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Changes in Vertebral Artery Blood Flow Following Various Head Positions and Cervical Spine Manipulation

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Abstract

Objective: The objective of the study was to investigate the cerebrovascular hemodynamic response of cervical spine positions including rotation and cervical spine manipulation in vivo using magnetic resonance imaging technology on the vertebral artery (VA).

Methods: This pilot study was conducted as a blinded examiner cohort with 4 randomized clinical tasks. Ten healthy male participants aged 24 to 30 years (mean, 26.8 years) volunteered to participate in the study. None of the participants had a history of disabling neck, arm, or headache pain within the last 6 months. They did not have any current or history of neurologic symptoms. In a neutral head position, physiologic measures of VA blood flow and velocity at the C1-2 spinal level were obtained using phase-contrast magnetic resonance imaging after 3 different head positions and a chiropractic upper cervical spinal manipulation. A total of 30 flow-encoded phase-contrast images were collected over the cardiac cycle, in each of the 4 conditions, and were used to provide a blood flow profile for one complete cardiac cycle. Differences between flow (in milliliters per second) and velocity (in centimeters per second) variables were evaluated using repeated-measures analysis of variance.

Results: The side-to-side difference between ipsilateral and contralateral VA velocities was not significant for either velocities ($P = .14$) or flows ($P = .19$) throughout the conditions. There were no other interactions or trends toward a difference for any of the other blood flow or velocity variables.

Conclusions: There were no significant changes in blood flow or velocity in the vertebral arteries of healthy young male adults after various head positions and cervical spine manipulations. (J Manipulative Physiol Ther 2014;37:22-31)

Key Indexing Terms: *Blood Flow Velocity; Manipulation Spinal; Hemodynamic; Head Movements; Vertebral Artery; Vertebrobasilar Insufficiency; Chiropractic*

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Each year, stroke costs the Canadian economy $3.6 billion in physician services, hospital costs, lost wages, and decreased productivity.[1] Although rare in the general population, vertebrobasilar artery (VBA) stroke, such as spontaneous vertebral artery (VA) dissection, is a leading cause of nonatherosclerotic stroke in young adults.[2-4] It has been proposed that an underlying genetic predisposition, triggered by risk factors associated with environmental exposure, with or without trivial trauma may serve as an etiologic model.[5] However, the exact pathogenesis of VBA stroke is poorly understood.[4,6] It is well documented that patients who experience VBA stroke have a change in blood flow in the affected VA.[2,7,8] Others have noted signs and symptoms of vertebrobasilar insufficiency with certain head positions.[9-12] Authors speculate that mechanical compression or stretching of the VA at extremes of head position is a potential causative factor for VA blood flow change and is most likely to occur in the suboccipital

part (V3) of the VA.[13-17] As a result of Bernoulli principle, there is an increase in blood flow velocity at and/or immediately beyond the point of constriction of a vessel owing to either stretching or compressive forces.[17] This may result in spurting and turbulent flow immediately downstream from the region of distortion[15] that may evoke a local thrombogenic response,[18] leading to VBA stroke. A change in VA blood flow after head rotation, especially contralateral to the direction of rotation, has been demonstrated in several studies.[17] However, these results yield some inconsistencies and are inconclusive with respect to clinical relevancy.[14,15,17]

There is continuing controversy about the effects of cervical range of motion and therapeutic physical interventions, including cervical spinal manipulation (CSM) and or sustained mobilizations, on the blood flow within the VAs and cerebrum. End-of-range motion, manipulation, and mobilization techniques are some of the common physical interventions used by manual therapists to treat neck pain and headaches. There are large well-designed epidemiologic, clinical studies and reviews reporting CSM to be a safe and effective treatment of neck pain and headache.[19-25] A recent population-based, case-control, and case-crossover study found that there was no excess risk of VBA stroke after chiropractic care for neck pain and headaches when compared with physician care.[21] At the ecologic level, the increase in VBA stroke does not seem to be associated with an increase in the rate of chiropractic use.[26] However, at the mechanistic level, few studies have examined the effects of CSM on VA blood flow. This has led to uncertainty on whether there is a potential risk in apparently healthy individuals for minor trauma or altered hemodynamics in cervical blood vessels from these maneuvers. Using Doppler ultrasound, Licht and colleagues[27] observed increased blood flow in the VA of dissected pigs lasting 40 seconds after receiving CSM. When examining the effects of CSM on human VA blood flow, Licht et al.[18,28] reported no significant difference in VA blood flow between a CSM group and a control group. The limited number of trials, inconsistencies within the results, and poor methodology make conclusions about the effects of CSM on VA blood flow difficult to interpret.

Ultrasonography studies are the most common techniques used to evaluate blood flow in the vertebral arteries. Although ultrasound techniques have been shown to be reliable, produce an image in real time, and are relatively inexpensive,[29-31] they are hampered by its user dependency, limited insonation angles, and unidirectional velocity encoding.[32,33] When imaging the vertebral arteries, there are additional challenges. Approximately 7% cannot be imaged because of their depth[34] and ultrasound waves cannot pass through bone, limiting visualization of portions of the VA that pass through osseous foraminae.[31] Furthermore, surface-based ultrasound lacks resolution when compared with other imaging techniques.[29,30,35,36] This limits visualization to only gross alterations in vessel size,[36] hindering the ability to locate any anatomical abnormality directly, and demonstrates the results of anatomical disruption as a variation in flow.[37] Subtle changes such as mild stenosis resulting in hemodynamic flow changes of less than 50% may also be missed by the ultrasound.[29,30,38]

Imaging blood flow across a range of cervical spine positions, including rotation and manipulation in vivo, under clinically relevant circumstances has the potential to provide a systematic estimate of alterations to the cerebrovascular hemodynamics. Magnetic resonance imaging (MRI) techniques such as phase-contrast magnetic resonance angiography have greater sensitivity than standard techniques such as Doppler ultrasound and are considered the criterion standard for both diagnosis of VBA strokes[8,29,37-39] and blood-flow volume quantification.[35,40] The intrinsic sensitivity of MRI to flow offers the possibility of analyzing blood flow hemodynamics without restrictions to anatomical coverage or flow direction.[33] Examining VA flow after various head positions and manipulation using phase-contrast MRI has yet to be reported. Therefore, the purpose of this study was to observe VA blood flow after manipulation and various head positions to assist in the understanding of the extent to which head/neck motion may interact with VA blood flow as a direct contributor to VBA stroke.

Methods

Participants

Healthy volunteers were recruited from the campus of a local chiropractic college. Included were healthy men aged 18 to 35 years who have received CSM, as part of their routine training program, within the last 3 months before data collection. Participants were judged to be clinically healthy based on a health-history questionnaire. Exclusion criteria included a history of disabling neck, arm, or headache pain within the last 6 months; any current or history of neurologic symptoms including facial or extremity weakness, abnormal sensation to the face, body, or extremities, uncontrolled movements, abnormal gait, dizziness, unexplained nausea/vomiting, difficulty with speaking or swallowing; or a history of claustrophobia. All participants also refrained from vigorous physical activity, alcohol, and caffeine 1 day before commencement of the study. The study was approved by the local ethics committees of St Joseph's Healthcare Hamilton at McMaster University in Hamilton, Ontario, and Canadian Memorial Chiropractic College in Toronto, Ontario. Written informed consent was obtained from all of participants before the study commenced. Data were collected at the Imaging Research Centre, Hamilton, Ontario. The study was registered with www.clinicaltrials.gov, NCT01205490.

This pilot study was conducted as a blinded examiner cohort with randomized clinical tasks, in which each participant received 4 head position conditions (neutral, 45° rotation, maximum rotation, and CSM). Tasks were selected based on their use in evaluation or treatment during clinical