Original article

Doppler studies evaluating the effect of a physical therapy screening protocol on vertebral artery blood flow

C. Arnolda,*, R. Bourassa a, T. Langerb, G. Stonehamc

a School of Physical Therapy, University of Saskatchewan, 210-1121 College Drive, Saskatoon, Sask S7N 0W3, Canada
b Department of Anatomy, College of Medicine, University of Saskatchewan, Canada
c Department of Medical Imaging, College of Medicine, University of Saskatchewan, Canada

Received 21 November 2002; received in revised form 22 May 2003; accepted 7 July 2003

Abstract

General and isolated cervical positional tests are used to screen for potential vertebro-basilar insufficiency (VBI). There is limited research evaluating vertebral artery blood flow in these positions to justify the rationale of progressive mechanical stress occurring to the arteries. The purpose of the study was to determine vertebral artery blood flow in six cervical positions used in clinical practice. A comprehensive cervical assessment was conducted on 22 men and women (mean age 35) with no known vascular pathology. Vertebral artery peak systolic (PS), end diastolic (ED) flow rates and resistive index (RI) were measured using duplex colour Doppler sonography (sampling at C3–C5) in neutral, rotation, extension, combined rotation-extension, combined rotation-extension-traction, deKelyn’s position and a C1–C2 pre-manipulative hold. Results showed there was a significant decrease in PS and ED in the contra-lateral artery during the pre-manipulative hold, and a decrease in ED in the contra-lateral artery during rotation. There was no effect of age, gender or mobility restriction on these blood flow changes. The pre-manipulative hold had the greatest response with 34% of the arteries demonstrating a complete cessation of ED flow. In conclusion the pre-manipulative hold and rotation created the greatest mechanical stress to the contra-lateral vertebral artery. These two positions may be useful screening positions to identify individuals at risk of VBI due to inadequate collateral blood flow.

© 2003 Elsevier Ltd. All rights reserved.

Keywords: Vertebral artery; Doppler; Screening; Cervical movement; Physical therapy

1. Introduction

Recent evidence suggests that stroke is linked to manipulation more often than previously reported in individuals less than 45 years of age (Rothwell et al., 2001). The causes of arterial dissection induced by manipulation are not known, however, the most frequently injured site is at C1–C2, likely due to the elongation of the artery occurring at this region during cervical movements (Mann and Refshauge, 2001).

The vertebral arteries provide the posterior circulation to the brain and are vital in maintaining brainstem function. Vertebro-basilar insufficiency (VBI) is defined as episodes of cerebral or brainstem ischaemia causing symptoms (Grant, 1994). VBI screening tests may detect someone at risk of injury by evaluating collateral flow to supply the brain while temporarily occluding one artery. If there is vascular pathology restricting collateral flow, there is a risk of ischaemia occurring during cervical treatment (Rivett et al., 1999).

Although there are a variety of screening tests reported, a common test used in Canadian PT practice is a progression of cervical movements proposed to gradually add mechanical stress to the arteries (Canadian Physiotherapy Association Orthopedic Division, 2003–2004a). The purpose of the stress test is to reproduce potential signs or symptoms of VBI in a safe, gradual progression of neck motion. If central neurological signs or symptoms such as nystagmus, dysphasia or hemianopia are reproduced, this warrants immediate referral to a physician for further testing. The reproduction of other signs or symptoms such as dizziness, blurring of vision or nausea, not necessarily originating due to central ischaemia, indicates the need to carry out further differentiation tests (Meadows, 1999). The order may vary with different practitioners, however common
movements utilized in the stress test are: cervical rotation, extension, combined rotation and extension and adding traction to the combined extension–rotation position (Arnold, 2003; Canadian Physiotherapy Association Orthopedic Division, 2003–2004a). Achieving full available range of motion is an important component of the test, as well as including both upper and lower cervical motion. Each position should be held for at least 10 s or until symptoms arise, with a minimum of 10 s resting time before progressing to the next movement (Aspinall, 1989; Meadows, 1999; Australian Physiotherapy Association, 2000). Some clinicians advocate the use of a deKleyn’s or Wallenberg’s position where the head is extended and rotated over the end of the bed (Carey, 1995); however, others suggest that the additional stress of the head hanging over the end of the bed as well as the safety concern if the client loses consciousness makes this position potentially dangerous (Meadows, 1999). Alternatively, combined rotation and extension can be achieved by lordosing the cervical spine with the head remaining on the bed. This position is more likely to be used during treatment. There have been no studies comparing vertebral blood flow in this alternative position to deKleyn’s position.

If the graduated stress test is negative and the therapist decides manipulation is the technique of choice, a final test prior to manipulation would be a pre-manipulative hold (PMH). This is a sustained hold of the manipulative position for a minimum of 10 s and released for 10 s, to ensure that no potential VBI symptoms are reproduced. (Aspinall, 1989; Australian Physiotherapy Association, 2000).

A recent literature review (Mann and Refshauge, 2001) reported that in 16 out of 20 Doppler studies, there was diminished blood flow in the contra-lateral artery during cervical rotation whether extension was added or not. However, it is difficult to reach a consensus from these studies, as there are considerable differences in methodology. Sole use of continuous wave Doppler ultrasound questions conclusions regarding findings of “complete occlusion” as the artery cannot be directly visualized (Licht et al., 1998). Limited descriptions of neck position make it unclear if full range of motion was achieved, active or passive movement was tested or if movements were performed in sitting or supine. Only 6 studies have included a sample with symptoms of VBI; two of these used the same sample (Thiel et al., 1994; Cote et al., 1996) and only two identified the clinical test used to determine VBI (Thiel et al., 1994; Rivett et al., 1999). These two studies report conflicting results, one finding a significant decrease in blood flow for both symptomatic participants and a control group and the other found no change in blood flow. In studies of healthy populations with and without neck pain, but with no VBI symptoms, the majority has found diminished blood flow in the contra-lateral artery with rotation or combined extension–rotation. However, a recent study examining the reliability of Doppler ultrasound has questioned results from two of these studies (Johnson, 2000). Other positions in the stress test sequence, including extension, the addition of manual traction and the PMH in the upper cervical spine has limited research with no consensus on the capability of these positions to detect VBI symptoms indicative of occlusive risk (Grant, 1994; Thiel et al., 1994; Li et al., 1999; Mann and Refshauge, 2001).

The purpose of this study was: (1) to measure blood flow velocity in the contra- and ipsi-lateral vertebral arteries during a stress test sequence commonly used in Canadian PT clinical practice, (2) compare blood flow changes in a full deKleyn’s position compared to a modified extension–rotation position with the head remaining on the bed with and without traction applied, (3) measure blood flow in a PMH at C1–C2 and (4) pilot the ability to measure flow in these positions in a healthy population with no known vascular pathology prior to conducting the sequence on a symptomatic population.

2. Method

Prior to the study, two pilot Doppler tests were conducted to ensure that the ultrasound technologist would be able to locate and sample the artery in all positions. The technologist was a qualified, experienced ultrasonographer. Participants were recruited by advertisements at university and health care facilities. This study was approved by the University of Saskatchewan Ethics Committee and informed consent was obtained prior to the PT assessment. Exclusion criteria included any contraindication to manipulation such as: osteoporosis, anti-coagulant medication, significant cardiac or neurological disease, inflammatory joint disease, ligamentous instability, malignancy, a positive VBI screening test or recent fractures. Other conditions (for example known inner ear conditions or marked postural hypotension) that may mimic signs or symptoms of VBI as well as any history of heart disease or vascular pathology were also excluded. Unless there was a severe restriction to physiological range of motion, participants with a history of neck pain or injury were included in order to represent the population that would be typically seen in a clinical situation. All participants were screened by telephone interview and questioned regarding symptom history, medications and vascular disease. Following the interview, the same PT who would be conducting the movement progression with the Doppler test assessed participants. The PT had 24 years of clinical experience and advanced training in manual and manipulative therapy. The PT assessment included a detailed history, VBI screening tests and a thorough
examination of the cervical spine. Physiological range of motion was evaluated by observing active movement in sitting and applying passive over pressure at end range. Biomechanical range of motion was assessed at each cervical segment. Physiological and segmental biomechanical restrictions were graded by the PT as mild, moderate or severe. The same PT re-evaluated and confirmed the grading category just prior to the Doppler test. Physiological restrictions were generalized to the whole cervical spine. Biomechanical restrictions were classified into cranio-vertebral restrictions (any restriction at atlanto-occipital joints, C0–C1, or atlanto-axial joints, C1–C2) or mid-to-lower cervical spine restrictions (any restriction at joints C2–C7).

The Doppler test was conducted within 1 week following the PT assessment. The participant was positioned supine on the table with no pillow 5–10 min prior to the test to allow for a period of haemodynamic stabilization. Heart rate was measured in the resting position in supine as radial pulse rate for 30 s and blood pressure using a standard cuff and stethoscope. Representative Doppler spectral waveforms were obtained in supine with the spine in a neutral position from both the right and left vertebral arteries using a 7 MHz probe on a duplex Doppler ultrasound machine with colour flow imaging (ATL 3000 HDI). The same qualified technician performed all Doppler scans and the same PT performed all movement progressions. The sampling region was with the probe in the midportion of the extra cranial segment of the vertebral artery (approximately C3–C5). Sampling of PS (peak systolic velocity, cm/s), ED (end diastolic velocity, cm/s), and RI (resistive index, peak systolic–end diastolic/peak systolic) were recorded in each position for both ipsi- and contra-lateral arteries using the same order of sampling for each test. Decreases in PS and ED are indicative of decreased blood flow due to occlusion or narrowing of the artery more distal to the site of measurement. A high RI signifies increased resistance to flow distal to the sampling site with a maximum possible value of 1.0.

Scanning was performed from the ipsi-lateral anterior aspect of the sternocleidomastoid muscle at an angle of less than 60°. With more extreme neck positioning, (i.e. rotation) scanning was still performed from an anterior approach, but often required locating the ultrasound probe more medially on the sternocleidomastoid muscle when rotation was toward the side of the artery being interrogated. Colour Doppler was utilized when needed to assist in locating the vertebral artery. The position was held as long as necessary to obtain a sample in both arteries. All positions were held for at least 25 s and no sampling was initiated until the position had been held for 10 s. Subjects were rested in a neutral position on the bed for 10 s before re-positioning for the next movement test. Subjects were asked to report any symptoms during and after each test movement and were observed for neurological signs.

For each of the positions, full available end range passive movement was obtained. The movement sequence (performed in both directions) was: (1) cervical rotation (rot), (2) extension with the head supported on the bed (ext), generated by lordosing the mid and lower cervical spine and extending the upper cervical spine, (3) combined rotation and extension (rot–ext) as in # 2, (4) adding manual traction to the cervical spine while sustaining # 3 (rot–ext–tr), (5) a deKleyn’s test (deK) with the subject positioned at the end of the bed (level with the third thoracic vertebrae) in order that the head could hang over the edge in full rotation–extension, supported by the PT and (6) a pre-manipulative hold (PMH) at the atlanto-axial joint complex positioned in cranio-vertebral side flexion combined with contra-lateral rotation down to and including C1–C2, with
digital pressure on C1–C2 just short of manipulative thrust (Figs. 1–6).

Following the test procedure, the subject rested in supine with no pillow. Heart rate, blood pressure and a neutral, resting Doppler scan of both arteries were re-

measured. A radiologist reviewed all scans following testing to provide a qualitative assessment for artery pathology or abnormal discrepancy in arterial diameters.

3. Data management and analysis

SPSS version 11.0 was used for statistical analysis. Paired samples t-tests were used to determine any significant differences ($P<0.05$) for resting Doppler samples, pre- and post-BP and HR measurements. Because there was no difference between left and right artery flow in neutral, all arteries were pooled ($n=44$) for the analysis of position change. (Individual blood flow changes for left and right arteries were also evaluated, with similar results to the pooled data, therefore just the pooled results are presented in this paper.) Changes in PS, ED and RI values for all arteries (contra-lateral to movement sequence and ipsi-lateral to movement sequence) during the stress test sequence were compared using a general linear model repeated measures analysis. A Bonferroni correction was used for multiple comparisons for each relative change in PS, ED and RI from neutral to each position (corrected $P<0.05$). Age, gender and mobility restriction were entered as co-variates to determine if these factors influenced blood flow changes.

4. Results

4.1. Subjects

There were 14 females and 8 males, mean age $35 \pm 10.5$ years. Table 1 outlines demographic information and findings from the PT assessment for the 22 participants. There were six subjects reporting a history of potential VBI symptoms such as dizziness, blurring of
vision and headaches, but symptoms were not reproduced in the VBI stress test sequence conducted during the PT assessment.

4.2. Blood flow responses in neutral

There were no significant differences ($P > 0.05$) between mean neutral blood flow values before and after the testing sequence (PS pre-test neutral mean = 56.5 cm/s ± 12.3, post-test = 56.8 cm/s ± 15.0; ED pre-test neutral mean = 18.4 cm/sec ± 5.0, post-test = 18.2 cm/sec ± 4.5). Although there was a small decrease in post-test pulse rate (3 bpm, $P < 0.05$), there were no significant differences in pre- and post-test resting BP. In order to account for sources of variability in neutral haemodynamics, the means for pre- and post-test neutral PS, ED and RI were used as the resting baseline values. There were no artery pathologies identified by the radiologist and any minor discrepancies in arterial diameters were equally distributed across left and right arteries.

4.3. Blood flow responses during the stress test sequence

The artery was visualized in all positions on both ipsi- and contra-lateral sides. The means and standard deviations for PS, ED and RI for neutral and the six different neck positions for all 44 arteries can be found in Table 2. Figs. 7–9 depict mean change scores occurring in contra- and ipsi-lateral arteries for PS, ED and RI during the stress test sequence.

There were significant changes in mean blood flow (corrected $P < 0.05$) during the test sequence. The most consistently significant drop in blood flow and increase

---

Table 1

Subject demographics and findings from the physical therapy assessment

<table>
<thead>
<tr>
<th>PT assessment findings</th>
<th>n</th>
<th>n</th>
<th>n</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Symptoms reported</td>
<td>16</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vascular stress test findings</td>
<td>22</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physiological mvt. Restrictions</td>
<td>15</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biomechanical mvt. Restrictions</td>
<td>14</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>History of neck pain</td>
<td>14</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>History of neck injury</td>
<td>17</td>
<td>5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$^a$ Subjective reports of potential VBI symptoms such as dizziness, blurring of vision.
$^b$ Presence of any central ischaemia signs or symptoms during a progressive vascular stress test, Negative indicates no signs or symptoms reproduced.
$^c$ Active physiological movement.
$^d$ Passive movement testing at atlanto-occipital and atlanto-axial joints.
$^e$ Passive movement testing at mid-lower cervical spine.

Table 2

Mean values for PS, ED, RI for all arteries grouped by movements in the contra- and ipsi-lateral directions in relation to the artery

<table>
<thead>
<tr>
<th></th>
<th>Neutral (mean of two tests)</th>
<th>Rot.</th>
<th>Ext</th>
<th>Rot-ext</th>
<th>Rot-ext-tr</th>
<th>DeK.</th>
<th>PMH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contralateral artery (n=44)</td>
<td></td>
<td>57.6</td>
<td>51.9</td>
<td>61.2</td>
<td>57.2</td>
<td>59.3</td>
<td>63.4</td>
</tr>
<tr>
<td>PS</td>
<td></td>
<td>57.6</td>
<td>(18.8)</td>
<td>(13.8)</td>
<td>(9.5)</td>
<td>(16.0)</td>
<td>(17.3)</td>
</tr>
<tr>
<td>SD</td>
<td></td>
<td>(12.6)</td>
<td>(12.6)</td>
<td>(12.6)</td>
<td>(12.6)</td>
<td>(12.6)</td>
<td>(12.6)</td>
</tr>
<tr>
<td>ED</td>
<td></td>
<td>18.3</td>
<td>14.8*</td>
<td>18.5</td>
<td>18.7</td>
<td>18.2</td>
<td>18.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(4.3)</td>
<td>(4.3)</td>
<td>(4.3)</td>
<td>(4.3)</td>
<td>(4.3)</td>
<td>(4.3)</td>
</tr>
<tr>
<td>RI</td>
<td></td>
<td>0.68</td>
<td>0.74*</td>
<td>0.70</td>
<td>0.67</td>
<td>0.70</td>
<td>0.70</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.06)</td>
<td>(0.06)</td>
<td>(0.06)</td>
<td>(0.06)</td>
<td>(0.06)</td>
<td>(0.06)</td>
</tr>
<tr>
<td>Ipsilateral artery (n=44)</td>
<td></td>
<td>57.6</td>
<td>62.3</td>
<td>61.2</td>
<td>60.9</td>
<td>62.9</td>
<td>63.1</td>
</tr>
<tr>
<td>PS</td>
<td></td>
<td>57.6</td>
<td>(22.0)</td>
<td>(13.8)</td>
<td>(14.8)</td>
<td>(22.8)</td>
<td>(24.0)</td>
</tr>
<tr>
<td>SD</td>
<td></td>
<td>(12.6)</td>
<td>(12.6)</td>
<td>(12.6)</td>
<td>(12.6)</td>
<td>(12.6)</td>
<td>(12.6)</td>
</tr>
<tr>
<td>ED</td>
<td></td>
<td>18.3</td>
<td>18.3</td>
<td>18.5</td>
<td>17.8</td>
<td>17.6</td>
<td>17.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(4.3)</td>
<td>(4.3)</td>
<td>(4.3)</td>
<td>(4.3)</td>
<td>(4.3)</td>
<td>(4.3)</td>
</tr>
<tr>
<td>RI</td>
<td></td>
<td>0.68</td>
<td>0.71</td>
<td>0.70</td>
<td>0.71</td>
<td>0.73*</td>
<td>0.74*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.06)</td>
<td>(0.06)</td>
<td>(0.06)</td>
<td>(0.06)</td>
<td>(0.06)</td>
<td>(0.06)</td>
</tr>
</tbody>
</table>

rot. = rotation, ext. = extension, rot.-ext. = combined rotation and extension, rot.-ext.-tr = combined rotation, extension and traction, deK. = deKlley’s position, PMH = pre-manipulative hold.

*Significant difference compared to neutral, $P < 0.05$ (bonferroni correction for multiple comparisons).
Rotation were more than two standard deviations below the 0% change line. The tendency for reduced flow in the contra-lateral artery during the PMH was the most obvious deviation from normal variability, with 23 of the 44 tests below the 95% confidence limit for PS and 16 for ED. Of those 16 arteries, 15 demonstrated a complete cessation of blood flow during ED.

When age, gender and mobility restrictions were considered as co-variates in the repeated measures analysis, the statistical change in mean blood flow response remained unchanged. As well, no correlations were found between position change scores and BP, presence of any symptom history or neck pain. Although the majority of individuals with substantial decreases in PS and ED in the contra-lateral artery during the PMH were graded as having full cranio-vertebral mobility, there were 3 subjects with limited cranio-vertebral mobility who had a complete cessation of ED in this position. In other words, significant decreases in blood flow during the C1–C2 PMH occurred despite restricted motion at the upper cervical spine.

5. Discussion

It is apparent that not all individuals at risk of injury or death during a cervical manipulation can be adequately screened. The causes and precipitating factors are still not clear enough to provide clinicians with a sensitive screening protocol. We are unable to make conclusions regarding the sensitivity of the stress test sequence to identify individuals with vascular pathology as our sample consisted of healthy men and women. However, by determining the pattern of blood flow changes that occur during the test, it provides evidence which cervical positions mechanically stress the vertebral arteries. If there is compromise of collateral flow, there is a greater risk of brain ischaemia when the neck is placed in a position where the patent artery is mechanically stressed (Rivett et al., 1999). It is also possible that if there is a pre-existing weakness or predisposition to embolize, the position that stresses the arterial wall causing cessation of flow may be the position more likely to tear the artery or slough a thrombus or atherosclerotic plaque, although this is yet to be proven (Mann and Refshauge, 2001).

This study evaluated a sequence of cervical movements used in PT practice to screen for VBI. No other studies have evaluated blood flow both ipsi-laterally and contra-laterally throughout this stress test sequence to determine if blood flow changes reflect that the artery is being progressively stressed. The findings from this study support that only full range cervical rotation and the PMH at C1–C2 stressed the vertebral arteries sufficiently to demonstrate reduction of blood flow.
One of the limitations of this study, similar to other Doppler studies, is the lack of knowledge of ultrasound reliability, particularly when measuring in more extreme neck positions such as rotation and extension. The reliability of Doppler sampling is very dependent on the skill of the technologist to accurately locate and identify the arteries. Consistency of measurement in a neutral position was confirmed by repeating this test following the movement progression. However, with the neck in extreme positions, it becomes more difficult for the technologist to locate the vertebral artery. We did not perform a reliability test of these positions, however we did address this limitation by using technically advanced equipment, a highly skilled technologist and sampling at a region where the artery is more easily visualized extra cranially at C3–C5. Although one could argue that measuring at the mid cervical spine is less sensitive than measuring specifically at the site of proposed artery stretching, (C1–C2), there is support that duplex Doppler measurements at the mid cervical region are accurate in identifying pathology at any level of vertebro-basilar circulation (Nicolau et al., 2000). We were able to consistently visualize and sample both vertebral arteries at this level in all positions. This study used advanced duplex ultrasound technology with colour flow imaging. Previous studies reporting the effect of cervical movements have used ultrasound equipment with several technical limitations, the most important being poor localization of the vertebral artery (Johnson, 2000). The sophistication of colour flow imaging increases the ability to locate and verify accurate sampling.

The only two positions that consistently demonstrated blood flow changes indicative of distal narrowing occurring higher up in the cervical spine were rotation and the PMH. The contra-lateral vertebral artery is elongated by approximately 5 mm during cervical rotation (Sim et al., 2000) with 50–90% of cervical spine rotation attributed to movement at the atlanto-axial joint (Mercer and Bogduk, 2001). Thus, the vertebral artery is more vulnerable to shear and tensile forces where it exits C2 and runs vertically and laterally to C1 due to the degree of movement at this region (Goel et al., 1988). In order to gain maximal specific end of range motion of C1–C2 for the PMH, the cervical spine was positioned above and below C1–C2 with physiological coupling of side flexion toward the opposite side of the rotation. This is a manipulative position used in PT practice when locking is necessary (Canadian Physiotherapy Association Orthopedic Division, 2003–2004b). By producing unilateral anterior or posterior gliding motion of the atlas on the axis, maximal stress is proposed to occur to the vertebral artery as a final progressive test (Aspinall, 1989). Other studies have compared blood flow in neutral before and after manipulation and have found no significant change (Licht et al., 2000), however, to the authors’ knowledge, no other studies have measured vertebral artery blood flow during a simulated hold of a cervical manipulation. We found that the drop in both systolic and diastolic velocities were sufficient to totally occlude flow in one artery for several subjects and decrease the flow by greater than 50% for the majority of the sample. The PMH as compared to any other position tested produced the greatest mechanical stress to the contralateral vertebral artery. This may be due to the isolation of maximal motion specifically at the region where the artery is most vulnerable to tensile forces.

The order of movement progression was the same for all subjects. This method was chosen in order to more closely reflect what is done in clinical practice, gradually adding further stress to the arterial system. However, because the PMH was the last movement in the sequence for all subjects and demonstrated the greatest flow decrease, it is not completely clear if the order of testing may have affected the results. Because blood flow quickly returned to pre-test values when measured again immediately after the PMH, one would not expect there to be a latent effect. In fact, the second most occlusive position was rotation, which was the first movement in the sequence. Nonetheless, in order to determine the possible effect of testing order, a subsequent study is currently being conducted with random variation of test positions.

Despite the consistent observation of occlusion of one artery during the PMH, there was only one subject who reported any symptoms potentially indicative of ischaemia. Transient dizziness was reported at the beginning of the hold and then following the release of the position. In this case, ED did drop to 0 and PS dropped by 65%. Cessation of flow is generally not a risk to the brain, because there are other pathways that will allow circulation to the brainstem, cerebellum, and posterior cerebrum. In fact, we frequently observed increases in flow rates in the ipsi-lateral vertebral artery during the PMH. This pattern was not consistently observed in any other position. If an individual presented with pathology in one artery, the PMH by stressing the patent artery, may significantly compromise posterior circulation to the brain. One would expect ischaemic symptoms to present in this situation.

The combined position of extension–rotation did not occlude vertebral artery flow in this study. In fact, mean blood flow tended to return to or increase slightly above resting values. This position has been proposed to stress the artery to a greater extent than rotation and extension performed separately (Carey, 1995; Canadian Physiotherapy Association Orthopedic Division, 2003–2004a). The findings from this study would support the opposite: rotation alone mechanically stressed the contra-lateral vertebral artery more than combined extension–rotation, whether in a full deKleyn’s
position or with the head remaining on the bed. Previous studies have reported conflicting results for deKleyn’s position (Thiel et al., 1994; Li et al., 1999) and there have been no previous studies measuring blood flow in the alternative position, inducing rotation and extension with the head remaining on the bed. We found no consistent blood flow response in either of these positions. It is possible that when attempting to combine full extension with rotation, it is difficult to achieve full physiological rotation. If rotation is the primary movement found to reduce arterial flow, the addition of extension may actually diminish the stress to the contralateral artery. From the results of this study, we propose that combining extension and rotation is not a necessary progression to further stress the artery if rotation alone has already been tested. A recent screening protocol recommends rotation as a minimal testing position to screen for those with symptoms (Australian Physiotherapy Association, 2000). Previous research demonstrating equal reduction of blood flow in both rotation and combined rotation–extension adds further support that screening both positions may not be necessary (Rivett et al., 1999).

A progression of the extension–rotation position is the addition of manual traction in order to add further stress to the artery without dropping the head over the end of the bed. There is limited knowledge of the effect of traction on blood flow. Cadaveric studies have found that traction significantly increases the stress on the arteries, however it is not clear if the same force is being applied manually in vivo (Brown and Tatlow, 1963; Rivett, 1997). Our findings suggest that manual traction applied to the cervical spine while it is in an extended and rotated position does not add any additional stress to the artery.

There was never cessation of flow observed with extension alone. This movement induced combined extension at both lower and upper cervical regions with the head on the bed. Despite reports of vascular injuries occurring in an extended position (Wouter, 2001) only one study has found decreased blood flow with cervical extension (Li et al., 1999). It is unlikely that cervical extension places notable stress upon the healthy vertebral artery.

Our finding of no effect of mobility restriction on blood flow changes is clinically important. It appears that mild to moderate movement restriction at the cranio-vertebral joints does not provide a protective effect to limit stretching of the contra-lateral artery. Significant drops in blood flow occurred for three individuals in the PMH even in the presence of cranio-vertebral movement restrictions. No other studies have attempted to quantify segmental movement restrictions and measure the relationship to blood flow changes. It is possible that over time the vertebral artery adapts to movement restrictions resulting in the same degree of arterial stretching occurring at the individual’s limitation of range, similar to end range stretching of a fully mobile spine. Further study with a larger sample of biomechanical segmental restrictions would assist in understanding the effect of degree of movement on vertebral artery stretching.

Developing a screening protocol that is known to mechanically stress at least one vertebral artery should assist to evaluate the ability of collateral flow to maintain brainstem function. This study concludes that full range physiological rotation and a PMH at C1–C2 should provide sufficient mechanical stress to reproduce observable symptoms to screen out individuals with unilateral pathology. For individuals with specific history of positional symptom reproduction, other movements may need to be employed. It should also be noted that due to the dramatic change in blood flow observed in the PMH, clinicians need to be cautious using this position particularly for individuals with history that may pre-dispose them to increased risk of arterial dissection and those with symptoms that may suggest VBI or inhibited collateral flow. Further study is still required to verify if these positions can reproduce symptoms that would alert the practitioner to possible risk.

Acknowledgements

We would like to acknowledge the contributions of Dean MacMillan for his technical expertise and John Berzolla for his assistance with this study. We also gratefully acknowledge Physiotherapy Foundation of Canada; Continuous Research Fund, School of Physical Therapy, University of Saskatchewan for the financial support.

References


