

## Chiropractic and stroke: association or causation?

Serious complications following spinal manipulative therapy (SMT) of the cervical spine, including stroke, are relatively rare. Estimates vary between 1 : 400,000 cervical spine manipulations and 1 : 5.6 million (1,2). However, there is controversy on how frequent events such as stroke are, and whether there is a causal relationship with SMT. Even more controversy can be found specifically relating to chiropractic SMT and whether this has a higher risk than other types of SMT. Both sides of the debate appear to have extremists with a biased perspective. Previous articles have not provided a comprehensive review of the evidence for and against chiropractic. A recent article noted several weaknesses or inconsistencies in some articles discussing chiropractic treatment and stroke (3). A critical review of a paper previously published in the *International Journal of Clinical Practice* has been conducted to provide evidence for the alternative theories regarding the safety of chiropractic SMT and whether there is a causal relationship with the stroke (4). A critical review of the current literature will also help to assess any misconceptions or distortion of the results of studies on chiropractic and stroke.

### Background

Ischaemic stroke is a significant cause of morbidity and death, even in younger age groups such as under 45 years of age (5). Some studies have estimated an annual occurrence of 10.8/100,000 (0.01% of the population), with vertebral artery dissection (VAD) and carotid artery dissection (CAD) occurring in 1/100,000–2.6/100,000 cases, respectively (6). The most frequently reported risk factors are dyslipidaemia (60%), smoking (44%) and hypertension (39%), but 33% had an undetermined aetiology. In addition to dyslipidaemia, smoking and hypertension, other reported risk factors include obesity, cardiovascular disease, history of transient ischemic attack (TIA), diabetes mellitus (type 1 & 2), atrial fibrillation, hormone replacement therapy, migraine, heavy drinking, recent or acute infection, recent heavy drinking, oral contraceptive pill (OCP), obstructive sleep apnoea, illicit drug use, lupus anticoagulant, active malignancy, gravidity or postpartum period and other genetic factors (7–15). VAD has been reported to occur after hyperextension

movements of the cervical spine (such as archery or ceiling painting), minor traumas or falls, and spontaneously (16–19).

Some studies have suggested that chiropractic causes stroke, however, there are often plausible alternate explanations which have been overlooked (Table 1 gives alternative explanations for cases described by Ernst in 2010). For example, Johnson et al. reported a case of VAD which occurred 15 days after a chiropractic treatment (20). A 44-year-old man developed acute neck pain after his first cricket match in over 20 years (whilst bowling). He consulted a chiropractor who gave SMT which provided some relief from the pain. Five days after this treatment, he developed vertigo which lasted 4 days and then resolved spontaneously. He suffered another episode of vertigo (including headache, vomiting, tinnitus, double vision and arm weakness) and returned to the chiropractor who referred him immediately to the hospital. He was

admitted to hospital, but died some 15 days after the SMT and 18 days after the cricket game which triggered the acute neck pain. No details were given on standard risk factors for dissection or stroke, but widespread vertebral changes were noted. Obviously, in a 15-day interval, many other events could have occurred leading to the VAD.

Another example, reported by Stevinson et al. was a case of subdural haematoma (SDH) after a chiropractic treatment (21). This was reported in a paper which was a survey of neurologists recalling potential cases of VAD over a 12-month period. This article had three lines of text describing the clinical background of this case, which makes it more likely that an important clinical fact was overlooked (such as trauma causing the SDH). It is also impossible to imagine what mechanism could cause a SDH after a neck manipulation. In both these cases, there are clearly numerous other potential causes of the VAD or the adverse event (SDH).

A man aged 46 was diagnosed with acute subdural haematoma occurring immediately after chiropractic

**The evidence for causality of vertebral artery dissection from chiropractic is weak**

treatment. A burrhole was required. There was no neurological deficit at one month or six month follow-up.

Some cases of VAD have also occurred prior to the patient receiving the chiropractic SMT they were seeking (22,23). This article will assess if a causal relationship exists between chiropractic and stroke.

## Causation criteria

Testing a causal relationship usually requires an agreement with a number of specific criteria, which were first described by Hill (24). The nine criteria are:

- Strength
- Consistency
- Specificity
- Temporality
- Biological gradient or dose–response relationship
- Plausibility
- Other explanations
- Experimental confirmation
- Coherence

## Strength

The first criterion in Hill's paper relates to the strength of any association. Hill gives the example of Percival Pott who identified scrotal cancer in chimney sweeps as 200 times higher to workers not exposed to chimney soot.

A study by Smith et al. used a nested case–control design, to review all those patients under age 60 with cervical arterial dissection ( $n = 151$ ) and ischaemic stroke or TIA between 1995 and 2000 at two academic stroke centres (25). They compared results of the cases with VAD/TIA ( $n = 7$ ) to controls ( $n = 3$ ). However, the number of cases that Smith assessed is a number too small to not be questioned. In addition, the time period was up to 30 days after the SMT which is inconsistent with all other studies. Furthermore, Smith included cases of TIA which is also inconsistent with all the other studies (TIA is a benign condition and often asymptomatic in patients). If only two cases from the VAD/TIA group are altered because of the 30-day measure or because of TIA, then the results are not statistically significant. (The Johnson paper discussed above highlights the possibility of other factors causing the VAD in the 30-day period.)

A review of the methodology of the Smith study revealed many other flaws and the results section demonstrated that the two groups were significantly different in many areas (26). For example, 10 cases were excluded (i.e. more than cases included) because of iatrogenic cause of the VAD. A total of 21

cases were excluded from the dissection group, which is three times the size of the included cases.

An important point of Smith's paper '.... patients with dissection were more likely ... to have had neck or head pain preceding stroke or TIA' confirms the 2008 Cassidy study (discussed later), which concluded that patients present to either a chiropractor or GP with neck pain because of their stroke already being present (27). In the Smith study, 76% of people with VAD had neck pain prior to the stroke vs. 40% of the controls ( $p < 0.001$ ) and 39% of the control group had previously had SMT without any VAD. A total of seven people had a VAD or TIA within 30 days of SMT over a 5-year period at two academic stroke units from a total of 1107 patients. There was no discussion about what activities or other treatment these seven patients had in that 30-day period.

Smith's paper states that 'Information about location, duration and quality of neck pain and head pain was incomplete due to limited patient recall'. But they also concluded '... that spinal manipulation is independently associated with vertebral arterial dissection, even after controlling for neck pain'. Also, Smith stated 'two of the dissection patients had VAD within seconds of receiving SMT'. This would suggest that the VAD must have been present before the SMT, as it seems impossible for a thrombus to instantly form, dislodge, travel to the cerebral cortex to cause a stroke '...within seconds of receiving SMT'.

Saaed et al. reported that headache and/or neck pain was the prominent feature in 88% of patients in their study, and was a warning sign in 53%, preceding onset of stroke by up to 14 days (28). This study identified three patients in a 10-year period who were reported to have chiropractic SMT that triggered the stroke. However, there is no evidence to show that these patients did not have the VAD prior to any SMT because of some other more common cause (e.g. minor neck trauma).

Rothwell et al. studied hospitalization records to identify vertebrobasilar accidents (VBAs) in Ont., Canada, during 1993–1998 (29). They matched 582 cases for age and sex to four controls from the Ontario population with no history of stroke at the event date. Public health insurance billing records were used to document the use of chiropractic services before the event date. The Rothwell study compared results of cases with VAD ( $n = 5$ , i.e. 1% of cases) to controls ( $n = 4$ ), which are again numbers too small to be reliable. Using the Rothwell data, one could argue that the control group for the < 45 years were nine times as likely to have a chiropractic treatment in the previous month than the VAD group. However, the major weakness with the Rothwell

study was the lack of any clinical data associated with the VAD cases. That is, what were the events/symptoms that lead the patient to consult the chiropractor.

Some authors have expressed concerns of ‘several hundred cases of vascular accidents after spinal manipulation’ as evidence. However, many of these cases of SMT were not delivered by a qualified chiropractor, and most did not describe any well documented risk factors for stroke. For example, Hufnagel et al.:

... analyzed the clinical course and neuroradiological findings of ten patients aged 27–46 years, with ischemic stroke secondary to vertebral artery dissection (VAD; *n* = 8) or internal carotid artery dissection (CAD; *n* = 2), all following chiropractic manipulation of the cervical spine. (30)

However, none of the ten cases above described by Hufnagel, had a chiropractor perform the SMT. That is, seven cases had the SMT from an orthopaedic specialist and three from a physiotherapist.

Further examples include Chen et al. who reported a 72-year-old man who developed a haematoma in the ligamentum flavum (31). The paper states ‘... following traditional massage therapy’. Also, Morandi et al. reported a 49-year-old female who developed a caudal spinal cord ischaemia after a lumbar SMT (32). The paper states ‘Three weeks into the episode, a physician performed lumbar vertebral manipulation’. Both these papers use chiropractic as a key word and as a consequence, falsely increase the perceived association of chiropractic with stroke.

Other cases of the stroke have been reported as spontaneous or related to trivial trauma, such as sport, turning the neck whilst driving or reversing, yoga and coughing. These events may have preceded the chiropractic treatment or have occurred at a similar time to the chiropractic treatment, but are often unreported. In fact, the event that triggered the stroke may have also produced neck pain, for which the patients sought treatment from a chiropractor. Marx et al. evaluated cases of arterial dissection in Germany from 1996 to 2005 (42). In the seven cases of ICAD and the nine cases of VAD, a causal link to SMT could not be made. In addition, in five of the seven cases of ICAD and seven of the nine cases of VAD, there was a clear evidence that the dissection was present prior to the SMT.

As a consequence, the strength of any association for stroke with chiropractic SMT appears negligible.

### Consistency

Hill’s second criterion relates to consistency. An association is consistent if results are confirmed in different settings and with different types of investigations. The association between SMT and stroke is controversial, with some studies (usually case reports) reporting a relationship, but other studies (such as case–controlled studies) reporting only an association.

Cassidy et al. assessed cases of VBA strokes admitted to Ontario hospitals from 1 April 1993 to 31 March 2002 (27). Four controls were age and gender matched to each case. Case and control exposures to chiropractors and PCPs were determined from health billing records in the year before the stroke date. In

**Table 1** Alternative theories or additional information

Author	Year	Reported injury	Other factors/comments
Lipper et al. (33)	1998	Cord hemisection (Brown-Sequard syndrome)	Two previous unremarkable SMT sessions, neurologist prescribed exercise, steroids and muscle relaxant
Chung (34)	2003	Cervical cord injury	Bonesetter SMT, minimal clinical information
Tseng et al. (35)	2002	Cervical epidural haematoma	Excessive SMT, minimal clinical information
Segal et al. (36)	1996	Cervical epidural haematoma	One week of neck pain after lifting heavy objects
Tolge et al. (37)	1993	Phrenic nerve palsy	Minimal clinical information
Schram and Vosik (38)	2001	Phrenic nerve palsy	Neck pain from lying on sofa, initial relief of pain, dyspnea 12 h later
Padua et al. (39)	1996	Myelopathy and radiculopathy	Paper not available (abstract only)
Schmitz et al. (40)	2005	Cervical fracture	SMT by medical practitioner, no X-rays because of pregnancy
Chen et al. (31)	2005	Haematoma of cervical ligamentum flavum	72-years old, with haematoma of ligamentum flavum after massage
Tome et al. (41)	2004	Multiple cervical disc herniations	Spanish, minimal clinical information
Tseng et al. (35)	2003	Rupture of cervical disc	Excessive SMT, minimal clinical information

SMT, spinal manipulative therapy.

the case-crossover analysis, cases acted as their own controls. Their study found 818 VBA strokes hospitalised in a population of more than 100 million person-years. In those aged < 45 years, cases were about three times more likely to see a chiropractor or a PCP before their stroke than controls. Results were similar in the case-control and case-crossover analyses. There was no increased association between chiropractic visits and VBA stroke in those older than 45 years. Positive associations were found between PCP visits and VBA stroke in all the age groups. Practitioner visits billed for headache and neck complaints were highly associated with subsequent VBA stroke.

Cassidy concluded VBA stroke is a very rare event in the population. The increased risks of VBA stroke associated with chiropractic and PCP visits is likely because of patients with headache and neck pain from VBA dissection seeking care before their stroke. The study found no evidence of excess risk of VBA stroke associated with chiropractic care compared with primary care.

Some studies have reported 'trivial trauma' of the neck, which included sports activities and SMT, could precipitate stroke (28). Haldeman et al. concluded stroke is a potential consequence of any neck movement (43). Therefore, there appears to be consistency with neck movement causing stroke, but not with SMT.

### Dose-response relationship

Some authors have also expressed opinions about a dose-response relationship with chiropractic and stroke. For example, Ernst reported that a dose-response relationship can be detected because of more chiropractors causing vascular accidents than osteopaths (44). Ernst believes this is because of osteopaths tendency to prefer soft tissue techniques (mobilisation) and employ SMT techniques less frequently. If this had been reported in any published studies, a dose-response relationship comparison may be possible, but there is no evidence to support this theory. Also, one could argue that it is a comparison of the safety of different techniques and not dose-response. For example, one would also need to consider the relative size of each profession and the utilization rates of the public for each profession.

Ernst highlighted in his 2010 paper 'Vascular accidents are associated much more commonly with chiropractors than with osteopaths' (4). However, Table 2 demonstrates that most cases are not a chiropractor delivering the SMT (see Table 2). That is, from the 17 references that Ernst cited, 5 were probably qualified chiropractors, 5 were stated as not chiropractors, 6 were from countries with no legislation for chiropractic, and one the paper was not attainable.

Other studies have also noted patients can have had many sessions of chiropractic SMT without experiencing CVA, and then suddenly a VAD occurs

**Table 2** Profession of person delivering SMT (combination of references from Tables 1 and 2 from Ernst's 2010 paper)

Author	Year	Qualified chiropractor	Reason
Donzis and Factor (45)	1997	Not related to SMT	VAD not reported and atypical infarct
Jones et al. (46)	1998	Yes	USA
Hillier and Gross (47)	1998	Possible	UK has some legislation
Garner and Case (48)	1996	Unknown	Paper not available
Chung (34)	2002	No	Bonesetter
Vibert et al. (49)	1993	Unlikely	Country with no legislation for chiropractic
Yokota et al. (50)	2003	Unlikely	Country with no legislation for chiropractic
Lipper et al. (33)	1998	Yes	USA
Chung (34)	2002	No	Bonesetter
Tseng et al. (35)	2002	Unlikely	Country with no legislation for chiropractic
Segal et al. (36)	1996	Yes	USA
Tolge et al. (37)	1993	Yes	USA
Schram and Vosik (38)	2001	Yes	USA
Padua et al. (39)	1996	Unlikely	Country with no legislation for chiropractic
Schmitz et al. (40)	2005	No	Medical practitioner
Chen et al. (31)	2005	No	Massage therapist
Tome et al. (41)	2004	Unlikely	Country with no legislation for chiropractic
Tseng et al. (35)	2003	Unlikely	Country with no legislation for chiropractic

SMT, spinal manipulative therapy; VAD, vertebral artery dissection.

(51). A 26-year-old woman had experienced a mild headache, cough and low-grade fever for 4 days and was given antibiotics. The patient had received over 20-chiropractic manipulations over the previous 2 years and was taking oral contraceptives. The symptoms of bilateral stroke began 36 h after the chiropractic SMT. This suggests that a new situation occurred which caused the VAD and not as a consequence of SMT.

There is also a previously reported situation, where chiropractic is reported as the profession of the person giving the SMT, when this has been incorrectly documented (52). In another example, Reuter describes 36 cases of VAD after chiropractic SMT, where 18 (50%) the SMT was delivered by an orthopaedic surgeon, 5 (14%) by a physiotherapist, 2 (6%) by a GP, 1 (3%) by a neurologist, 1 (3%) by a homoeopath and 3 (9%) by an unknown person (53). This leaves four cases (11%) where the SMT was delivered by a chiropractor (i.e. 89% the SMT was delivered by a non-chiropractor). The cases were collected by a retrospective survey over a 3-year period. Importantly, there was no table describing risk factors for any of the patients, including the chiropractic patients, and this article was also from a country where chiropractic practice is not regulated (i.e. there are no standards for education) (54).

Therefore, a dose–response relationship does not appear to exist.

### Temporality

Temporality states that the exposure must always precede the outcome. Often with the cases of chiropractic and stroke, a clear time-line between the onset of initial symptoms and the stroke has not been established. For example, Jeret described a case of a 51-year-old man who had chiropractic manipulation of his neck and presented to the hospital 5 days later (55). The patient was reported to have had intermittent slurred speech, left facial droop and mild left hand weakness for 2–3 days. There was no description for the onset of the presenting symptom to the chiropractor and no description of any known risk factors for CVA previously reported. Interestingly, the initial symptoms were all related to a left side infarct and 2 weeks after admission to a hospital, the patient had a right sided infarct. It is plausible this man had stroke because of risk factors other than chiropractic.

In addition, other events which immediately preceded the stroke have often not been documented in case reports. For example, Jeret described a second case of a 64-year-old man who had chiropractic manipulation from his daughter.

A 64-year-old man presented to the hospital 4 days after ‘gentle’ manipulation of his neck by his daughter, a chiropractor. He awoke at 2 a.m. feeling that his right arm was strange and that, in fact, it was not a part of his body.

In this case, other events which immediately preceded the stroke have not been documented. It is also plausible this man had stroke because of risk factors other than chiropractic. For example, during sleep his neck may have been in an extended and rotated posture for a prolonged time, which then caused the compromise to the blood flow in the vertebral artery (VA).

Therefore, a clear temporal relationship of chiropractic and stroke is not established.

### Plausibility

Some authors have postulated that hyperextension and/or rotation of the upper spine, beyond the physiological range puts a strain on the VA which, in predisposed individuals, may result in an intimal tearing. However, if this were the case then many more CVA's would be reported as neck SMT is performed millions of times each week. Also, other studies have reported that the force exerted on the VA during SMT is not enough to produce any tearing of the VA (56). Herzog et al. concluded that VA strains obtained during SMT are significantly smaller than those obtained during diagnostic and range of motion testing, and were much smaller than failure strains. They concluded that cervical SMT performed by trained clinicians did not appear to place undue strain on VA, and thus does not seem to be a factor in vertebro-basilar injuries.

Mitchell conducted a study on 60 male subjects and 60 female subjects (240 VAs), using transcranial Doppler sonography to measure intracranial VA blood flow, with the cervical spine in neutral and then rotated maximally to the left and later to the right (57). There was a significant decrease ( $p = 0.001$ ) in intracranial VA blood flow following cervical spine rotation, irrespective of side, but greater on the contralateral side, in the total sample and in male subjects. Female subjects had a significantly higher blood flow than male subjects, and although they showed a significant decrease in contralateral rotation, there was no significant difference in blood flow on the ipsilateral side. The results of this study suggest that full neck movement may affect VA blood flow, but this appears less than SMT (58). Modern chiropractic SMT procedures do not require full cervical spine rotation or extension.

Many case reports of stroke after SMT do not discuss other plausible reasons for the VAD to have had



occurred other than just SMT. Sedat et al. described a case of dissection of the postero-inferior cerebellar artery (PICA) after cervical manipulation (59). A 42-year-old woman had a cerebellar syndrome related to an infarct in the area supplied by the PICA, confirmed by computed tomography (CT) of the brain. A cervical extradural origin of PICA and a dissection of it was detected in the CT scan. Anatomical variations of the vertebral arteries and their branches are not infrequent and may be another plausible reason for stroke unrelated to the SMT. The author acknowledged the anatomical variance had played a vital role in the patient's complications to manipulative therapy.

### Other explanations

As discussed above, arterial dissection can occur spontaneously, therefore, an alternative explanation to SMT causing the VAD usually does exist.

For example, a case of a 26-year-old woman who received 'chiropractic SMT' is described by Soper et al. (60). The patient had received numerous neck manipulations for neck stiffness which had been present for 1 month. In one treatment, she received an injection of lidocaine and betamethasone, which was followed by a forcible, bilateral rotation of her neck (given by a medical practitioner). She developed pronounced neurological signs and was taken to the hospital where CT scans of the neck identified bilateral VAD. A subsequent MRA revealed that the VAD dissection extended from T1 to C2 on the left and complete occlusion on the right, with a small traumatic pseudoaneurysm present.

Galtes et al. presented the case of a 40-year-old woman cyclist who was struck by a car (while wearing a helmet), and was neurologically near normal at presentation to the Emergency Department (61). She was again presented 48 h later with acute right hemiparesis, decreasing level of consciousness and unsteadiness. CT revealed massive cerebellar infarction, but CT angiography was normal. The patient died in coma 7 days after injury and autopsy revealed bilateral oedematous cerebellar infarction and bilateral VAD. They concluded the possible influence of trauma may be further underestimated if longer intervals between vessel dissection and ischaemia occur.

Sepelyak et al. described three cases of paediatric arterial ischaemic stroke which occurred after trivial head or neck trauma sustained during a sports activity (62). One case involved a 10-year-old boy developing hemiparesis after a collision during a soccer match. Another case involved a 12-year-old boy developing parathesias and headaches after a lacrosse match. The third case involved a 7-year-old boy

developing numbness 3 h after a karate practice. All recovered to have no or minimal residual deficits after treatment.

Had any of the previously discussed patients presented to a chiropractor, then this may have appeared that chiropractic SMT caused their condition. In addition, many other case reports describe patients who have had multiple SMT sessions, and then suddenly they have an adverse reaction (60,63–67). It appears apparent that something had changed in the patient immediately before the last SMT which caused a (transient) arteriopathy, allowing a VAD to occur. Therefore, there are alternative explanations for VAD other than just SMT.

### Experimental confirmation

As the VA becomes the basilar artery entering the base of the skull, it bends sharply from a vertical to a horizontal path. This should be the site where any VAD because of SMT would occur. But many cases of VAD after SMT have occurred at most sites all along the VA, including intracranial (68). This appears to support the theory that the VA has been weakened by some other factor or event which preceded the SMT.

Saeed et al. conducted a retrospective analysis of hospital records in a tertiary academic centre for the period 1989–1999 and identified 26 patients with VAD (13 men and 13 women) (28). They reported possible precipitating factors were identified in 14 patients (53%), with sporting activity (golf, soccer, running and baseball) and chiropractic manipulations being the most common (15% and 11%, respectively). However, seven patients (26%) had minor neck trauma, which was reported to be up to 3 years before the VAD. In addition, 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. This supports the premise that patients may present to a chiropractor with neck pain after a trivial event that caused the VAD and not the SMT.

### Specificity

There are numerous possible causes for arterial dissections other than neck manipulations (10,12,18,69,70). Vascular accidents have reported after many types of neck movement, neck injury or sporting activities. Millions of SMT procedures are given every year, yet very few cases of VAD after SMT are reported (2). This should also be viewed in the context that 1/100,000 of population have VAD each year. Therefore, when chiropractors see 1 million patients in a year, 10 will have a VAD, but this does not mean that the SMT caused the VAD.

In cases where there has been a VAD or stroke, other causes are overlooked. For example, Albuquerque et al. reviewed 13 cases of artery dissection and chiropractic SMT, and concluded '... a significant percentage (31%, 4/13) of patients were left permanently disabled or died as a result of their arterial injuries' (68).

However, if this article is critically reviewed, we find the case where a person died was a 73-year-old female, with no other clinical details given. For example, did she have any history of dyslipidaemia, smoking and hypertension, obesity, cardiovascular disease, history of TIA, diabetes mellitus (type 1 & 2), atrial fibrillation, hormone replacement therapy, migraine, heavy drinking, recent or acute infection, recent heavy drinking, OCP, obstructive sleep apnoea, illicit drug use, lupus anticoagulant, active malignancy, gravidity or postpartum period and other genetic factors. Stroke in a geriatric patient is a very common occurrence, especially if any of the above risk factors were present.

In addition, only one of the 13 cases had the VAD at the V3 segment (where it wraps around the C1 vertebrae) as a single site. One could argue that if SMT was the cause of the VAD, then why are not more found at the V3 segment. Nine of the 13 cases had multiple sites for VAD and ICAD, with some even intracranial or bilateral. Also, four of the 13 had timelines of more than 7 days for the stroke to occur after the chiropractic SMT. The paper reported that four patients were left permanently disabled or died as a result of their arterial injuries; however, only one case has any clinical information. This case was a 30-year-old male who had dissections of V3, V4 and the basilar artery. It was reported he had significant complications after surgery to repair the dissections (thrombosis of the stents) which possibly caused the permanent disability.

Therefore, VAD specifically because of chiropractic is not established.

### Coherence

Coherence describes the need for any causal association to be compatible with the existing theory and knowledge. It had been previously accepted that manipulation can cause a vascular accident and thus did not contradict an accepted theory. As previously discussed, this was often based on poorly written case studies (3). However, considering the bulk of new arguments, the criterion of coherence does not seem to be fulfilled.

Stevenson et al. conducted a survey of neurologists to assess VAD after SMT (21). Stevenson acknowledged that their study had many weaknesses

including recall bias. In addition, they acknowledge that they have very limited case details regarding previous neurological symptoms, who delivered the SMT, and why the patient received SMT. 'Only rarely was it possible to check the patient file or the case notes'. Yet from this, other authors state that the number of cases on VAD after chiropractic is grossly underestimated (4). It is just as possible that the number of cases on VAD after chiropractic is overestimated as the neurologists have overlooked other possible causes of the VAD and assumed it was only because of SMT. In addition, one of the few cases discussed highlights the limited case information and also notes the SMT was from an osteopath (21).

An alternative theory could be that a situation arose where a patient had a VAD commencing, because of other factors such as minor trauma, sports, sustained neck positions or excessive neck movements. This was predisposed by an arteriopathy (possibly transient) because of hypertension, hyperlipidaemia, hyperhomocysteinaemia, recent infection, smoking, diabetes, migraine, or other combinations of factors. Once the VAD had commenced, the patient would complain of neck pain or headache, for which they then sought treatment, possibly from a chiropractor, or another healthcare practitioner. If this healthcare practitioner did not take a thorough clinical history, then they may overlook these above factors and perform an SMT when it may have been contra-indicated. Therefore, an existing VAD is exacerbated, the thrombus is dislodged and creates the stroke.

### Conclusion

There is lack of compelling evidence that SMT is causally associated with stroke. Physical triggers, including SMT, can serve as plausible final link between the underlying disease and stroke (for instance, in case of arterial dissection with existing connective tissue weakness). It appears few of Hill's criteria for causality appear connected with VAD and chiropractic. There may be some links or association with SMT and VAD in untrained practitioners, but this has not been established with chiropractors. The quality of evidence suggesting causation between chiropractic and VAD is mostly weak. Therefore, causality between chiropractic and vascular accidents has not been determined.

It is possible that healthcare practitioners are not taking a thorough history to determine the cause of the VAD after SMT. Healthcare practitioners are probably missing many clinical facts, because they now only record the patient having SMT. They

should enquire about other possible causes or circumstances for VAD. This may include minor neck trauma, a change in chronic neck pain or headache, recent infection or other predisposing lifestyle factors such as smoking, hyperlipidaemia, hypertension, and hyperhomocysteinaemia. Therefore, it is important that healthcare practitioners take a thorough clinical history to determine the cause of VAD.

Systematic prospective studies are needed to assess the safety of cervical spine SMT with regards to cere-

brovascular events. Such studies should also account for the education of the practitioner.

## Disclosure

None.

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