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EDITORIAL

Can Cervical Spine Manipulation Cause Immediate Thromboembolic Stroke?

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ABSTRACT

Aim: The aim was to perform a narrative review of the research cited in a 2025 commentary by Wilder et al. entitled, *Informed Consent in Chiropractic: Commentary on Brown & Lehman's "Informed Consent Regarding Risk of Stroke from Cervical Spine Manipulation"*. Specifically, to review research cited to support there is no evidence that cervical spine manipulation (CSM) can dislodge a thrombus from an existing cervical artery dissection (CeAD) and cause immediate thromboembolic stroke.

Results: Our review found that 24 studies were referenced as part of discussions that CSM cannot cause thromboembolic stroke, and none of those 24 references rule out CSM as a potential cause of thromboembolic stroke. Wilder et al. misinterpret Brown and Lehman's focus on stroke risk, not CeAD causation, in informed consent. Their discussion of studies supporting that CSM cannot cause CeAD is a separate discussion from whether CSM can cause stroke. Limitations were noted in three epidemiological stroke studies due to small stroke case numbers, no immediate exposure periods, failure to exclude CSM as a cause of stroke, and inapplicability to the population most at-risk for CeAD-related stroke, those under 45 years of age. Six studies acknowledge the plausibility of the thromboembolic mechanism of causation. Two practice guidelines and one animal study do not support Wilder et al.'s opinions.

Conclusion: We conclude there is no convincing evidence that CSM can cause CeAD, but when signs and symptoms of CeAD are present, the patient must be informed and referred to medical emergency because in that clinical setting, there is a risk that CSM may dislodge a thrombus and cause thromboembolic stroke. The 24 studies reviewed by Wilder et al. fail to rule out this risk, and in some cases support it. By acknowledging this risk and prioritizing informed consent, the chiropractic profession can uphold its commitment to patient-centered, evidence-based care.

Introduction

INFORMED CONSENT

Informed consent to the risks of treatment is the standard of care for all healthcare professions, including chiropractic.[1 2 3] The risks of chiropractic treatment must be determined from the best available evidence[4] in order to ensure patient-centered, evidence-based care. Risks that carry serious consequences, such as paralysis or death, should be regarded as material risks requiring disclosure.[5]

2025 Brown & Lehman[6]

In a 2025 narrative review, Brown & Lehman reviewed eight studies authored by chiropractic physicians and found unanimous agreement that informed consent to the risk of stroke from CSM is the standard of care for the chiropractic profession.[6] No contrary studies were found. Another recent study had similar findings.[7]

The authors made their recommendations based on a biologically plausible mechanism of causation of immediate thromboembolic stroke by CSM.[8] Specifically, it is plausible that the sudden neck movement from CSM performed in the presence of an existing CeAD may dislodge a loosely adherent thrombus resulting in an immediate thromboembolic stroke.[9 10 11] This thromboembolic mechanism of causation provides a biologically plausible explanation for numerous cases of immediate stroke following CSM.[12 13 14 15]

This mechanism of causation does not premise any tensile forces on the arterial wall from CSM.[16] The speed of the sudden neck movement associated with CSM causes embolization of a loosely adherent cervical artery thrombus, not stretching of the arterial wall.[10]

2025 Wilder et al.[17]

Wilder et al. responded with a commentary entitled, *Informed Consent in Chiropractic: Commentary on Brown & Lehman's "Informed Consent Regarding Risk of Stroke from Cervical Spine Manipulation.*[17] The crux of their commentary was the conclusion that: "We find no evidentiary support for their theory that CSM can cause a pre-existing vascular clot to move, and therefore, no support for their call for a universal informed consent for the risk of stroke from CSM."

Due to the life-threatening nature of stroke, randomized controlled trials (RCTs) to establish causation are unethical.[4] In the absence of RCTs to establish causation, probabilistic reasoning and inference using the best available evidence to assess risk must be relied on.[18]

Evidentiary support for the plausibility that sudden neck movement from CSM can dislodge a loosely adherent thrombus from an existing CeAD and cause an immediate thromboembolic stroke comes from 18 peer reviewed studies consisting of one case report,[9] six case series,[10 19 20 21 22 23] six review studies,[24 25 26 27 28 29] one biomechanical study,[30] three epidemiological studies[11 31 13] and one systematic review.[32] These studies come from researchers in chiropractic, medicine, physical therapy, osteopathy, and biomechanics.

Wilder et al. object that the evidentiary support for a thromboembolic mechanism of causation of stroke by CSM comes from low-level evidence such as case reports, case series and narrative reviews. However, as noted, one biomechanical study,[30] three epidemiological studies[11 21 31] and one systematic review[32] also support the plausibility of this causal mechanism.

Wilder et al. object that Brown and Lehman's conclusions are not drawn from rigorous scientific validation. However, probabilistic reasoning and inference are scientific concepts, primarily rooted in mathematics and statistics. They are embedded in evidence-based and patient-centered medicine, where statistical tools and clinical guidelines rely on probability to balance benefits, risks, and costs.

Wilder et al.'s assertion that *no evidence* supports the thromboembolic causal mechanism necessitates scrutiny to ensure evidence-based, patient-centered chiropractic care.

Aim

The aim was to perform a narrative review of the research cited by Wilder et al.[17] Specifically, to review research cited to support that there is no evidence that CSM can dislodge a thrombus from an existing CeAD and cause immediate thromboembolic stroke. For the purposes of this review, the cervical arteries are defined as the vertebral artery and the internal carotid artery.

Results

Our review found that 24 studies were referenced as part of discussions that CSM cannot cause thromboembolic stroke, and none of those 24 references rule out CSM as a potential cause of thromboembolic stroke. Table 1 summarizes our analysis of the study design, relevance to stroke causation, discussion of CeAD or stroke, and acknowledgment of the thromboembolism mechanism. None of the 24 studies rule out CSM as a potential cause of immediate thromboembolic stroke. 15 studies on CeAD are not relevant to the causation of stroke by CSM, three epidemiological stroke studies have significant limitations, six studies explicitly acknowledge an immediate thromboembolic stroke mechanism, and the remaining three studies do not support Wilder et al.'s conclusions.

Table 1: Analysis of 24 studies reviewed

Study	Study Design	Rule Out CSM as Cause of Stroke	Discuss Stroke or CeAD	Acknowledge Thromboembolic Stroke Mechanism
2008 Cassidy et al.[11]	Epidemiological	No	Stroke	Yes
2015 Kosloff et al.[33]	Epidemiological	No	Stroke	
2015 Whedon et al.[31]	Epidemiological	No	Stroke	Yes
2007 ACC Guideline[5]	Practice Guideline	No	Stroke	
2020 Rushton et al.[34]	Practice Guideline	No	Stroke	
2002 Haldeman et al.[35]	Case Series	No	Stroke	
2008 Wynd et al.[36]	Animal Study	No	Stroke	
2013 Tuchin[24]	Review	No	Stroke	Yes
2016 Paulus & Thaler[29]	Review	No	Stroke	Yes
2016 Church et al.[37]	Systematic Review	No	CeAD	
2022 Whedon et al.[38]	Epidemiological	No	CeAD	
2023 Whedon et al.[39]	Epidemiological	No	CeAD	
2002 Symons et al.[40]	Biomechanical	No	CeAD	Yes
2002 Haynes et al.[41]	Biomechanical	No	CeAD	
2010 Wuest et al.[42]	Biomechanical	No	CeAD	
2012 Herzog et al.[43]	Biomechanical	No	CeAD	
2013 Symons et al.[30]	Biomechanical	No	CeAD	
2022 Gorrell et al.[44]	Biomechanical	No	CeAD	
2023 Gorrell et al.[16]	Biomechanical	No	CeAD	
2024 Fagundes et al.[45]	Biomechanical	No	CeAD	
2004 Haneline et al.[28]	Review	No	CeAD	Yes
2014 Biller et al.[46]	Review	No	CeAD	
2019 Chaibi & Russell[47]	Review	No	CeAD	
2024 Tuchin[48]	Review	No	CeAD	

Discussion

EQUIVOCATION OF CERVICAL ARTERY DISSECTION & STROKE

Wilder et al. incorrectly interpret that Brown and Lehman were advocating for the universal inclusion of CeAD and stroke risks in the informed consent process for CSM. Per the title of their study, Brown and Lehman are concerned with informed consent regarding risk of *stroke* from CSM, not *dissection*.[6]

Dissection and stroke are separate and distinct medical conditions; they are not one clinical entity. CeAD is a tear in the inner lining of a cervical artery that causes characteristic neck pain and headache.[47 49 50] The most common type of stroke presents with a loss of blood supply to the brain which causes ischemic symptoms.[51] While dissection can cause stroke, dissection is not a stroke. There is no inevitable progression of CeAD to stroke. Only 2% of all strokes are estimated to be caused by CeAD.[49] The vast majority of CeADs will not progress to stroke with medical treatment,[52] and may heal and become asymptomatic without any treatment.[53 54]

Wilder et al. reference 15 studies which discuss CeAD, and only nine which discuss stroke. (See Table 1) Brown and Lehman agree that there is no convincing evidence that CSM can cause dissection in normal cervical arteries.[6] However, this is a separate discussion from whether CSM can cause stroke. Each of the 15 studies discussing CeAD are reviewed here.

2016 Church et al.[37]

This systematic review and meta-analysis regarding the causation of CeAD by CSM was published in the *Cureus Journal of Medical Science* by six neurosurgeons from the Department of Neurosurgery at Penn State Hershey Medical Center.[37] Their meta-analysis of five epidemiological studies revealed an association between chiropractic and CeAD. The authors concluded that this association may be explained by the known association of neck pain with CeAD and CSM, and that the dissection may have been present before the neck manipulation.[11 31 33 55]

Church et al. concludes there is no convincing evidence of a causal relationship between CSM and CeAD. However, the conclusion of this study applies to the causation of CeAD by CSM, not the causation of thromboembolic stroke by CSM.

2022 Whedon et al.[38]

This geriatric epidemiological case-control and case-crossover study by Whedon et al. concluded that among Medicare beneficiaries aged 65 and older who received CSM, the risk of CeAD is no greater than that among control groups.[38] Wilder et al. point out the conclusion that CSM does not appear to be significant risk factor for CeAD. However, this conclusion applies to the risk of CeAD from CSM, not the risk of stroke from CSM.

2023 Whedon et al.[39]

This epidemiological case-control study by Whedon et al. concludes that among privately insured US adults the overall risk of CeAD is very low.[39] As noted by Wilder et al., the findings suggest that the association between CSM and CeAD is not causal in nature. However, these conclusions apply to the association between CSM and CeAD, not the association between CSM and thromboembolic stroke.

EIGHT BIOMECHANICAL STUDIES

Wilder et al. cite eight biomechanical studies which show no evidence of causation between CSM and CeAD.[16 30 40 41 42 43 44 45] However, the conclusions of these studies apply to the causation of CeAD by CSM, not the causation of thromboembolic stroke by CSM.

2004 Haneline et al.[28]

This review study on the diagnosis of internal carotid artery dissection (ICAD) in chiropractic practice by Haneline et al. concluded that there is no credible evidence to support the opinion that CSM causes ICAD. However, this conclusion does not apply to the causation of stroke by CSM.

2014 Biller et al.[46]

This review study on CSM and CeAD was published in the journal *Stroke* by 11 MDs and one chiropractor (Dr. Preston Long) on behalf of the American Heart Association Stroke Council and endorsed by the American Association of Neurological Surgeons and Congress of Neurological Surgeons.[46]

Biller et al. concluded that biomechanical evidence is insufficient to establish the claim that CSM causes CeAD.[46] However, similar to the Church et al. systematic review study,[37] this conclusion applies to the causation of CeAD from CSM, not the causation of thromboembolic stroke from CSM.

Wilder et al. do not discuss Biller et al.'s conclusion that patients with neck pain from VAD may present to chiropractors for treatment and it is plausible that CSM could exacerbate the VAD and increase the risk of stroke.[46]

2019 Chaibi & Russell[47]

This review study by Chaibi and Russell proposed a risk-benefit assessment strategy to exclude CeAD prior to the performance of CSM.[47] Wilder et al. observe that Chaibi and Russell did not propose disclosure of the risk of CeAD from CSM.[17] However, this is not relevant to disclosure of the risk of thromboembolic stroke from CSM, nor was it the objective of the study.

The objective of this study was to perform a comprehensive literature review and propose a clinical assessment protocol to exclude CeAD prior to neck manipulation. It was not the objective of the authors to opine on informed consent to the risk of dissection or stroke from CSM.

2013 Tuchin[48]

This review study on CSM and CeAD by Tuchin analyzed 16 case reports (containing 17 cases) from 2019 to 2024 and concluded that the chiropractic profession should be aware of inappropriate case report conclusions which incorrectly imply chiropractic manipulation as a cause of CeAD.[48] However, Tuchin's conclusion applies to the causation of CeAD by CSM, not the causation of stroke by CSM.

EPIDEMIOLOGICAL STROKE STUDIES

Wilder et al. reference three epidemiological stroke studies in their claim that there is no evidentiary support that CSM can cause thromboembolic stroke. However, epidemiological studies cannot answer questions of causation. They can only address associations, odds and risks. These studies have significant limitations which include small stroke case numbers,[11 33] no immediate exposure periods,[11 31 33] explicit warnings they have not excluded CSM as a cause of stroke,[11 33] and inapplicability to the population most at-risk for CeAD-related stroke, those under 45 years of age.[33 31]

2008 Cassidy et al.[11]

This epidemiological case-control and case-crossover study of CSM and stroke by Cassidy et al. came to two conclusions. First, the authors conclude that there is a similar association between vertebrobasilar artery (VBA) stroke and visits with a doctor of chiropractic (DC) and primary care physician (PCP).[11] Second, the authors conclude that the increased risks of VBA stroke associated with DC and PCP visits are explained by patients with VBA dissection-related neck pain and headache consulting both DCs and PCPs before their VBA stroke.

Their second conclusion supports that DCs and PCPs fail to diagnose existing VBA dissection. The failure of a DC to diagnose an existing VBA dissection and then perform CSM renders plausible a causal mechanism of immediate post-manipulative thromboembolic stroke.

Cassidy et al. support that CSM may dislodge a thrombus from an existing CeAD:[8] "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."[11] The thromboembolic stroke event acknowledged by Cassidy et al. could only occur immediately after CSM. However, this study did not evaluate an immediate exposure period post-manipulation, which is a significant limitation.[56] They also did not compare the 0-1-day DC exposure period with the 0-1-day PCP exposure period, another significant limitation.[7]

Wilder et al. note the size of the study base as a strength, 11 million patients evaluated over a period of 9 years, for over 109 million person-years of observation. However, Cassidy et al. only found 818 strokes, which is a significant limitation. Due to the rarity of dissection and stroke, large-scale epidemiological studies are difficult to perform. Cassidy et al. acknowledge that few databases can link incident VBA strokes with DC and PCP visits in a large enough population to perform a study of such a rare event.[11]

Cassidy et al. conclude, "We have not ruled out neck manipulation as a potential cause of some VBA strokes."[11] Concern has been raised that this study has been crudely interpreted to signify that CSM cannot cause stroke.[7]

2015 Kosloff et al.[33]

This epidemiological case-control study of CSM and stroke by Kosloff et al.[33] used the same study design as 2008 Cassidy et al.[11] with a different dataset and concluded that there was no significant association, *when the data were sufficient to calculate estimates*, between DC visits and stroke. It is notable that the disclaimer, "when

the data were sufficient to calculate estimates", was included in the Discussion, but not in the Abstract or the Conclusions of this study.

Wilder et al. note the size of the study base as a strength, 39 million patients evaluated over a period of 12 years. However, Kosloff et al. only found 1,829 VBA strokes, which they acknowledged as a significant limitation.

Despite finding a larger number of cases than Cassidy et al., data were insufficient to calculate estimates and confidence intervals in seven DC visit exposure periods.[11] Specifically, *there was insufficient data to compute an estimate in the 0-1-day exposure period in persons less than 45 years old*. The population most at risk for CeAD are those less than 45 years old.[57] Therefore, the population most at risk for thromboembolic stroke performed in the presence of an existing CeAD is also those under 45 years of age. Therefore, the conclusions of this study do not apply to the population most at risk for VAD, and the only exposure period for which an immediate post-manipulative stroke is plausible.

Kosloff et al. concluded that, "…the current study does not exclude cervical manipulation as a possible cause or contributory factor in the occurrence of VBA stroke."[33]

2015 Whedon et al.[31]

This geriatric retrospective cohort analysis of CSM and stroke by Whedon et al. concluded that among Medicare B beneficiaries aged 66 to 99 years with neck pain, incidence of vertebrobasilar stroke was extremely low.[31]

However, conclusions of this geriatric population study do not apply to those less than 45 years old, those who are most at risk for VAD and immediate post-manipulative thromboembolic stroke. Whedon et al. acknowledged that VAD and associated thromboembolism are the most plausible mechanism by which spinal manipulation could cause stroke.[31]

STUDIES ACKNOWLEDGING THROMBOEMBOLIC MECHANISM OF STROKE FROM CSM

In addition to Cassidy et al.[11] and Kosloff et al.[33] four other studies acknowledge an immediate thromboembolic mechanism of causation of stroke by CSM.[24 28 29 40] A companion study[13] to the Haldeman et al. study[35] acknowledges the thromboembolic mechanism.

2002 Symons et al.[40]

One of the biomechanical studies cited by Wilder et al. supports a thromboembolic mechanism. Symons et al. states that an ischemic event sustained in the vertebrobasilar system during CSM can arise from physical obstruction of the vertebral artery by a dislodged thrombus, embolus, or atherosclerotic plaque.[40]

2002 Haldeman et al.[35]

This 2002 case series by Haldeman et al. concludes that strokes after CSM are unpredictable and should be considered an inherent, idiosyncratic, and rare complication of CSM.[35] This conclusion acknowledges that strokes are a risk of CSM, although this analysis of the case series data does not acknowledge a causal thromboembolic mechanism.

However, another 2002 analysis of the same case series data by the same authors acknowledges that thromboembolic and thrombotic mechanisms of stroke from CSM are plausible: "It [our data] 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."[13]

2004 Haneline et al.[28]

This review study on the diagnosis of internal carotid artery dissection (ICAD) in chiropractic practice by Haneline et al. recommends that any identified ICAD patient not receive CSM, as case reports have correlated worsening of ICAD with CSM.[28] The authors state, "…any form of excessive or abrupt cervical motion may dislodge an embolus".

2013 Tuchin[24]

In this review study of CSM and stroke, Tuchin acknowledges that physical triggers, including CSM, can serve as plausible final link between dissection and stroke.[24] Tuchin concludes that a patient experiencing neck pain and/or headache from VAD could seek CSM from a chiropractor, physical therapist, or some other healthcare practitioner. If that healthcare practitioner did not perform a thorough history taking,[47] then they may overlook the existing VAD and perform CSM when it is contraindicated. Therefore, an existing VAD could be exacerbated, *dislodge a local thrombus and cause an immediate thromboembolic stroke*.[8 24]

2016 Paulus & Thaler[29]

This review study by Paulus and Thaler concluded that case misclassification threatens the validity of studies investigating the relationship between CSM and stroke caused by VAD.[29] The authors also concluded that CSM could exacerbate a VAD or disturb the mural/luminal thrombus such that a portion of it could be dislodged and embolize into the brain (or retina, in the case of an ICAD).

PRACTICE GUIDELINES ON STROKE

2007 Association of Chiropractic Colleges Informed Consent Practice Guideline[5]

In this practice guideline, the ACC recommends Informed Consent to the risks of treatment but takes no position on whether stroke is a risk of CSM.[5] The ACC does not discuss any specific risks from any specific procedures. However, they do recommend disclosure of any risk which carries serious consequences, such as paralysis or death. The risk of stroke does carry such serious consequences. Wilder et al. note that this practice guideline is no longer accessible on the ACC website, however, this guideline has not been rescinded by the ACC.

2020 Rushton et al.[34]

This multi-disciplinary practice guideline from the International Federation of Orthopedic Manipulative Physical Therapists is a collaboration from researchers in physical therapy, chiropractic and osteopathy, including chiropractic researcher Dr. Sidney Rubinstein.[34] The

guideline outlines an examination strategy to exclude vascular pathologies of the neck, such as CeAD, prior to CSM.

The authors recommend that informed consent to the risks of CSM be obtained explicitly either verbally or in writing and that it be recorded in a standardized manner. Wilder et al. refer to this as a call for "non-specific informed consent". However, Rushton et al. specifically acknowledge the risk of VBA stroke from CSM in Table 9 of their study.

ANIMAL STUDY

2008 Wynd et al.[36]

This canine study by Wynd et al. found that CSM did not alter the dimensions of pre-existing vertebral artery lesions in anesthetized dogs.[36] The implication noted by Wilder et al. is that CSM performed in the presence of a VAD does not exacerbate the VAD with regard to dislodging a thrombus and causing thromboembolic stroke. However, this canine study has substantial limitations which Wilder et al. did not discuss.

Wynd et al. investigated vertebral artery lesions at the C4 level in canines, not the C0-C2 level, the site of the commonly affected V3 segment in humans.[46] Most significantly, the authors did not document the time from the creation of the vertebral artery lesion to the CSM, but that time appears to be short. Many strokes following CSM occur weeks after the onset of symptoms of CeAD,[13] likely because a healing vertebral artery thrombus becomes more loosely adherent and easier to dislodge and embolize to the brain.[10]

Limitations

This is a narrative review, not a systematic literature review. As such, a comprehensive critical analysis of quality of the evidence was not performed.[58] Narrative reviews also lack meta-analysis, potentially overemphasizing qualitative interpretations. The study's narrative review design may have introduced selection bias. Also, because it focused on the references cited by Wilder et al., it may have excluded other relevant evidence.

Recommendations

No epidemiological studies or systematic literature reviews have been performed on the causation of *immediate* post-manipulative stroke. The four major epidemiological studies on CSM and stroke did not include an evaluation of an *immediate* exposure period.[11 31 33 55] The 2012 systematic review by Haynes did not focus on *immediate* stroke.[32] We recommend that such studies be performed, as they may advance the state of knowledge in this area and elevate the standard of care.

Conclusion

We conclude that there is no convincing evidence that CSM can cause CeAD,[37] however, when signs and symptoms of CeAD are present, the patient must be informed and referred to emergency medical services.[47] In that clinical setting there is a risk that CSM may dislodge a thrombus and cause an immediate thromboembolic stroke.[9 10 11 13 19 20 21 22 23 24 25 26 27 28 29 31 32 40] The 24 studies reviewed from Wilder et al. fail to rule out this risk.

Chiropractors should adhere to the standard of care by employing evidence-based risk assessment strategies, such as those outlined by Chaibi et al.,[47] Rushton et al.,[34] Harper et al.,[59] and Thomas et al.,[60 61] to exclude CeAD prior to performing CSM. Implementing thorough clinical evaluations, including patient history, physical examination, and, when indicated, advanced imaging (CTA, MRA), can mitigate the risk of stroke and enhance patient safety. By acknowledging this risk and prioritizing informed consent,[2 6 7] the chiropractic profession can uphold its commitment to patient-centered, evidence-based care.

Disclosure Of Potential Conflicts Of Interest

Steven Brown, DC, DIAMA, serves as a medicolegal expert witness in malpractice cases of CSM, CeAD and stroke.

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