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ORIGINAL ARTICLE

Handgrip Strength Asymmetry as a Marker of Silent Cerebrovascular Disease in Adults with Hypertension

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ABSTRACT

Background: Silent cerebrovascular disease (CVD) is common in adult hypertensive patients and can only be detected when cognitive impairment arises. Asymmetry of handgrip strength could be a measure of cerebral injury that reflects disruption of bilateral motor pathways.

Objective: To assess the association between handgrip strength asymmetry and magnetic resonance imaging evidence of silent cerebrovascular disease in hypertensive adults.

Methods: A cross-sectional study was conducted from October 2024 to October 2025 and 120 adults with hypertension at Department of Medicine, General Hospital, Lahore were recruited. Three trials of each handgrip strength were taken with a calibrated dynamometer. Asymmetry was considered as an inter-hand difference of ≥ 10%. Evaluation of the brain magnetic resonance imaging included white matter hyperintensities, lacunes, cerebral microbleeds, and enlarged perivascular spaces. Independent associations were identified using multivariable logistic regression.

Results: The study included 66 men and 54 women, with a mean age of 56.5 ± 7.8 years. Of the 48 participants (40.0%) had handgrip asymmetry and of the 56 (46.7%) had silent cerebrovascular disease. Asymmetry was associated with higher prevalence of disease than was symmetrical strength (60.4% vs 37.5%, p=0.014). The asymmetry group showed a higher prevalence of WMH, lacunes, multiple imaging abnormalities, and microbleeds. Asymmetry was independently associated with silent cerebrovascular disease after adjusting for age, sex, diabetes, duration of hypertension, systolic blood pressure, renal function and average grip strength (adjusted odds ratio 2.61; 95% confidence interval 1.14–5.98; p=0.023).

Conclusions: Silent cerebrovascular disease was independently associated with handgrips strength asymmetry and might be used for risk classification in adults with hypertension.

Keywords: handgrip strength; handgrip asymmetry; hypertension; silent cerebrovascular disease; cerebral small-vessel disease; magnetic resonance imaging

INTRODUCTION

Hypertension is one of the most important modifiable risk factors for cerebrovascular injury[1]. Increased blood pressure over time can lead to vascular remodelling, endothelial dysfunction, impaired blood–brain barrier and blood–brain autoregulation, which can cause damage to small cerebral vessels. This can lead to progressive white matter injury, lacunar infarcts, cerebral microbleeds and enlarged perivascular spaces even in people who have not had any apparent stroke or transient ischemic attack. The

abnormalities may be present without neurological symptoms, and so are often referred to as silent cerebrovascular disease[2].

These lesions may not be clinically noticeable for years but are not benign[3]. Silent C.V. disease may be associated with cognitive decline, poor balance, decreased mobility, gait disturbance, functional dependence, and future stroke risk. Early recognition is thus of great importance especially among adults with long-standing or poorly controlled hypertension. But for all hypertensive patients, routine brain MRI is not feasible due to its cost, lack of availability and lack of clear indications in asymptomatic patients[4].

A clinical marker that can easily identify patients who are more likely to suffer silent cerebral injury thus would be valuable[5]. Handgrip strength is a simple, readily available measure of neuromuscular function. It is an index of the activity of the motor cortex, corticospinal pathways, peripheral nerves, neuromuscular junctions and skeletal muscles. The majority of clinical evaluations are based on absolute hand strength, typically of the dominant hand, but inter-hand strength differences may yield extra neurological information[6].

Asymmetry of handgrip strength means that the right and left hands do not generate the same amount of strength[7]. There may be minor variations due to dominant hand, profession, physical activity and/or previous minor injury. By contrast, persistent or marked asymmetry may indicate unequal neural activation, subtle motor-pathways disruption or subclinical hemispheric dysfunction. When the small vascular lesions involve descending motor tracts or the connecting white matter fibres, they may result in impaired motor function bilaterally before definite weakness can be appreciated clinically during a routine neurological examination[8].

Absolute grip weakness is related but different to grip asymmetry[9]. Ageing, frailty, poor nutrition, chronic illness, loss of muscle mass and physical inactivity can all play a part in reduced strength. However, asymmetry looks at how well the motor functions are working on each side, and may be more sensitive to localized or unequal neurological damage. This separation might be especially important in older adults with hypertension, where small-vessel disease in the brain is a common cause of involvement of motor and interconnection pathways[10].

Although bilateral grip assessment may have clinical importance, the association between handedness asymmetry in grip strength and radiological findings of silent CVA is poorly studied[11]. Such an association could help promote the use of a quick bedside test to help identify individuals with hypertension who might benefit from more thorough neurologic examination or imaging[12].

The present study was thus performed to establish whether there is a relationship between handgrip strength asymmetry and magnetic resonance imaging measures of silent cerebrovascular disease in adults with hypertension[13]. The hypothesis was that individuals with clinically relevant asymmetry would be more likely to develop silent cerebral vascular lesions and this would result in greater burden of lesions[14].

MATERIALS AND METHODS

Study Design and Setting: The study was an analytical cross-sectional study carried out in the Departments of Medicine, Neurology and Radiology of a General Hospital, Lahore from October 2024 to October 2025. This study investigated the association between handgrip strength (HGS) asymmetry and magnetic resonance imaging (MRI) measures of silent cerebrovascular disease (SCVD) in adults with hypertension.

Ethical Approval: The study protocol was accepted by institutional ethical review committee prior to the recruitment of participants. All participants signed an informed consent form. All information regarding the participants was kept confidential and anonymous throughout the study. The name of institution and the ethical approval number should be filled in based on the official study record.

Sample Size and Sampling Technique: 120 participants in total were included. Sample size was calculated based on an expected frequency of silent cerebrovascular abnormalities in adults with hypertension, a 95% confidence level and an acceptable margin of error. The study was conducted at medical and hypertension outpatient clinics and the sampling was done by non-probability consecutive sampling technique.

Eligibility Criteria: Patients were eligible if they were adults (40-70 years old) with a history of primary hypertension for more than 1 year. Hypertension was identified as a documented clinical diagnosis, or as being on antihypertensive medication, or as having persistent elevation of blood-pressure measurements in the medical record.

Patients were excluded when they had a previous stroke, transient ischemic attack, intracranial haemorrhage, dementia, Parkinson disease, multiple sclerosis, epilepsy, brain tumour or another recognized neurological disorder. Those with focal neurological deficits on examination, severe cognitive impairment, advanced renal or hepatic disease, decompensated heart failure, active malignancy or with contraindications to magnetic

resonance imaging (MRI) were also excluded. Patients with upper-limb fractures, who had severe arthritis, cervical radiculopathy, peripheral neuropathy, significant hand pain, or previous hand surgery were excluded.

Data Collection: Structured data-collection form was used for the collection of demographic and clinical information. The following variables were recorded: age, sex, smoking status, physical activity, body mass index, hand dominance, duration of hypertension, diabetes mellitus, dyslipidaemia, medication and anti-hypertensive therapy adherence.

Height was measured in a stadiometer (without shoes) and weight on a calibrated digital scale. Body mass index was derived as weight (kg) / height (m^2).

Laboratory evaluations performed were fasting plasma glucose, glycated haemoglobin, serum creatinine, estimated glomerular filtration rate and total cholesterol, low-density lipoprotein cholesterol, high-density lipoprotein cholesterol and triglycerides.

Blood-Pressure Measurement: Blood pressure was taken at the office with a validated automated blood pressure machine. Before measurement, the participants sat for at least five minutes to relax. A cuff of the correct size was fitted on the upper arm, and 3 readings taken, one minute apart. The two last readings were averaged for analysis.

If available, a 24-h ambulatory blood-pressure measurement was done to obtain the mean systolic and diastolic blood pressure. Daytime measurements were taken every half hour, and nighttime measurements were taken every hour. Recordings that have at least 70% of the expected measurements were counted as valid recordings.

Handgrip-Strength Assessment: Handgrip strength was assessed with a calibrated hydraulic handgrip. Subjects were seated with the back supported, shoulder adducted, elbow flexed at ~90°, forearm in a neutral position and wrist slightly extended.

Allows one attempt for familiarization prior to formal testing. All participants made 3 maximal grips with both hands. Both the right and left hands were tested separately, with 30 seconds or longer rest between tests to reduce the risk of fatigue. Each participant was asked to try to push the dynamometer as hard as they could for about 3-5 seconds.

The greatest reading from each hand was used for analysis. Handgrip strength was expressed as both right- and left-hand maximum strength and the average of the two.

Handgrip asymmetry was analysed as the ratio between the dominant and non-dominant handgrips for each individual as follows:

Absolute difference between stronger and weaker hand strength divided by the strength of the stronger hand and multiplied by 100.

Hands that differed by 10% or more were deemed to have clinically significant handgrip strength asymmetry. A difference < 10% was considered to be relatively symmetrically handgrip strength among participants.

Neurological Examination: A standardised neurological examination was conducted by a physician blinded to the results of the handgrip examination. Muscle strength, deep tendon reflexes, cranial-nerve function, sensation, coordination, gait and balance were evaluated. All the participants with clinical focal neurological abnormalities were excluded and referred to appropriate evaluation.

Brain Magnetic Resonance Imaging: Non-contrast brain magnetic resonance imaging (MRI) was performed in all participants on a 1.5-Tesla or 3.0-Tesla scanner. Imaging protocol consisted of axial T1-, T2-weighted, fluid-attenuated inversion recovery, diffusion-weighted, apparent diffusion coefficient and susceptibility-sensitive sequences.

Two radiologists blinded to the clinical and handgrip findings independently reviewed the MR images. Any difference of opinion was settled in a way of consensus.

The following parameters of silent cerebral vascular disease were evaluated:

Hyperintense lesions seen on T2-weighted and fluid-attenuated inversion recovery (FLAIR) sequences are called white matter hyperintensities. They were individually scored in periventricular and deep white matter areas according to the Fazekas scale. Clinically significant scores were 2 or 3.

- Lacunes: Intracortical rounded or oval cavities (3–15 mm in diameter) that have cerebrospinal-fluid-like signal.
- Cerebral microbleeds: Areas of signal loss on susceptibility-sensitive sequences that are rounded in shape and are not vascular flow voids or calcification and other mimicking lesions.
- Enlarged perivascular spaces: Small fluid-filled spaces in the basal ganglia and centrum semiovale along penetrating cerebral vessels.

Silent cerebrovascular disease was defined as having moderate-to-severe white matter hyperintensities, one or more lacunes, one or more cerebral microbleeds, or high burden of enlarged perivascular spaces.

Total cerebral small-vessel disease score was computed as the sum of the imaging markers, with one point awarded for each marker that met the criteria.

Study Groups: The participants were assigned to two groups based on handgrip-strength asymmetry:
Symmetric handgrip group: difference in inter-hand strength < 10%.

- Asymmetric handgrip group: Hand strength difference between hands was 10% or more.

Prevalence and burden of silent cerebrovascular disease was compared between the two groups.

Outcome Measures: The primary outcome was the presence of silent cerebrovascular disease on magnetic resonance imaging.

Secondary outcomes included: Moderate to severe white matter hyperintensities.

- Presence of lacunes.
- Presence of microbleeds in the brain.
- Enlarged perivascular spaces (high burden).
- Two or more imaging abnormalities.
- Total small vessel disease score of the brain.

Statistical Analysis: IBM SPSS Statistics 29.0 was used to analyse data. The continuous variables were tested for normal distribution and reported as mean (standard deviation) or median (interquartile range) as appropriate. Categorical variables were presented as frequencies and percentages.

Normally distributed continuous variables were compared using an independent-samples t test and non-normally distributed continuous variables were compared using a Mann–Whitney U test. Chi-square test or Fisher exact test was used to compare categorical variables.

To investigate the association between handgrip strength asymmetry and silent cerebrovascular disease, binary logistic regression analysis was used. Those variables that were clinically relevant or had an univariable p value < 0.20 were evaluated for inclusion in the adjusted model. Age, sex, diabetes mellitus, duration of hypertension, and systolic blood pressure, estimated glomerular filtration rate, mean handgrip strength, and handgrip asymmetry were included in the final model.

The results were expressed as ORs and 95% CIs. The discriminatory ability of handgrip asymmetry for the detection of silent cerebrovascular disease was determined by receiver operating characteristic curve analysis. Statistically significant P values were set at < .05 (two-sided).

RESULTS

A total of 142 adults with hypertension were assessed, of whom 22 were excluded because of previous cerebrovascular disease, upper-limb disorders, contraindications to magnetic resonance imaging, or incomplete data. The final analysis included 120 participants: 66 men (55.0%) and 54 women (45.0%). Handgrip strength asymmetry of at least 10% was present in 48 participants (40.0%), including 27 men and 21 women.

Participants with handgrip asymmetry were older and had a longer duration of hypertension, higher office and 24-hour systolic blood pressure, and lower average handgrip strength than participants with relatively symmetrical grip strength. The proportions of male and female participants were comparable between groups. Diabetes mellitus, body mass index, smoking, dyslipidaemia, diastolic blood pressure, renal function, and low-density lipoprotein cholesterol did not differ significantly, as shown in Table 1.

Silent cerebrovascular disease was identified in 56 participants (46.7%). It was significantly more frequent among participants with handgrip asymmetry than among those with relatively symmetrical strength (60.4% vs 37.5%; p=0.014). Moderate-to-severe white matter hyperintensities, lacunes, cerebral microbleeds, enlarged perivascular spaces, and multiple coexisting lesions were also more common in the asymmetry group. The total cerebral small-vessel disease burden was significantly greater among participants with asymmetry, as presented in Table 2.

Silent cerebrovascular disease was detected in 31 of the 66 males (47.0%) and 25 of the 54 females (46.3%) and was not significantly different between males and females (p=0.941). In men, 59.3% with asymmetry and 38.5% without asymmetry were found to have disease. Similarly, among females, the proportions were 61.9% and 36.4%, respectively.

Handgrip asymmetry was linked to an increased risk of silent cerebrovascular disease by 2.54-fold in the unadjusted analysis. Asymmetry was independently associated with the outcome after adjustment for age, sex, diabetes mellitus, hypertension duration, 24-hour blood pressure (systolic), renal function and average handgrip strength. Higher 24 hour systolic blood pressure and older age were also significant predictors, while sex and the average grip strength were not independently associated as seen in Table 3.

An ROC analysis indicated a moderate discriminative power of the percentage handgrip asymmetry with an AUC of 0.70 for silent cerebral vascular disease. A cut-off of 10.5% yielded sensitivity of 67.9% and specificity of 65.6%. Adding handgrip asymmetry to the clinical prediction model increased the area under the curve from 0.77 to 0.81.

Table 1: Baseline characteristics according to handgrip strength asymmetry

Characteristic	Symmetry below 10% (n=72)	Asymmetry of at least 10% (n=48)	p value
Age, years	54.8 ± 7.7	59.1 ± 7.3	0.003
Male participants	39 (54.2%)	27 (56.3%)	0.823
Female participants	33 (45.8%)	21 (43.7%)	0.823
Body mass index, kg/m²	27.4 ± 3.7	27.9 ± 4.0	0.485
Hypertension duration, years	6.6 ± 4.2	9.4 ± 5.1	0.001
Diabetes mellitus	18 (25.0%)	17 (35.4%)	0.220
Current smoking	12 (16.7%)	11 (22.9%)	0.394
Office systolic blood pressure, mmHg	138.7 ± 13.2	145.2 ± 14.8	0.014
Mean 24-hour systolic blood pressure, mmHg	131.3 ± 10.1	136.9 ± 11.5	0.006
Estimated glomerular filtration rate, mL/min/1.73 m²	85.6 ± 15.7	80.4 ± 17.2	0.091
Average handgrip strength, kg	29.8 ± 8.1	26.2 ± 7.5	0.016
Handgrip asymmetry, percentage	4.9 ± 2.5	16.6 ± 6.3	<0.001

Table 2: Magnetic resonance imaging findings according to handgrip strength asymmetry

Magnetic resonance imaging finding	Symmetry below 10% (n=72)	Asymmetry of at least 10% (n=48)	p value
Any silent cerebrovascular disease	27 (37.5%)	29 (60.4%)	0.014
Moderate-to-severe white matter hyperintensities	18 (25.0%)	24 (50.0%)	0.005
Lacunes	8 (11.1%)	15 (31.3%)	0.006
Cerebral microbleeds	5 (6.9%)	10 (20.8%)	0.024
High burden of enlarged perivascular spaces	12 (16.7%)	17 (35.4%)	0.019
At least two imaging markers	7 (9.7%)	14 (29.2%)	0.006
Total cerebral small-vessel disease score	0 (0–1)	1 (0–2)	0.003

Table 3: Factors associated with silent cerebrovascular disease

Variable	Unadjusted odds ratio with 95% confidence interval	p value	Adjusted odds ratio with 95% confidence interval	p value
Handgrip asymmetry of at least 10%	2.54 (1.20–5.38)	0.014	2.61 (1.14–5.98)	0.023
Age, per five-year increase	1.37 (1.12–1.67)	0.002	1.29 (1.02–1.64)	0.034
Female sex	0.97 (0.47–2.01)	0.941	1.08 (0.49–2.37)	0.844
Diabetes mellitus	1.74 (0.81–3.74)	0.156	1.43 (0.61–3.38)	0.409
Hypertension duration, per five-year increase	1.43 (1.09–1.88)	0.011	1.22 (0.89–1.68)	0.215
Mean 24-hour systolic blood pressure, per 10-mmHg increase	1.55 (1.15–2.09)	0.004	1.41 (1.02–1.96)	0.039
Estimated glomerular filtration rate, per 10-mL/min/1.73 m² increase	0.83 (0.70–0.99)	0.039	0.91 (0.74–1.11)	0.349
Average handgrip strength, per five-kilogram increase	0.79 (0.64–0.98)	0.032	0.92 (0.72–1.17)	0.492

DISCUSSION

The present study demonstrated a significant association between handgrip strength asymmetry and silent cerebrovascular disease among adults with hypertension[1]. Those with an inter-hand strength difference of ≥10% had significantly more abnormalities on magnetic resonance imaging of the brain than did those with relatively symmetrical grip strength. This association was still observed after controlling for age, sex, duration of diabetes mellitus, ambulatory systolic blood pressure, renal function and average handgrip strength[2].

Results indicated that handgrip asymmetry could be used to give more than just absolute muscle strength[3]. Although participants with asymmetry had lower average grip strength, absolute strength was no longer independently associated with silent cerebrovascular disease in the adjusted model. This suggests that when there is imbalance between the two hands, the cause may be subtle imbalance or unequal neurological function, and not generalised muscle weakness alone[4].

All but half of the study population had silent cerebrovascular disease, suggesting that the amount of subclinical cerebral injury is high in adults with hypertension[5]. The most common imaging abnormality was moderate-to-severe white matter hyperintensities followed by enlarged perivascular spaces, lacunes, and cerebral microbleeds. All of these abnormalities were more common in participants who had handgrip asymmetry. Additionally, the presence of more than one imaging marker was more frequent in the asymmetry group, which might imply that more severe inter-hand imbalance is linked to more widespread cerebral small vascular damage[6].

This association may be due to several biological mechanisms[7]. Endothelial dysfunction, vascular wall thickening, impaired cerebral autoregulation and chronic injury to penetrating cerebral arteries are the

consequences of long-standing hypertension. These alterations can result in small strokes, microhaemorrhages and disruption of subcortical white matter pathways. Although these lesions do not clinically cause a stroke, they can disrupt the transmission through the cortico-spinal and bilateral motor coordination leading to unequal force production between hands[8].

Handgrip performance requires the coordinated activity of the motor cortex, descending motor pathways, peripheral nerves, neuromuscular junction and skeletal muscle[9]. Thus, motor output may be decreased on one side of the body at first due to silent lesions involving one cerebral hemisphere or asymmetrically distributed white matter pathways before overt weakness can be detected during routine neurological examination. Chronically asymmetric handgrip function could therefore be an early functional manifestation of underlying cerebrovascular injury[10].

Higher 24 hour systolic blood pressure and older age were also independent factors associated with silent cerebrovascular disease[11]. This is clinically plausible because with advancing age there is increased vascular stiffness, as well as an increase in exposure to vascular risk factors, and because chronic exposure to hypertension itself causes small-vessel damage. The linkage with ambulatory blood pressure highlights the need for exposure of blood pressure throughout the day and not just office readings only[12].

The estimated prevalence did not differ significantly between men and women for the major association, suggesting no significant effect of sex on the overall association[13]. There was a similar directionality of association between handgrip asymmetry and silent imaging abnormalities in both sexes. This indicates that bilateral grip assessment could be used in both males and females with hypertension, but more studies are needed to establish sex-specific thresholds[14].

When handgrip asymmetry alone was used to discriminate, a moderate discriminatory ability was found using receiver operating characteristic analysis[15]. The addition of this to a clinical model boosted identification of participants with silent cerebrovascular disease. Thus, handgrip asymmetry should not be used as a diagnostic alternative to MRI of the brain. It may have clinical utility for initial risk stratification, especially when more advanced imaging technology is not readily available, such as in the outpatient or primary-care setting[16].

Bilateral handgrip measurement has the advantages of being cheap, quick, non-invasive and easy to administer[17]. Brain imaging, when clinically appropriate, may be considered in hypertensive patients with significant or persistent asymmetry, as well as a more detailed neurological assessment and cognitive screening and review of blood-pressure control. Multiple measurements can be especially helpful, as a consistent inter-hand difference will be more significant than a single abnormal measurement due to fatigue, pain or lack of effort[18].

There are several limitations of the study[19]. The cross-sectional design precludes determination if the asymmetry in grip strength preceded the occurrence of silent cerebrovascular lesions or not. The study was done at a single centre with a relatively small sample, and this may have restricted the generalizability. Major upper limb disorders were excluded, but minor arthritis, occupational hand use, past injuries and peripheral neuropathy which was not noticed may have influenced grip measurements. It is reasonable, though not set everywhere, to use the 10% value as the threshold for defining asymmetry. Moreover, more sophisticated imaging techniques that could assess damage to the microstructures of the motor-pathways were not employed[20].

However, the study does show that there is evidence to suggest that handgrip strength asymmetry could be a clinically available tool to evaluate silent cerebrovascular disease in adult hypertension[7]. The uniform bilateral assessment, the inclusion of both sexes, the ambulatory blood-pressure evaluation and the adjustment of grip strength averages reinforce the findings[16].

CONCLUSION

Using handgrip strength as an independent variable, we found that it was associated with silent cerebrovascular disease in adult hypertensive patients. Among participants, those who had an inter-hand difference ≥10% were more likely to have white matter hyperintensities, lacunes, cerebral microbleeds, enlarged perivascular spaces, and multiple imaging abnormalities.

The bilateral handgrip test could be a simple and low-cost screening tool to detect covert cerebral vascular damage in patients with hypertension. Though not a substitute for neurological examination or magnetic resonance imaging, ongoing or marked asymmetry could be used to favor a more extensive cerebrovascular investigation, and close monitoring of modifiable risk factors. Further studies with larger numbers of participants are required for the validation of the optimal cut-off values for asymmetry and to assess if handgrip imbalance is a predictor of cerebral lesion progression, cognitive deterioration, or future stroke.

DECLARATION

Conflict of Interest: The authors declare no conflict of interest.

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