JOURNAL OF CONTEMPORARY CHIROPRACTIC

WHAT EVIDENCE CAN CASE REPORTS ON SPINE MANIPULATIVE THERAPY AND CERVICAL ARTERY DISSECTION PROVIDE?

Peter Tuchin, DC, PhD[1]

ABSTRACT

Objective: Case reports are sometimes used in discussion about the role of cervical spine manipulative therapy (SMT) in vertebral artery dissection (VAD). Some authors of case reports also make incorrect statements regarding causality of SMT and these rare types of stroke. Case reports often have limited clinical details. This paper looks at the evidence presented in case reports.

Methods: A review of recent cervical artery dissection (CAD) case reports was conducted to assess what role SMT may play in the onset of CAD stroke. This paper assessed recent case reports of CAD and reviewed the clinical features of case reports and potential triggers of CAD stroke.

Results: A search of the Pubmed database found 16 papers (17 cases) using the terms "cervical spine manipulation", "case report," and "CAD" from 2019 to April 2024. The majority of case reports made inappropriate conclusions and provide little contribution to knowledge about SMT and CAD. Many case reports incorrectly used the term "chiropractic" when referring to SMT provided by a non-chiropractor (e.g. massage therapist). In addition, most case reports had minimal information regarding risk factors and the onset of any neck pain or headache, prior to SMT.

Conclusion: The chiropractic profession should be aware of inappropriate case report conclusions which incorrectly imply chiropractic manipulation as a cause of CAD. *(J Contemporary Chiropr 2024;7:132-140)*

Key Indexing Terms: Cervical Artery Dissection; Cervical Spine; Chiropractic Manipulation Case Report

INTRODUCTION

Cervical artery dissection (CAD) is a rare event, with an annual incidence of approx. 3.6 per 100,000 population. (1,2) CAD includes both Internal carotid artery dissection (ICAD) and vertebral artery dissection (VAD). ICAD has been estimated at 2.6 per 100,000 populationand VAD at 1 per 100,000 population. Most cases of CAD are described as spontaneous, with neck pain or headache being the first symptom. (3,4) Past studies found that people with spontaneous CAD appeared healthy and were also younger (<45 yrs. old) compared to non-CAD stroke. (5) Stroke may follow CAD, but it is estimated that CAD accounts for only 2% of all ischemic strokes. (6,7)

Many case reports of CAD following SMT have been published, despite the rarity of CAD. (8) Case reports may be frequently published due to a perception that SMT increases the possibility of CAD. (9) However, many case reports of SMT and CAD have significant omissions, errors and flaws. (10,11) There is also a perception that Doctors of Chiropractic (DCs) may be poor at diagnosing CAD or potential contra-indications for SMT. (12)

Some studies have suggested a non-causal association between SMT and CAD. (13-16) However, some of these

[1] Faculty of Chiropractic, Retired

studies have statistical issues, which render their conclusions less robust. For example, small cohort size, large inclusion criteria, and poor matching to controls can limit their statistical strength. (17)

As CAD is a rare event, an effective way to examine this is to perform a systematic review of case reports to determine potential significant clinical features as well as potential trigger factors for the CAD. (11) In addition, a systematic review would help clinicians to have a better understanding of the clinical features and pathophysiology of CAD to assist in their identification of possible CAD cases.

This paper reviews all recent case reports on CAD and SMT, and highlights strengths and weaknesses in these case reports.

Location of Artery Dissection

VAD and ICAD may arise from a tear of the inner wall (tunica intima) or outer adventitial layer. Blood under arterial pressure enters the deeper layers forming an intramural haematoma 'dissecting' the artery and causing alteration of blood flow. (18)

Other spontaneous CADs result from a sub-adventitial tear caused by hemorrhage in the tunica media or tunica adventitia. This creates a pseudo-aneurysm or degeneration of the media-adventitial border with formation of micro-haematomas, thus weakening the vessel wall. (19) A subset of patients with spontaneous CAD showed signs of a generalized transient inflammatory arteriopathy in PET-CT and contrast enhanced high resolution MRI. (20) Ro *et al.* propose a theory of suspected artery dissection following histological preparations of vertebral artery dissections removed from cadavers. They propose a defect occurs in the tunica media due to unknown reasons. [Ro (21)]

Dissection occurs when the structural integrity of the arterial wall is compromised. Intimal tears lead to arterial blood dissecting between the layers of the arterial wall. The blood within the arterial wall precipitates hematoma and clot formation. The subsequent compromise in arterial blood flow secondary to the stenosis then leads to the symptoms of cervical artery dissection and ultimately, stroke. (21)

Vertebral artery dissection can be either extracranial (V1, V2, or V3), or intracranial (V4) Extracranial dissections that follow SMT are considered to usually involve the distal extracranial segment near the atlas and axis (V3). (See Figure 1)

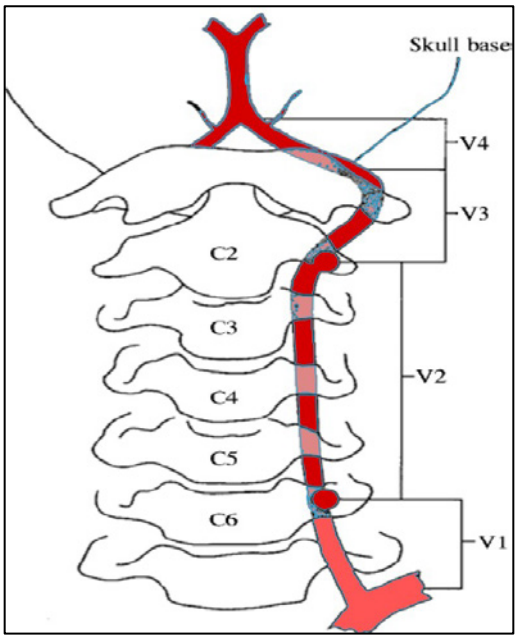


Figure 1. *vertebral artery dissection sections (From- Wikipedia)*

KEY:
V1 = C7 *(pre foraminal)*
V2 = C6 to C2 *(foraminal)*
V3 = C 2 to dura,
V4 = intracranial

METHODS

A comprehensive search of the Pubmed and Google scholar for case reports (from 2019 up to April 2024) was conducted to identify papers using the key terms of SMT, case report and CAD. The abstracts of all papers retrieved were then assessed for inclusion, and reviewing if the treatment was described as "chiropractic" and if the adverse event was a CAD. This was determined by a review of the details provided describing the SMT procedure, and by reviewing the country of origin for the case report. Any description of the SMT was assessed to determine if this was a commonly performed chiropractic procedure or if it described SMT commonly performed by other practitioners.

All case studies or case series were then critically reviewed for the clinical details contained in paper. Specifically, each paper was reviewed to assess

Table 1. *Summary of cases reviewed*

AUTHOR	YEAR	AGE	SEX	COUNTRY	PROVIDER	OTHER
TOLUIE(26)	2024	48	?	USA	DC/DO?	
IWAMOTO (27)	2024	30	F	USA	DC	
YEUNG (28)(*abstract*)	2023	48	F	USA	DC	
CHEN (29)-case 1	2022	51	M	China		DC*
CHEN – case 2	2022	55	M	China		DC*
ARNING (30)	2022	47	F	Germany		DC*
ABIDOYE (31)*(abstract)*	2022	40	M	USA/GA	DC	
PIENING (32)	2022	26	F	USA/IL		Self
YAP (33)	2021	35	M	China		DC/MT?+
XIA (34)	2021	44	M	USA/NY	DC	
LINDSAY (35)	2021	47	M	USA/MA	DC	
MONARI (36)	2021	39	F	Italy		DO
RAMOS (37)	2021	48	F	Brazil/SP		DC*
ALMUAIGEL (38)	2020	30	M	Saudia Arabia		DC*
ORSINI (39)	2019	34	F	France		DC*
CHEN (40)	2019	48	M	China		DC*
NOLAN	2019	30	F	NZ	DC	

KEY: DC = Doctor of Chiropractic. *DC = The term "chiropractor" was used in the report, but several countries (China, Germany, Italy, Brazil) have limited or no licensing/registration standards, which may call into question the education and therefore the profession of the "chiropractor". †MT = Massage Therapist. It was unclear in this case report whether the practitioner was a Doctor of Chiropractic or a Massage Therapist. DO = Doctor of Osteopathy

significant risk factors for CAD and stroke that had been previously identified in the literature. (22-24) These factors included use of oral contraceptive pill (OCP), history of

hypertension, hyperlipidemia, atherosclerosis, family history, smoking, presenting symptom (especially neck pain), past history of headaches or migraine.

In addition to items that were assessed relating to the description of the treatment performed, the time lapse between SMT and the adverse event was reviewed. This included examining the presenting symptom to the SMT practitioner, the onset of symptoms relating to the adverse event, and assessing any other events that could be a confounding factor for identification of the relationship between SMT and the adverse event. (10,25)

Case reports were excluded if the paper was not published in English or a translation of the article could not be obtained. Papers were only the abstract was available, was assessed separately. Any retrospective studies, commentaries or letters to the editor were not included for review.

RESULTS

A search of the databases found 16 papers (17 cases) using the terms "spinal manipulation", "case report" and "VAD" from 2019 to April 2024. (Table 1) These papers were then reviewed to assess key clinical information.

Case Summaries

Toluie reported a case of a 48yo patient who experienced immediate neurological signs following SMT. (26) The authors did not report any incident which initiated the onset of pain prior to presentation for SMT. The patient experienced pain for 2 weeks prior to SMT, and again the authors did not report clinical features during the 2 weeks interval. For example, does the person regularly play sport or other activities, did they

experience any neurological symptoms in this 2-week period, did they seek other treatment (e.g. NSAIDS, massage, etc.) that have been known to trigger VAD. There may also be a question whether the SMT was delivered by a chiropractor, osteopath, or another practitioner.

In 2024, Iwamoto *et al* described a 30-year-old female who experienced VAD following chiropractic treatment and roller coaster riding. In reviewing this article, the authors state the chiropractic treatment was one month prior to the onset of stroke symptoms. In addition, the authors describe the patient "having many roller coaster rides" in the week prior to onset of stroke symptoms. Furthermore, the patient presented to the emergency department (ED) and was discharged after minor treatment. The patient represented the following day at the emergency department with worsening symptoms of headache and neurological issues.

In a conference abstract presented by Yeung (28), the only clinical information reported was –48-year-old female went to chiropractor for chronic neck pain and developed right-sided weakness, nausea, dizziness, and vomiting immediately after neck manipulation.

The lack of clinical information reported by Yeung leaves the reader ill-informed about other factors which may be more relevant. For example, as previously noted, had there been recent changes in the chronic neck pain due to other events (such as sport) which may have been the cause of the CAD. (41) In addition, there are numerous risk factors for stroke, not recorded, which will be discussed later.

The term "after" was used in the Chen (29) case series, but then the actual time period from SMT to the onset of stroke symptoms was reported as 1 and 2 days, respectively. This may call into question what happened immediately after the SMT, and if there were any other events before the onset of the first stroke symptoms occurred. For example, activities or sports (which have been commonly reported before CAD), may have occurred after the SMT.

In the first case from China, Chen 2022 described 1 case of new onset neck pain 2 days after "chiropractic" SMT. However, no information was provided on what symptoms were present prior to SMT or reasons why the person sought treatment. For example, while there may have been new onset neck pain after treatment, the person may have experienced headache after an activity requiring neck movement, some time prior to presentation to the "chiropractor", which was the reason the artery dissected. In addition, if the SMT caused the dissection, why did the patient not experience immediate pain at the time of the SMT? As noted previously, China does not have government laws to set standards for practice as a "chiropractor".

Chen 2022 also discussed a second case, with reported new onset neck pain one day after "chiropractic" SMT. Again, no information was provided on what symptoms were present prior to SMT or reasons why the person sought treatment. As noted above, if the SMT caused the dissection, why did the patient not experience immediate pain at the time of the SMT?

In addition, the terms "sudden," "following," and "during" can also be found in case reports, again with no actual time period noted.

Piening (32) reports a case where a 26yo female performed a self-SMT during an exercise session. They reported the person had no medical history, no previous neck pain and was not using medications. However, it is not entirely clear whether this means she had no history of migraine, was not using the oral contraceptive pill (OCP), and had not taken over-the-counter anti-inflammatory medications (e.g. Ibuprofen). These are known risk factors for stroke and probably relevant for this person. The person visited an ED 4 day later, where she reported the "following" day after the exercise and self SMT, she noted some eyelid droop and a smaller pupil on one side.

In another example, Yap (33) discussd a 35-year-old male who had SMT sometime "in the prior two weeks" before a stroke. It is unclear if the patient received SMT, massage therapy, or both, prior to the stroke. The term "chiropractor massage" was used, and in China Traditional Chinese Medicine practitioners provide both services, but the actual education of practitioner is unknown. Therefore, this may also be a case of massage triggering a CAD.

If the onset of the first stroke symptoms is actually "immediate," one would question how an artery dissects, forms a blood clot, which then dislodges and forms an embolism in the brain, and how this can occur "immediately" after SMT. If the onset of the first stroke symptoms was "immediate," it seems more likely that a blood clot, from an existing dissection, dislodged after the SMT and formed an embolism in the brain.

This should also be considered when people experiencing CAD have often described neck pain or headache, prior to seeking SMT treatment. Few, if any,

case reports question any events or factors which may have contributed to the first onset of neck pain or headache. Many cases of CAD have been reported after minor activities or sports, and the resultant stroke is described as spontaneous.

Timeline Between Onset of Symptoms And SMT

The actual time period which elapsed from the SMT to the onset of stroke symptoms is often not expressly or clearly reported. Terms described later in this paper may call into question the actual time between the SMT and the onset of the first stroke symptoms. For example, some authors use the term "after" but then describe a long period for onset of symptoms. (See Table 2)

Events Preceding The SMT

Four case reports noted neck pain preceding the SMT and 4 noted headaches, but only 1 described any events which may have triggered the neck pain/headache, and potentially damaged the artery. The following case report noted vigorous exercise/sex before the onset of a headache, but then went on to note SMT treatment two months later as the cause of the dissection.

Table 2. *Timeline between stroke symptoms and SMT*

AUTHOR	TERM USED	TIME LINE
TOLUIE	"Immediate"	Unknown
IWAMOTO	"Four weeks"	No initial neuro symptoms
YEUNG (*abstract*)	"Immediate"	Unknown
CHEN -case 1	"After"	2 days
CHEN – case 2	"After"	1 day
ARNING	"Pre-existing"	Pre-existing
ABIDOYE *(abstract)*	"Two months"	Two months
PIENING	"After" & "Following"	1 day
YAP	"In the prior 2 weeks"	Unknown
XIA	"Sudden"	A few days
LINDSAY	"Previously"	6 years
MONARI	"After"	A few days
RAMOS	"After" & "During"	Unknown
ALMUAIGEL	"Before" & "During"	Unknown
ORSINI	"3 weeks"	3 weeks
CHEN	"After"	Recent massage
NOLAN	"Shortly after"	Unknown

This is a 40-year-old male with medical history of migraine headaches and cervicalgia, evaluated for a sudden onset of headache, associated with nausea, vomiting, blurred vision, and dizziness, two months after a chiropractic manipulation. He also reported rigorous exercise and sexual intercourse prior to the headache onset. Vital sign is significant for a 10/10, non-radiating right-sided headache. Neurological examination revealed right ptosis and miosis. Labs were unremarkable. CTA of neck showed tapering of the right ICA with near occlusion at the skull base. (31)

Location of Dissection (Table 3)

From the cohort of 16 cases, 22 dissections were reported. Only five cases from the cohort had dissections at the V3 level, which is argued as the area for most susceptible site of strain on the VA during SMT. However, these case reports also had other issues, making any conclusion ambiguous. For example, Turner reported a VAD at V3, but this happened 6 years prior to a second presentation to an ED, where the patient was found to have connective tissue disease (Ehlers- Danlos syndrome). This is a known and common reason for artery dissections.

Table 3. *Location of dissection*

AUTHOR	LOCATION
TOLUIE	Right V3
IWAMOTO	Right V3/V4; Left V2
YEUNG (*abstract*)	Right V1
CHEN -case 1	Right ICA3
CHEN – case 2	Right ICA3
ARNING	Right V2
ABIDOYE *(abstract)*	Right ICA1
PIENING	Left ICA1
YAP	Left ICA
XIA	Left V2; Right V3
LINDSAY	Left V3
MONARI	Right V2
RAMOS	Bilateral VA
ALMUAIGEL	Bilat V4 and BA
ORSINI	Bilat V2, V3 and BA
CHEN	Left V2
NOLAN	Unknown

Another case report from Xia (34), reported 2 dissections in the same patient (1 V2, and 1 at V3). However, the Xia case report also had other issues (see below), making their conclusion also ambiguous.

This is a case presentation of a 44 year old male who was transferred from another emergency department for left homonymous inferior quadrantanopia noted on an optometrist visit. He reported sudden onset left homonymous hemianopia after receiving a high velocity cervical spine adjustment at a chiropractor appointment for chronic neck pain a few days prior.

As can be noted, there is no discussion about the alteration of neck pain or headache, prior to, or immediately following the SMT. In addition, the person had presented to another ED and no description of their diagnostic procedures or treatment was reported. It is also possible that the person delivering the SMT may have had minimal education or qualifications in SMT as China has no legislation governing SMT. Therefore, even though the VAD occurred at the V2 and V3 levels, other factors appear more significant for this case.

One case had dissection at the V1 level, which has not been identified as an area for strain on the VA during SMT. (See table 4) Several cases had dissections at the V2 level. These areas of the VA are not where the artery has significant change of direction. Studies testing VA strength have confirmed that forces imparted during SMT are not enough to damage a healthy artery.

Five cases from the cohort of 17 had dissections in the internal carotid artery (ICA), which has also not been identified as an area for strain during SMT.

Another case had bilateral dissections in the VA, with the specific level not reportable, due to the acquirement of an abstract only. However, this case is also discussed later as a probable negligence case by an un-trained lay manipulator.

Negligence

Case reports may also follow examples of what may appear to be clinical negligence. Ramos (37), reported a case where a patient had ankylosing spondylitis and consequently SMT caused C5 fracture with vascular complications. Ankylosing spondylitis would be regarded by most chiropractors as a contra-indication for SMT, unless there were extenuating circumstances.

Table 4. *Location summary*

LOCATION	NUMBER
V1	1
V2	6
V3	5
V4	3
Unknown	2
ICAD	5
TOTAL	22

Limitations

I can only rely on what information was contained in the case report published, which may have been truncated due to publication limitations. In addition, the clinicians involved with the case, may have collected data, which the authors of the case report did not include in their publication. The absence of key clinical information could be significant in determining any relationship of SMT to VAD.

There were 2 articles for which only abstracts were obtained, and unable to access a full paper. Therefore, all the case details may not have been identified. One of these abstracts noted the VAD occurred in the V1 segment of the vertebral artery, which is not the segment that would not be affected by SMT.

DISCUSSION

As noted in the result section, the term "immediate" has not been defined or quantified. Our recommendation is to note the actual time period (i.e., less than 60 seconds, 1 to 2 minutes, more than 2 minutes), when stroke symptoms begin after a treatment. This is critical in discussing trigger events for CAD, and also to discuss any negligence that may be due to a clinician.

Strokes can occur in all age groups, including young people, and in some types of "spontaneous" stroke (e.g., VAD and ICAD dissection), the first symptoms are new or sudden onset of neck pain and headache.

Bin Saeed *et al*, reported headache and/or neck pain was the prominent feature in 88% of patients and was a warning sign in 53%, preceding onset of stroke by up to 14 days. (42) They also reported the most common clinical features included vertigo (57%), unilateral facial paraesthesia (46%), cerebellar signs (33%), lateral

medullary signs (26%) and visual field defects (15%).

Other studies have reported similar symptoms of early CAD as dizziness/vertigo (58%), headache (51%) and neck pain (46%). (43) A recent study reported that 73% of patients reported headache or neck pain preceding onset of stroke, and 42% reported vertigo or dizziness. (44)

Unfortunately, a clear symptom pattern for stroke in people under 45 years old has not been defined. For primary care physicians, this makes the task of identifying a VAD or ICAD (prior to stroke symptoms) very challenging. Stroke can also occur in children and the symptom pattern is even more unclear.

VAD case reports often describe the myriad of clinical variations that can occur, and the vast description of the presenting complaint to which clinicians may encounter. One example of a VAD case report and the clinical description is presented below. This highlights the overlap between symptoms of acute neck pain, migraine and VAD.

A 39-year-old active-duty male without significant past medical history presented to the emergency department (ED) at the San Antonio Military Medical Center in Texas for evaluation of severe vertigo with associated nausea and vomiting. He had participated in a Jiu-Jitsu match the evening prior to his presentation and reported that he was placed in a choke hold within the last 12 seconds of the match. He denied losing consciousness during this hold.

Once released, he attempted to stand and developed sudden onset vertigo with severe nausea, leading to multiple bouts of emesis. He additionally developed a throbbing, left-sided headache radiating down the left side of his neck. While the vertigo resolved within an hour, he continued to experience bouts of nausea and emesis, prompting him to present to the ED for further evaluation. The patient's past medical history was remarkable only for multiple prior concussions, and his only medication was occasional ibuprofen. He denied the usage of recreational drugs. (45)

As can be noted in the preceding case report, a fit, active male with no past history presented with symptoms of neck pain and possible migraine. There was not strong evidence suggestive of VAD, however, there are also many gaps in the clinical history. For example, past history or episodes of migraine, any potential changes in their pattern, onset of neck pain, relationship to his sport activity, other risk factors (hypertension, smoking, recent infection, etc.)

Had the above patient presented to a chiropractor for treatment of his neck pain, then this case may have been seen as evidence of SMT causing the VAD. However, this patient presented to an Emergency Department for treatment of his neck pain, but this was not seen as evidence of ED treatment causing the VAD. Even if this patient had received SMT for his neck pain, the most plausible explanation for the cause of this VAD was the Jiu-Jitsu choke hold, not the SMT.

CONCLUSION

Some case report examples of VAD and SMT have incorrect statements regarding causality of SMT for these rare types of stroke. This critical review of recent CAD case reports and SMT highlighted the myriad of clinical features in the case reports and the potential for many other probable factors as a trigger for stroke after a person starts experiencing neck pain or headache. In addition, the term "chiropractor" is often incorrectly used in case reports of SMT and CAD.

ACKNOWLEDGEMENTS

This study is the result of a joint review of case reports with Dr. Steven Brown. After reaching consensus on the joint review of case reports, the authors had separate opinions on the content and direction of the study, and two separate and distinct studies were produced. The similarities in the separate studies are due to the joint review of the case report material

REFERENCE

1. Lee VH, Brown RD, Jr., Mandrekar JN, Mokri B. Incidence and outcome of cervical artery dissection: a population-based study. Neurol 2006;67(10):1809-1812

2. Béjot Y, Aboa-Eboulé C, Debette S, *et al*. Characteristics and outcomes of patients with multiple cervical artery dissection. Stroke 2014;45(1):37-41

3. Schievink WI. Spontaneous dissection of the carotid and vertebral arteries. New Engl J Med 2001;344(12):898-906

4. Arnold M, Cumurciuc R, Stapf C, Favrole P, Berthet K, Bousser MG. Pain as the only symptom of cervical artery dissection. J NEurol Neurosurg Psychiatr 2006;77(9):1021-1024

5. Haneline MT, Lewkovich GN. An analysis of the etiology of cervical artery dissections: 1994 to 2003. J Manipulative Physiol Ther 2005;28(8):617-622

6. Schievink WI, Debette S. Etiology of cervical artery dissections. Neurol 2011;76(17):1452.

7. Engelter S, Dallongeville J, Kloss M, *et al*. Thrombolysis in cervical artery dissection–data from the Cervical Artery Dissection and Ischaemic Stroke Patients (CADISP) database. European J Neurol 2012;19(9):1199-1206

8. Ernst E. Adverse effects of spinal manipulation: a systematic review. J Royal Soc Med 2007;100(7):330-338

9. Ernst E. Vascular accidents after neck manipulation: cause or coincidence? Int J Clin Pract 2010;64(6):673-677

10. Tuchin P. A replication of the study 'Adverse effects of spinal manipulation: a systematic review'. Chiropr Man Therap 2012;20(1):30

11. Wynd S, Westaway M, Vohra S, Kawchuk G. The quality of reports on cervical arterial dissection following cervical spinal manipulation. PLoS One 2013;8(3):e59170

12. Turner RC, Lucke-Wold BP, Boo S, Rosen CL, Sedney CL. The potential dangers of neck manipulation & risk for dissection and devastating stroke: an illustrative case & review of the literature. Biomed Res Rev. 2018;2(1).

13. Rothwell DM, Bondy SJ, Williams JI. Chiropractic manipulation and stroke: a population- based case-control study. Stroke 2001;32(5):1054-1060

14. Smith WS, Johnston SC, Skalabrin EJ, *et al*. Spinal manipulative therapy is an independent risk factor for vertebral artery dissection. Neurol 2003;60(9):1424-1428

15. Cassidy JD, Boyle E, Cote P, *et al*. Risk of vertebrobasilar stroke and chiropractic care: results of a population-based case-control and case-crossover study. Spine 2008;33(4 Suppl):S176-183

16. Engelter ST, Grond-Ginsbach C, Metso TM, *et al*. Cervical artery dissection: trauma and other potential mechanical trigger events. Neurol 2013;80(21):1950-1957

17. Biller J, Sacco RL, Albuquerque FC *et al*. Cervical arterial dissections and association with cervical manipulative therapy: a statement for healthcare professionals from the American Heart Association/American Stroke Association. Stroke 2014;45(10):3155-3174

18. Mokri B, Houser OW, Sandok BA, Piepgras DG. Spontaneous dissections of the vertebral arteries. Neurol 1988;38(6):880

19. Thomas LC. Cervical arterial dissection: An overview and implications for manipulative therapy practice. Man Ther 2016;21:2-9

20. Pfefferkorn T, Saam T, Rominger A, *et al*. Vessel wall inflammation in spontaneous cervical artery dissection: a prospective, observational positron emission tomography, computed tomography, and magnetic resonance imaging study. Stroke 2011;42(6):1563-1568

21. Ro A, Kageyama N. Pathomorphometry of ruptured intracranial vertebral arterial dissection: adventitial rupture, dilated lesion, intimal tear, and medial defect. J Neurosurg 2013;119(1):221-227

22. Rubinstein SM, Peerdeman SM, van Tulder MW, Riphagen I, Haldeman S. A systematic review of the risk factors for cervical artery dissection. Stroke 2005;36(7):1575-1580

23. Micheli S, Paciaroni M, Corea F, Agnelli G, Zampolini M, Caso V. Cervical artery dissection: emerging risk factors. Open Neurol J 2010;4:50-55

24. Yaghi S, Maalouf N, Keyrouz SG. Cervical artery dissection: risk factors, treatment, and outcome; a 5-year experience from a tertiary care center. Int J Neurosci 2012;122(1):40-44

25. Tuchin P. Chiropractic and stroke: association or causation? Int J Clin Practice 2013;67(9):825-833

26. Toluie A, Joseph AT, Hrehorovich PA. Vertebral artery dissection in a young adult: a case report. Cureus 2024;16(4)

27. Iwamoto S, Hsu MD, Ta APD, Leo A, Chu H, Chu G. Twists and turns: a chiropractic roller coaster experience unraveling the intricacies of bilateral vertebral artery dissection. Cureus 2024;16(2)

28. Yeung, editor. Case diagnosis: right vertebral artery dissection and ischemic strokes after chiropractic manipulation. Physiatr 2023; 2023

29. Chen Y, Mofatteh M, Nguyen TN *et al*. Carotid artery dissection and ischemic stroke following cervical chiropractic manipulation: two case reports. Vascular Endovascular Surg 2022;56(3):303-307

30. Arning C, Hanke-Arning K. Vertebral artery dissection after—and also before—chirotherapy. J Neurol 2022;269(6):3353-3354

31. Abidoye O, Ogbuagu H, Al-Rubaye R. Carotid artery dissection following cervical spine manipulation: an association or causative relationship. Chest 2022;161(6):A76

32. Piening K, Piening NM, Chiou A. Internal carotid artery dissection following self- manipulation: A case report. SAGE Open Med Case Rep 2022;10:2050313X221122451

33. Yap T, Feng L, Xu D, Zhang J. A near-fatal consequence of chiropractor massage: massive stroke from carotid arterial dissection and bilateral vertebral arterial oedema. BMJ Case Rep 2021;14(8)

34. Xia C, Pfaff L, Kaur N, Suryadevara N, Masoud H. Abstract 1122-000200: Chiropractor manipulation leading to bilateral vertebral artery dissection and acute ischemic stroke. Stroke 2021;1(S1):e12091

35. Lindsay ME, Dudzinski DM, Yoon BC, Jaff MR, Thakuria JV. Case 30-2021: A 47-year-old man with recurrent unilateral head and neck pain. N Engl J Med 2021;385(14):1317-1325

36. Monari F, Busani S, Imbrogno MG, *et al*. Vertebral artery dissection in term pregnancy after cervical spine manipulation: a case report and review the literature. J Med Case Rep 2021;15(1):530

37. Ramos GB, Ranzani Martins R, *et al*. Spinal cord injury, vertebral artery dissection, and cerebellar strokes after chiropractic manipulation. Neurol 2022;99(22):995-996

38. Almuaigel MF, Althwanay A, Alamri A. spontaneous bilateral dissection of the vertebral artery: a case report. Cureus 2020;12(7):e9310

39. Orsini GG, Metaxas GE, Legros V. Locked-in syndrome following cervical manipulation by a chiropractor: a case report. J Crit Care Med 2019;5(3):107-110

40. Chen WJ, Qiao HY, Fang GT, Zhong X. Vertebral artery dissection probably caused by massage: a case report. Chin Med Sci J 2019;34(1):65-68

41. Dittrich R, Rohsbach D, Heidbreder A *et al*. Mild mechanical traumas are possible risk factors for cervical artery dissection. Cerebrovasc Dis 2007;23(4):275-281

42. Saeed AB, Shuaib A, Al-Sulaiti G, Emery D. Vertebral artery dissection: warning symptoms, clinical features and prognosis in 26 patients. Canadian J Neurol Neurosci 2000;27(4):292-296

43. Gottesman RF, Sharma P, Robinson KA *et al*. Clinical characteristics of symptomatic vertebral artery dissection: a systematic review. Neurologist 2012;18(5):245-254

44. Shibahara T, Yasaka M, Wakugawa Y *et al*. Improvement and Aggravation of Spontaneous Unruptured Vertebral Artery Dissection. Cerebrovascular Dis Extra 2017;7(3):153-164

45. Powell T, Fullam T, Hammett J, Nettlow D, Harris J. Vertebral artery dissection in active-duty soldier due to mixed martial arts choke hold. Fed Pract 2018;35(7):12-17