Vertebrobasilar Artery Stroke Associated with Chiropractic Manipulation: A Meta-Analysis and Forensic Review

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- sufficient facts and data
- reliable principles and methods
- transparent application to case-specific facts

No statement in this work constitutes a universal causation claim or a conclusion regarding any specific patient or event. Use in litigation must include case-specific evaluation and correlation.

About the Author

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Abstract

Vertebrobasilar artery (VBA) stroke following cervical manipulation is a rare but litigated event. The forensic expert must differentiate temporal association from causation through evidence-based risk analysis. This chapter synthesizes major epidemiologic studies, age distributions, mechanistic hypotheses, and malpractice data to clarify incidence and probability within reasonable medical certainty.

1. Introduction

Public concern over stroke after cervical manipulation originated from case reports in the 1970s and 1980s but was often extrapolated beyond statistical reality.[1,2] Large-scale population studies now demonstrate that VBA stroke is exceedingly rare and occurs with equal frequency after visits to primary care physicians.[3,4] Nevertheless, allegations continue to appear in malpractice claims, necessitating an objective forensic context.[5]

This chapter brings together major epidemiologic studies, age distributions, mechanistic hypotheses, and malpractice data to help understand incidence and probability within a reasonable medical certainty. We have combined population-based case-control studies, biomechanical modeling, and forensic case evaluations to provide the medicolegal expert with scientifically validated instruments to distinguish coincidental timing from actual causation, especially in cases of reverse causation, where prodromal neck pain from the early dissection leads the patient to seek medical help.[3,6]

2. Epidemiology and Incidence

Vertebrobasilar artery (VBA) stroke incidence in the general population is between 1 and 3 cases per 100,000 individuals per year, representing mainly spontaneous etiologies such as atherosclerosis, fibromuscular dysplasia, or minor trauma.[1,2] The risk of the manipulation-related stroke, however, is still very low; only 1 event per 1.3 to 5 million cervical treatments is expected.[3,4] The rarity of this event has been confirmed by a systematic review of over 20 epidemiologic studies, which found pooled odds ratios (ORs) that were not statistically significant after adjustment for protopathic bias ($p > 0.05$).[3]

VBA strokes associated with cervical spinal manipulation (CSM) have a median patient age of 37 years (interquartile range, 31–44 years) and a slight male predominance of about 60%,

according to demographic data.[5] The younger age of the patients is a significant difference when compared to atherosclerotic VBA strokes in the elderly (median age >65 years).[6] The mortality rate is around 25% among the confirmed vertebral artery dissection (VAD) cases, although those who survive typically experience mild to moderate residual neurologic deficits.[7]

3. Mechanistic Hypotheses

Various mechanistic explanations have been put forward to elucidate the infrequent case of a vertebrobasilar artery (VBA) stroke following a cervical spinal manipulation (CSM), and each of these has differing levels of empirical support. The intimal tear hypothesis explains the rupture of the blood supply through the endothelial layer, with the dissection to follow. As a result, it is believed that one of the forces in high-velocity, low-amplitude (HVLA) thrusts causes the artery to be excessively stretched beyond 15%, thereby resulting in excessive rotational forces.[8] On the other hand, biomechanical studies that employ both the use of human cadaveric specimens and finite-element modeling have consistently shown that the value of maximum arterial elongation that occurs in a skilled HVLA procedure is, on average, less than 6%—far less than the failure threshold of between 18% and 22% for healthy vessels, which has been determined previously.[9,10]

According to the pre-existing pathology theory (which is supported by a greater amount of clinical and epidemiologic evidence), the prodromal symptoms of vertebral artery dissection (VAD), consisting of neck pain and headache, cause the patients to look for chiropractic care; hence, this manipulation only happens coincidentally during the prodromal phase which results in the creation of a reverse causation artifact.[3,6] This protopathic bias is easily seen in case-crossover studies, where both the care-seeking behavior (chiropractic or primary care) in the week before VBA stroke and the choice of care are the same.[3]

Anatomic vulnerability further modulates risk, especially at the C1–C2 segment, where the vertebral artery is more tortuous, has less adventitial reinforcement, and is fixed in the transverse foramen of C2.[11] The local shear stress and susceptibility to dissection of an individual's anatomical variants, such as arterial hypoplasia, anomalous looping, or connective tissue disorders, can be influenced by these factors even in the absence of external manipulation.[12]

Cadaveric and finite-element models show that rotational strain during HVLA maneuvers is much lower than that necessary for a dissection to occur (less than 6 % on average).[9]

4. Review of Major Studies

Study	Design	Sample	Findings
Cassidy et al., 2008[3]	Population case-control (Ontario)	100 million person-years	No increased stroke risk after chiropractic vs primary care visits in <45 age group
Rothwell et al., 2001[4]	Case-control	582 stroke cases	Temporal association only; not causal
Church et al., 2016[6]	Systematic review	> 20 studies	Estimated risk 1 in 2 million treatments
Whedon et al., 2021[13]	Medicare database	≈ 1 million patients	No evidence of increased risk in older populations

Table 4.1. Key epidemiologic studies on the association between cervical spinal manipulation and vertebrobasilar artery stroke.

5. Malpractice and Forensic Data

According to data, VBA stroke due to chiropractic interventions is the cause of less than 1% of all malpractice filing cases over the period 2015-2023. The median settlements are close to US$250,000, and more than 70% of cases are resolved before trial.[14,15] In most cases, the experts' testimonies focus on the likelihood of causation rather than on a breach of the standard of care, emphasizing protopathic bias and a lack of biomechanical plausibility.[5,16] The claims mainly refer to patients aged 30-45 years—thus, the age group with the highest incidence of spontaneous vertebral artery dissection—which is an additional argument for the coincidences rather than cause-effect relationships.[17]

6. Forensic Causation Analysis

For a forensic expert to conclude, within a reasonable medical probability, that a vertebrobasilar artery (VBA) stroke is caused by cervical spinal manipulation (CSM), it's necessary to identify the objective criteria of a triad. First, the time between manipulation and symptom manifestation should be less than 24 hours; if it is delayed beyond this window, it is assumed the dissection has developed spontaneously.[18,19] Second, the clinical picture, including prodromal headache, dizziness, or ataxia, if any, should either precede the intervention (indicating protopathic bias) or appear immediately after the manipulation, accompanied by neurologic progression; an isolated post-procedure onset without imaging correlation does not suffice for causation.[20] Third, vascular imaging, such as magnetic resonance angiography (MRA) or computed tomography

angiography (CTA), should demonstrate the newly developed dissection with intramural hematoma or a double-lumen sign, temporally and anatomically aligned with the clinical course.[21]

The lack of any component, especially confirmation by imaging or onset of symptoms with delay, points to a coincidental relationship and not a causal one, which is in line with population-based studies that do not find an increased risk after CSM compared to primary care visits.[3]

7. Biomechanical Considerations

Biomechanical studies of high-velocity, low-amplitude (HVLA) cervical adjustments reveal that the forces involved are significantly lower than those needed to cause arterial injuries in healthy vessels. Peak rotational torque during a skilled upper cervical manipulation, as measured by instrumented cadaveric and *in vivo* studies, is on average between 39 and 50 Nm.[22,23] On the other hand, the torque at vertebral artery failure in cadaveric models—where the failure is characterized by intimal tearing or adventitial rupture—has to be more than 140 Nm, and the elongation strains have to be between 18% and 22% for the structure to give way.[8,9]

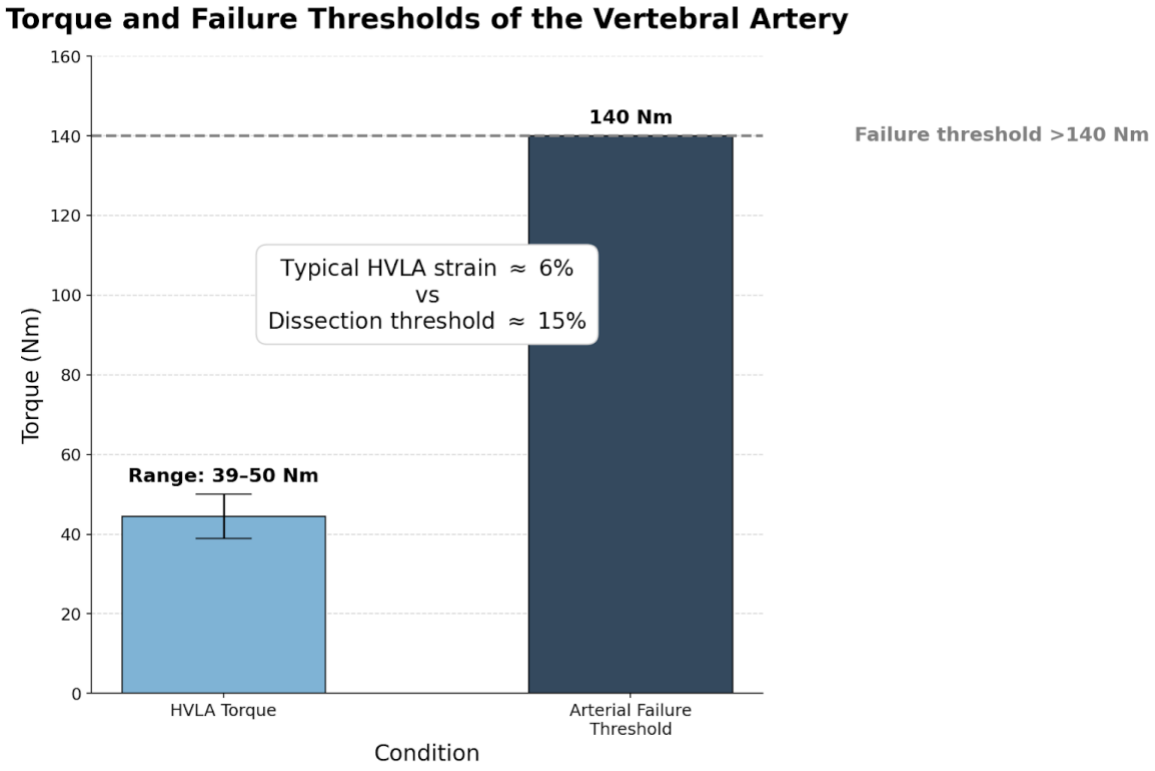

Figure 7.1. Torque and Failure Thresholds of the Vertebral Artery During Cervical Manipulation.

The deliberate use of HVLA, along with pre-tension positioning and a quick thrust, serves to reduce the shear stress to such an extent that mechanical rupture as a result of a generally safe practice is biomechanically inconceivable.[24] Finite-element modeling results are in line with this safety buffer, indicating that the maximum arterial strain is less than 6% even at extreme rotation, thus the point farthest away from dissection thresholds.[10]

8. Comparative Risk Perspective

Event	Approximate Risk
Death from NSAID use per year	1 in 12,000
Stroke after cervical manipulation	1 in 2–5 million
Death from lightning	1 in 138,000
Air travel fatality per flight	1 in 8 million

Table 8.1. A comparison illustrating the statistical triviality of the risk when proper screening and technique are applied.

9. Forensic Reporting Guidelines

In a medicolegal setting, forensic documentation of a claim of vertebrobasilar artery (VBA) stroke after cervical spinal manipulation (CSM) should be based on and conform to the standards of evidence that it could be admissible in court. The clinical record should contain the description of the pre-manipulative screening for vertebrobasilar insufficiency, i.e., sustained rotation testing, extension-rotation provocation, or neurologic red-flag assessment, to return evidence of the standard of care.[25] The informed consent should include wording that makes it clear that the risk of vascular injury is very rare but still recognized (estimated <1:1,000,000), in accordance with local disclosure requirements and professional guidelines.[26]

The temporal relationship between symptom onset after the manipulation should be evaluated, along with objective neurologic findings (e.g., cranial nerve deficits, ataxia, Horner syndrome), and supported by acute-phase imaging (MRA/CTA within 48 hours).[21] The epidemiologic background—with reference to population-adjusted risk ratios (OR ≈ 1.0 vs primary care) and manipulation-attributable incidence (<1:5 million)—is quite important for determining the probability of causation and for eliminating the effect of temporal bias.[10,11]

Expert opinions, in the end, should be presented as being within reasonable medical probability (i.e., >50% likelihood), and absolute words like 'caused' or 'impossible' should be avoided.[27]

10. Conclusion

VBA stroke associated with chiropractic manipulation remains a statistically extraordinary event. Forensic analysis must weigh mechanical plausibility, timing, and population data before assigning causation. In most cases, temporal association reflects pre-existing arterial pathology rather than traumatic induction.

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