



The Relationship between Diastolic Blood Pressure and the Event of the First Ischemic Stroke in Hypertension Patients

Epa Danisa Surbakti*, Aldy S. Rambe, R.A. Dwi Pujiastuti

Department of Neurology, Faculty of Medicine, Universitas Sumatera Utara, Medan, Indonesia

Abstract

Edited by: Branislav Filipović
Citation: Surbakti ED, Rambe AS, Pujiastuti RAD. The Relationship between Diastolic Blood Pressure and the Event of the First Ischemic Stroke in Hypertension Patients. Open Access Maced J Med Sci. 2022 Oct 27; 10(B):2253-2257. https://doi.org/10.3889/oamjms.2022.9880
Keywords: Diastolic blood pressure; Hypertension; Ischemic stroke
***Correspondence:** Epa Danisa Surbakti, Department of Neurology, Faculty of Medicine, Universitas Sumatera Utara, Medan, Indonesia. E-mail: danisaepa@yahoo.com
Received: 19-Apr-2022
Revised: 26-Jul-2022
Accepted: 17-Oct-2022
Copyright: © 2022 Epa Danisa Surbakti, Aldy S. Rambe, R.A. Dwi Pujiastuti
Funding: This research did not receive any financial support
Competing Interests: The authors have declared that no competing interests exist
Open Access: This is an open-access article distributed under the terms of the Creative Commons Attribution-NonCommercial 4.0 International License (CC BY-NC 4.0)

BACKGROUND: Stroke has been the second leading cause of death and the third cause of disability worldwide. A record of hypertension and an increase in diastolic blood pressure (DBP) after the first stroke were associated with an increased risk of a second stroke. DBP has historically been considered as the leading cause of cardiac arrest in adults with hypertension. In the previous studies, it was found a relationship between DBP with stroke and functional outcomes.

AIM: This research was carried out to determine the relationship between DBP and the event of ischemic stroke for the 1st time in hypertension patients.

METHODS: This research is a case-control that was selected using a consecutive sampling technique, where 47 hypertensive patients with ischemic stroke as the case group were matched with 47 hypertensive patients without stroke as the control group. The research was conducted at H. Adam Malik Hospital, Medan and a network hospital.

RESULTS: In this research, most samples in the case and control groups were men with 30 subjects (63.8%) with a mean age value of 58.11 ± 10.85 years. At TDD ≥ 90 mmHg, 34 subjects (72.3%) had ischemic stroke and 21 subjects (44.7%) did not. At TDD < 90 mmHg, the percentage of ischemic stroke was 13 subjects (27.7%) and 26 subjects (55.3%) were non-ischemic stroke with $p = 0.006$, OR = 3.02.

CONCLUSION: There is a significantly close relationship between diastolic blood pressure and the event of ischemic stroke.

Introduction

Stroke has been the second leading cause of death and the third cause of disability in the world. In Europe, stroke is the second leading cause of death with the incidence of 1.1 million deaths per year. In America, stroke is currently the fourth leading cause of death [1].

According to data in Indonesia, stroke occupies the third rank of the group of degenerative diseases after heart disease and malignancy. The highest prevalence of stroke (per mil) based on a doctor's diagnosis is in the East Kalimantan at 14.7% and the lowest is in Papua at 4.1%. The highest prevalence of stroke at the age of 75 and above is 50.2%. The prevalence of stroke per mil in the population aged 15 and above based on a doctor's diagnosis in 2018 was the highest in those who were not/not yet in school at 21.2%, and the lowest was at junior high school graduate at 6.8% [2].

Based on the research at 25 hospitals in North Sumatra, it was found that stroke occurred in women (52.7%) not much different from men (47.3%), and the mean age of the subjects was 59 years (age ranged between 20 and 95 years), and the highest number of subjects is in the age of 40–59 (46.5%) and

60–79 (42.5%). Head CT scan results in this study showed cerebral infarction in 302 (53.7%) patients, hemorrhagic in 152 (27%) patients, and hemorrhagic infarction in 12 (2.1%) patients. Ninety-six patients (17.1%) did not undergo a head CT scan [3].

Hypertension is a major cause of stroke, with an increased risk of blood pressure above 115/75 mmHg. Evidence from clinical trials suggests that this risk can be reversed by controlling blood pressure [4]. In a study conducted by Chen *et al.* (2019), it was found that the incidence of ischemic stroke increased by 50% in TDD between 80 and 90 mmHg and 131% at diastolic blood pressure (DBP) 90 mmHg and was safe in the range of 70–80 mmHg [5].

A study by Bangalor *et al.* (2017) revealed that there was a relationship between DBP and stroke outcome in ischemic stroke patients undergoing thrombolytic therapy for every 10 mmHg change from the reference value (70 mmHg) [6]. Furthermore, according to Stead *et al.* (2005), it was found that DBP of 70–105 mmHg had a better outcome than DBP < 70 mmHg [7].

The purpose of this study is to determine the relationship between DBP and the incidence of ischemic stroke for the 1st time in hypertension patients at H. Adam Malik Hospital, Medan.

Methodology

This research is a case-control. The case group was ischemic stroke patients who had a history of hypertension who had done the ECG and had a history of LVH or myocardial infarction. The case group was taken from patients who had a history of hypertension yet no history of ischemic stroke and performed an ECG and had a history of LVH or myocardial infarction. The research sample was taken at H. Adam Malik Hospital Medan from May 2021 to August 2021 using the consecutive method. Cases and control groups in the study were 47 people and matched according to gender, age, and patient risk factors.

Table 1 : Description of research subject characteristics

Characteristics	Ischemic stroke	
	Yes n (%)	No n (%)
Age (years) (Mean)	58.11 ± 10.8	58.11 ± 10.8
Gender		
Man	30 (63.8)	30 (63.8)
Women	17 (36.2)	17 (36.2)
Occupational		
Housewife	12 (25.0)	11 (23.4)
Entrepreneur	9 (19.1)	10 (21.3)
Retired	5 (10.6)	6 (12.8)
Farmer	17 (36.2)	12 (25.5)
Government employees	4 (8.5)	8 (17.1)
Race		
Java	7 (14.9)	14 (29.8)
Bataknese	33 (70.2)	19 (40.4)
Malay	3 (6.4)	5 (10.6)
Padang	2 (4.3)	6 (12.8)
Aceh	2 (4.3)	3 (6.4)
Education		
Primary school	3 (6.4)	6 (12.5)
Junior high school	8 (15.6)	5 (10.6)
Senior high school	23 (48.9)	24 (51.1)
Bachelor	13 (27.7)	12 (25.5)
SBP (mmHg) (Mean)	153.83 ± 22.58	139.57 ± 14.73
DBP (mmHg) (Mean)	98.85 ± 15.99	89.15 ± 8.55
Clinical outcome (NIHSS days 7)		
Mild	13 (27.7)	
Moderate	23 (48.9)	
Severe	11 (23.4)	
Electrocardiogram		
LVH	41 (87.2)	27 (57.4)
Miokard Infark	6 (12.8)	20 (42.6)

Blood pressure measurement is done during the patient's visit to the hospital. The inclusion criteria in the case group were acute ischemic stroke patients, aged over 18 years, had a history of hypertension for at least 2 years, had a head CT scan, performed an ECG, and had a history of myocardial infarction and LVH. The control group was adjusted to the case group. Exclusion criteria for recurrent stroke cases, patients with malignancy, and (systemic inflammation response syndrome) conditions, to determine the functional outcome of ischemic stroke patients using the NIHSS (National Institute of Health Stroke Scale) score on day 7. Then, the criteria for control exclusion were patients with history of stroke and patients with malignancy. To determine the functional outcome of ischemic stroke patients, the NIHSS score was used.

The research data were analyzed statistically with Windows SPSS (Statistical Product and Science Service) computer program version 22.0. To determine the relationship between DBP and the incidence of ischemic stroke, Chi-square test and logistic regression were performed.

Results

The mean age of all subjects was 58.11 ± 10.85 years. The most gender was male of 30 subjects (62.5%). The highest level of education in the two groups was senior high with 23 subjects (48.9%) and 24 subjects (51.14%). In the occupational status, most subjects in the ischemic stroke group were farmers, as many as 17 subjects (36.2%) and in the non-ischemic stroke group as many as 12 subjects (25.5%), followed by housewives as many as 12 subjects (25%) in the ischemic stroke group and 11 subjects (23.4%) in the non-ischemic stroke group. The characteristics of the most ethnic groups in the two groups were the Batak, as many as 33 subjects (70.2%) in the ischemic stroke group and 19 subjects (40.4%) in the non-ischemic stroke group. The mean systolic blood pressure for the ischemic stroke group was 153.83 ± 22.58 mmHg and non-ischemic stroke was 139.5 ± 14.7 mmHg. The mean diastolic pressure in the ischemic stroke group was 98.8 ± 15.9 mmHg (Table 1). and non-ischemic stroke was 89.15 ± 8.5 mmHg. Numerical data in this study are normally distributed; thus, it uses the mean in its delivery.

Table 2: Relationship between diastolic blood pressure and first ischemic stroke incidence in stroke patients with hypertension

DBP	Ischemic stroke		p-value	OR (95% CI)
	Yes n (%)	No n (%)		
≥90 mmHg	34 (72.3)	21 (44.7)	0.006	3.02 (1.37–7.65)
<90 mmHg	13 (27.7)	26 (55.3)		

Uji Chi-square.

Ischemic stroke patients had clinical outcomes with the highest NIHSS score on day 7 in the moderate category 23 (48.9%). Characteristics of disease risk factors in both groups were DM with 26 subjects, 26 smoking subjects, and 18 subjects with hypercholesterolemia. In both groups, the most ECG images were LVH as many as 41 subjects (87.2%) and 27 subjects (57.4%).

Table 3: Multivariate analysis of the relationship diastolic blood pressure with the 1st-time ischemic stroke in hypertension patients

Characteristics	Coefficient	S.E.	Wald	df	p	OR	CI 95%	
							Min.	Max.
Age	0.002	0.040	0.004	1	0.952	1.002	0.928	1.083
Gender	0.854	1.298	0.432	1	0.511	2.348	0.184	29.915
SBP	-0.037	0.019	3.882	1	0.049	0.964	0.930	1
DBP	-0.065	0.028	5.398	1	0.020	0.937	0.887	0.990
DM	-0.262	0.652	0.161	1	0.688	0.770	0.214	2.765
Smoke	-0.071	0.933	0.006	1	0.940	0.932	0.150	5.798
Hypercholesterolemia	-0.508	0.603	0.708	1	0.400	0.602	0.185	1.963
ECG	-1.973	0.647	9.289	1	0.002	0.139	0.039	0.494
Housewife			5.532	4	0.237			
Entrepreneur	-1.153	1.445	0.637	1	0.425	0.316	0.019	5.357
Retired	-2.033	1.169	3.027	1	0.082	0.131	0.013	1.294
Government employees	-2.303	1.449	2.526	1	0.112	0.100	0.006	1.711
Farmer	-2.417	1.089	4.926	1	0.026	0.089	0.011	0.754
Constant	15.493	4.231	13.406	1	0.000	5352388.569		

In this study, the incidence of ischemic stroke and non-ischemic stroke experienced by hypertensive patients was obtained from the history and physical examination as well as supporting examinations that had previously been adjusted to the research criteria.

At DBP ≥ 90 mmHg, the percentage of ischemic stroke was 34 subjects (72.3%), while the non-ischemic stroke was 21 subjects (44.7%). At DBP < 90 mmHg, the percentage of ischemic stroke was 13 subjects (27.7%) and 26 subjects (55.3%) were non-ischemic strokes (Table 2).

Table 4: The relationship between diastolic blood pressure and functional outcome in ischemic stroke patients with hypertension

DBP	Functional outcome			p value
	Mild n (%)	Moderate n (%)	Severe n (%)	
≥ 90 mmHg	6 (46.2)	17 (73.9)	11 (100)	0.013
< 90 mmHg	7 (53.8)	17 (26.1)	0 (0)	

Uji Mann-Whitney.

Based on the Chi-square test, $p = 0.006$ and OR 3.02 (95% Confidence interval (CI) 1.37–7.65), thus, it can be concluded that there is a significant relationship between DBP and the incidence of ischemic stroke, where DBP ≥ 90 mmHg can have a risk of ischemic stroke as much as 3.02 times compared to DBP < 90 mmHg.

Regresi logistic

In the multivariate analysis, it was found that the variables that had a significance value below 0.05 were SBP, DBP, ECG, and occupation of farmer (Table 3). This means that the variables of SBP, DBP, ECG, and occupation of farmer affect the incidence of ischemic stroke in the analysis model.

In this study, to assess the functional outcome in patients with ischemic stroke, the NIHSS score was used on day 7. At DBP > 90 mmHg, the functional outcome was mild category in ischemic stroke as many as six subjects (46.2%), moderate category as many as 17 subjects (73.9%), and the heavy category as many as 11 subjects (100%). Meanwhile, in the DBP group < 90 mmHg, the functional outcome in the mild category of ischemic stroke was 7 subjects (53.8%), the moderate category was 17 subjects (26.1%), and the severe category was 0 subjects (0%) (Table 4). Based on the Mann-Whitney test, $p = 0.013$, therefore, it can be concluded that there is a significant relationship between DBP and functional outcome in ischemic stroke.

Discussion

In this study, it was found that the age characteristics of all subjects in the case and control groups had a mean value about 58.11 ± 10.85 years. This is in a line with the research of McEvoy *et al.* in 2016 which stated that the age of hypertensive patients in the study carried out had a mean of 56.7 ± 5.7 years [8]. In the study conducted by Flint *et al.*, it was also found that

the median age in hypertensive patients was around 53 years [9]. This is because the increase in pressure is largely related to changes in arterial and arteriolar stiffness. Stiffness of the great arteries is mainly due to arteriosclerotic structural changes and calcifications. The increase in DBP at the age of 50 years is largely due to an increase in peripheral vascular resistance in small blood vessels. Other pathophysiological factors that contribute to the increase in blood pressure with aging include decreased baroreceptor sensitivity, increased response to sympathetic nervous system stimulation, changes in renal and sodium metabolism, and changes in renin-aldosterone [10].

The dominant gender was male with 30 subjects (63.8%). This is in line with research conducted by Steviyani in 2018 and El-Harizah in 2016 mentioning that there are more men than women. Gender differences in stroke are due to the female hormone of estrogen that plays an important role in vasodilation of blood vessels [10], [11].

The most ethnic groups in both groups are Batak, with 33 subjects (70.2%) and 19 subjects (40.4%). This is in line with research by Rambe *et al.* (2013) in the ischemic stroke group found as many as (40.7%) Batak ethnicity and research conducted by El-Harizah on 100 stroke patients at the neurology polyclinic and inpatient ward of USU Medical Faculty/H. Adam Malik Hospital, Medan in the period of December 2015–April 2016, it was found that the most tribes suffering from stroke were the Batak, for 63 patients (63%).

The cause of the high incidence of stroke in the Batak ethnic group compared to non-Batak may be caused by non-modifiable risk factors, namely, genetic and modifiable stroke risk factors. Batak culinary contains high levels of cholesterol. The Batak has a greater tendency to be obese and is more temperamental and emotional than other ethnic groups so that it can cause blood pressure to increase more easily [3], [11], [12], [13], [14].

In this study, the incidence of ischemic stroke and non-ischemic stroke experienced by hypertensive patients was obtained from the history and physical examination as well as supporting examinations that had previously been adjusted to the research criteria. At DBP 90 mmHg, the percentage of ischemic stroke was 34 subjects (72.3%) and 21 subjects (44.7%). At DBP < 90 mmHg, the percentage of ischemic stroke was 13 subjects (27.7%) and non-ischemic stroke was 26 subjects (55.3%). Based on the Chi-square test, $p = 0.006$ and OR of 3.02 (95% CI 1.37–7.65), thus, it can be concluded that there is a significant relationship between DBP and the incidence of ischemic stroke, where DBP is ≥ 90 mmHg, 3.02 times more at risk of having an ischemic stroke for the 1st time than DBP < 90 mmHg.

This is in line with research conducted by Chen *et al.* in 2019 which showed a relationship between

diastolic pressure and the incidence of ischemic stroke for the 1st time in elderly patients with hypertension, where DBP ≥ 90 mmHg had a 2.31 times risk of having an ischemic stroke for the 1st time compared to DBP < 90 mmHg with $p = 0.02$. The incidence of ischemic stroke increases by 50% in blood pressure between 80 and 90 mmHg and 131% at blood pressure ≥ 90 mmHg and is safe in the range 70–80 mmHg [19]. Reshef *et al.* stated that there was a relationship between DBP > 80 mmHg with ischemic stroke, where blood pressure diastolic > 80 mmHg risk of 1.83 times having ischemic stroke with $p = 0.031$ (HR = 1.83, $p = 0.031$, 95% CI: 1.06–3.15). In atherosclerotic blood vessels, an increase in blood pressure can form turbulence, especially at the bifurcation point which accelerates thrombus formation and releases emboli into the narrowed blood vessel area which causes impaired perfusion and increases the risk of infarction [5], [16].

This study has inclusion criteria in research subjects who have a history of LVH and myocardial infarction due to increased diastolic pressure characterized by low cardiac output which can cause the left ventricular wall to hypertrophy (increased left ventricular mass/volume ratio) which will later cause left ventricular stiffness. At the beginning of diastole, there will be relaxation and subsequently cause a greater resistance to filling at the end of diastole. This will cause the diastolic pressure to increase and lead to diastolic heart failure. Mechanisms that contribute to left ventricular diastolic abnormalities include great artery stiffness, hypertension, ischemia, diabetes, and intrinsic myocardium with or without hypertrophy [17].

The mechanism of stroke in heart failure can be caused by embolism or cerebral hypoperfusion. The cause of LV dysfunction is an increase in the left ventricular end-diastolic volume which promotes blood stasis in the left ventricle and left atrium, increasing the likelihood of thrombus formation and the risk of embolic stroke. Various factors associated with heart failure predispose to thrombosis, including vascular pathology, increased coagulability, and impaired blood flow. Several studies have shown that patients with heart failure have increased plasma concentrations of fibrinopeptide A, D-dimer, von Willebrand factor, fibrinolytic products, beta-thromboglobulin, and endothelial procoagulants [18].

The previous studies have linked White Matter Lesion (WML) with DBP. WML represents a region of the brain that is susceptible to the decrease in perfusion pressure that occurs during diastole. In a healthy brain, autoregulatory mechanisms are able to adjust mean arterial pressure low or high (between 50 and 150 mmHg), enough to meet the needs of various cerebral regions. Areas of the brain that have impaired perfusion will experience further hemodynamic insufficiency, which, in turn, can lead to ischemic stroke. Micro emboli are common in patients with severe arterial stenosis, and hypoperfusion can lead to emboli formation [15], [16].

To assess the functional outcome in patients with ischemic stroke, the NIHSS score on day 7 was used. At DBP ≥ 90 mmHg, the functional outcome in the mild category of ischemic stroke was six subjects (46.2%), moderate category was 17 subjects (73.9%), and weight category as many as 11 subjects (100%). Meanwhile, in the DBP group < 90 mmHg, the functional outcome in the mild category of ischemic stroke was seven subjects (53.8%), the moderate category was 17 subjects (26.1%), and weight category as many as 0 subjects (0%).

Based on the Mann–Whitney test, $p = 0.013$, thus, it can be concluded that there is a significant relationship between DBP and functional outcome in ischemic stroke. This is in line with research conducted by Naito *et al.* which showed that DBP was a predictor used to see poor functional outcomes compared to others. A previous report showed that an increase in DBP over SBP during the acute phase of stroke was independently associated with worse functional outcome at 3 months [19].

In the study of Bangalor *et al.* (2017), there was an association between DBP and stroke outcome in ischemic stroke patients undergoing thrombolytic therapy for every 10-mm-Hg change from the reference value (70 mm Hg) [6]. In a study conducted by Nathanson *et al.*, they compared DBP by gender. In patients, high DBP predicts poor functional outcome in men, but not in women. High DBP can increase edema formation because the main cause of cerebral edema is an increase in capillary pressure which depends on the mean arterial blood pressure [20].

This study has some limitations including not analyzing the factors that affect blood pressure in research subjects. Furthermore, in ischemic stroke patients, there is no differentiation between thrombus and embolic strokes.

References

1. Jauch EC, Saver JL, Adams HP, Bruno A, Connors JJ, Demaerschalk BM, *et al.* Guidelines for the early management of patients with acute ischemic stroke: A guideline for healthcare professionals from the American Heart Association/American Stroke Association. *Stroke*. 2013;44(3):870-947. <https://doi.org/10.1161/STR.0b013e318284056a> PMID:23370205
2. Riset Kesehatan Dasar (Riskesdas). Badan Penelitian dan Pengembangan Kementerian Kesehatan Republik Indonesia (Balitbangkes Kemenkes). Jakarta: Riset Kesehatan Dasar (Riskesdas); 2018. Available from: <https://www.litbang.kemkes.go.id/laporan-riiset-kesehatan-dasar-riskesdas> [Last accessed on 2021 Jan 20].
3. Rambe AS, Fithrie A, Nasution I, Tonam D. Profil Pasien Stroke Pada 25 Rumah Sakit di Sumatera Utara 2012 Survei Berbasis Rumah Sakit. *Neurona*. 2013;30(2):1-7.
4. Waard DD, Borst GJ, Bulbulia R, Huijbers A, Halliday A. Diastolic

- blood pressure is a risk factor for peri-procedural stroke following carotid endarterectomy in asymptomatic patients. *Eur J Vasc Endovasc Surg.* 2017;53:626-31. <https://doi.org/10.1016/j.ejvs.2017.02.004>
PMid:28318997
5. Chen CL, Huang JY, Liu L, Yu YL, Shen G, Lo K, *et al.* Relationship between diastolic blood pressure and the first ischaemic stroke in elderly patients with hypertension. *Postgrad Med J.* 2019;96(1139):525-9. <https://doi.org/10.1136/postgradmedj-2019-137018>
PMid:31806734
 6. Bangalor S, Schwamm L, Smith EE, Hellkamp AS, Suter RE, Xian Y, *et al.* Blood pressure and in-hospital outcomes in patients presenting with ischaemic stroke. *Eur Heart J.* 2017;38:2827-35. <https://doi.org/10.1093/eurheartj/ehx330>
PMid:28982227
 7. Stead LG, Gilmore RM, Decker WW, Weaver AL, Brown RD. Initial emergency department blood pressure as predictor of survival after acute ischemic stroke. *Neurology.* 2005;65:1179-83. <https://doi.org/10.1212/01.wnl.0000180939.24845.22>
PMid:16247043
 8. McEvoy JW, Chen Y, Rawlings A, Hoogeveen RC, Ballantyne CM, Blumenthal RS, *et al.* Diastolic blood pressure, subclinical myocardial damage, and cardiac events. *J Am Coll Cardiol.* 2016;68(16):1713-22. <https://doi.org/10.1016/j.jacc.2016.07.754>
PMid:27590090
 9. Flint AC, Conell C, Ren X, Banki NM, Chan SL, Rao VA, *et al.* Effect of systolic and diastolic blood pressure on cardiovascular outcomes. *N Engl J Med.* 2019;381:243-51. <https://doi.org/10.1056/NEJMoa1803180>
PMid:31314968
 10. Pinto E. Blood pressure and ageing. *Postgrad Med J.* 2007;83:109-14. <https://doi.org/10.1136/pgmj.2006.048371>
PMid:17308214
 11. Steviyani. Hubungan Antara Kadar Serum Neuron Spesifik Enolase Dengan Volume Lesi dan Luaran Fungsional Pada Pasien Stroke Fase Akut. Repository USU. (Universitas Sumatera Utara); 2018. Available from: <https://repositori.usu.ac.id/handle/123456789/10451/137112004> [Last accessed on 2021 Jul 10].
 12. El-Harizah Q. Faktor Risiko Hipertensi, Dislipidemia, Merokok, Asam urat, Obesitas, Diabetes Melitus, dan Riwayat Stroke dalam Keluarga pada Penderita Stroke. Repository USU (Universitas Sumatera Utara); 2016. Available from: <https://repositori.usu.ac.id/handle/123456789/41452> [Last accessed on 2021 Jul 10].
 13. Sjahrir H. *Stroke Iskemik.* Medan: Yandira Agung; 2003.
 14. Manurung M, Diani N. dan Agianto. Analisa Faktor Risiko Stroke pada Pasien Stroke Rawat di RSUD Banjar baru. *Jurnal DK.* 2015. 3(1):74-85.
 15. Tambunan LP. Perbedaan faktor risiko stroke antara suku Batak dan non-Batak di RSUP. H. Adam Malik Medan. Repository USU (Universitas Sumatera Utara); 2018. Available from: <https://repositori.usu.ac.id/bitstream/handle/123456789/15268/157041084> [Last accessed on 2021 Jul 10].
 16. Reshef S, Fried L, Beauchamp N, Scharfstein D, Reshef D, Goodman S. Diastolic blood pressure levels and ischemic stroke incidence in older adults with white matter lesions. *J Gerontol A Biol Sci Med Sci.* 2011;66A(1):74-81. <https://doi.org/10.1093/gerona/gql166>
PMid:21030465
 17. Vasan RS. Diastolic heart failure. The condition exists and needs to be recognised, prevented, and treated. *BMJ.* 2003;327(7425):1181-2. <https://doi.org/10.1136/bmj.327.7425.1181>
PMid:14630731
 18. Cuadrado-Godia E, Ois A, Roquer J. Heart failure in acute ischemic stroke. *Curr Cardiol Rev.* 2010;6(3):202-13. <https://doi.org/10.2174/157340310791658776>
PMid:21804779
 19. Naito H, Hasomi N, Kuzume D, Nezu T, Aoki S, Marimoto Y, *et al.* Increased blood pressure variability during the subacute phase of ischemic stroke is associated with poor functional outcomes at 3 months. *Sci Rep.* 2020;10(1):811. <https://doi.org/10.1038/s41598-020-57661-z>
PMid:31964961
 20. Nathanson D, Patrone C, Nyström T, Euler MV. Sex, diastolic blood pressure, and outcome after thrombolysis for ischemic stroke. *Stroke Res Treat.* 2014;2014:747458. <https://doi.org/10.1155/2014/7474582014>
PMid:25302134