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Is There a Difference in Blood Flow Velocity between Bilateral Common Carotid Arterises in Community-Dwelling Elderly with Unilateral Chewing Habit and Forward Head Posture?: An Observational Cross-Sectional Study

Background: Due to aging, blood flow rate decreases, also posture and chewing habit may be changed.
Objective: To identify that changes in blood velocity in the common carotid arteries (CCAs) in old persons with unilateral chewing habit (UCH) and forward head posture (FHP) in the elderly.
Design: An observational cross-sectional study.
Methods: Chewing habits, FHP, and CCAs velocities were assessed in 85 elderly subjects. Chewing habits were measured by visual observation. CCAs measured the peak systolic velocity (PSV), end-diastolic velocity (EDV), minimum diastolic velocity, and resistivity index. The subjects were divided into UCH and bilateral chewing habit groups depending on chewing habit. The subjects were also divided into >49 degrees and <49 degrees for comparison of blood flow between the left and right CCAs.
Results: In the UCH, the chewing side had significantly higher EDV (*P*=.003), PSV (*P*=.023) than the non-chewing side. There was no significant difference in velocity between the CCAs in the FHP.
Conclusion: This study shows that the blood flow velocity of the chewing side of UCH was higher, and unilateral chewing affects the CCAs velocity and thus highlight the importance of chewing habit in the elderly than head posture.

Keywords: *Blood velocity; Common carotid artery; Chewing habit; Elderly; Head posture*

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INTRODUCTION

Chewing is a rhythmic function involving peripheral organs, sensory input, and the coordinated action of the central nervous system. Previous study suggested that chewing ability is correlated with cognitive state in elderly persons.[1] A recent study has reported a significant association between head posture and unilateral chewing habit (UCH) in elderly persons.[2] The head-neck and jaw have also been reported to be biomechanically and functionally linked.[3] These studies suggest that the masticatory and neck muscles become co-activated during chewing.[4]

A recent study suggests that mastication is a complex movement generated from neural networks in various parts of the brain, including the primary motor cortex and prefrontal cortex.[5] The blood flow volume of the common carotid artery (CCA) increases during chewing, and this significantly increases cerebral blood flow and blood flow velocity.[6] Chewing can occur on both sides, but most people predominantly use one side over the other while chewing (i.e., UCH).[7] A recent study has reported that UCH can increase with age and that they are significantly associated with age.[2] The age-related decrease in flow velocity in CCA is known.[8] Most studies have focused on blood flow at peak systolic velocity (PSV) and end diastolic velocity (EDV), and a study determined that velocity decreases with age.[9] A previous study demonstrated that the PSV and EDV decreased with age and that the PSV velocity in CCA significantly decreased during lifetime.[10]

The CCA lends itself to non-invasive investigation because of its anatomic location.[11] Many studies have performed spectral analysis of the blood flow, and they showed that its wave forms vary with aging and vascular disease. This analysis is a very powerful non-invasive tool for clinical diagnosis such as carotid artery disease. Therefore, Doppler ultrasound is a popular technique for investigating the hemodynamic of cerebrovascular and cardiovascular circulation.[12]

As previously reported,[2,5,6] chewing can change the blood flow in the CCA. Also, in elderly, forward head (FH) and UCHs can increase and the physiologic blood velocity in the CCA. It is important to identify changes in blood flow to the brain according to the head posture and chewing habits of the elderly, and to recognize the importance of posture and chewing habits.

Therefore, this study was aimed at investigating the changes in blood velocity in both CCAs in old person with different chewing habits and head postures. This study hypothesized that there are significant differences in the blood velocity in both CCAs in old person with UCHs and forward head posture (FHP).

SUBJECTS AND METHODS

Participants and procedure

This cross-sectional observational study included 85 elderly persons (age range, 65–84 years) who were recruited through various means of community center advertisement such as posters. Participants were selected using the following inclusion and exclusion criteria. The inclusion criteria were age >65 years, ability to perform activities of daily living independently, and no history of cardiovascular disease, except take of antihypertensive medication because hemodynamic parameters in the carotid artery are not associated use of antihypertensive medication.[13] The exclusion criteria were intake of medication and/or substances (e.g., coffee, which has caffeine) that affect blood flow before measurement,[14] pain during chewing, dental implants or orthodontic prosthesis, Mini-Mental State Examination (MMSE) score <24, unable to maintain ultrasound measurement posture, and contraindication to any of the measurement procedures. This study used the G-power 3.1.7[15] for calculation of the sample size, which was determined on the basis of power=.95, α=.05, and effect size=.5. The participants' age, medication intake, and presence of diabetes were recorded based on self-report, and their weight, height, blood pressure, chewing habit, and the PSV, EDV, and resistivity index (RI) of the CCA were measured. Before experimental process, detailed information about the study procedure and safety was offered to the patients, and they signed a written informed consent. This study was approved by the Institutional Review Board of G University (Clinical trial registration number: KCT0003407). All data collection took place at a community center. Whereas researchers were aware of measurement purpose of participants, outcome assessors and data analysts were kept blinded. The data for the study were collected from August 2016 through February 2017.

Outcome measurements

Measurement of CCA velocity: Measurement was performed after the subject's posture was stabilized after remaining in the supine position for 5 minutes.[16] The subject gently turned his head to the other side while the head was slightly extended during the examination. We used a linear probe and Doppler ultrasonographic system (ClearVue550; Philips Healthcare, Andover, MA, USA). Carotid Doppler sonography was performed with a 4 to 12 MHz linear transducer.[17] All ultrasound readings were evaluated and appraised by a technician who had no previous information on the participants. Intima media thickness (IMT), i.e., the distance between the intima media at the posterior wall on the longitudinal plan e, was measured in the left and right carotid (at 10 mm proximal to the carotid bulb) arteries. Carotid artery velocity measured the PSV, EDV, minimum diastolic velocity, and resistive index (RI). During the measurement, excessive rotation of the subject's head or excessive pressing of the probe was avoided.

Determination of UCH: UCH refers to consistent chewing of food on the same side. Chewing habits were measured by visual observation, which is a direct method of measurement.[18] In this study, the subjects were asked to sit on a chair in the upright posture and chew a gum for 1 minute.[2] The number of strokes on the right and left was counted, and the side with more strokes was designated as the UCH.

Head posture measurement: The head posture was associated craniocervical angle,[19] therefore in this study head posture was measured using the craniocervical angle. The FHP was defined as head postures of 49–36 degree in community-dwelling elderly subjects aged 65 years or older.[20] Therefore, in this study, FHP was defined as FHA ≤49 degree. With the participants comfortably seated on a chair, the head posture in the sagittal plane was measured using the angle between the horizontal line and the line from the tragus to the C7 (using its spinous process as landmark). This angle was then analyzed using the Global Posture Analysis System (Chinesport, Udine, Italy).[2] Previous studies have indicated that cranio-cervical angle measurements have good test-retest reliability (intra-class correlation coefficient, .88).[21]

Statistical Analysis

All statistical analyses were conducted using SPSS version 23 (IBM Corp., Armonk, NY, USA). Frequency and descriptive statistics were analyzed to determine the subjects' general characteristics. The normal distribution of data was determined with the Shapiro-Wilk test. A paired t-test was used to compare the variables in the intra-group of chewing habit and FHP. All obtained measurements were compared between the chewing and non-chewing sides in the UCH group and between the left and right sides in the bilateral-chewing-habit (BCH) group. Independent t-test was performed to compare general characteristics between the two groups. The subjects were divided into ≥49 degree and <49 degree groups according to their FHAs. The dependent variables were compared between the left and right sides. Outcome variables are shown as mean±standard deviation (SD). The significance level was set at α=.05.

RESULTS

The UCH group and BCH groups comprised 41 (mean age 70.86 years) and 44 (mean age 73.00 years) individuals, respectively. The characteristics of all 85 participants are shown in Table 1.

In the UCH group, EDV (*P*=.003) and PSV (*P*=.023) were significantly difference in the chewing side compared with the non-chewing side (Table 2). No significant differences in the EDV and PSV were observed in the BCH group (Table 3). No significant difference was found between the left and right sides in the FHA <49 degree (Table 4) and FHA ≥49 degree groups (Table 5).

Table 1. General characteristics of the subjects.

Variables (unit)	Unilateral chewing (n=41)	Bilateral chewing (n=44)
Age (year)	70.86 ± 6.22	73.00 ± 5.57[a]
Sex (male/female)	11 (26.8)[b] / 30 (73.2)	13 (29.5) / 31 (70.5)
Systolic blood pressure (mmHg)	135.50 ± 16.38	130.47 ± 14.85
Diastolic blood pressure (mmHg)	75.04 ± 9.27	74.37 ± 10.14
Heart rate	73.12 ± 9.45	76.22 ± 12.04
Weight (cm)	59.66 ± 7.53	61.74 ± 10.85
Height (kg)	155.74 ± 7.23	156. ± 6.98
Body mass index (kg/m^2)	23.59 ± 2.70	24.97 ± 3.10
Less 49 degrees	25 (62.5)[b], 43.07 ± 4.03[a]	22 (48.9), 44.23 ± 4.40
Over 49 degrees	16 (37.5), 53.24 ± 2.48	22 (51.1), 54.93 ± 4.23

[a]mean±standard deviation, [b]number of person (%).

Table 2. Comparison of blood velocity of common carotid artery in unilateral chewing group.

Variables (unit)	Non Chewing side	Chewing side	Difference (95% CI)	*P*
IMT (mm)	.10 ± 0.03	.10 ± .03	-.01 ± 0.03 (-.01 ~ .00)	.749
PSV (cm/sec)	47.24 ± 13.56	52.38 ± 16.61	-5.15 ± 13.89 (-9.53 ~ -.76)	.023*
EDV (cm/sec)	11.59 ± 5.01	13.81 ± 5.75	-2.22 ± 4.49 (-3.63 ~ .79)	.003**
MDV (cm/sec)	12.30 ± 5.19	14.03 ± 6.72	-1.72 ± 6.33 (-3.72 ~ .27)	.089
Resistance index	.71 ± 0.06	.69 ± .05	.01 ± 0.05 (-.00 ~ .03)	.096

*P<.05, **P<.01, IMT: Intima media thickness, PSV: Peak systolic velocity, EDV: End diastolic velocity, MDV: Minimum diastolic velocity

Table 3. Comparison of blood velocity of common carotid artery in bilateral chewing group.

Variables (unit)	Left	Right	Difference (95% CI)	*P*
IMT (mm)	.11 ± .03	.12 ± .03	−.01 ± .14 (−.02 ~ .03)	.405
PSV (cm/sec)	48.09 ± 14.55	50.25 ± 15.97	−2.16 ± 14.32 (−6.52 ~ 2.18)	.321
EDV (cm/sec)	12.76 ± 5.17	13.73 ± 5.46	−1.03 ± 4.67 (−2.46 ~ .38)	.148
MDV (cm/sec)	11.37 ± 5.17	12.74 ± 7.38	−1.37 ± 6.62 (−3.38 ~ .64)	.177
Resistance index	.73 ± .06	.72 ± .06	.01 ± .05 (−.00 ~ .03)	.114

IMT: Intima media thickness, PSV: Peak systolic velocity, EDV: End diastolic velocity, MDV: Minimum diastolic velocity

Table 4. Comparison of blood velocity of common carotid artery in <49 degrees. (n=47)

Variables (unit)	Left side	Right side	Difference (95% CI)	*P*
PSV (cm/sec)	46.97 ± 12.58	47.03 ± 11.25	−.063 ± 11.650 (−4.546 ~ 4.672)	.978
EDV (cm/sec)	12.04 ± 4.41	11.98 ± 5.44	−.417 ± 3.810 (−1.924 ~ 1.089)	.574
MDV (cm/sec)	10.52 ± 5.83	11.69 ± 6.22	1.164 ± 1.212 (−1.327 ~ 3.657)	.346
Resistance index	.73 ± .06	.74 ± .08	.015 ± .065 (−.010 ~ .041)	.226

IMT: Intima media thickness, PSV: Peak systolic velocity, EDV: End diastolic velocity, MDV: Minimum diastolic velocity

Table 5. Comparison of blood velocity of common carotid artery in ≥49 degrees. (n=38)

Variables (unit)	Left side	Right side	Difference (95% CI)	*P*
PSV (cm/sec)	48.83 ± 16.53	49.97 ± 16.02	1.138 ± 12.230 (−2.828 ~ 5.105)	.565
EDV (cm/sec)	13.56 ± 5.94	13.58 ± 5.97	.017 ± 4.680 (−1.503 ~ 1.537)	.982
MDV (cm/sec)	11.24 ± 7.92	12.96 ± 6.04	1.175 ± 2.695 (−1.093 ~ 4.544)	.223
Resistance index	.73 ± .07	.73 ± .07	.000 ± .059 (−.018 ~ .020)	.928

IMT: Intima media thickness, PSV: Peak systolic velocity, EDV: End diastolic velocity, MDV: Minimum diastolic velocity

DISCUSSION

This study compared blood velocities in the CCAs in community-dwelling old person with different chewing habits and head postures. The UCH group showed higher EDV and PSV in the chewing side than in the non-chewing side compared with the BCH group. However, no significant difference in head posture was found in the FHA <49 degrees and FHA ≥49 degree groups.

The prefrontal cortex of the brain becomes activated during chewing,[22] and jaw movements cause changes in cerebral blood flow,[6] which is attributed to changes in blood flow in the carotid artery.[23] Shinagawa et al[24] reported that subjects with UCH are significantly more dependent on the blood oxygenation level in the primary sensorimotor cortex. Chewing causes a local increase in neural activity in the brain, some of which vary with age.[5,22] In addition, chewing causes regional increases in brain neuronal activities, which are related to biting force. Biting force is closely associated with masseter muscle activity, and there is greater cerebral blood flow in the working side of the masseter muscle that performs intensive isometric contraction.[6,25] Therefore, as the masseter muscle in the chewing side becomes activated, the amount of blood flow to the chewing side will increase. In this study, higher PSV and EDV were observed in the chewing side in the UCH group. This may be because as the movements of the masticatory muscle and the tongue associated with the jaw movement increase in the chewing side during mastication, the amount of blood flow to the primary sensory cortex increases. This finding is similar to a previous finding in which higher blood velocities were observed in the chewing side than the non-chewing side.

The CCAs send blood from the heart to the brain. Reduced EDV and PSV in the CCA are associated with the risk of cardiovascular disease (CVD). EVD is a predictor of CVD,[26] and patients with stroke have higher RIs than non-stroke patients.[27] Furthermore, EDV and PSV are more sensitive parameters in predicting patient conditions, and differences in the left and right EDVs can be observed depending on the patients' conditions.[28] In this study, significantly lower PSV and EDV were observed in the non-chewing side than the chewing side in the elderly subjects with UCH.

There are limitations to this study. First, our experiment was conducted cross sectional study, the results could only indicate at the point. Second, the factors affecting blood flow velocity are hypertension, diabetes, and blood lipid. However, in this study, diabetes, and blood lipid were not measured except blood pressure. Also, the activity of the masticatory muscles during chewing may also affect blood flow.[6,22] Third, authors did not consider the reliability of visual observation, a tool for evaluating chewing habits. Finally, there was a difference in the ratio between men and women in this study. However, this study did not consider this part. Therefore, the author suggests that periodic follow-up of the subject, and further prospective research is necessary.

A previous study has also reported that changes in cerebral hemodynamics occur according to head position.[29] Although previous studies analyzed these changes while the subjects were in supine and sitting positions, our study compared blood velocities at different FHAs in the sitting position. Therefore, the FHP was not associated with changes in the blood velocity in the CCAs in this study. In this study, chewing habits are more responsible for the changes in blood velocity, than FHP, in the CCAs, and differences in blood velocity were observed in both CCAs in the UCH group. Since this study is a cross-sectional study, subsequent long-term follow-up research is needed. Moreover, since cerebral blood flow may be associated with depression in patients with cognitive impairment,[30] we suggest studying the associations among cerebral blood flow, chewing habit, depression, and cognitive impairment.

CONCLUSION

In conclusion, UCH showed higher EDV and PSV in the chewing side than in the non-chewing side compared with the BCH in community-dwelling old person. The present findings show that unilateral chewing affects the CCA velocity rather than FHC, so this study can confirm the importance of chewing habit management in the aging.

CONFLICT OF INTEREST

The author in this study declare that there is no conflict of interest.

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