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LITERATUREREVIEW

Cervical Arterial Events and spinal manipulation: A scoping review of terminology and ratio risk

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Background: To the authors' knowledge, this is the first paper to conduct a scoping review of the literature examining the reported ratios between cervical spinal adjustments or manipulation (CeSAM) and cervical vascular accidents (CeVA). This review highlights how several authors have cited pre-existing ratios in their own calculations, sometimes without recalculating based on primary data. Furthermore, the paper addresses the diverse and often inconsistent acronyms used in the literature, contextualising them within their relevant anatomical structures, particularly in relation to the cervical spine and the Circle of Willis.

Intervention: Sixteen distinct acronyms associated with cervical vascular accidents (CeVA) have been identified in the literature. This paper provides an anatomical overview of the cervical vascular system—focusing on the vertebral and carotid arteries, and the Circle of Willis—followed by an analysis of how these acronyms have been applied. All peer-reviewed publications presenting incidence or risk ratios linking CeSAM to CeVA were reviewed and synthesised. A summary table presents the primary practitioners involved in each study alongside the associated ratios reported.

Outcome: This review presents the currently available literature reporting ratios or frequencies of cervical vascular accidents in association with cervical spinal manipulation. It distinguishes between primary ratios, calculated directly from empirical data, and secondary ratios, where authors have cited figures from prior studies. Reported incidence rates in the literature vary widely, ranging from 1 per 4,500 treatments to 1 per 5.85 million manipulations. These figures are contrasted with the spontaneous incidence of cervical artery dissection in the general population, estimated between 1 and 3 per 100,000 people annually, highlighting the uncertainty and inconsistency in the data.

Conclusion: Cervical artery dissection, although rare, remains the most serious reported iatrogenic complication associated with cervical spinal manipulation. The current body of literature suggests a weak association between CeSAM and CeVA, with no definitive causal link established. Nonetheless, the frequency and interpretation of reported ratios vary widely. Moreover, the literature tends to emphasise adverse events, with insufficient reporting of positive outcomes or appropriate referrals made by Chiropractors and manual therapists. In light of the Montgomery ruling (2015), it is no longer a matter of establishing causation alone; all available information, risks, uncertainties, and benefits, must be disclosed to patients, placing the practitioner in a clearly defined advisory role.

Indexing terms: Cervical vascular accident; carotid artery accident; vertebral artery accident; cervical chiropractic adjustments, osteopathic, or physiotherapy manipulation; CVA.

Anatomy of the Vertebral Artery and Regional Segments:
Acronym Use and Confusion in Cervical Vascular Accident Literature

> *... Collating all the data provided by the 19 authors who calculated a ratio yielded an average of 2.40 adverse events of CeVA in 1,531,713 adjustments or treatments (CeSAM)...'*

An area of ongoing confusion in the literature concerning cervical vascular accidents (CeVA) is the sheer number and inconsistency of acronyms used to describe both vascular events and anatomical regions. (1) The terminology must be standardised to improve reporting accuracy and minimise misclassification errors. Frequently, only serious adverse events are reported, and these are often inappropriately generalised to all forms of spinal manipulation, thereby linking the chiropractic profession to cases where the intervention was not performed by a chiropractor. (2) This issue is compounded by the tendency of many authors to refer to all forms of spinal manipulation as "chiropractic adjustments," even when delivered by other healthcare providers.

Tuchin (2012) (3) reviewed and replicated the paper by Ernst (2007), (4) who had called for a restriction on cervical spinal adjustment or manipulation (CeSAM) in the interest of patient safety, while also stating that the true incidence of cervical vascular accidents (CeVA) is unknown. Tuchin identified multiple errors and omissions in Ernst's work that significantly undermined the validity of the conclusions, particularly those implicating chiropractors in CeVA cases.

Rubinstein et al (2005) (5) conducted a systematic review and identified several additional risk factors associated with CeVA, including connective tissue disorders, migraines, recent infections, vascular abnormalities, and atherosclerosis. Manipulative therapy of the neck was included as a possible, but not exclusive, risk factor.

Numerous peer-reviewed publications have introduced a wide range of acronyms to describe different vascular accidents and cerebrovascular pathologies that may result in compromised blood flow to the brain. (6) These include, among others:

- Vertebral artery disease (VAD) (7)
- Vertebral artery occlusion (VAO) (8)
- Cervical artery dissection (CAD) (9)
- Cerebrovascular accident (CVA)
- Cerebrovascular artery dissection (CVAD or CAD)
- Cerebrovascular artery disease (CVAD or CAD)
- Cerebrovascular incident/injury (CVI)
- Vertebral artery incident/injury (VAI)
- Cranio-cervical dissection (CCD) (10)
- Internal carotid artery dissection (ICAD) (11)
- Cerebrovascular incident/injury (CVI) (12)

Given the breadth and inconsistency of these terms, it is unsurprising that many articles conflate these conditions and link them all to CeSAM. To aid clarity, Figures 1 and 2 in this paper differentiate these acronyms and align them with their respective anatomical structures, particularly the vertebral and carotid arteries and the Circle of Willis.

The vertebral arteries arise bilaterally from the subclavian arteries. On the right side, the subclavian artery branches from the brachiocephalic trunk, which itself arises from the aortic arch. On the left, the subclavian artery originates directly from the aorta, following the emergence

of the left common carotid artery. Each vertebral artery ascends through the cervical spine from the level of C6 to C1, entering the transverse foramen of C6 and continuing superiorly through the foramina of the cervical vertebrae. At the level of the foramen magnum, the left and right vertebral arteries converge to form the basilar artery, which subsequently contributes to the Circle of Willis.

Figure 1: The origin and course of the vertebral artery (VA) are mapped into four distinct segments that converge to form the circle of Willis. (Adapted from Theil (1991) (13), drawn by author NRN 2024)

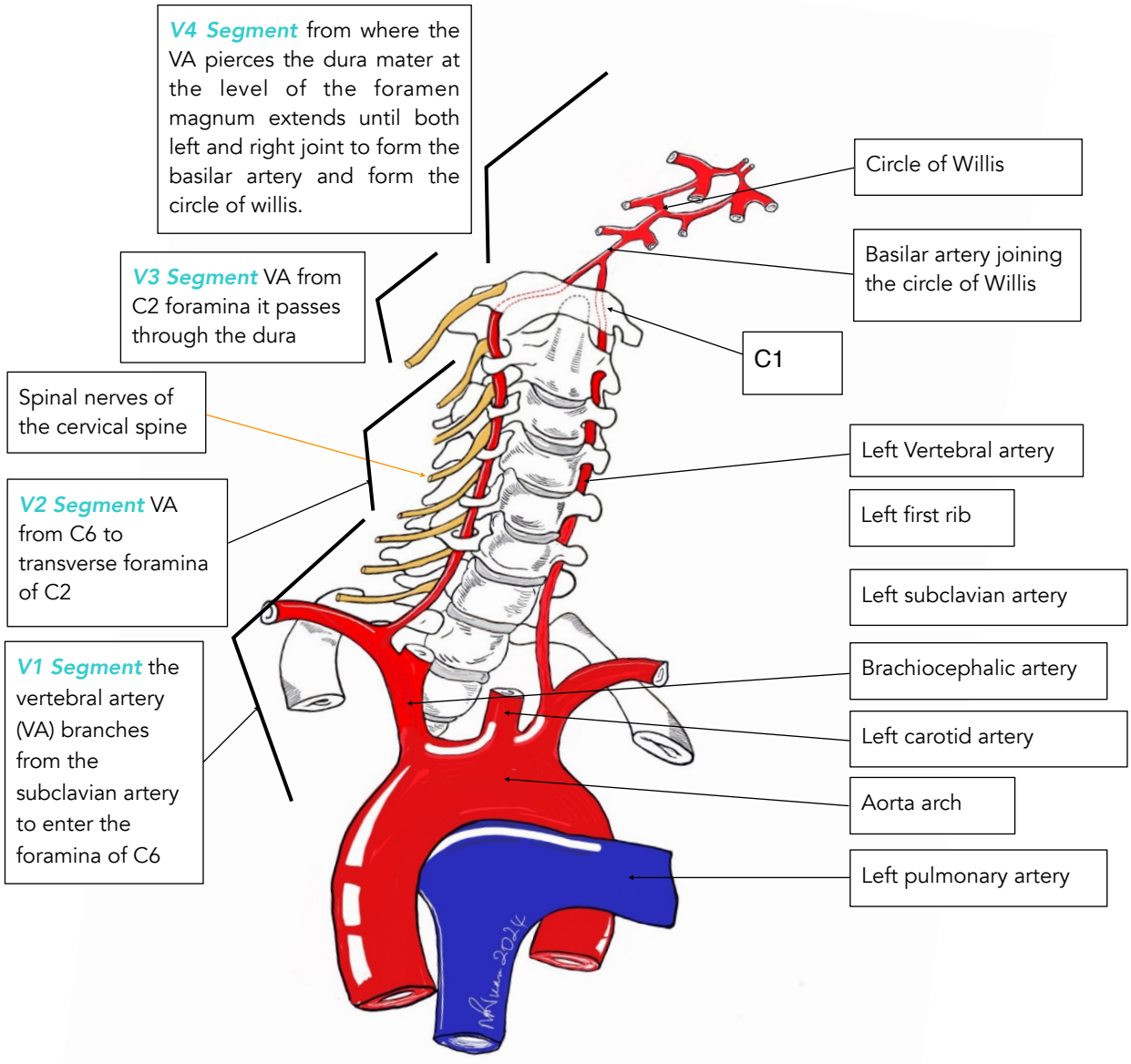


Figure 2: A summary of the acronyms and anatomical segmental location as seen in Figure 1, with four different segments. (Adapted from Sharma et al. (2019) (17) drawn by author NRN 2025

Segments V 1,2,3

Vertebral artery disease (VAD)

Vertebral artery disease can reduce or cut off the blood supply to the brain. (7)

Cranio cervical dissection (CCD) tears in one or more tissue layers that make up the Cranio cervical artery. (14)

Vertebral artery occlusion (VAO) (Bilateral **Vertebral Artery Occlusion,** which can occur after cervical Trauma. (8)

Vertebral artery dissection (VAD) (dissection is a tear in one or more tissue layers that make up the vertebral artery. (9)

Cervical or carotid artery dissection (CAD)

Cervical artery dissection or Cranio cervical dissection (CCD) occurs when there is a tear in a carotid or vertebral art.

Vertebral artery Incidence/injury (VAI) Blunt traumatic **vertebral injury** (VAI) is frequently associated with head and neck injury. (15)

Vertebral basilar artery insufficiency (VBAI) and Vertebrobasilar insufficiency (VBI) are defined by inadequate blood flow through the posterior circulation of the brain. (16)

Internal carotid artery dissection (ICAD) is defined as inadequate blood flow through the anterior circulation of the (11)

Segments V4

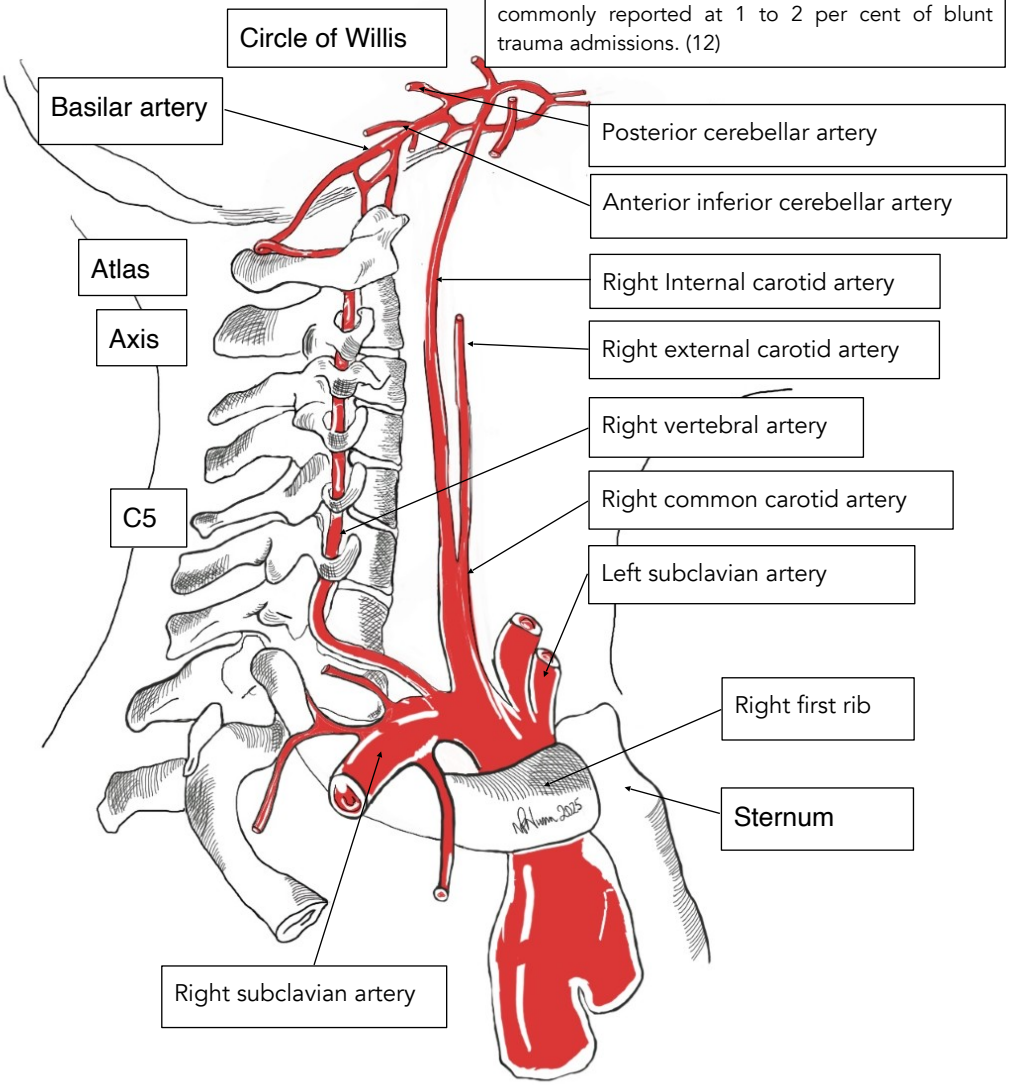
Cerebrovascular artery disease (CVAD, CAD)

Cerebrovascular disease affects blood flow in the blood vessels of the brain from stenosis or narrowing, clot formation causing artery blockage (embolism), or blood vessel rupture (haemorrhage), leading to an ischaemic stroke, mini-stroke, or hemorrhagic stroke. (7)

Cerebrovascular accident (CVA) occurs when there is a tear in a cerebral artery of the brain. (9)

Cerebrovascular artery dissection (CVAD, CAD) occurs when there is a tear in a cerebral artery of the brain. (9)

Cerebrovascular incidence/injury (CVI), the incidence of blunt cerebrovascular injury is commonly reported at 1 to 2 per cent of blunt trauma admissions. (12)



The vertebral artery is classically divided into four anatomical segments, designated V1 to V4. These segments are illustrated in Figure 1, with further discussion on their labelling and nomenclatural variation across the literature provided in Figure 2.

The segments are described as follows:

V1 – Pre-foraminal Segment (Extraosseous Segment)

This segment begins at the origin of the vertebral artery from the subclavian artery. It courses posteriorly through the scalene triangle, passing behind the common carotid artery, and enters the transverse foramen of C6.

V2 – Inter-foraminal Segment (Pars Transversaria)

The V2 segment extends from the transverse foramen of C6 to that of C2. It travels vertically through the transverse foramina of the cervical vertebrae, protected within a bony canal formed by these foramina.

V3 – Extradural Segment (Atlas Loop)

After emerging from the transverse foramen of C2, the vertebral artery curves laterally and posteriorly around the lateral mass of C1, then loops medially along the groove on the posterior arch of C1, pierces the posterior atlanto-occipital membrane, and passes through the spinal dura and arachnoid membranes. This segment is highly flexible, accommodating head rotation through its capacity to stretch, straighten, and bend.

V4 – Intradural Segment (Intracranial Segment)

As the vertebral artery ascends between the anteriorly placed atlanto-occipital joint capsule and the posterior atlanto-occipital membrane, it pierces the dura mater at the level of the foramen magnum. From this point, it enters the cranial cavity and continues intracranially until it unites with its contralateral counterpart to form the basilar artery. (13, 17)

Literature search

A comprehensive search of four databases; MEDLINE, CINAHL, EMBASE, and the Cochrane Library, was conducted up to February 2025 to identify literature reporting cervical vascular accidents (CeVA) associated with cervical spinal adjustment or manipulation for neck pain.

The initial selection was performed by the first reviewer (NRN). The second reviewer (SB) independently screened the same sources using the following MeSH terms:

> "cervical adjustment," "cervical manual therapy," and "cervical manipulation," linked with "cervical" or "carotid vascular accident," "CVA," "vertebral accident (VA)," or "vertebrobasilar accident." These terms were further cross-referenced with professional identifiers such as "chiropractor," "physiotherapist," "osteopath," and "medical practitioner," all within the context of treating the "cervical spine" for neck pain, stiffness, or unilateral headaches.

We included randomised controlled trials (RCTS), prospective or cross-sectional observational studies, and surveys, particularly those that drew a conclusion or gave a calculated ratio of CeVA to cervical adjustment or manipulation. The final resolution was reached through discussion with a third reviewer (AB) and a fourth reviewer (JH).

Many studies have demonstrated methodological weaknesses, including the inappropriate pooling of distinct vascular events, such as vertebral artery dissection (VAD) and internal carotid artery dissection (ICAD), with broader cerebrovascular accidents (CVAs), without specifying the onset, duration, or origin of the dissection. Additionally, several articles referred broadly to “manipulation” or “high-velocity, low-amplitude (HVLA) manoeuvres” without detailing the spinal level at which the intervention was performed. However, nearly all reviewed studies did specify

the professional background of the practitioner delivering the treatment. This information, along with the reported statistical ratio of CeVA incidents, is summarised in Table 1, presented in chronological order.

Table 1 presents in chronological order the Authors and statistical ratios of CeVA or strokes to cervical adjustments (CeSAM).

Date	**First Author**	**Title of paper**	**Practitioner CH -Chiropractor PT-Physiotherapist, OP -Osteopath PCP-Primary care provider MP-Manual therapist NS-not specified**	**Study design**	**Nomenclature used**	**RATIO estimation with other authors reviewed and cited, if recorded in the article**
1980	Jaskoviak (18)	Complications arising from manipulation of the cervical spine	CH OS PT PCP NS	Files at National College	Vertebrobasilar injuries	No VBI events reported between 1965-1980 (5 million adjustments)
1981	Robertson (19)	Neck Manipulation as a Cause of Stroke	NS	Editorial	brainstem ischemia, vascular dissecting aneurysm, or vascular dissection	No adverse events
1981	Hosek (20)	Editorial response to Cervical Manipulation	CH	National study for chiropractic visits with calculation on the assumption	Vertebrobasilar injuries	**Ratio** 1: 1,000,000
1985	Dvorak et al. (21)	How dangerous is the manipulation of the cervical spine?	CH	Survey of manual therapists	Brain stem ischaemia	**Ratio** 1:400,000
1987	Terrett (22)	Terrett AGJ. Vascular accidents from cervical spine manipulation: report on 107 cases.	CH	Case reports	Vascular accidents	**Ratio** 1.5-2: 1,000,000
1988	Henderson et al. (23)	Henderson DJ, Cassidy JD. Vertebral artery syndrome. In: Vernon H, ed. Upper cervical syndrome: chiropractic diagnosis and treatment. Baltimore: Williams & Wilkins, 1998:195-222.	CH	Files at CMCC	Cervical vascular accidents	No CeVA in 500,000 treatments
1991	Patijn (24)	Complications in manual medicine: A review of the literature	CH	Literature review	Vertebral Basilar Artery Complications	**Cited** 1:400,000 (Dvorak et al.) (21) **Ratio** 1:518,886
1991	Frisoni (25)	Vertebrobasilar Ischemia After Neck Motion	CH	Review	Vertebrobasilar ischemia	**Ratio** 1:400,000

1992	Haldeman et al. (26)	Guidelines for chiropractic quality assurance and practice parameters.	CH	Guidelines	Cerebrovascular Ischaemia Cerebrovascular accidents	**Ratio** 1:2,000,000
1993	Powell et al. (27)	A risk/benefit analysis of spinal manipulation therapy for relief of lumbar or cervical pain	CH	Review	Arterial injury or cerebrovascular accidents	**Ratio** 1:1,500,000
1993	Carey (28)	A report on the occurrence of cerebrovascular accidents in chiropractic practice	CH	Report	Cerebrovascular accidents	**Ratio** 1: 3.460,000-5,800,000 1:3,000,000
1993	Michaeli (29)	Reported occurrence and nature of complications following manipulative physiotherapy in South Africa	PT	Survey	Cerebrovascular accidents	No CeVA events for manipulation, but one recorded after mobilisation **Ratio** 1: 228,050
1994	Haynes et al. (30)	Stroke following cervical manipulation in Perth	CH	Systematic review	vertebrobasilar occlusive stroke. The	**Ratio** 5:100,000 over 5 years
1995	Lee et al. (31)	Neurologic complications following chiropractic manipulation: a survey of California neurologists	CH	Survey questionnaire	Vertebral artery dissection (VBD)	In the survey of neurologists, 21% of those responding reported a stroke following chiropractic procedures between 1990 and 1991. **Cited Terrett (22)** 1:500,000 from this paper.
1995	Dabbs et al. (32)	A risk assessment of cervical manipulation vs NSAIDS for the treatment of neck pain	CH	Literature review	Vertebrobasilar strokes	**Ratio** 20:2,000,000= 1: 100,000
1995	Haldeman et al. (33)	Unpredictability of Cerebrovascular Ischemia Associated With Cervical Spine Manipulation Therapy	CH	Retrospective review of 64 medicolegal records	Cerebrovascular Ischaemia	**Cited** 1: 400,000 (Dvorak et al.) (21) **Cited** 1: 3,850,000 (Carey) (28) 1.46: 1,000,000 **Ratio** 1:1,300,000
1996	Senstad et al. (34)	Predictors of side effects of spinal manipulative therapy	CH	Questionnaire	Cerebrovascular accidents	No CAD adverse events reported
1996	Klougart et al. (35)	Safety in Chiropractic Practice Part 1: The occurrence of cerebrovascular accidents after manipulation to the neck in Denmark from 1978-1988	CH	Survey	Cerebrovascular accidents	**Ratio** 1:1,300,000
1996	Assendelft et al. (36)	Complications of spinal manipulation. A comprehensive review of the literature	CH,	Literature review	Vertebrobasilar accidents	1:20,000 to 1: 1,000,000 <5:100,000
1996	Hurwitz et al. (37)	Manipulation and mobilisation of the cervical spine. A systematic review of the literature	PT, CH,	Systematic review of the literature	Vertebrobasilar accidents	**Cited** 1: 3,850,000 (Carey) (28)
1997	De Bray et al. (38)	Extracranial and intracranial vertebrobasilar dissections: diagnosis and prognosis	NS	survey	Extracranial and intracranial vertebrobasilar dissections	12% of VBA related to CeSAM

1997	Leboeuf-Yde et al. (39)	Side effects of chiropractic treatment: a prospective study	CH	Prospective interview survey	Cerebrovascular accident Cerebrovascular insult	**Cited** 1:100,000 (Dabbs et al.) (32) No CVA reported in this study
1998	Coulter (40)	Efficacy and Risks of Chiropractic Manipulation: What Does the Evidence Suggest?	CH	Survey	Vertebrobasilar accidents	**Ratio** 6. 39: 10,000,000
1999	Di Fabio (41)	Manipulation of the Cervical Spine: Risks and Benefits.	CH, MT, OP, NS, PCP	Review	Vertebrobasilar accidents	**Ratio** 1: 50,000 to 1: 5,000,000 **Cited** 6. 39: 10,000,000 (Coulter) (40)
1999	Vikers and Zollman (42)	The manipulative therapies: osteopathy and chiropractic	CH OS	Guideline review	strokes	**Ratio** 1:20,000 to 1: 1,000,000
2000	Norris et al. (43)	Sudden neck movement and cervical artery dissection	CH	Prospective survey	Cervical artery dissection	Stroke resulting from neck manipulation occurred in 28%
2000	Barret and Breen (44)	The adverse effects of spinal manipulation	CH	Questionnaire	Not acknowledged	No CeVA adverse events
2000	Saeed et al. (45)	Vertebral artery dissection: Warning symptoms, clinical features and prognosis in 26 patients	CH	Retrospective analysis of hospital records	Vertebrobasilar dissection	**Cited** 1:20,000 (Assendelft et al.) (36)
2000	Dunne et al. (46)	Neurological complications after spinal manipulation: a regional survey. Proceedings of the 7th Scientific Conference of the International Federation of Orthopaedic Manipulative Therapists.	PCP MP	Regional survey	Vertebral artery dissections	**Ratio** 1:4,500
2001	Haldeman et al. (47)	Arterial dissections following cervical manipulation: the chiropractic experience	CH	Review of malpractice data from the Canadian Chiropractic Protective Association	Vertebral artery dissections	**Ratio** 1: 5,850,000
2001	Mann and Refshauge (48)	Causes of complications from cervical spine manipulation	PT, CH	Review guideline	Vertebral artery dissections	**Cited** 1:20,000 (Vikers and Zollman (42) **Cited** 1: 1,000,000(Vikers and Zollman (42) **Cited** 1:4,500 (Dunne et al.) (46)
2001	Rothwell et al. (49)	Chiropractic manipulation and stroke: A population-based case-control study	CH, PT, OP, NS, PCP	Population-based case-control study	Stroke	**Cited** 1:1,300,000 (Klougart et al.) (35) **Cited** 1:400,000 (Dvorak et al.) (21) **Ratio 1.3: 100,000**
2001	Cohn (50)	A review of the literature regarding stroke and chiropractic.	CH	Review	strokes	8: 1,000,000

2001	Stevinson et al. (51)	Neurological complications of cervical spine manipulation	CH	Survey	Cerebrovascular accidents Stroke	**Cited** 1-3: 1,000,000 (Dabbs et al.,) (32) **Cited** 1: 300,000 (Michaeli) (29) **Cited** 5:100,000 (Hayes et al.) (30) **Cited** 1: 1,300,000 (Klougart et al. (35) **Ratio 1:2,000,000**
2002	Haldeman et al. (52)	Unpredictability of Cerebrovascular Ischemia Associated With Cervical Spine Manipulation Therapy: A review of sixty-four cases after spine manipulation	CH	Retrospective review of 64 medicolegal records	Cerebrovascular Ischaemia	**Cited** 1 in 400,000 (Dvorak et al.) (21) **Cited** 1 in 3.850,000(Carey) (28) **Cited** 1 1.300,000 (Klougart et al.) (35) **Ratio** 1.46 per 1,000,000
2002	Haldeman et al. (53)	Clinical perceptions of the risk of vertebral artery dissection after cervical manipulation	CH	Retrospective review of cases	Vertebral artery dissection	1: 5,846,381
2002	Ernst (54)	Manipulation of the cervical spine: a systematic review of case reports of serious adverse events, 1995–2001	CH, PT, OP, NS, PCP	Systematic review of evidence from case reports	Vascular accidents	12% of VBA follow cervical spine manipulations
2003	Beletsky et al. (55)	Cervical arterial dissection: time for a therapeutic trial?	CH PT	Prospectively enrolled consecutively referred patients with angiographically proven acute vertebral or carotid arterial dissection.	Cervical arterial dissection	Dissection after neck manipulation was observed in 20 out of 116 patients, and no ratio was given.
2003	Smith et al. (56)	Spinal manipulative therapy is an independent risk factor for vertebral artery dissection.	CH	Case-control study design	Vertebral artery dissection	This study found a strong relationship between recent SMT and vertebral artery dissection. No Statistical ratio due to the data pool
2003	Dziewas et al. (57)	Cervical artery dissection - clinical features, risk factors, therapy, and outcome in 126 patients	CH	Retrospective standardized interview	Cervical artery dissection	16% of patients who presented over a 10-year period
2003	Haneline et al. (58)	Association of internal carotid artery dissection and chiropractic manipulation	CH	Retrospective review	Internal carotid artery dissection	**Cited** 1,00,000 Hurwitz et al (37) **Ratio** 1:601,145,000
2004	Brontfort et al. (59)	Efficacy of spinal manipulation and mobilisation for low back pain and neck pain: a systematic review and best evidence synthesis	CH PCP	Systematic review	cerebrovascular complication	**Cited** 1.5-2: 1,000,000 (Terrett) (22)
2004	Caigne et al. (60)	How common are the side effects of spinal manipulation, and can these side effects be predicted?	CH, PT, OP	Prospective survey	cerebrovascular accidents	No CAD adverse events

2004	Gross et al. (61)	A Cochrane Review of Manipulation and Mobilisation for Mechanical Neck Disorders	CH PCP	Systematic review of randomised trials	Adverse events	**Cited** 1: 1,000,000 (Assendelft et al.) (36) **Ratio** 1: 1.300,000 to 5:1,000,000.
2004	Magarey et al. (62)	Pre-manipulative testing of the cervical spine review, revision and new clinical guidelines	PT	Survey	vertebral artery dissection	No CAD adverse events were reported But estimates 1:50,000
2005	Thanvi et al. (63)	Carotid and vertebral artery dissection syndromes.	CH	The background incidence of CVA, which is 20% of strokes in those aged <45	Carotid and vertebral artery dissection	2: 100,000 No clear history
2005	Terrett (64)	Terrett AGJ, Kleynhans AM. Cerebrovascular complications of manipulation. In: Haldeman S, editor. Principles and practice of chiropractic. 3rd edition	CH	Chapter in book, pages 1149-1164. Haldeman S, editor. Principles and practice of chiropractic. 3rd edition	cervicocerebral artery (vertebrobasilar and carotid) stroke syndromes (cerebrovascular accidents [CVAs]) or stroke-like cerebrovascular incidents (CVIs)	**Cited** 1: 400,000 (Dvorak et al.) (21) **Cited** 1: 3.850,000(Carey) (28) **Cited** 1: 1,300,000 (Klougart et al.) (35) **Cited** 1.3: 100,000 (Rothwell et al.) (49) **Cited** 1: 1: 5,850,000 (Haldeman et al.) (47) **Cited** 1:2,000,000 (Dabbs et al.) (32) but should be 1:100,000 **Cited** 1:500,000 (Lee et al.) (31), so the ratio given in this paper
2006	Dittrich et al. (65)	Mild mechanical traumas are possible risk factors for cervical artery dissection.	NS	Prospective case-controlled study	Cervical artery dissection	No association between CeSAM as a risk factor and CAD
2007	Garner et al. (66)	Chiropractic care of musculoskeletal disorders in a unique population within the Canadian community health centres	CH	Pragmatic study	Non labelled	No adverse events during the study period
2007	Ernst (67)	Adverse effects of spinal manipulation: a systematic review	OS PT PCP CH	Systematic review	Vertebral artery dissection, vascular accident, stroke	**Cited** 6.39:10,000,000 (40)
2007	Theil et al. (68)	Safety of Chiropractic Manipulation of the Cervical Spine: A Prospective National Survey	CH	Prospective National Survey	Serious adverse event	No serious adverse events **Cited** 1: 300,000 Michaeli (29) **Cited** 1.46: 1,000,000 (Haldeman) (33) **Cited** 1.3: 100,000 (Rothwell) (49)

2008	Rubinstein et al. (69)	Benign adverse events following chiropractic care for neck pain are associated with worse short-term outcomes but not worse outcomes at three months	CH	Prospective, multicentre, observational cohort study	Adverse event	No CAD adverse events
2008	Cassidy et al. (70)	Risk of vertebrobasilar stroke and chiropractic care: results of a population-based case-control and case-crossover study	CH	Population-based case-control and crossover study	Vertebrobasilar artery stroke	No evidence of excess risk of VBA with chiropractic care
2008	Miley et al., (71)	The safety of chiropractic manipulation of the cervical spine: a prospective national survey	CH	Prospective national survey	Vertebral artery dissection	**Ratio** 1.3: 100,000
2009	Kerry et al. (72)	Cervical arterial dysfunction: knowledge and reasoning for manual physical therapists.	PT	Clinical Commentary	Cervical arterial dysfunction	Non given
2009	Gouveia et al., (73)	Safety of chiropractic interventions: A systematic review	CH	Systematic review	strokes	**Ratio** 5:100,000 **Cited** 1.46:10,000,000 (Haldeman) (33) **Cited** 1:518,886 (Patijn) (24) **Cited** 1:1,000,00 (Leboeuf-Yde et al.) (39) from Dabbs et al.) (32) which is 1:100,000
2009	Boyle et al. (74).	Examining vertebrobasilar artery stroke in two Canadian provinces	CH	Ecological study.	Vertebrobasilar artery (VBA) stroke	VBA stroke does not seem to be associated with an increase in the rate of chiropractic utilisation.
2010	Carnes (75)	Adverse events and manual therapy: A systematic review	CH PCP	Systematic review	Cervical artery dissection stroke	The risk of major adverse events with manual therapy is low
2010	Carlesso et al. (76)	Adverse events associated with the use of cervical manipulation and mobilisation for the treatment of neck pain in adults: A systematic review	CH, PT, OP	Systematic review	Strokes	**Cited** 1: 2,000,000 (Stevenson) (51), but stated the calculation method is often flawed. **Ratio** 1:100,000
2010	Murphy et al. (77)	Does case misclassification threaten the validity of studies investigating the relationship between neck manipulation and vertebral artery dissection stroke?	CH	Review of case-control study	Cervical and Vertebral Artery Dissection	The relationship between CMT (CeSAM) and VAD (CeVA) is not causal.
2010	Ernst (78)	Vascular accidents after neck manipulation. Cause or coincidence	CH, PCP	Review Des Moines: National Chiropractic Mutual Insurance Company, 1996.	Vascular accidents	**Cited** 1: 40,000 (Terrett) (22) **Ratio** 1:1,000,000
2011	Anders et al. (79)	Safety of Cervical Manipulation: Are Adverse Events Preventable and Are Manipulations Being Performed Appropriately?	PT CH PCP NS	Retrospective review	Cerebrovascular accidents	**Cited** 1: 50,000 (Magarey et al.) (62) **Cited** 1:2,000,000 but should read 1: 5,850,000 Haldeman et al. (53)

2012	Tuchin (3)	A replication of the study 'Adverse effects of spinal manipulation: a systematic review.'	CH	S y s t e m a t i c review	vertebral artery dissection vascular accident stroke	Making conclusions regarding causality from any case study or multiple case studies is unwise. The number of errors or omissions in the Ernst (2007) paper significantly limits any reported conclusions. The quality of the 2007 paper does not add to the understanding of whether there is any link between SMT (CeSAM) and VAD (CeVA).
2013	Tuchin (80)	Chiropractic and Stroke: Association or Causation	CH	Review	stroke	**Cited** 1: 400,000 (Dvorak et al.) (21) **Cited** 1: 5,600,000 Haldeman et al. (47)
2013	Wynd et al. (81)	The Quality of Reports on Cervical Arterial Dissection Following Cervical Spinal Manipulation	CH	Systematically collect and synthesise	Cervical artery dissection Common carotid, internal carotid, vertebral, or vertebrobasilar, stroke	Association possible, no stats given
2013	Engelter et al. (82)	Cervical Artery Dissection and Ischemic Stroke Patients Study Group. Cervical artery dissection: trauma and other potential mechanical trigger events	NS	Multi-centre case-control study	Cervical artery dissection	Not given
2014	Biller et al. (83)	Cervical arterial dissections and association with cervical manipulative therapy. A Statement for Healthcare Professionals From the American Heart Association/American Stroke Association	CH MT OP PT	Questionnaire	Cervical artery dissection CAD or CD	Unclear whether this is due to a lack of recognition of preexisting CeVA in these patients or due to trauma caused by CeSAM
2015	Chung et al. (84)	The association between cervical spine manipulation and carotid artery dissection: A systematic review of the literature	CH	Lit review for internal carotid artery dissection	carotid artery dissection	The incidence of carotid artery dissection after cervical spine manipulation is unknown
2016	Vaughan et al. (85)	Manual therapy and cervical artery dysfunction: identification of potential risk factors in clinical encounters	OS	Review	cervical artery dysfunction	**Cited** 2.6 persons per 100,000 (Smith et al.) (56). But no Statistical ratio was given, so the origin of the ratio is not known

2017	Neilson et al. (86)	The risk associated with spinal manipulation: an overview of reviews	CH MT OP PT	Review	Vertebrobasilar dissection strokes	Stroke **Ratio** 1: 200,000–2,000,000 Vertebrobasilar accident **Ratio** 1: 228,050–1,000,000 Cerebrovascular accident **Ratio** 1:228,050–3,850,000
2017	Cassidy et al. (87)	Risk of Carotid Stroke after Chiropractic Care: A Population-Based Case-Crossover Study	CH PCP	Population-Based Case-Crossover Study	Carotid Stroke	Non given
2017	Kranenberg et al. (88)	Adverse events associated with the use of cervical spine manipulation or mobilisation and patient characteristics: a systematic review	CH	Systematic review	Cervical arterial dissection	**Cited** 2.6-2.9:100.000 (Lee et al.) (31) who stated, 21% of neurologists responding But gave no ratio of 1:500,000, but this was cited in Terrett (2005) (22)
2022	Whedon et al. (89)	The association between cervical artery dissection and spinal manipulation among US adults.	CH	A case-control study with matched control	Cervical arterial dissection	No adverse events
2023	Gorrell et al. (90)	Reporting of adverse events associated with spinal manipulation in randomised clinical trials: an updated systematic review.	CH PCP PT OP MT	Systematic review	cervical artery dysfunction	No Adverse events
2023	Chu et al. (91)	A retrospective analysis of the incidence of severe adverse events among recipients of chiropractic spinal manipulative therapy	CH OP MT, Chuna	Retrospective analysis	Adverse events	No Adverse events were identified that were life-threatening or resulted in death.
2023	Rushton et al. (92)	International Framework for Examination of the Cervical Region for Potential of Vascular Pathologies of the Neck Prior to Musculoskeletal Intervention: International IFOMPT Cervical Framework	PT MT	Guidelines	Vascular pathology	**Cited** 0.4:100,000 5:100,000 (Neilson et al.) (86) **Ratio** 0.79: 100,000
2024	Pankrath et al. (93)	Adverse Events After Cervical Spinal Manipulation - A Systematic Review and Meta-Analysis of Randomised Clinical Trials	PT CH OP	Systematic Review and Meta-analysis of Randomised Clinical Trials	strokes in the vertebrobasilar or carotid artery	No serious Adverse events were detected following HVLA manipulations in the studies, no conclusion can be drawn about the causal association between cervical manipulation and serious AEs.

Results

A total of 3,818 articles were correlated with the MESH terms (see Appendices 1 and 2). Using the combined identification that linked the two CeVA and CeSAM in all their combinations, 2385 articles were rejected because they were either duplicated, or cervical vascular accident was linked to other types of treatments or connective tissue disorders or did not involve both cervical vascular accident and adjustment, or manipulation in the body of the text or was performed on animals. A total of seventy-seven studies met the criteria. (see Appendix 1 and 2)

Seventy-seven articles that matched the criteria, including 13 surveys, 16 systematic reviews, nineteen retrospective reviews, nine prospective studies (including an observational cohort study), six case control studies (of which 1 was a case study), five literature reviews, two population-based studies, a pragmatic study and an ecological study, two clinical commentaries and three editorial guidelines. No randomised control studies were found. No definitive conclusions can be drawn due to the small number of studies, with weak calculated associations, moderate study quality, and notable ascertainment bias.

From the 77 studies, only 32 calculated a ratio of CeVA to CeSAM, ranging from 1:4500 to 6:39:10,000,000. Many studies used existing ratios from previously published peer-reviewed papers.

The most frequently cited authors were Dvorak et al. (1985) (21) with a ratio of 1:400,000 and Dabbs et al. (1995) (32) with a ratio of 1:100,000, both of whom were cited six times. Assendelft et al. (1996) (36) with a ratio of 1:20,000, Carey (1993) (28) with a ratio of 1:3,850,000, and Klougart et al. (1996) (35) with a ratio of 1:1,300,000 were all cited four times. Lastly, Coulter (1998) (40), with a ratio of 6.39:10,000,000, was cited three times. All others were used less than twice.

- A total of 19 articles (18, 21, 22, 25, 26, 27, 28, 30, 32, 35, 36, 40, 42, 46, 47, 50, 62, 71, 86), presented a clear calculated ratio of CeVA to CeSAM, which was supported by a further 13 (24, 33, 41, 49, 51, 52, 53, 58, 61, 73, 76, 78, 92) articles that also calculated a ratio, citing other the previous authors
- A total of 15 articles (18, 19, 23, 34, 44, 60, 65, 69, 70, 74, 77, 89, 90, 91, 93) found no adverse events and provided no ratio
- Seven articles (31, 38, 43, 54, 55, 57, 66) reported only the percentage of adverse events among the study participants.
- Eight authors (37, 45, 48, 59, 63, 67, 79, 88) only cited authors who had made ratio calculations.
- Four authors (39, 68, 80, 85) reported no association but cited others who had calculated the ratio.
- Nine authors (3, 56, 72, 75, 81, 82, 83, 84, 87) used wording to classify such as ‘strong relationship’, ‘low’, ‘unknown’, and ‘unclear’.
- One author, Michaeli (1993) (29), reported no association between CeSAM and CeVA, but recorded a ratio of 1:228 050 which was the total number of manipulations but not mobilisations between 1971 and 1989 and one, Magarey et al. (2004) (62), who reported no adverse effect as very low, but cited a ratio of 1:50,000.

Table 2: Studies that calculated a ratio from adverse events and those that found no adverse events.

Studies parameters	Authors	Range	
Those studies that calculated a ratio	Jaskoviak 1980 (18) Dvorak et al. 1985 (21), Terrett 1987 (22), Frisoni 1991 (25), Haldeman 1992 (26), Powell et al. 1993 (27), Carey 1993 (28), Haynes et al. 1994 (30), Dabbs et al. 1995 (32), Klougart et al. 1996 (35), Assendelft et al. 1996 (36), Coulter (40), Vikers and Zollman1999 (42), Dunne et al. 2000 (46), Haldeman et al. 2001 (47), Cohn 2001 (50), Thanvi et al. 2005 (63), Miley et al. 2008 (71), Neilson et al. 2017 (86)	1:4,500 to 6. 39: 10,000,000	19
Those who calculated a ratio but also cited other authors	Patijn 1991 (24), Haldeman et al. 1995 (33), Di Fabio 1999 (41), Rothwell et al. 2001 (49), Stevinson et al. 2001 (51), Haldeman et al. 2002 (52), Haldeman et al. 2002 (53), Haneline et al. 2003 (58), Gross et al. 2004 (61), Gouveia et al. 2009 (73), Carlesso et al. 2010 (76), Ernst 2010 (78) Ruston et al. 2023 (92)	These authors cited the ratio of other authors but also calculated their own ratio From 1:20,000 to 1: 2,000,000	13
Those who experienced no adverse events but gave a ratio	Magarey et al. 2004 (62)	But estimates 1:50,000	1
Those who gave a percentage	Lee et al. 1995 (31), De Bray et al. 1997 (38), Norris et al. 2000 (43), Ernst 2002 (54), Beletsky et al. 2003 (55), Dziewas et al. 2003 (57), Garner et al. 2007 (66)	A percentage was applied, but only to the cases that took place	7
Those who found no adverse events and no ratio	Jaskoviak 1980 (18), Robertson 1981 (19), Henderson et al. 1988 (23), Senstad et al. 1996 (34), Barret and Breen 2000 (44), Caigne et al. 2004 (60), Dittrich et al. 2006 (65), Rubinstein et al. 2008 (69), Cassidy et al. 2008 (70), Boyle et al. 2009 (74), Murphy et al. 2016 (77), Whedon et al. 2023 (89), Gorrell et al. 2023 (90), Chu et al. 2023 (91), Pankrath et al. 2024 (93)		15
Those who reported a ratio, but also stated there was no association	Michaeli 1993 (29)	No CeVA but recorded a ratio of 1:228 050	1
Those who only cited other authors	Hurwitz et al. 1996 (37), Saeed et al. 2000 (45), Mann and Refshauge 2001 (48), Brontfort et al. 2004 (59), Terrette 2005 (63), Ernst 2007 (67), Anders et al. 2011 (79), Kranenberg et al. 2017 (88)	All cited other authors' ratio	8
Those who reported no ratio as there was no association, but also cited other authors	Leboeuf-Yde et al. 1997 (39), Theil et al. 2007 (68), Tuchin 2013 (80), Vaughan et al. 2016 (85)	No association, but cited other authors' ratio	4
Wording: a strong relationship or positive, none given or low or unclear or unknown	Tuchin 2012 (3), Smith et al. 2003 (56), Kerry et al. 2009 (72), Carnes et al. 2010 (75), Wynd et al. 2013 (81), Engelter et al. 2013 (82), Biller et al. 2014 (83), Chung et al. 2015 (84), Cassidy et al. 2017 (87)	Used wording and gave no ratios	9

Table 3: Only studies that calculated a ratio for CeVA to CeSAM. Using the highest published figure for adverse events, along with the lowest published figure for the number of treatments.

Author	Ratio of Adverse events	Number of treatments
Jaskoviak 1980 (18)	5:	1,000,000
Dvorak et al. 1985 (21)	1:	400,000
Terrett 1987 (22)	1.5-2:	1,000,000
Frisoni 1991 (25)	1:	400,000
Haldeman 1992 (26)	1:	2,000,000
Powell et al. 1993 (27)	1:	1,500,000
Carey 1993 (28)	1:	3,000,000
Haynes et al. 1994 (30)	5:	100,000
Dabbs et al. 1995 (32)	1:	100,000
Klougart et al. 1996 (35)	1:	1,300,000
Assendelft et al. 1996 (36)	5:	100,000
Coulter (40)	6. 39:	10,000,000
Vikers and Zollman1999 (42)	1:	20,000
Dunne et al. 2000 (46)	1:	4,500
Haldeman et al. 2001 (47)	1:	5,850,000
Cohn 2001 (50)	8:	1,000,000
Thanvi et al. 2005 (63)	2:	100,000
Miley et al. 2008 (71)	1.3:	100,000
Neilson et al. 2017 (86)	1:	228,050
Average	2.40	1,531,713

Table 4: Studies that calculated a ratio for CeVA to CeSAM and cited other authors' ratios.

Author	Ratio of Adverse events	Number of treatments
Patijn 1991 (24)	1:	518,886
Haldeman et al. 1995 (33)	1:	300,000
Di Fabio 1999 (41)	1:	50,000
Rothwell et al. 2001 (49)	1.3:	100,000
Stevinson et al. 2001 (51)	1:	2,000,000
Haldeman et al. 2002 (52)	1.46:	1,000,000
Haldeman et al. 2002 (53)	1:	5,846,381
Haneline et al. 2003 (58)	1:	601,145,000
Gross et al. 2004 (61)	1:	300,000
Gouveia et al. 2009 (73)	1:	20,000
Carlesso et al. 2010 (76)	1:	100,000
Ernst 2010 (78)	1:	1,000,000
Ruston et al. 2023 (92)	1:	100,000
Average	1.06	47,113,867
Haneline et al removed	1.06	944,606
Combined	1.88	1,304,446

Discussion

A review of Tables 1, 3, and 4 shows a vast range of ratios, from the most conservative calculation of 1 in 4,500 (46) to a ratio of 6.39:10,000,000 (40). Haldeman et al. (2001) (47) initially reported a ratio of 1:5.8 million and then revised this to 1.46:1,000,000 in 2002 (52, 53). Gouveia et al. (2009) (73) provided a range of 5:100,000 to 1.46:1 million, based on data from Haldeman et al. (2002) (52).

> Collating all the data provided by the 19 authors who calculated a ratio yielded an average of 2.40 adverse events of CeVA in 1,531,713 adjustments or treatments (CeSAM) (Table 3)

Including the ratios with other citations in Table 4, the figure is 1.06: 47,113,867; however, with Haneline et al. removed, the figure is 1.06: 944,606. A combined average of both gives Table 3 and Table 4, gives a value of 1.88: 1,304,446, excluding the data from Haneline et al. (2003).

Reviewing the ratio of CeVA and CeSAM revealed that the majority calculated a ratio based on the association between CeVA and cervical spine adjustment or manipulation; however, many quoted the work of other authors, which made providing a ratio challenging. Ratios have not decreased significantly despite the increasing availability of papers in the form of case studies over the years. (90, 91, 92, 93) Clark et al (2022) (94) and Lucas et al (1998) (95) showed an annual incidence of spontaneous carotid-artery dissection ranging from 2 to 3 per 100,000. Spontaneous vertebral artery dissection can be estimated at 1 to 1.5 per 100,000. Notably, the data presented in Tables 3 and 4 indicate a combined incidence of 1.88 per 1,304,446, underscoring the rarity of VBAI when compared to the already uncommon carotid and vertebral artery dissection. This highlights the need for heightened awareness and understanding of these serious vascular conditions.

Apart from the most common modifiable risk factors such as high blood pressure, high cholesterol, obesity, type 2 diabetes, oral contraceptives, poor diet, and excess alcohol, smoking, discussed by Triano et al (2006), (96) and listed age <45, sudden severe neck or head pain, dizziness or vertigo, polycystic kidney disease, connective tissue disorders, fibromuscular dystrophy and recent infection of the upper respiratory tract as high-risk non-modifiable factor. (96) A review of the ratios in the literature associating CeSAM with CeVA, the lowest published ratio or average of CeVA and CeSAM appears to be equivalent to the background incidence of spontaneous vertebral artery dissection or carotid artery dissection. Tuchin (2024) (97) reviewed the relationship between vertebral arterial dissection (VAD) and massage therapy, concluding that the risk of VAD after Chiropractic adjustments was no greater than that of other professions involved in neck treatments. However, the literature appears to have a vast statistical variation with no consensus. Many articles describe the association between CeVA and CeSAM, but there is a lack of articles on best practices for practitioners identifying CeVA and making appropriate referrals. To date, the argument has been one-sided, with only two articles found that present the positive aspect of seeing a Chiropractor, showing that if a CeVA is suspected, the patient is not treated but referred to the appropriate medical service. (100, 101)

So, why does the peer-reviewed literature not present a balanced view showing best practices?

Are primary contact practitioners able to identify patients presenting with a pending cervical vascular dissection? This was reviewed in detail by Ruston et al (2023) (92), who discussed clinical reasoning and shared decision-making with the associated risk of orthopaedic manual therapy (OMT) (92, 98), as noted by Chaibi and Russell (2019). (99) explained that injuries can occur in three ways.

1. Firstly, the injury may be purely coincidental, given its close temporal relationship.
2. Secondly, injuries may be iatrogenic, causing trauma to a typical or susceptible arterial wall, producing thrombosis and/or embolisation.
3. Thirdly, some patients may be vulnerable to arterial dissection because of hypermobility or a pre-existing pathology. (99)

Thomas (2016) (100) conducted a review of CeAD injuries and concluded that four possible mechanisms are consistent with the second point made by Chaibi and Russell (2019). (99) The force of cervical adjustments or manipulation can damage the arterial wall:

1. Existing damage to a blood vessel may cause an embolism to detach with an adjustment.
2. The position of the artery during the adjustment could alter blood flow to the brain.
3. The adjustment may cause arterial vasospasm, which alters blood flow.

Symons et al. (2002) (158) tested the strain required to damage the vertebral artery in cadavers. They concluded that a typical force from an adjustment is unlikely to cause mechanical damage to the vertebral artery under normal circumstances. Moser et al. (2019) (102) and Norris et al (2000) (43) reported that the stretch of the vertebral artery in the upper cervical spine at end-range rotation for mobilisation, adjusting, or manipulative techniques can reduce, but not occlude, the blood flow in the vertebral artery on the side opposite the direction of rotation. This was substantiated by Saeed et al (2000), (45) who found that 53% of their patients who presented with signs and symptoms of vascular dissection had been involved with either sports activity or Chiropractic manipulation before their onset. Both sports and Chiropractic were combined, and they concluded that the ongoing dissection was exacerbated because the warning signs were not recognised (Saeed et al, 2000). (45)

The body can compensate for the flow to the brain because four vessels enter the Circle of Willis. (103) (see Figures 1 and 2) Supported by Erhardt et al. (2015) (104) and Quesnele et al (2014)l (105) who found that head position and upper neck manipulation do not significantly affect blood flow in vertebral arteries leading into the Circle of Willis. The weak link occurs when more than one artery is not functioning, leading to a disrupted flow to the Circle of Willis, or the artery is already dissecting, and the adjustment propagates emboli, resulting in ischaemia and VBAI. (90)

Turner et al (2018). (106) stated that osteopaths and physiotherapists are inexperienced in detecting the signs and symptoms of a dissection. However, Futch et al (2015) (107) and Kier et al (2006), (108) found in their case reports that a vascular examination, supported by qualified Chiropractors or those in Chiropractic educational establishments under supervision, recognises the underlying signs and symptoms of a CeVA and refers the patient if they suspect a vascular accident is occurring. (109) In the presence of a new headache that has never been experienced, an accurate history of past medical conditions is important, particularly those linked to connective tissue disorders. (110) Bilateral blood pressure measurement will indicate atherosclerotic risk factors, pulse rate for atrial fibrillation, cranial nerve examination, cerebellar signs for facial symptoms, balance, and coordination covering the **d**iplopia, **d**ysphagia, **d**ysarthria, **d**rop attacks, **d**izziness, **a**taxia, **n**ausea, **n**umbness, and **n**ystagmus, known as '5D, 1A and 3 N'. (107, 108, 111, 112, 113, 114)

Finally, consent is not a one-time process; it is an ongoing process that should be obtained at the point of all treatment to ensure that the patient can agree to withdraw from treatment at any time. Ioannidis et al (2004) reported that there should be better reporting of adverse effects. (115) However, there should also be better reporting of best practices, and we encourage those who have identified patients with CeVA to report them. (116) Many acronyms are related to both the neck arteries and the brain's cerebral systems, leading to considerable confusion in the current literature. Most primary care practitioners involved in treating the cervical spine are unsure or confused, but they acknowledge an association. (86) However, there is an assumption that there is no conclusive proof of CeVAs due to cervical manipulation. (108)

The evidence indicates no strong association between cervical spine adjustments and CeVA performed by a primary contact practitioner. (30, 86, 94) Cervical vascular accidents involving carotid and vertebral arteries are rare but serious. We must prioritise addressing our patients' safety, demonstrating our professionalism through appropriate diagnostic support for early recognition, and enhancing our reputation among other professionals applying the legal precedents in 2015 in the UK (117, 118, 119).

Conclusion

This paper reviews the current body of knowledge on Cervical Arterial Vascular Abnormalities (CeVA) related to CeSAM, clarifying their classifications and associated nomenclature. Currently, the evidence is weak for an association between CeSAM and CeVA, and the available data suggest no causal effect from CeSAM. It has addressed the ongoing ambiguity surrounding the ratios of CeVA to CeSAM, a point of contention noted by numerous authors, while acknowledging that recent legal precedents in the UK in 2015 have rendered much of the argument for association and causation academically obsolete.

Nevertheless, the ethical obligation to inform remains paramount. All available information must be communicated to patients, enabling them to make well-informed choices, particularly those presenting signs suggestive of CeVA using the current data.

We advocate for the continued reporting of such cases through reflective, case-based discussions within the literature, including both positive and negative outcomes. This contribution helps balance the prevailing narrative and offers tangible guidance for clinicians involved in CeSAM, reinforcing the responsibility to recognise, act appropriately, and refer with clinical diligence.

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Competing interests

The authors declare no potential conflicts of interest concerning research, authorship and/or publication of this article.

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Abbreviations

CAD: Cervical artery dissection

CeVA: Cervical vascular accident

CeSAM: Cervical spine adjustment or manipulation

CD: Cervical arterial dissection

CMT: Cervical manipulative therapy

CVT: Cerebral venous thrombosis

CVAD or CAD: Cerebrovascular artery disease /dissection

CVI: Cerebrovascular incidence/injury

CCD: cranio-cervical dissection

CVA: Cerebrovascular accident

CCD: Cranio-cervical dissection

ICAD: Internal carotid artery dissection

PCP: Primary contact practitioner

VAI: Vertebral artery Incidence/injury

VBAI: Vertebral basilar artery insufficient

VA: vertebral artery

VAD: Vertebral arterial dissection

VAO: Vertebral artery occlusion

PMHx, Past medical history

FHx, Family medical history

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Appendix 1

Key terms used in searches

Database	Search terms	Returns
PubMed	(((Cervical vascular accidents [MeSH Terms]) OR (Vertebro basilar accident)) OR (carotid vascular accident)) AND ((Chiropractic manipulation [MeSH Terms]) OR (Osteopathic manipulation) OR (Physiotherapy manipulation) AND (cervical chiropractic adjustment [MeSH Terms]) OR (manual therapy)))	1695
Cochrane	(((Cervical vascular accidents) or (Vertebro basilar accident) OR (carotid vascular accident)) AND ((spinal manipulation) or (Chiropractic manipulation [MeSH descriptor]) OR (Physiotherapy manipulation) Or (Osteopathic Manipulations) OR (cervical chiropractic adjustment)))	1141
CINAHL With Full Text	MH Cervical vascular accidents OR Vertebro basilar accident OR carotid vascular accident AND MH spinal manipulation OR Chiropractic manipulation OR Physiotherapy manipulation OR MH Osteopathic Manipulations OR cervical chiropractic adjustment	983

Appendix 2

Inclusion & Exclusion Criteria

Inclusion	Exclusion
Cerebrovascular accidents	Any other adverse condition
Vertebro basilar accident	Not human
English	Any language other than English
Adults human	Paediatrics/juveniles
Conservative management	Surgery
Manipulation/Adjustments	Not full text
Full text	

Appendix 3

PRISMA 2009 Flow Diagram (Moher et al, 2009) (112)