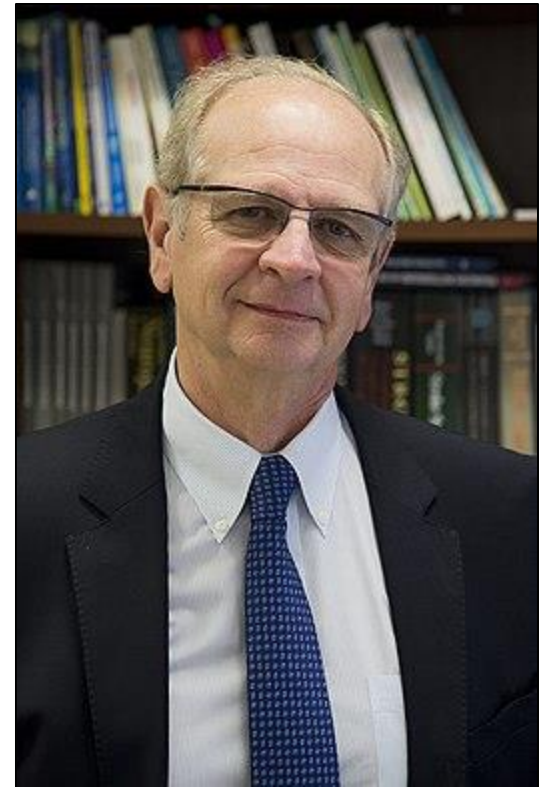
Literature Search: 12 Results

Year	Lead Author	Field	Design	Publication	Mechanism(s)
1989	Mas	Neurology	Case Report	Neurology	Thromboembolic Thrombotic
1999	Haldeman	Neurology (Chiropractic)	Case Series	Spine	Thromboembolic Thrombotic
2000	Norris	Neurology	Case Series	Canadian Medical Association Journal	Thromboembolic
2002	Haldeman	Neurology (Chiropractic)	Case Series	Journal of Neurology	Thromboembolic Thrombotic
2003	Smith	Neurology	Case Control	Neurology	Thromboembolic Thrombotic
2008	Cassidy	Chiropractic	Case Control	Spine	Thromboembolic
2009	Schwartz	Neurology	Case Series	Journal of Stroke & Cerebrovascular Diseases	Thromboembolic Thrombotic
2011	Albuquerque	Neurology	Case Series	Journal of Neurosurgery	Thromboembolic Thrombotic
2013	Tuchin	Chiropractic	Review	International Journal of Clinical Practice	Thromboembolic
2015	Whedon	Chiropractic	Case Cohort	Journal of Manipulative & Physiological Therapeutics	Thromboembolic
2016	Thomas	Physical Therapy	Review	Manual Therapy	Thromboembolic Thrombotic
2016	Neeb & Reuter	Neurology	Review	Treatment-Related Stroke	Thromboembolic Thrombotic

Plausible Mechanisms of Causation of Stroke

1989 Mas Case Report & Autopsy

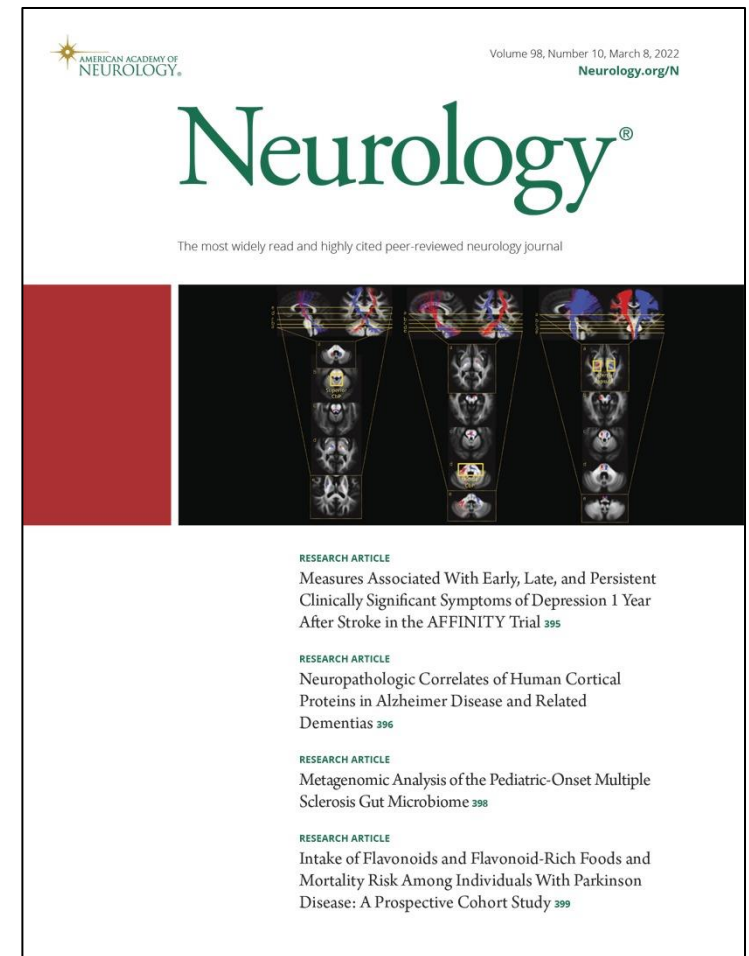
- “A previously healthy 35-year-old woman consulted a DC following 3 weeks of cervical and occipital pain.”
- “She had two CSMs on successive days. About one-half hour after the second CSM, she complained of paresthesia over the right side of her body and then over the left, in both instances sparing the face. There was no dysphagia. She then became comatose over the course of 15 minutes.”
- “She died 10 hours after admission, 16 hours after the onset of symptoms.”



Plausible Mechanisms of Causation of Stroke

1989 Mas Case Report & Autopsy

- “The most likely mechanism of brain ischemia in the present case was artery-to-artery embolism from the right vertebral artery to the basilar artery with subsequent fragmentation and disappearance of the clot.”
- Mas JL, et al.
- **Dissecting aneurysm of the vertebral artery and cervical manipulation: a case report with autopsy.**
- Neurology. April 1989.



Plausible Mechanisms of Causation of Stroke

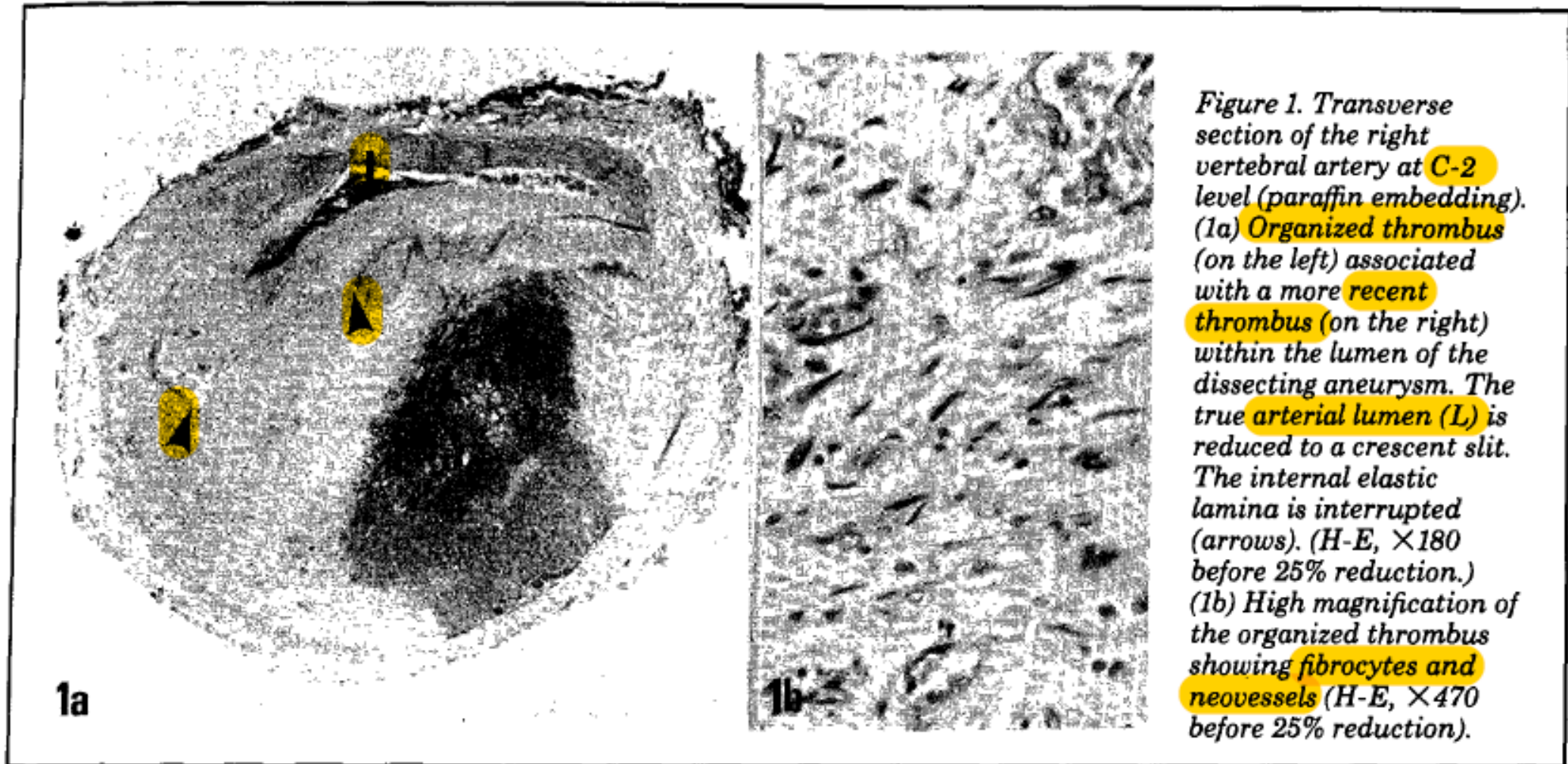
1989 Mas Case Report & Autopsy

- “In this case, the lesions of different age within the dissecting aneurysm were a striking finding, not previously described. The lower part of the dissection contained an organized thrombus (a few weeks old) composed of ***fibrocytes*** and ***neovessels***, while the upper part contained a recent thrombus formed of ***fibrin*** and ***blood cells***.”
- “CSMs less than 3 days before death could have accounted for the recent dissecting aneurysm, but not for the other. This latter aneurysm, which was a few weeks old, dated from approximately the same time as the onset of cervical and occipital pain.”



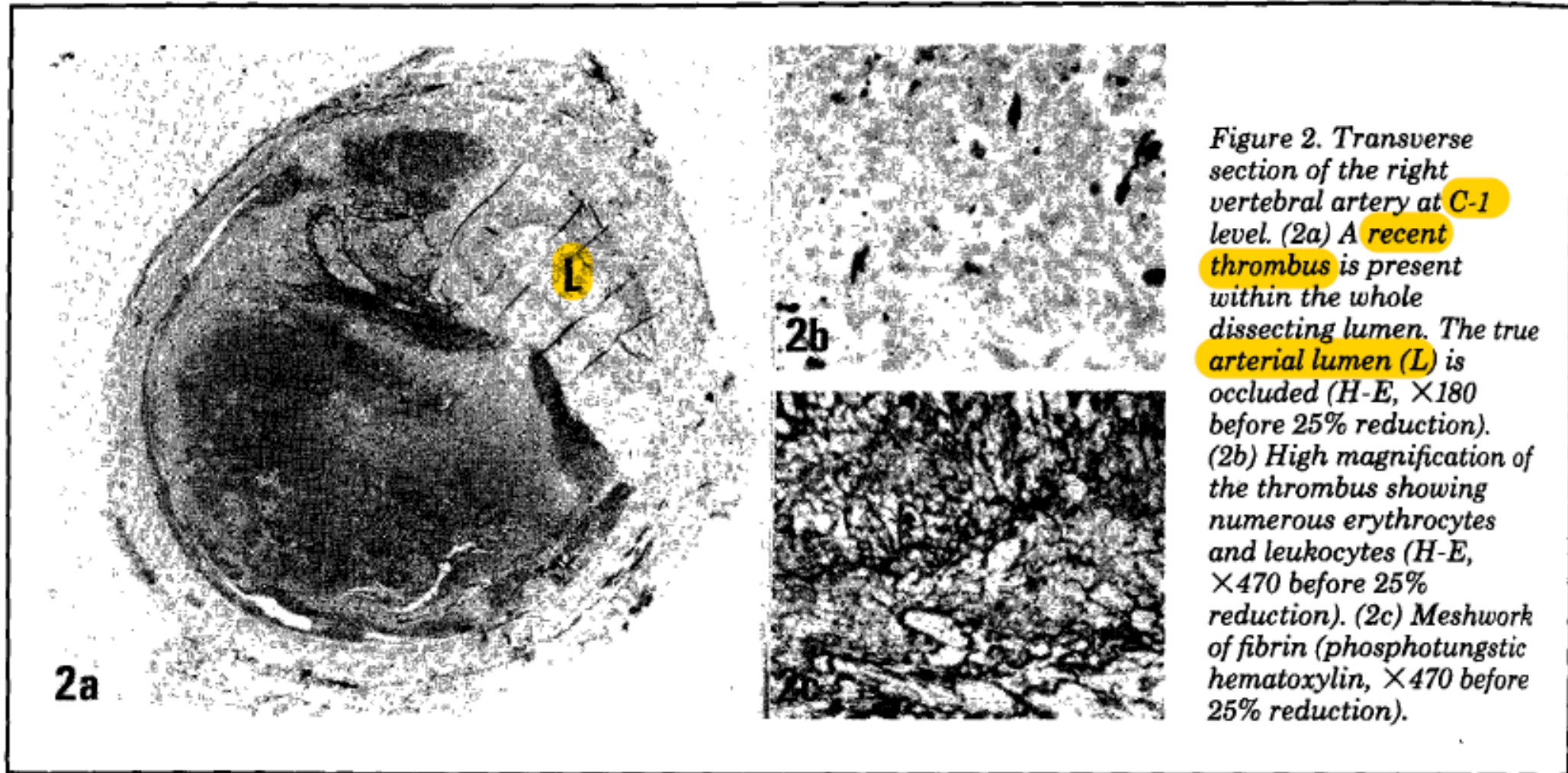
Plausible Mechanisms of Causation of Stroke

1989 Mas Case Report & Autopsy



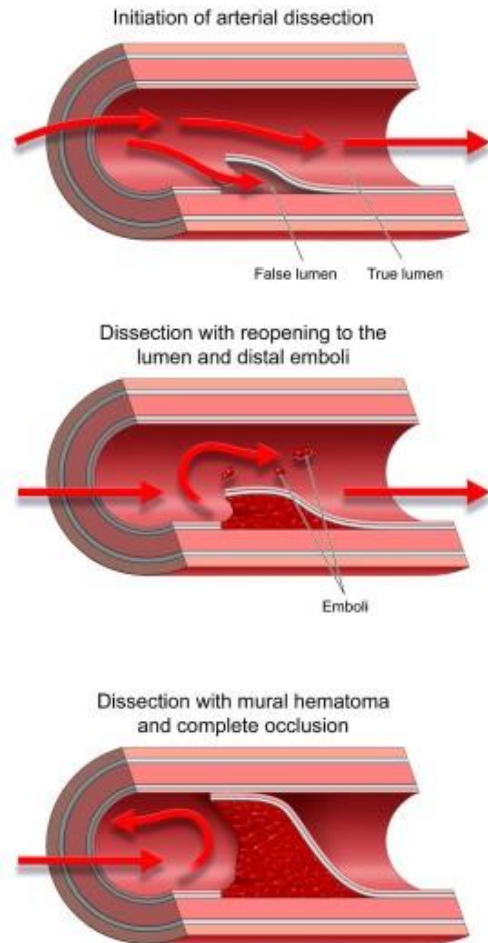
Plausible Mechanisms of Causation of Stroke

1989 Mas Case Report & Autopsy



Plausible Mechanisms of Causation of Stroke

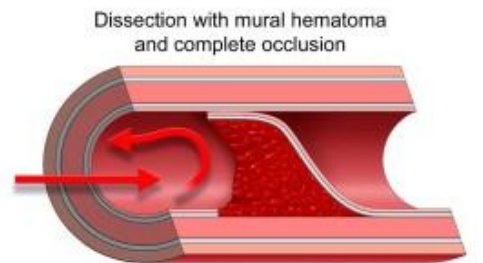
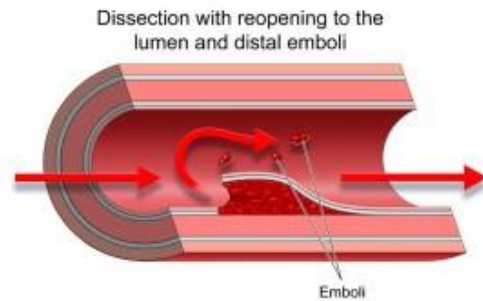
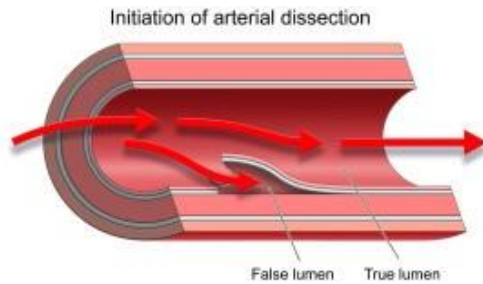
1989 Mas Case Report & Autopsy



- “Thus, cervical pain that precedes and motivates chiropractic cervical manipulation may be the first symptom of a hitherto unrecognized spontaneous (or traumatic) dissection.”
- “In such a case, cervical manipulation would precipitate stroke by either worsening arterial damage, leading to positional occlusion of an already narrowed artery, or dislodging an intraluminal thrombus.”

Plausible Mechanisms of Causation of Stroke

1989 Mas Case Report & Autopsy



- **1. Thromboembolic Mechanism**
- Sudden neck movement from CSM could dislodge a loosely adherent cervical artery thrombus. The dislodged embolus may travel and occlude a smaller artery that supplies the brain, resulting in ischemic stroke.
- **2. Thrombotic Mechanism**
- An already large cervical artery thrombus could be suddenly repositioned in such a way that it blocks the cervical artery, resulting in ischemic stroke from vascular occlusion.

Plausible Mechanisms of Causation of Stroke

Literature Search: 12 Results

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1989	Mas	Neurology	Case Report	Neurology	Thromboembolic Thrombotic
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2002	Haldeman	Neurology (Chiropractic)	Case Series	Journal of Neurology	Thromboembolic Thrombotic
2003	Smith	Neurology	Case Control	Neurology	Thromboembolic Thrombotic
2008	Cassidy	Chiropractic	Case Control	Spine	Thromboembolic
2009	Schwartz	Neurology	Case Series	Journal of Stroke & Cerebrovascular Diseases	Thromboembolic Thrombotic
2011	Albuquerque	Neurology	Case Series	Journal of Neurosurgery	Thromboembolic Thrombotic
2013	Tuchin	Chiropractic	Review	International Journal of Clinical Practice	Thromboembolic
2015	Whedon	Chiropractic	Case Cohort	Journal of Manipulative & Physiological Therapeutics	Thromboembolic
2016	Thomas	Physical Therapy	Review	Manual Therapy	Thromboembolic Thrombotic
2016	Neeb & Reuter	Neurology	Review	Treatment-Related Stroke	Thromboembolic Thrombotic

Plausible Mechanisms of Causation of Stroke

1999 Haldeman Case Series (NCMIC)



- “Because most CSMs are administered to treat neck pain and headaches, these patients with a dissection in progress on seeing a practitioner are likely to be manipulated, and that in turn could precipitate a vascular occlusion or dislodge an embolus.”
- Haldeman S, et al.
- **Risk factors and precipitating neck movements causing vertebrobasilar artery dissection after cervical trauma and spinal manipulation.**
- *Spine*. April 1999.

Plausible Mechanisms of Causation of Stroke

2000 Norris Case Series

- “Neck pain is a reliable symptom of the onset of dissection, followed a variable time later by neurological deficits caused by blood splitting the arterial wall following the intimal tear.”
- “These otherwise asymptomatic lesions will heal when left alone, but if there is vigorous neck movement or manipulation at a later date, a loosely adherent clot may dislodge and embolize to the brain.”



Plausible Mechanisms of Causation of Stroke

2000 Norris Case Series

- “...a fragile clot formed over an otherwise asymptomatic arterial tear is easily dislodged by abrupt head movement, especially rotation.”
- Norris JW, et al.
- **Sudden neck movement & cervical artery dissection.**
- *Canadian Medical Association Journal.*
- July 2000.



Plausible Mechanisms of Causation of Stroke

2002 Haldeman Case Series (NCMIC)



- “The sudden onset of acute and unusual neck and/or head pain may represent a dissection in progress and be the reason a patient seeks manipulative therapy that then serves as the final insult to the vessel leading to ischemia.”
- Haldeman S, et al.
- **Stroke, cerebral artery dissection, and cervical spine manipulation therapy.**
- *Journal of Neurology*. August 2002.

Plausible Mechanisms of Causation of Stroke

2002 Haldeman Case Series (NCMIC)



- “Our data raise the possibility that in certain cases manipulation may not be the primary insult causing the dissection but rather an aggravating factor or coincidental event precipitating ischemia.”
- “It does, however, suggest that many of these dissections may be spontaneous or due to trivial trauma and that manipulation may be simply the final insult that precipitated the vascular occlusion or release of a thrombotic embolism.”

Plausible Mechanisms of Causation of Stroke

2003 Smith Case Control Study

- Smith WS, Johnston SC, et al.
- **Spinal manipulative therapy is an independent risk factor for vertebral artery dissection.**
- Neurology.
- May 2003.



Plausible Mechanisms of Causation of Stroke

2003 Smith Case Control Study

- Smith reasoned that if CSM was prompted by pain from CAD, [1999 & 2002 Haldeman] it could contribute to the risk of stroke by either extending the dissection or dislodging an embolus.
- “From this case report and our study, it appears that SMT may exacerbate pre-existing dissections, producing immediate or delayed embolization.”



Plausible Mechanisms of Causation of Stroke

1993 Johnson Case Series & Autopsy

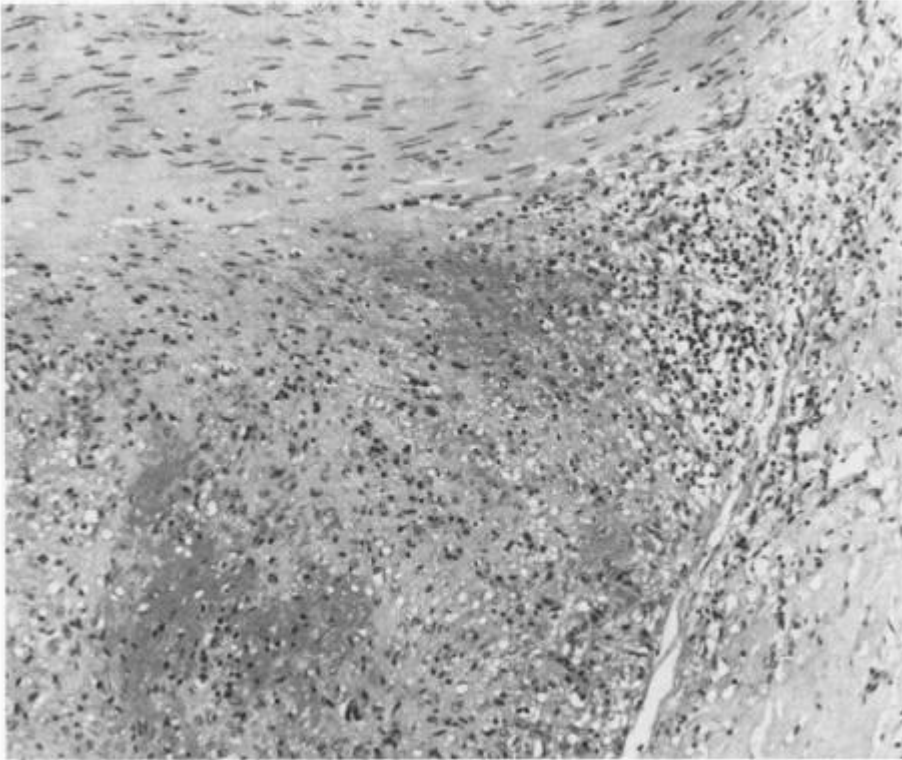


Figure 10 Well established granulation tissue around and within haematoma. Media is towards top of field and adventitia to right (haematoxylin and eosin).

- “This man certainly had vertebral artery disease before his neck manipulation.”
- Johnson CP, et al.
- **Use of histomorphometry in the assessment of fatal vertebral artery dissection.**
- Journal of Clinical Pathology.
- November 1993.

Plausible Mechanisms of Causation of Stroke

2008 Cassidy Case Control Study

- Cassidy assumed a thromboembolic mechanism of immediate stroke by CSM in the design of the study, and the conclusions of the study support thromboembolic and thrombotic mechanisms.
- Cassidy JD, et al.
- **Risk of vertebrobasilar stroke and chiropractic care: results of a population-based case-control and case-crossover study.**
- Spine. February 2008.



Plausible Mechanisms of Causation of Stroke

2008 Cassidy Case Control Study

- 1. “We have not ruled out neck manipulation as a potential cause of some VBA strokes.”
- 2. “It might also be possible that chiropractic manipulation, or even simple range-of-motion examination by any practitioner, could result in a thromboembolic event in a patient with a pre-existing vertebral artery dissection.”
- 3. “For the chiropractic analysis, the index date was included in the hazard period, since chiropractic treatment might cause immediate stroke and patients would not normally consult a chiropractor after having a stroke.”

Plausible Mechanisms of Causation of Stroke

2008 Cassidy Case Control Study

- “The increased risks of VBA stroke associated with chiropractic and PCP visits is likely due to patients with headache and neck pain from VBA dissection seeking care before their stroke.”
- **This is consistent with a thromboembolic or thrombotic mechanism of immediate stroke after CSM, which requires that VBA dissection be present before CSM.**



Plausible Mechanisms of Causation of Stroke

2008 Cassidy Case Control Study

- “We found no evidence of excess risk of VBA stroke associated with chiropractic care compared to primary care.”
- We found no evidence of excess failure to diagnose & refer VBA dissection associated with chiropractic care compared to primary care.
- We found that DCs and PCPs fail to diagnose and refer VBA dissection to medical emergency at the same rate.



Plausible Mechanisms of Causation of Stroke

2017 Cassidy Case-Crossover Study

- “Associations between chiropractic and PCP visits and stroke were similar and likely due to patients with early dissection-related symptoms seeking care prior to developing their strokes.”
- Cassidy JD, et al.
- **Risk of Carotid Stroke after Chiropractic Care: A Population-Based Case-Crossover Study.**
- J Stroke Cerebrovasc Dis. April 2017.



Plausible Mechanisms of Causation of Stroke

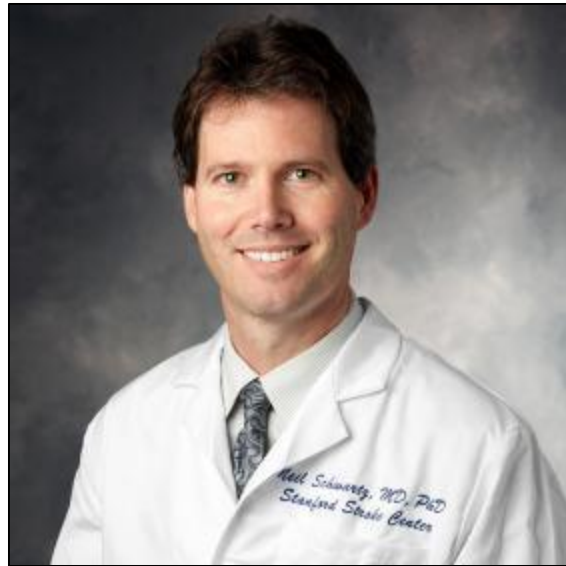
2009 Schwartz Case Series



- Schwartz NE, et al.
- **Clinical & radiographic natural history of cervical artery dissections.**
- J Stroke Cerebrovasc Dis.
- 2009.

Plausible Mechanisms of Causation of Stroke

2009 Schwartz Case Series



- “Certainly, patients may have visited a chiropractor for relief of neck pain that could have been secondary to a dissection, [1999 & 2002 Haldeman, 2008 Cassidy] but even if this were the case, we cannot rule out that the adjustment acted as a “second hit,” leading to worsening of the dissection or embolism from a stable dissection.”

Plausible Mechanisms of Causation of Stroke

2011 Albuquerque Case Series



- Albuquerque FC, et al.
- **Cranio cervical arterial dissections as sequelae of chiropractic manipulation: patterns of injury and management.**
- Journal of Neurosurgery.
- December 2011.

Plausible Mechanisms of Causation of Stroke

2011 Albuquerque Case Series



- “Patients often visit the chiropractor complaining of head or neck pain, and a certain percentage may have preexisting arterial dissections.” (Haldeman & Cassidy)
- Nonetheless, patients can present within hours to days of CSM with new objective neurological deficits or more severe neurological complaints. This temporal relationship suggests that either the arterial injury was produced de novo [by CSM] or made worse as a result of manipulation.
- “Stroke is produced either by propagation of a thrombus from the dissected arterial segment or by severe dissection-induced arterial stenosis and secondary ischemia.”

Plausible Mechanisms of Causation of Stroke

2013 Tuchin Review Study

- “Physical triggers, including SMT, can serve as plausible final link between the underlying disease and stroke (for instance, in case of arterial dissection with existing connective tissue weakness).”
- Peter Tuchin, DC, PhD
- **Chiropractic and stroke: association or causation?**
- Int J Clin Pract. September 2013.



Plausible Mechanisms of Causation of Stroke

2013 Tuchin Review Study

- After recent studies [2008 Cassidy] showing no evidence of a causal association between CSM and VAD, an alternative theory is needed to explain the phenomenon of immediate post-manipulative stroke.
- “An alternative theory could be that a situation arose where a patient had a VAD commencing, because of other factors such as minor trauma, sports, sustained neck positions or excessive neck movements.”



Plausible Mechanisms of Causation of Stroke

2013 Tuchin Review Study

- “This was predisposed by an arteriopathy (possibly transient) because of hypertension, hyperlipidaemia, hyperhomocysteinaemia, recent infection, smoking, diabetes, migraine, or other combinations of factors.”
- “Once the VAD had commenced, the patient would complain of neck pain or headache, for which they then sought treatment, possibly from a DC, or another healthcare practitioner.”



Plausible Mechanisms of Causation of Stroke

2013 Tuchin Review Study

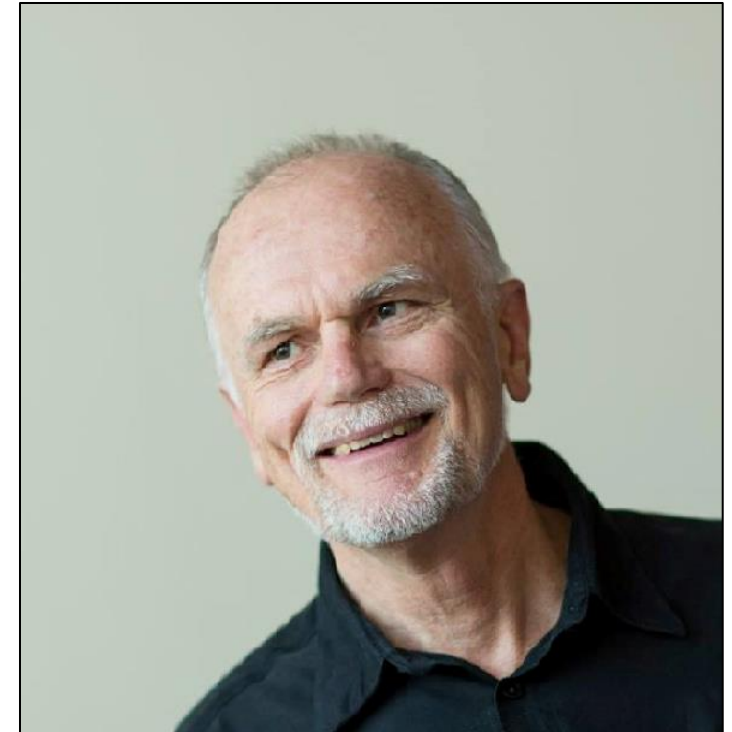
- “If this healthcare practitioner did not take a thorough clinical history, then they may overlook these above factors [dissection] and perform an SMT when it may have been contra-indicated.”
- “Therefore, an existing VAD is exacerbated, the thrombus is dislodged and creates the [thromboembolic] stroke.”



Plausible Mechanisms of Causation of Stroke

2015 Whedon Case Cohort Study

- “Among Medicare B beneficiaries aged 66 to 99 years with neck pain, incidence of vertebrobasilar stroke was extremely low.”
- “Because VAD and associated thromboembolism are the most plausible mechanism by which CSM could cause stroke, our findings support current best evidence suggesting that CSM is unlikely to be a significant cause of stroke in older adults.”
- Whedon JM, et al.
- **Risk of stroke after chiropractic spinal manipulation in medicare B beneficiaries aged 66 to 99 years with neck pain.**
- J Manipulative Physiol Ther. February 2015.



Plausible Mechanisms of Causation of Stroke

2016 Thomas Review

- “CSM performed when a CAD is present could further damage the artery or propagate an embolus.”
- “What cannot be ruled out is the possibility that CSM or trivial neck strain may cause CAD in a susceptible artery, extend a CAD, or propagate an embolus.”
- Requires close temporal relationship.
- Thomas LC.
- **Cervical arterial dissection: An overview and implications for manipulative therapy practice.**
- Man Ther. February 2016.



Plausible Mechanisms of Causation of Stroke

2016 Neeb & Reuter Review



- Neeb, Lars & Reuter, Uwe
- **Stroke after chiropractic manipulations.**
- *Treatment-Related Stroke: Including Iatrogenic and In-Hospital Strokes* (pp. 123-129).
- Cambridge: Cambridge University Press.

Plausible Mechanisms of Causation of Stroke

2016 Neeb & Reuter Review



- Observed that a CAD that leads to stroke in a temporal relationship to CSM is not necessarily caused by CSM.
- Patients with spontaneous CAD commonly experience neck pain which is often misdiagnosed as pain of MSK origin.
- For the treatment of neck pain these patients may seek CSM which could “...contribute to the risk of stroke by *exacerbating* the pre-existing dissection or *dislodging* an embolus.”

Plausible Mechanisms of Causation of Stroke

Literature Search: Results

Year	Lead Author	Field	Design	Publication	Mechanism(s)
1989	Mas	Neurology	Case Report	Neurology	Thromboembolic Thrombotic
1999	Haldeman	Neurology (Chiropractic)	Case Series	Spine	Thromboembolic Thrombotic
2000	Norris	Neurology	Case Series	Canadian Medical Association Journal	Thromboembolic
2002	Haldeman	Neurology (Chiropractic)	Case Series	Journal of Neurology	Thromboembolic Thrombotic
2003	Smith	Neurology	Case Control	Neurology	Thromboembolic Thrombotic
2008	Cassidy	Chiropractic	Case Control	Spine	Thromboembolic
2009	Schwartz	Neurology	Case Series	Journal of Stroke & Cerebrovascular Diseases	Thromboembolic Thrombotic
2011	Albuquerque	Neurology	Case Series	Journal of Neurosurgery	Thromboembolic Thrombotic
2013	Tuchin	Chiropractic	Review	International Journal of Clinical Practice	Thromboembolic
2015	Whedon	Chiropractic	Case Cohort	Journal of Manipulative & Physiological Therapeutics	Thromboembolic
2016	Thomas	Physical Therapy	Review	Manual Therapy	Thromboembolic Thrombotic
2016	Neeb & Reuter	Neurology	Review	Treatment-Related Stroke	Thromboembolic Thrombotic

Steven Brown, DC, Dipl Med Ac

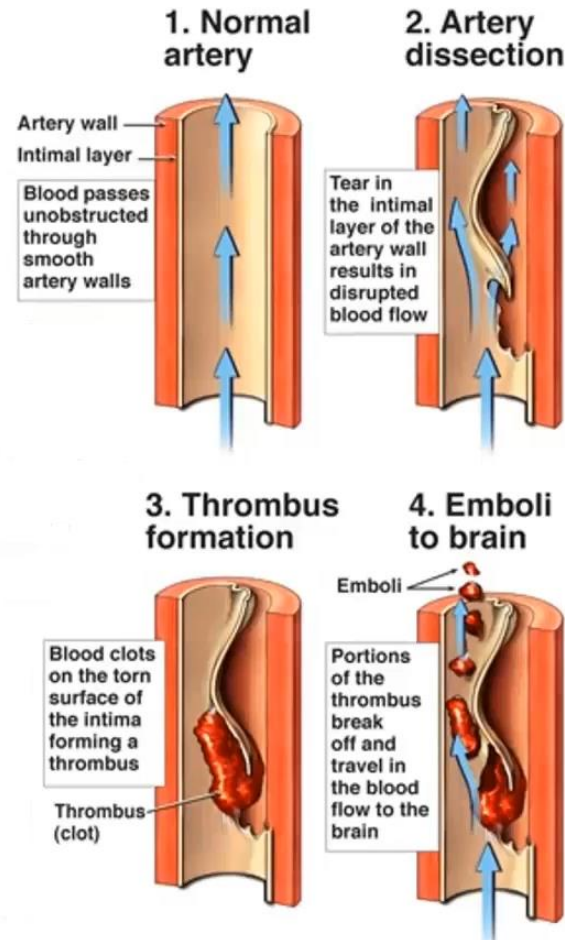
Postgraduate Course: CSM, CAD & Stroke



- **Answering Questions about Chiropractic & Stroke: Part 1 & 2**
- 2 hours
- **William Lauretti, DC, FICC, FACC**
- American Chiropractic Association
- NCMIC Speaker's Bureau
- Northeast College of Health Sciences

Plausible Mechanisms of Causation of Stroke

2023 Lauretti ACA Seminar



- “We may be seeing those patients in that Stage 3 where they have the thrombus there, and the cervical adjustment may be enough force to not create a dissection, but *it may be enough force to break the clot free.* And that may be why the patient is having symptoms right in the chiropractor’s office right after that.”
- **William Lauretti, DC, FICC, FACC**

Steven Brown, DC, Dipl Med Ac

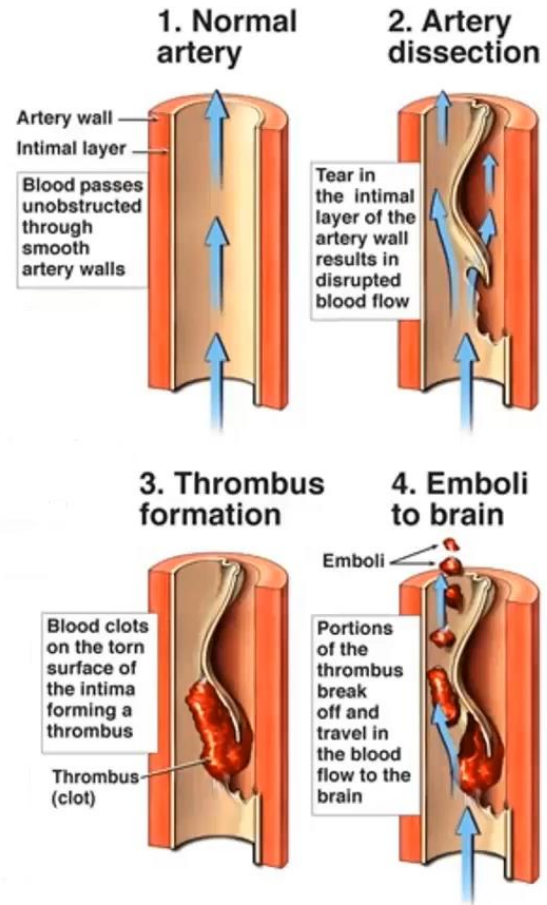
Postgraduate Course: CSM, CAD & Stroke



- **Stroke & Manipulation 104**
- 8 hours
- **Stroke & Manipulation 106**
- 4 hours
- **Joseph Ferezy, DC, DACAN, FIACN**
- *Chirocredit.com*
- *Chiroclasses.com*

Plausible Mechanisms of Causation of Stroke

2018 Ferezy ChiroClasses Seminar



- “Let’s say that the artery was dissecting, but not a stroke, and then the adjustment was given, the dissection continued along, or a thrombus broke an emboli off of it and that traveled, and the person had a stroke, then you could say that the adjustment precipitated the stroke.”

- **Joseph Ferezy, DC, DACAN, FIACN**

Plausible Mechanisms of Causation of Stroke

2008 Wynd Contrary Study



- Lesions to the VA wall were created by angioplasty in 10 anesthetized canines.
- Resulting injury dimensions were quantified using intravascular US before and after CSM.
- In this animal model, CSM did not alter the dimensions of pre-existing VA lesions.
- Wynd S, et al.
- **Effect of CSM on a pre-existing vascular lesion within the canine vertebral artery.**
- Cerebrovasc Dis. 2008.

Plausible Mechanisms of Causation of Stroke

2008 Wynd Contrary Study



- CAD & CSM to C4 level, not C0-C2.
- Time from creation of CAD to CSM appears to be short. Most immediate strokes after CSM occur days to weeks after the onset of symptoms of CAD.
- 1989 Mas & 1996 Johnson case studies with autopsy that show CSM may exacerbate existing CAD were not referenced.

Plausible Mechanisms of Causation of Stroke

Allegedly Contrary Epidemiological Studies



- 2008 Cassidy, 2017 Cassidy, 2015 Kosloff, and 2015 Whedon have been referenced to support no causal relationship between CSM and post-manipulative stroke.
- However, the conclusions of these studies are not applicable to immediate post-manipulative stroke.

Plausible Mechanisms of Causation of Stroke

Allegedly Contrary Epidemiological Studies



- Epidemiological studies based on claims data cannot establish **temporality** in the 0-1-day cohort.
- Claims data can establish whether stroke and CSM occurred on the **same day** but cannot establish the **time lapse** from CSM to stroke and cannot establish whether the stroke occurred **before or after** CSM in the 0-1-day cohort.
- These studies cannot establish an **immediate** cohort.

Plausible Mechanisms of Causation of Stroke

Allegedly Contrary Epidemiological Studies



- A 0–1-day cohort is normally the shortest cohort possible. However, researchers must *speculate* what came first, the CSM or the stroke.
- Therefore, the conclusions of these studies *as regards the 0–1-day cohort* have substantial limitations.
- Cassidy & Kosloff did *not* rule out a causal association between CSM and stroke. Whedon noted that a thromboembolic mechanism of causation was plausible.

Plausible Mechanisms of Causation of Stroke

CSM, the Susceptible Artery & Immediate Stroke

- It is plausible that CSM could cause CAD in a susceptible artery, but it would not be likely to cause immediate thromboembolic or thrombotic stroke.
- It takes time for a thrombus to form, dislodge, embolize and block a smaller artery that supplies the brain, resulting in a **thromboembolic stroke**.
- It takes time for a thrombus to form and become so large that it blocks the artery, resulting in a **thrombotic stroke**.
- Normal Clotting Time (NCT) is 4-10 minutes. (Labpedia)
- Tuchin P. **Chiropractic and stroke: association or causation?** Int J Clin Pract. September 2013.



Plausible Mechanisms of Causation of Stroke

CSM, the Susceptible Artery & Immediate Stroke



- Immediately after CSM the initial dissection may cause sudden neck pain and headache or a brief syncope.
- May cause further immediate symptoms such as nausea, vertigo, and tinnitus.
- A stroke is not likely to occur immediately, and if it occurs at all, it would not be until hours or days later due to enlargement of the dissection or propagation of a thrombus.
- Hufnagel A, et al.
- **Stroke following chiropractic manipulation of the cervical spine.**
- Journal of Neurology. August 1999.

Plausible Mechanisms of Causation of Stroke

Reactions to this Study

- **1.** There is no convincing evidence that CSM can cause CAD in a healthy cervical artery. (2016 Church)
- **2.** It is plausible that CSM can cause thromboembolic or thrombotic stroke when performed in the presence of CAD. (12 studies)
- **Chiropractors & Defense Attorneys:** “No way! CSM can’t cause stroke!”
- **Neurologists & Plaintiff Attorneys:** “No way! CSM can cause CAD!”
- **Physical Therapists:** “Makes sense.”

Plausible Mechanisms of Causation of Immediate Stroke by Cervical Spine Manipulation: A Narrative Review

Plausible Mechanisms of Causation of Immediate Stroke by Cervical Spine Manipulation: A Narrative Review

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Abstract

It has been proposed that cervical spine manipulation (CSM) can cause dissection in healthy cervical arteries, with resultant immediate stroke. However, research does not support a causal association between CSM and cervical artery dissection (CAD) in healthy cervical arteries. The objective of this study was to review the literature to identify plausible mechanisms of causation of immediate stroke by CSM. Immediate stroke is defined as a stroke occurring within seconds or minutes of CSM. Our review found plausible thromboembolic and thrombotic mechanisms of causation of immediate stroke by CSM in the literature. The common premise of these mechanisms is CAD being present before CSM, not occurring as a result of CSM. These mechanisms of causation have clinical and medicolegal implications for physicians performing CSM.

- **Part 1**
- Biography & Case Review
- **Part 2**
- Plausible Mechanisms of Causation
- **Hour 3**
- Clinical & Medicolegal Implications