



ASSESSMENT OF AUTONOMIC DYSFUNCTION IN ISCHEMIC STROKE PATIENTS

Pradeep Kumar Maurya

Postgraduate Student, Department of Medicine, Moti Lal Nehru Medical College and Associated Swaroop Rani Hospital, Prayagraj, Uttar Pradesh, India

Piyush Saxena

MD (Medicine), Professor, Department of Medicine, Moti Lal Nehru Medical College and Associated Swaroop Rani Hospital, Prayagraj, Uttar Pradesh, India

Sujit Kumar

MD (Medicine), Professor, Department of Medicine, Moti Lal Nehru Medical College and Associated Swaroop Rani Hospital, Prayagraj, Uttar Pradesh, India

Ashish Rai

DM (Neurology), Assistant Professor, Department of Medicine, Moti Lal Nehru Medical College and Associated Swaroop Rani Hospital, Prayagraj, Uttar Pradesh, India

Kaushlendra Nath Tripathi

MD (Medicine), Assistant Professor, Department of Medicine, Moti Lal Nehru Medical College and Associated Swaroop Rani Hospital, Prayagraj, Uttar Pradesh, India

ABSTRACT

Background: Stroke is a leading cause of mortality and long-term disability globally, particularly ischemic stroke. Autonomic nervous system dysfunction following ischemic stroke is increasingly recognized, showing symptoms like cardiovascular regulation issues, heart rate variability abnormalities, orthostatic hypotension, and bowel and bladder disturbances. The objectives of this study were to evaluate the prevalence and pattern of autonomic dysfunction among patients with acute ischemic stroke and to correlate autonomic dysfunction parameters with stroke severity and functional outcomes. **Methods:** A prospective observational study was conducted in the Department of General Medicine, SRN Hospital, Moti Lal Nehru Medical College, Prayagraj, from 2025 to 2026 after ethical approval. Total 113 patients aged ≥ 18 years with radiologically confirmed ischemic stroke presenting within 72 hours were enrolled after written informed consent. Patients with hemorrhagic stroke, pre-existing autonomic dysfunction, or medications affecting autonomic function were excluded. Clinical history, examination, NIHSS score, neuroimaging, and laboratory investigations were recorded. Autonomic function was assessed using heart-rate variability, blood-pressure variability, orthostatic testing, sustained handgrip, deep-breathing response, and Valsalva maneuver. Functional outcome was assessed using mRS at discharge. Data were analyzed using SPSS 24.0; $p < 0.05$ was considered significant. **Results:** Total 113 ischemic stroke patients, males predominated (70%), with the largest age group being 51–70 years (47%). Hypertension (55%) and diabetes mellitus (41%) were the most frequent comorbidities. Autonomic dysfunction was observed in 41 patients on handgrip testing, 56 on heart-rate response to deep breathing, and 16 on Valsalva testing. True orthostatic hypotension was identified in 22 patients (19.5%), among whom abnormal deep-breathing response was most frequent (54.5%). Significant correlations were observed between NIHSS and handgrip response ($r = 0.45$, $p = 0.046$), Valsalva ratio ($r = 0.38$, $p = 0.039$), and deep-breathing response ($r = 0.29$, $p = 0.021$). ANOVA demonstrated significant differences across stroke-severity groups. Autonomic parameters also differed significantly between good and poor functional outcomes ($p < 0.05$). **Conclusion:** Autonomic dysfunction is common in ischemic stroke and significantly associated with stroke severity and poor functional outcomes. Early autonomic assessment may improve risk stratification, complication prevention, and comprehensive stroke management.

KEYWORDS : Ischemic Stroke, Autonomic Dysfunction, Autonomic Nervous System; Heart Rate Variability; Valsalva Maneuver; Handgrip Test; Orthostatic Hypotension; Stroke Severity; Nihss; Functional Outcome; Modified Rankin Scale

INTRODUCTION

One of the primary causes of disability in young adults is stroke, affecting approximately 15 million people globally each year, as reported by the World Health Organization (WHO). This condition results in around 5 million fatalities and an equal number of individuals facing permanent disabilities. The Global Burden of Diseases indicates a significant 26% increase in global stroke deaths over the last two decades, escalating from 4.66 million in 1990 to 5.87 million in 2010. Stroke, historically associated with older populations, is increasingly impacting younger adults aged 18–44 years, a trend confirmed by a 2012 National Inpatient Sample (NIS) study. This pattern persisted into 2017, highlighting the rise in stroke-related mortality and disability in this demographic.[1,2] Strokes can be classified into two main types: hemorrhagic stroke (10%–20% incidence) and ischemic stroke (80%–90%). In the United States, United Kingdom, and Australia, the incidence ranges from 8% to 15%, with about 12% to 15% of cases reported per 100,000 people annually. In

contrast, Asia exhibits higher rates of hemorrhagic stroke, ranging from 15% to 40%, compared to developed nations, where it stands at 15%–20%. Neuroimaging studies in India indicate a higher ratio of infarction to hemorrhage, varying from 1.86:1 to 2.21:14.4, exceeding the average ratio of 5:1 observed in Western countries.[3,4]

Ischemic stroke represents a significant neurological disorder stemming from the interruption of cerebral blood flow, leading to focal brain injury and considerable potential for disability and mortality. While stroke predominantly manifests neurologically, it also induces systemic disturbances, notably affecting cardiovascular autonomic regulation. There is a growing recognition of autonomic dysfunction as a crucial aspect of the pathophysiology associated with acute ischemic stroke, which may have implications for complications, recovery outcomes, and long-term prognoses.[5]

The autonomic nervous system (ANS) plays a critical role in

maintaining cardiovascular homeostasis via its sympathetic and parasympathetic components, which regulate heart rate, vascular tone, blood pressure, and visceral functions. This regulation is orchestrated by the central autonomic network, encompassing the insular cortex, anterior cingulate cortex, amygdala, hypothalamus, brainstem nuclei, and their interconnected pathways. Stroke-related damage to these structures can disturb the balance between sympathetic and parasympathetic functions. Notably, the insular cortex is vital for cardiovascular autonomic control; lesions in this area, known as insular infarctions, are linked to significant cardiovascular dysregulation and heightened sympathetic activation.[6]

Autonomic disturbances following ischemic stroke can present as irregularities in heart rate and blood pressure control, cardiac arrhythmias, myocardial injury, changes in baroreflex sensitivity, and compromised cardiovascular responses to physiological stress. During the acute phase of stroke, a predominance of sympathetic activity alongside diminished parasympathetic activity has been observed. These autonomic dysfunctions may lead to subsequent systemic complications and negatively impact neurological recovery.[7]

Several non-invasive methods are available for evaluating autonomic function. Heart-rate response to deep breathing and the Valsalva ratio primarily assess parasympathetic cardiovascular function, whereas the sustained handgrip test evaluates sympathetic-mediated blood-pressure responses. Studies using standardized autonomic function testing have demonstrated impaired parasympathetic responses in patients with acute ischemic stroke, with abnormalities potentially persisting during the chronic phase.[8]

Recent evidence indicates that evaluating autonomic dysfunction can yield important insights into stroke severity, cardiovascular complications, and long-term prognosis. Measures pertaining to heart-rate variability and baroreflex are being researched as potential prognostic indicators.[5] Conducting systematic assessments of autonomic function through straightforward bedside cardiovascular reflex tests could aid in detecting autonomic impairment in ischemic stroke patients, thereby enhancing the understanding of its correlation with stroke severity and functional outcomes. This study aims to assess autonomic dysfunction in ischemic stroke patients and examine its association with both stroke severity and functional outcomes.

The objectives of this study were to evaluate the prevalence and pattern of autonomic dysfunction among patients with acute ischemic stroke and to correlate autonomic dysfunction parameters with stroke severity and functional outcomes.

Methods

The hospital-based prospective observational study was carried out in the Department of General Medicine, Swaroop Rani Nehru (SRN) Hospital, Moti Lal Nehru Medical College, Prayagraj, Uttar Pradesh, India over a period of one year (March 2025– March 2026) after obtaining approval from the ethical clearance, Institutional Ethics Committee. Total 113 patients aged 18 years and above with radiologically confirmed ischemic stroke, presenting within 72 hours of symptom onset, and willing to provide written informed consent were included. Exclusion criteria comprised patients who did not consent, those diagnosed with intracerebral hemorrhage, individuals with pre-existing autonomic dysfunction (e.g., Parkinsonism or diabetic autonomic neuropathy), and patients on medications affecting autonomic functions including beta-blockers.

After obtaining informed consent, eligible patients with acute ischemic stroke were enrolled according to predefined

inclusion and exclusion criteria. A detailed clinical history was obtained from the patient or attendant using a structured case record form, including demographic characteristics, vascular risk factors, previous cerebrovascular events, medication history, and relevant family history. General and systemic examinations were performed, and baseline vital parameters were recorded.

Stroke severity was assessed at admission using the National Institutes of Health Stroke Scale (NIHSS). CT and/or MRI brain was performed to confirm ischemic stroke, determine infarct location and size, and classify the stroke subtype according to the TOAST criteria. Routine laboratory investigations, including complete blood count, blood glucose, HbA1c, lipid profile, serum electrolytes, and renal function tests, were performed.

Autonomic function assessment was conducted after adequate resting in a quiet environment. ECG was recorded for heart-rate variability analysis, and frequency-domain parameters including LF, HF, and LF/HF ratio were calculated. Blood-pressure variability was assessed during resting conditions and autonomic testing. Orthostatic blood pressure was measured in the supine position and after standing. Sympathetic function was evaluated using the sustained handgrip test, while parasympathetic function was assessed using heart-rate response to deep breathing and the Valsalva maneuver.

Patients were monitored during hospitalization for autonomic and neurological complications. Functional outcome was assessed using the Modified Rankin Scale at discharge. Hospital complications, duration of stay, and mortality were also documented.

Statistical Analysis

The data were entered into Microsoft Excel and analyzed using SPSS version 24.0. Quantitative variables were expressed as mean $\pm$ standard deviation, and qualitative variables as frequency and percentage. Continuous variables were compared using Student's t-test or Mann-Whitney U test, while categorical variables were analyzed with Chi-square or Fisher's exact test. Correlation analysis assessed the association between autonomic dysfunction parameters and stroke severity, along with clinical outcomes. Multivariate regression identified independent prognostic factors for poor outcomes, with a significance threshold of $p < 0.05$.

RESULTS

The study involved 113 patients with gender distribution showing 79 males (70%) and 34 females (30%). Age-wise, 33 participants (29%) were aged 30–50 years, 53 (47%) were aged 51–70 years, and 27 (24%) were aged 71–90 years. Hypertension was present in 62 patients (55%), while 51 (45%) did not have it. Diabetes was observed in 46 participants (41%), and 67 (59%) were non-diabetic. Dyslipidaemia affected 29 patients (26%), leaving 84 (74%) without it. Coronary artery disease was present in 21 individuals (19%), while 92 (81%) were unaffected. Bowel or bladder dysfunction was noted in 70 cases (62%), with 43 (38%) not affected. Smoking history was reported by 26 patients (23%), while 87 (77%) were non-smokers. Alcohol consumption was reported by 32 participants (28%), and 81 (72%) did not consume alcohol. ACE inhibitors of 25 (22%) were using ACE inhibitors while 88 (78%) were not.

Table 1: Demographic Profile and Comorbidities Profile in Study Participants

	n=113	Percent (%)
Gender (n=113)		
Female	34	30
Male	79	70
Age group (years) (n=113)		

30 to 50	33	29
51 to 70	53	47
71 to 90	27	24
Hypertension (n=113)		
No	51	45
Yes	62	55
Diabetes Mellitus(n=113)		
No	67	59
Yes	46	41
Dyslipidaemia(n=113)		
No	84	74
Yes	29	26
Coronary Artery Disease (n=113)		
No	92	81
Yes	21	19
Smoking(n=113)		
No	87	77
Yes	26	23
Alcohol Use(n=113)		Percent (%)
Yes	32	28
No	81	72
ACE Inhibitors(n=113)		
No	88	78
Yes	25	22

In a study assessing autonomic dysfunction through various tests among 113 participants, the results highlighted notable distributions of dysfunction. In the handgrip test, 41 participants exhibited autonomic dysfunction, whereas 72 had normal responses. For heart rate response to deep breathing, 56 participants showed dysfunction, contrasting with 57 who had normal results. Additionally, an abnormal Valsalva ratio was identified in 16 participants, while 97 displayed normal values across the tests conducted. (Table 2)

Table 2: Distribution of Autonomic Dysfunction Across Different Autonomic Function Tests

Autonomic Function Test	Normal (n)	Dysfunction Present (n)	Total (n)
Handgrip Test	72	41	113
HR Response to Deep Breathing	57	56	113
Valsalva Ratio	97	16	113

The study assessed the distribution of orthostatic hypotension among participants, with 47 patients (41.6% of the population) identified with this condition. Excluding those with diabetes and on beta blockers, true orthostatic hypotension was present in 22 patients (19.5%). The analysis highlighted specific abnormalities in autonomic function tests among patients with true orthostatic hypotension: 12 patients (54.5%) demonstrated an abnormal heart rate response to deep breathing, 5 patients (22.7%) exhibited handgrip test abnormalities, and 2 patients (9.1%) had an abnormal Valsalva ratio. The findings emphasize the distinct test-wise abnormalities in this subgroup. (Table 3)

Table 3: Distribution of True Orthostatic Hypotension and Autonomic Function Test Abnormalities in True Orthostatic Hypotension Patients

Category	Number (n)	Percentage (%)
Orthostatic Hypotension	47	41.6
True Orthostatic Hypotension (excluding diabetes and beta blockers)	22	19.5
Autonomic Function Test	Abnormal (n)	Percentage (%)
Handgrip Test	5	22.7
Heart Rate Response to Deep Breathing	12	54.5
Valsalva Ratio	2	9.1

Pearson correlation analysis demonstrated a statistically significant positive correlation between NIHSS score at admission and several parameters of autonomic function

among 113 participants. Specifically, the handgrip test showed a correlation coefficient (r) of 0.45 with a p-value of 0.046, indicating that greater stroke severity correlates with increased rise in diastolic blood pressure. Additionally, the Valsalva ratio had a correlation coefficient of 0.38 (p = 0.039), and heart rate response to deep breathing displayed a correlation coefficient of 0.29 (p = 0.021). These results suggest a significant association between increasing stroke severity and greater autonomic dysfunction. (Table 4)

Table 4: Correlation Between Stroke Severity (NIHSS) and Autonomic Function Parameters

Variable	NIHSS at Admission (r)	p-value
Handgrip Test – Rise in Diastolic BP	0.45	0.046
Valsalva Ratio	0.38	0.039
Heart Rate Response to Deep Breathing	0.29	0.021

One-way ANOVA analysis revealed statistically significant differences in autonomic function among various stroke severity groups. Key findings included heart rate response to deep breathing, the increase in diastolic blood pressure during the handgrip test, and the Valsalva ratio, all varying significantly between groups (p < 0.05). The specific results showed an F value of 4.12 (p = 0.018) for heart rate response to deep breathing, an F value of 3.65 (p = 0.032) for the handgrip test, and an F value of 4.67 (p = 0.011) for the Valsalva ratio. These outcomes suggest a progressive degradation of autonomic function correlating with increased stroke severity, based on the analyzed parameters across the study population. (table 5)

Table 5: One-Way ANOVA of Autonomic Function Parameters Across Stroke Severity Groups

Autonomic Parameter	F value	p-value
Heart Rate Response to Deep Breathing	4.12	0.018
Handgrip Test – Rise in Diastolic BP	3.65	0.032
Valsalva Ratio	4.67	0.011

Independent samples t-test results demonstrate significant differences in autonomic function parameters between patients with favorable (good) and unfavorable (poor) functional outcomes. Specifically, the Valsalva ratio was lower in patients with good outcomes (mean: 1.70 ± 0.45) than in those with poor outcomes (mean: 1.92 ± 0.38), yielding a t-value of -2.31 and a p-value of 0.022. Similarly, the heart rate response to deep breathing averaged 15.61 ± 5.77 bpm in the good outcome group versus 12.98 ± 5.77 bpm in the poor outcome group, resulting in a t-value of 2.45 and a p-value of 0.016. Furthermore, the mean increase in diastolic blood pressure during the handgrip test was slightly higher in the poor outcome group (mean: 12.33 ± 4.03 mmHg) compared to the good outcome group (mean: 12.18 ± 4.17 mmHg), with a t-value of -2.10 and a p-value of 0.038. The study included observations from 67 patients with good outcomes and 46 patients with poor outcomes, highlighting a significant association between autonomic dysfunction and functional outcome. (Table 6)

Table 6: Comparison of Autonomic Function Parameters Between Functional Outcome Groups

Autonomic Parameter	Good Outcome Mean $\pm$ SD (n=67)	Poor Outcome Mean $\pm$ SD (n=46)	t-value	p-value
Valsalva Ratio	1.70 ± 0.45	1.92 ± 0.38	-2.31	0.022
HR Response to Deep Breathing	15.61 ± 5.77	12.98 ± 5.77	2.45	0.016
Handgrip Test – Rise in DBP	12.18 ± 4.17	12.33 ± 4.03	-2.10	0.038

DISCUSSION

The present study total 113 patients with ischemic stroke, with a male predominance (70%) and the majority belonging to the 51–70-year age group (47%). This demographic pattern is

consistent with the established epidemiology of ischemic stroke, in which increasing age and male sex are important determinants of cerebrovascular disease. Autonomic dysfunction is increasingly recognized as an important consequence of stroke because cerebral lesions can disrupt the central autonomic network involved in cardiovascular and visceral regulation.[9,10]

Hypertension (55%) was the most common comorbidity in the study population, followed by diabetes mellitus (41%) and dyslipidaemia (26%). This indicates a significant burden of vascular risk factors. Notably, hypertension and diabetes may affect stroke and autonomic dysfunction due to cardiovascular regulation abnormalities. Previous research shows that autonomic dysfunction is often observed post-ischemic stroke and is influenced by existing cardiovascular risk factors.[10,11]

Coronary artery disease was found in 19% of participants, indicating a cardiovascular risk profile. Bowel or bladder dysfunction affected 62% of patients, suggesting that these issues may indicate post-stroke autonomic involvement due to the role of autonomic pathways in controlling bladder and bowel functions.[9]

Smoking and alcohol consumption were reported in 23% and 28% of ischemic stroke patients, respectively, highlighting their roles as modifiable risk factors for cerebrovascular disease and related vascular and autonomic abnormalities. ACE inhibitors were utilized by 22% of participants, suggesting their impact on autonomic responses and cardiovascular metrics. The findings underscore the significant presence of vascular risk factors and autonomic clinical manifestations in these patients, advocating for systematic assessment of autonomic function during comprehensive stroke evaluations.[9,10]

The present study demonstrated variable frequencies of autonomic dysfunction across the three autonomic function tests. Abnormality was most frequent in the heart rate (HR) response to deep breathing, where 56 of 113 patients (49.6%) showed dysfunction, followed closely by the handgrip test, in which 41 patients (36.3%) demonstrated an abnormal response. In contrast, an abnormal Valsalva ratio was observed in only 16 patients (14.2%). This variation suggests that different components of the autonomic nervous system may be affected to different degrees following ischemic stroke. The study highlights a notable incidence of abnormal heart rate responses to deep breathing, which implies a considerable dysfunction in cardiac parasympathetic control within the observed group. Deep-breathing heart-rate variability, primarily driven by vagal activity, serves as an effective non-invasive indicator of cardiovagal function. Additionally, the handgrip test assesses cardiovascular sympathetic function by measuring the anticipated increase in blood pressure during prolonged isometric exertion.[13,14]

The findings indicate that a lower frequency of abnormal Valsalva responses, compared to other tests, suggests some preservation of autonomic pathways; however, variations in test sensitivity and the specific patterns or locations of cerebral injury may also play a role. Previous research has shown that autonomic dysfunction frequently occurs after ischemic stroke, with abnormalities differing based on the assessed autonomic domain.[15,16] The results underscore the importance of employing multiple complementary autonomic function tests instead of relying on a single test for identifying autonomic impairment post-stroke. The prevalence of abnormal cardiovagal and sympathetic responses in the study group advocates for the routine inclusion of autonomic assessments in comprehensive evaluations following ischemic stroke.

In the present study, orthostatic hypotension was identified in 47 of 113 patients (41.6%), indicating that postural blood-pressure abnormalities were relatively common among patients with ischemic stroke. After excluding patients with diabetes mellitus and those receiving beta-blockers, true orthostatic hypotension was present in 22 patients (19.5%). This reduction highlights the importance of accounting for comorbidities and medications that can independently influence cardiovascular autonomic responses when assessing orthostatic hypotension.

Among patients with true orthostatic hypotension, abnormalities were most frequently detected in the heart rate response to deep breathing, affecting 12 patients (54.5%). This test predominantly evaluates cardiovagal/ parasympathetic function, and the finding suggests that impaired parasympathetic cardiovascular regulation may contribute substantially to postural blood-pressure abnormalities in these patients. The handgrip test was abnormal in 5 patients (22.7%), suggesting involvement of sympathetic cardiovascular responses, whereas an abnormal Valsalva ratio was observed in only 2 patients (9.1%).

The findings highlight that stroke-related autonomic dysfunction likely involves various aspects of cardiovascular autonomic regulation, as evidenced by abnormalities observed in different autonomic tests. Previous research has demonstrated that conditions such as impaired blood-pressure regulation and orthostatic hypotension may arise after ischemic stroke, which are significant due to their links to cardiovascular instability and negative health outcomes.[8,10,11] Consequently, the study advocates for the implementation of objective autonomic function testing, in tandem with orthostatic blood-pressure measurements, to effectively identify clinically significant autonomic dysfunction in patients suffering from ischemic strokes.

The present study demonstrated a statistically significant positive correlation between stroke severity, assessed using the NIHSS score at admission, and all three autonomic function parameters. The strongest correlation was observed with the handgrip test-induced rise in diastolic blood pressure ($r = 0.45$, $p = 0.046$), followed by the Valsalva ratio ($r = 0.38$, $p = 0.039$) and heart rate response to deep breathing ($r = 0.29$, $p = 0.021$). These findings suggest that increasing neurological severity of ischemic stroke is accompanied by greater disturbance of cardiovascular autonomic regulation.

The relationship between the National Institutes of Health Stroke Scale (NIHSS) scores and autonomic abnormalities is supported by biological reasoning, as ischemic lesions can affect the central autonomic network, which includes the cortical, insular, hypothalamic, and brainstem structures that govern cardiovascular regulation. Increased neurological damage appears to correlate with more significant disruptions in both sympathetic and parasympathetic responses. Previous research indicates that autonomic dysfunction frequently occurs after ischemic stroke, and its severity may be tied to neurological condition and the features of the stroke.[10,11]

The study highlights a significant correlation between handgrip response and sympathetic cardiovascular activity, as well as an association with deep-breathing heart-rate response, indicating impairment in cardiovagal modulation. The relationship with the Valsalva ratio further reinforces the involvement of integrated autonomic cardiovascular responses. These findings suggest that the severity of the National Institutes of Health Stroke Scale (NIHSS) may serve as a crucial clinical marker for autonomic dysfunction in ischemic stroke.[8] However, due to the correlational nature of the analysis, causality cannot be confirmed. Thus, prospective studies are necessary to determine if autonomic dysfunction

independently predicts stroke severity and outcomes.

The present study demonstrated statistically significant differences in autonomic function across stroke severity groups. Heart rate response to deep breathing showed significant variation ($F=4.12$, $p=0.018$), indicating altered parasympathetic cardiovascular regulation with increasing stroke severity. Similarly, the handgrip test-induced rise in diastolic blood pressure differed significantly between groups ($F=3.65$, $p=0.032$), suggesting impairment of sympathetic vasomotor responses. The Valsalva ratio demonstrated the strongest association ($F=4.67$, $p=0.011$), further supporting progressive impairment of autonomic cardiovascular reflexes in patients with more severe ischemic stroke.

These findings are consistent with previous evidence that autonomic dysfunction is common following acute ischemic stroke and that its severity may be related to neurological impairment. A systematic review reported associations between impaired heart-rate variability or baroreceptor sensitivity and stroke severity, functional dependency, cardiovascular complications, and mortality.[15] Similarly, autonomic dysfunction was found to be more frequent among patients with greater stroke severity and insular involvement.[11]

The observed relationship may be explained by disruption of the central autonomic network, particularly pathways involving the insular cortex, which has an important role in cardiovascular autonomic regulation. Right-sided insular involvement has been associated with greater sympathetic activation and cardiovascular autonomic abnormalities.[16] Other studies have demonstrated reduced autonomic indices in patients with moderate or unfavorable stroke outcomes.[17] Thus, the present findings suggest that bedside autonomic tests may provide useful complementary information regarding stroke severity and potentially identify patients at increased risk of cardiovascular complications and poor outcome.

The present study demonstrated statistically significant differences in autonomic function between patients with good and poor functional outcomes. The Valsalva ratio differed significantly between groups ($p=0.022$), while heart rate response to deep breathing was also significantly lower in the poor-outcome group (12.98 ± 5.77 vs. 15.61 ± 5.77 bpm; $p=0.016$). These findings suggest that impaired autonomic cardiovascular regulation, particularly parasympathetic function, may be associated with unfavorable functional recovery after ischemic stroke. Previous studies using Ewing's autonomic function battery have demonstrated impairment of the Valsalva response and heart-rate response to deep breathing following ischemic stroke, supporting the relevance of these measures in post-stroke autonomic assessment.[8]

The handgrip-induced rise in diastolic blood pressure also showed a statistically significant difference ($p=0.038$), indicating that sympathetic cardiovascular regulation may contribute to functional outcome. Although the absolute difference between groups was small, the statistically significant result suggests altered autonomic reflexes in patients with poorer outcomes.

These observations are consistent with prospective studies showing that autonomic dysfunction independently predicts unfavorable functional outcome after acute ischemic stroke.[8,18] Similarly, lower heart-rate variability has been associated with greater neurological impairment and unfavorable modified Rankin Scale outcomes.[17] Thus, autonomic function testing may serve as a useful adjunctive prognostic tool for identifying stroke patients at increased risk of poor functional recovery.

The study highlights significant clinical implications regarding autonomic dysfunction in acute ischemic stroke patients, affecting over half of those examined. Routine screening is advocated to identify conditions like cardiovascular instability and orthostatic hypotension, which can impact rehabilitation and recovery. The study found orthostatic hypotension in 42% of patients, directly influencing mobility and functional recovery. Recommended strategies include non-pharmacological interventions such as hydration and postural training, as well as pharmacological options to mitigate arrhythmia risks. Strengths of the study include a robust sample size and focused data collection, while limitations comprise a single-center approach and lack of long-term follow-up. Recommendations stress the necessity for regular autonomic assessments, particularly for high-risk stroke patients, alongside future research that explores chronic autonomic dysfunction and advanced testing measures for deeper insights into stroke recovery.

CONCLUSION

Autonomic dysfunction is common in acute ischemic stroke and is significantly associated with greater stroke severity and poorer functional outcomes. Early bedside assessment of autonomic function may improve risk stratification and identify patients at increased risk of complications. Incorporating autonomic evaluation into routine stroke care may facilitate comprehensive neuro-cardiovascular management and potentially improve functional recovery and overall prognosis.

REFERENCES

- Kamalakannan S, Gudlavalletti ASV, Gudlavalletti VSM, Goenka S, Kuper H. Incidence & prevalence of stroke in India: a systematic review. *Indian J Med Res.* 2017;146:175-185.
- Yahya T, Jilani MH, Khan SU, et al. Stroke in young adults: current trends, opportunities for prevention and pathways forward. *Am J Prev Cardiol.* 2020;3:100085.
- Hisham NF, Bayraktutan U. Epidemiology, pathophysiology, and treatment of hypertension in ischaemic stroke patients. *J Stroke Cerebrovasc Dis.* 2013;22:e4-14.
- Jain M, Gupta S, Rijhwani P et al. Prevalence of hemorrhagic stroke subtypes, etiological causes and its association with various stroke related risk factors: an observational study. *J Mahatma J Univ Med Sci Technol.* 2023;7:78-83.
- Barkhudaryan A, Doeber W, Jauert N. Autonomic dysfunction after stroke: an overview of recent clinical evidence and perspectives on therapeutic management. *Clin Auton Res.* 2025 Aug;35(4):553-563. doi: 10.1007/s10286-025-01120-0. Epub 2025 Mar 25. Erratum in: *Clin Auton Res.* 2025 Aug;35(4):565-566. doi: 10.1007/s10286-025-01127-7. PMID: 40131648; PMCID: PMC12325444.
- Benarroch EE. The central autonomic network: functional organization, dysfunction, and perspective. *Mayo Clin Proc.* 1993 Oct;68(10):988-1001. doi: 10.1016/s0025-6196(12)62272-1. PMID: 8412366.
- Lago S, de Beukelaar TT, Casetta I, Arcara G, Mantini D. Heart Rate Variability and Autonomic Dysfunction After Stroke: Prognostic Markers for Recovery. *Biomedicines.* 2025 Jul 7;13(7):1659. doi: 10.3390/biomedicines13071659. PMID: 40722730; PMCID: PMC12292726.
- Xiong L, Leung HH, Chen XY, Han JH, Leung TW, Soo YO, Chan AY, Lau AY, Wong LK. Comprehensive assessment for autonomic dysfunction in different phases after ischemic stroke. *Int J Stroke.* 2013 Dec;8(8):645-51. doi: 10.1111/j.1747-4949.2012.00829.x. Epub 2012 Jul 3. PMID: 22759410.
- Miceli G, Cavallini A. The autonomic nervous system and ischemic stroke: a reciprocal interdependence. *Clin Auton Res.* 2008 Dec;18(6):308-17. doi: 10.1007/s10286-008-0495-7. Epub 2008 Oct 11. PMID: 18850312.
- De Raedt S, De Vos A, De Keyser J. Autonomic dysfunction in acute ischemic stroke: an underexplored therapeutic area? *J Neurol Sci.* 2015 Jan 15;348(1-2):24-34. doi: 10.1016/j.jns.2014.12.007. Epub 2014 Dec 8. PMID: 25541326.
- Nayani S, Sreedharan SE, Namboodiri N, Sarma PS, Sylaja PN. Autonomic dysfunction in first ever ischemic stroke: Prevalence, predictors and short term neurovascular outcome. *Clin Neurol Neurosurg.* 2016 Nov;150:54-58. doi: 10.1016/j.clineuro.2016.08.022. Epub 2016 Aug 23. PMID: 27588371.
- O'Donnell MJ, Chin SL, Rangarajan S, Xavier D, Liu L, et al; INTERSTROKE investigators. Global and regional effects of potentially modifiable risk factors associated with acute stroke in 32 countries (INTERSTROKE): a case-control study. *Lancet.* 2016 Aug 20;388(10046):761-75. doi: 10.1016/S0140-6736(16)30506-2. Epub 2016 Jul 16. PMID: 27431356.
- Ewing DJ, Clarke BF. Diagnosis and management of diabetic autonomic neuropathy. *Br Med J (Clin Res Ed).* 1982 Oct 2;285(6346):916-8. doi: 10.1136/bmj.285.6346.916. PMID: 6811067; PMCID: PMC1500018.
- Freeman R, Wieling W, Axelrod FB, Benditt DG, Benarroch E, Biaggioni I, et al. Consensus statement on the definition of orthostatic hypotension, neurally mediated syncope and the postural tachycardia syndrome. *Clin Auton Res.* 2011 Apr;21(2):69-72. doi: 10.1007/s10286-011-0119-5. PMID: 21431947.
- Yperzele L, van Hooff RJ, Nagels G, De Smedt A, De Keyser J, Brouns R. Heart rate variability and baroreceptor sensitivity in acute stroke: a systematic review. *Int J Stroke.* 2015 Aug;10(6):796-800.
- Meyer S, Strittmatter M, Fischer C, Georg T, Schmitz B. Lateralization in autonomic dysfunction in ischemic stroke involving the insular cortex. *Neuroreport.* 2004 Feb 9;15(2):357-61. doi: 10.1097/00001756-200402090-

- 00029.PMID:15076768
17. Zhao M, Guan L, Collet JP, Wang Y. Relationship between ischemic stroke locations, etiology subtypes, neurological outcomes, and autonomic cardiac function. *Neurol Res.* 2020 Aug;42(8):630-639. doi: 10.1080/01616412.2020.1782103. Epub 2020 Jul 23. PMID: 32701421.
18. Xiong L, Tian G, Leung H, Soo YOY, Chen X, Ip VHL, Mok VCT, Chu WCW, Wong KS, Leung TWH. Autonomic Dysfunction Predicts Clinical Outcomes After Acute Ischemic Stroke: A Prospective Observational Study. *Stroke.* 2018 Jan;49(1):215-218. doi: 10.1161/STROKEAHA.117.019312. Epub 2017 Dec 4. PMID: 29203690