



THE ASSOCIATION OF STRESS WITH BLOOD PRESSURE AND FASTING BLOOD GLUCOSE IN HYPERTENSIVE PATIENTS AT THE AUR DURI PRIMARY HEALTH CENTER, JAMBI CITY

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ABSTRACT

Background: Hypertension is a major risk factor for cardiovascular disease, the leading cause of death worldwide. One of its causal factors is environmental, namely psychological stress, which increases the secretion of cortisol and catecholamines and thereby alters several physiological functions, including blood pressure and fasting blood glucose. **Objective:** To determine whether stress is associated with blood pressure and fasting blood glucose in patients with hypertension. **Methods:** This was an observational quantitative study with a cross-sectional design, conducted at the Aur Duri Primary Health Center, Jambi City, in July 2021. A total of 33 patients with hypertension were recruited by purposive sampling. The research instruments were the Depression Anxiety Stress Scales-42 (DASS-42) questionnaire and an observation sheet. The data were analyzed using the chi-

square test and the independent-samples t-test. **Results:** The chi-square analysis yielded a p -value of 0.031 for the association between stress and blood pressure, whereas the independent-samples t-test yielded a p -value of 0.887 for the comparison of fasting blood glucose by stress status. **Conclusion:** Stress was significantly associated with blood pressure in patients with hypertension, whereas fasting blood glucose did not differ significantly between hypertensive patients with and without stress.

Keywords: *Hypertension, stress, blood pressure, fasting blood glucose*

INTRODUCTION

Hypertension is a major risk factor for cardiovascular disease, which is the leading cause of death worldwide. Several etiologies may underlie hypertension; the majority of patients (90–95%) have “essential” or primary hypertension. According to the *Department of Epidemiology, Tulane University School of Public Health and Tropical Medicine*, New Orleans, LA, USA (2020), the total number of hypertension cases worldwide in 2010 was estimated at 1.39 billion, with a slightly higher age-standardized prevalence in men (31.9%) than in women (30.1%). Most hypertension cases occur in developing countries.¹

Indonesia is one of the developing countries contributing to the burden of hypertension. According to the 2018 Basic Health Research (Riskesdas), the number of hypertension cases recorded in Indonesia in 2018 was approximately 658,201 individuals (34.1%), and the affected age range in the Indonesian population begins at 18 years.² According to data from the Jambi City Health Office, 20,468 individuals

(18.82%) had hypertension in 2020, of whom 23.17% were women and 14.5% were men; hypertension thus ranked first among the ten most common diseases in Jambi City. The Aur Duri Primary Health Center (Puskesmas) recorded the highest number of hypertension cases, namely 4,136 individuals (51.85%).³

The number of hypertension cases increases every year because the causes of hypertension are diverse and complex, involving both genetic and environmental factors. Among the environmental factors, various psychosocial factors, such as psychological stress, are believed to be important contributors to hypertension. In a study by Sarkar et al. (2019) investigating the prevalence of stress among hypertensive patients, 337 of the 400 hypertensive respondents (84.4%) were found to experience stress.⁴

The World Health Organization (WHO) reported in 2015 that depression and anxiety are the common mental disorders with the highest prevalence: more than 200 million people worldwide (3.6% of the population) suffer from anxiety disorders, whereas

322 million people worldwide (4.4% of the population) suffer from depression.⁵ According to Riskesdas 2018, 9.8% of the adult Indonesian population aged >15 years experienced emotional mental disorders such as depression, anxiety, and stress; in Jambi Province, emotional disorders were recorded in 3.6% of the adult population.⁶

Severe stress may contribute to the development of hypertension, as severe stress can raise blood pressure by inducing abnormal secretion of catecholamines, which in turn causes vasoconstriction of the peripheral blood vessels.⁷ A study by Ardian, Haiya, and Sari (2018) examining the association between stress level and blood pressure in hypertensive patients at the Bangetayu Primary Health Center, Semarang, found a significant association.⁸

Abnormal catecholamine secretion may also promote the conversion of hepatic glycogen stores into circulating glucose; when this elevation is sustained, it results in a condition known as hyperglycemia. High blood glucose levels are detrimental to the blood vessels because they can damage the vascular wall.⁹ A study by

Kuwabara et al. (2019) examining fasting blood glucose in non-diabetic individuals reported a positive correlation with hypertension.¹⁰

Based on the foregoing background, stress is considered to influence blood pressure and fasting blood glucose in hypertensive patients, and the Aur Duri Primary Health Center recorded the highest number of hypertension cases among the primary health centers in Jambi City. Therefore, the authors sought to investigate the association of stress with blood pressure and fasting blood glucose in hypertensive patients at the Aur Duri Primary Health Center, Jambi City.

METHODS

This was an observational quantitative study with a cross-sectional design, conducted at the Aur Duri Primary Health Center, Jambi City. This primary health center was selected because, according to the Jambi City Health Office, it recorded the highest number of hypertension cases in 2020. Data collection commenced in July 2021.

The study population comprised all patients diagnosed with hypertension

who attended the Aur Duri Primary Health Center, Jambi City, and fulfilled the inclusion criteria. Participants were selected by *purposive sampling*, that is, respondents were recruited on the basis of predefined criteria relevant to the study.

The minimum sample size for this study was calculated online using the *Raosoft* sample size calculator:

Raosoft Sample size calculator

What margin of error can you accept?
15 %

What confidence level do you need?
90 %

What is the population size?
2274

What is the response distribution?
50 %

Your recommended sample size is
30

Figure 1 Raosoft sample size calculation

A minimum sample of 30 participants was obtained; after adding 10%, the minimum total sample size of this study was 33 participants.

This study used primary data, comprising the DASS-42 questionnaire to assess stress and an observation sheet recording patient characteristics (age, sex, occupation, and history of antihypertensive medication use) together with the results of blood pressure and fasting blood glucose

measurements. These data were obtained through direct interviews with, and observation of, hypertensive patients attending the Aur Duri Primary Health Center, Jambi City, who were identified from secondary data, namely the diagnosis records of the General Outpatient Clinic of the Aur Duri Primary Health Center.

Data analysis comprised univariate analysis to describe the characteristics of hypertensive patients and bivariate analysis using the *chi-square* test, or *Fisher's exact* test when the requirements of the chi-square test were not met, to analyze the association between stress and blood pressure, as well as the *independent-samples t*-test to analyze the association between stress and fasting blood glucose.

RESULTS

A. Univariate Analysis

Table 1 Characteristics of hypertensive patients

Patient characteristics	n	%
Age		
Late adolescence	0	0
Early adulthood	0	0
Late adulthood	4	12.1
Early		

	elderly	14	42.4
	Late		
	elderly	7	21.2
	Senior		
	elderly	8	24.2
Sex	Male	11	33.3
	Female	22	66.7
Occupation	Unemployed	25	75.8
	Employed	8	24.2
History of antihypertensive medication use	Irregular	0	0
	Regular	33	100

This study recruited hypertensive patients diagnosed by general practitioners who attended the Aur Duri Primary Health Center, Jambi City; 33 respondents fulfilled the inclusion and exclusion criteria and underwent direct observation.

Age was categorized into six groups according to the Ministry of Health of the Republic of Indonesia: late adolescence, early adulthood, late adulthood, early elderly, late elderly, and senior elderly. As shown in Table 1, hypertension was observed in 4 patients (12.1%) in late adolescence, 14 patients (42.4%) in the early elderly group, 7 patients (21.2%) in the late elderly group, and 8 patients (24.2%) in the senior elderly group.

With respect to sex, 11 hypertensive patients (33.3%) were male and 23 hypertensive patients (66.7%) were

female.

The occupation of the respondents was categorized into two groups, unemployed and employed; according to the data obtained, 25 hypertensive patients (75.8%) were unemployed and 8 hypertensive patients (24.2%) were employed.

History of antihypertensive medication use was categorized into two groups, regular and irregular. As shown in Table 1, all 33 hypertensive patients (100%) took their antihypertensive medication regularly.

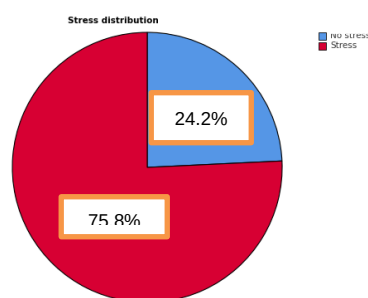


Figure 2 Distribution of stress

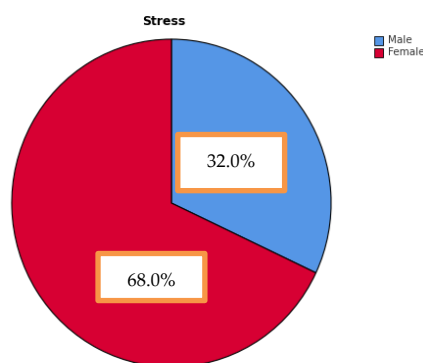


Figure 3 Distribution of stress by sex among hypertensive patients

Stress was categorized on the basis

of the DASS-42, with a score of <15 indicating no stress and a score of ≥ 15 indicating stress. In this study, 8 hypertensive patients (24.2%) had no stress, whereas 25 hypertensive patients (75.8%) had stress, as shown in Figure 2.

As shown in Figure 3, of the 25 hypertensive patients with stress, the majority were women (17 patients, 68.0%), whereas 8 patients (32.0%) were men.

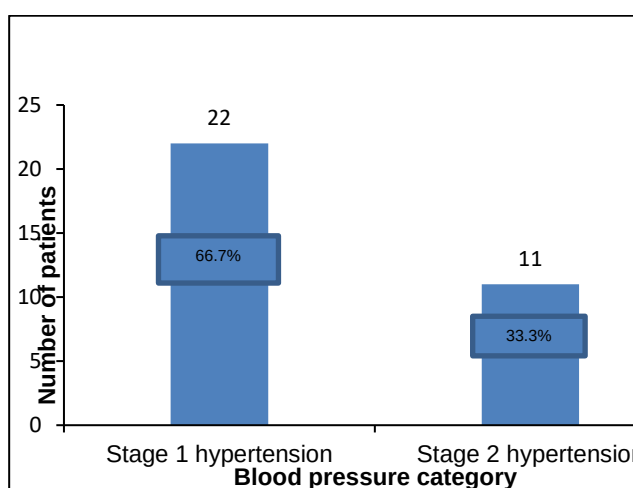


Figure 4 Distribution of blood pressure measurements

In this study, the patients' blood pressure was classified according to the JNC VII criteria into stage 1 and stage 2 hypertension. As shown in Figure 4, 22 patients (66.7%) had stage 1 hypertension and 11 patients (33.3%)

had stage 2 hypertension.

Table 2 Distribution of fasting blood glucose measurements

Variable	Value		Mean	Standard Deviation
	Minimum	Maximum		
Fasting blood glucose (mg/dL)	87	118	104.24	8.507

As shown in Table 2, the mean fasting blood glucose of the 33 patients was 104.24 mg/dL with a standard deviation of ± 8.507 , the highest fasting blood glucose value being 118 mg/dL and the lowest 87 mg/dL.

B. Bivariate Analysis

The data in this study were analyzed using the *chi-square test* for the association between stress and blood pressure and the independent-samples t-test (*independent sample T-test*) for the comparison of fasting blood glucose by stress status; on normality and homogeneity testing, the fasting blood glucose variable was normally distributed and homogeneous

As shown in Table 3, all 8 respondents (100%) in the no-stress category had stage 1 hypertension, and no respondent in the no-stress category had stage 2 hypertension. In the stress category, 14 patients (63.3%) had stage 1 hypertension and 11 patients (36.7%)

had stage 2 hypertension.

Because the data did not meet the requirements for the *chi-square* test, the alternative *Fisher's exact* test was used. As shown in Table 3, the *p*-value was 0.031, indicating a statistically significant association between stress and blood pressure in hypertensive patients at the Aur Duri Primary Health Center, Jambi City, since $p < 0.05$.

(independent sample *T*-test)

Table 3 Cross-tabulation of stress and blood pressure

Blood pressure (mmHg)						Total	p-value
Stress	Stage 1		Stage 2				
	hypertension		hypertension				
n	%	n	%	N	%		
Absent	8	100%	0	0%	8	100%	
Present	14	56.0%	11	44.0%	25	100%	

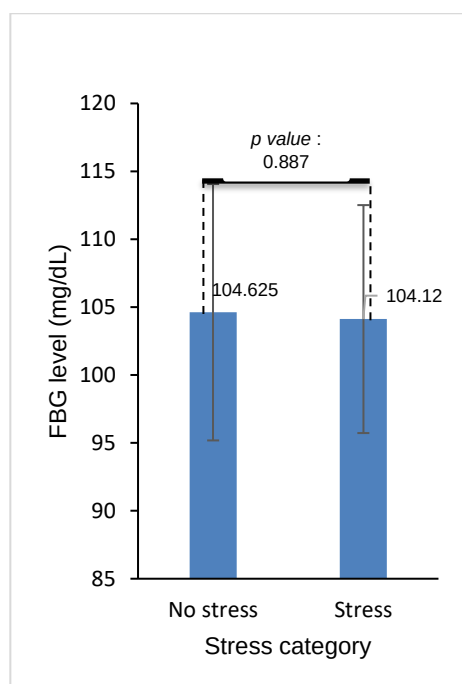


Figure 5 Comparison of fasting blood glucose by stress status

As shown in Figure 5, the mean fasting blood glucose was 104.625 mg/dL in patients with stress and 104.12 mg/dL in patients without stress. The independent-samples *t*-test

yielded a *p*-value of 0.887, which is greater than 0.05; therefore, there was no significant difference in fasting blood glucose between patients with and without stress.

DISCUSSION

A. Univariate analysis

1. Characteristics of hypertensive patients by age

In this study, as shown in Table 1, the early elderly group was the age group most frequently affected by hypertension (42.4%). This finding is consistent with a previous study by Tambuwun et al. (2021), in which the largest proportion of hypertensive patients was aged ≥ 46 years (early elderly and older), accounting for

89.4%, whereas only 10.6% were aged ≤ 46 years.¹¹ However, it differs from the study by Fitrianiingsih et al. (2016), which reported a higher frequency of hypertension among adolescents (57.6%); this discrepancy may be explained by the predominance of adolescents over adults and older adults in the sample of Fitrianiingsih's study.¹²

Advancing age promotes an increase in blood pressure through thickening of the arterial wall caused by collagen accumulation in the muscular layer, resulting in narrowing and stiffening of the blood vessels after the age of 40 years. Age cannot be prevented, as a person's age inevitably increases; nevertheless, its effect can be controlled through a healthy lifestyle, including dietary modification, since a large proportion of hypertension cases are attributable to unhealthy dietary patterns that increase the risk of hypertension.¹³

2. Characteristics of hypertensive patients by sex

In this study, as shown in Table 1, hypertension was more prevalent in women than in men, accounting for 69.7%. This finding is in line with the study by Pratiwi (2021), which found

that hypertension occurred more frequently in women (58.95%) than in men (41.04%).¹⁴ However, it differs from the study by Yudistira et al. (2019), which found that hypertension was most common in men (54.4%). This difference may be attributable to hormonal factors, as women have a lower risk of hypertension before approaching menopause, implying that the sample in Yudistira's study included fewer premenopausal or menopausal women.¹⁵

The higher incidence of hypertension in women is often attributed to changes in estrogen after menopause. Estrogen increases high-density lipoprotein (HDL) levels, which serve as a protective factor against atherosclerosis. This protective effect of estrogen is regarded as a form of immunity in women before menopause; however, during the premenopausal period, women begin to gradually lose the estrogen that has protected their blood vessels from damage. This process continues at menopause, when hormonal changes occur, namely a decline in the estrogen-to-androgen ratio, which leads to metabolic, inflammatory, and vascular changes that

may contribute to alterations in body composition and trigger increases in blood pressure and other cardiovascular risk factors. This process generally begins in women aged 45–55 years.¹⁴

3. Characteristics of hypertensive patients by occupation

As shown in Table 1, most hypertensive patients in this study were unemployed (75.8%). This may be because the sample was dominated by housewives, who have more time to visit the primary health center. This finding is consistent with the study by Nurmalita et al. (2019), in which hypertensive patients were predominantly in the “other occupations” category (housewives), accounting for 55.6%.¹⁶ However, it differs from the study by Tumenggung (2013), in which hypertension was most common among employed patients (56.7%); this may be because employed individuals predominated in that study’s sample, thereby influencing the results.¹⁷

Physical inactivity increases the risk of hypertension because it increases the risk of being overweight and is associated with a higher heart rate, so that the cardiac muscle must work

harder with each contraction.¹⁶

4. Characteristics of hypertensive patients by history of antihypertensive medication use

As shown in Table 1, all 33 hypertensive patients (100%) took antihypertensive medication regularly. This finding is in line with the Riskesdas 2018 results, in which 54.4% of hypertensive patients took antihypertensive medication regularly, 32.3% took it irregularly, and 13.3% did not take it at all.² However, it differs from the study by Hazwan and Pinatih (2017), which found that most hypertensive patients (70.0%) had low adherence to antihypertensive medication; this may be attributable to the patients’ limited awareness of the need to seek treatment for their condition.¹⁸

High medication adherence among patients with hypertension contributes to achieving optimal blood pressure and reducing hypertension-related complications. According to Green, an individual’s health behavior is influenced by predisposing factors, manifested in knowledge, attitudes, beliefs, and convictions regarding what can cure a disease; enabling factors,

manifested in the physical environment, such as health facilities; and reinforcing factors, manifested in the attitudes and behavior of health workers or of persons close to the individual. It can therefore be concluded that the health behavior of an individual or a community is determined by the knowledge, attitudes, beliefs, traditions, and other characteristics of that individual or community.¹⁹

5. Characteristics of hypertensive patients by stress

As shown in Figure 2, most hypertensive patients in this study experienced stress (75.8%). This finding is consistent with the study by Islami (2015), which reported that 70.2% of hypertensive patients experienced stress, compared with 29.9% who did not.²⁰

Stress can affect the cardiovascular system, particularly in hypertension, and is believed to be a psychological factor capable of raising blood pressure. Stress raises blood pressure through its effects on the hypothalamic–pituitary–adrenal axis and the sympathetic nervous system.²¹

This finding is also supported by the theory of Kaplan and Sadock (2005),

which states that stress is more common in women than in men, with women having a twofold higher risk of experiencing stress. This is attributed to hormonal differences and to differences in psychosocial stressors between women and men.²²

Estrogen levels during the perimenopausal period influence mood and cognitive changes through alterations in acetylcholine and serotonin levels in the central nervous system. Estrogen is a steroid hormone that acts by enhancing gene expression in the cell nucleus. There are two important estrogen receptors: the alpha receptor (α receptor), which influences cognitive function, and the beta receptor (β receptor), which influences the serotonergic system.²²

Mood and cognition are associated with the effects of estrogen on the central nervous system. Estrogen increases serotonin levels by decreasing *monoamine oxidase*, the enzyme that catabolizes serotonin, which is commonly referred to as the “happiness hormone”.²²

The decline in estrogen associated with the premenopausal period reduces serotonin levels in the body. In this

study, most patients belonged to the early elderly group, an age at which estrogen levels have already begun to decline.²²

6. Characteristics of hypertensive patients by blood pressure measurement

As shown in Figure 4, the blood pressure measurements of hypertensive patients attending the Aur Duri Primary Health Center most frequently indicated stage 1 hypertension (66.7%), compared with stage 2 hypertension (33.3%). This finding is in line with the study by Rahmi (2019), which measured the blood pressure of hypertensive patients attending the Simpang IV Sipin Primary Health Center and found stage 1 hypertension to be the most common category (56.7%).²³ However, it differs from the study by Sedayu et al. (2015), which found stage 2 hypertension to be more common (59.4%). This may be because that study examined hypertensive patients in the inpatient wards of Dr. M. Djamil General Hospital, Padang, an advanced referral facility to which many patients with severe hypertension and complications are referred.²⁴

Hypertension is a degenerative

disease. Blood pressure generally rises gradually with advancing age. Most patients have blood pressure in the prehypertensive range before being diagnosed with hypertension, and most diagnoses of hypertension are made between the third and fifth decades of life. Hypertension is inherently unstable and difficult to control, whether by pharmacological treatment or by other medical interventions.²³

With respect to patient characteristics, the early elderly group was the largest (42.4%). At this age, changes begin to occur in organs such as the heart and blood vessels: the vessels lose their elasticity and become stiff, so that blood flows through narrowed vessels, forcing the heart to work harder to pump blood throughout the body and resulting in increased blood pressure.¹³

7. Characteristics of hypertensive patients by fasting blood glucose measurement

As shown in Table 2, the mean fasting blood glucose of the patients was 104.24 mg/dL, which is still categorized as normal. This may be related to disease severity, as the sample of this study consisted exclusively of

hypertensive patients without other comorbidities. This finding is in line with the study by Mittal and Pooja, which investigated fasting blood glucose levels in patients with hypertension and reported a mean fasting blood glucose of 98.57 mg/dL, likewise within the normal range.²⁵ However, it differs from the study by Torry et al. (2014), which investigated fasting blood glucose in patients with acute coronary syndrome and found stage 1 and stage 2 hypertension in most patients (63.7%) and elevated fasting blood glucose in most patients (72.0%). This may be attributable to disease severity, given that acute coronary syndrome results from plaque build-up, which may be promoted by excess glucose in the blood vessels, leading to vascular occlusion and, consequently, increased blood pressure.²⁶

A study by Yin et al., which identified risk factors for impaired fasting glucose and diabetes in adult patients in northeastern China, found that overweight/elevated body mass index (an environmental factor) and a history of diabetes mellitus (a genetic factor) were significantly associated with the incidence of impaired fasting

glucose and diabetes.²⁷

Elevated fasting blood glucose results from insulin resistance and pancreatic β -cell dysfunction. Insulin resistance is common among individuals who are overweight or obese. Insulin cannot act optimally in muscle, adipose tissue, and the liver, forcing the pancreas to compensate by producing more insulin. When insulin production by the pancreatic β cells is insufficient to compensate for the increasing insulin resistance, blood glucose levels rise and hyperglycemia eventually develops. Clinically, insulin resistance denotes the need for higher-than-normal insulin concentrations to maintain normoglycemia. Progressive insulin resistance leading to chronic hyperglycemia ultimately results in pancreatic β -cell dysfunction, as the β cells become unable to produce sufficient insulin to compensate for the increased insulin resistance.²⁸

B. Bivariate analysis

1. Association between stress and blood pressure

In this study, the significance value was 0.031, i.e., $p < 0.05$; it can therefore be concluded that there was a significant association between stress

and blood pressure in hypertensive patients at the Aur Duri Primary Health Center, Jambi City. This finding is consistent with the study by Istiana and Yeni (2019), which demonstrated a significant association between psychosocial stress and the incidence of hypertension in rural and urban communities ($p < 0.05$).²⁹

Stress is a stimulus or situation that can cause distress and impose physical and psychological demands on an individual. The stress response raises blood pressure through complex mechanisms. Under stress, the body activates the stress system within the limbic system, specifically the hippocampus and amygdala. The stressed state stimulates the paraventricular nucleus (PVN) of the hypothalamus to secrete corticotropin-releasing hormone (CRH). CRH triggers the release of adrenocorticotrophic hormone (ACTH) from the anterior pituitary and stimulates the locus coeruleus/sympathetic nervous system. The locus coeruleus and the sympathetic nervous system provide a rapid-response mechanism for controlling various physiological

functions of the body, including the response to acute stress. The locus coeruleus and sympathetic nerves trigger the release of catecholamines from the adrenal medulla, and catecholamines act on arteriolar smooth muscle to induce vasoconstriction.³⁰

2. Comparison of fasting blood glucose by stress status

In this study, the p -value was 0.087, which is greater than 0.05; it can therefore be concluded that there was no significant difference in fasting blood glucose between patients with and without stress.

Dungan et al. discussed stress hyperglycemia with a greater focus on severe physical stress, noting that stress-induced increases in fasting blood glucose are influenced by the type and stage of the patient's underlying illness.³¹

Stress can increase fasting blood glucose in critically ill patients. A study by Vibo et al. examining the association between stress and fasting blood glucose in stroke patients found a significant association between stress and elevated fasting blood glucose ($p = 0.02$).³²

Stress-induced elevation of fasting

blood glucose occurs in several stages. Stress hyperglycemia involves a complex of counterregulatory hormones, including catecholamines, growth hormone, cortisol, and cytokines. Dysregulation of these hormones leads to gluconeogenesis and insulin resistance, which in turn increase blood glucose.³²

Under stress, the body activates the stress system within the limbic system, specifically the hippocampus and amygdala. The stressed state stimulates the paraventricular nucleus (PVN) of the hypothalamus to secrete CRH. CRH then triggers the release of ACTH from the anterior pituitary and activates the locus coeruleus (LC) and the sympathetic nervous system. ACTH acts on the adrenal cortex to produce cortisol, the LC acts on the adrenal medulla to produce epinephrine, and the sympathetic nerves trigger the release of norepinephrine. These three end-product hormones of ACTH, the LC, and the sympathetic nervous system regulate bodily functions during stress.³²

Stress can increase fasting blood glucose through activation of the stress system, which comprises acute and

chronic stress responses. The acute stress response is short-lived, and cortisol and catecholamine (stress hormone) levels return rapidly to baseline. The chronic stress response is a prolongation of the acute response, in which cortisol and catecholamine levels remain elevated for a prolonged period. Chronic stress responses may occur in critically ill patients, such as those with stroke, septicemia, or major depression. The chronic stress response induces cortisol–ACTH dissociation (an increase in cortisol that is not mediated by ACTH), which distinguishes it from the acute stress response.³²

Cortisol secretion can be modulated in the absence of ACTH (ACTH-independent). Bornstein et al. (2008) described cortisol–ACTH dissociation, showing that in inflammatory bowel disease, *interleukin-6* levels were associated with stimulation of cortisol secretion independent of ACTH. The same study also linked cortisol–ACTH dissociation in patients with major depression to adrenal gland enlargement leading to increased cortisol secretion, suggesting that neurochemical, neurohormonal, or neural stimulatory factors other than ACTH may be

responsible for adrenal hyperactivity in these conditions.³³

A study by Vermes et al., which measured basal cortisol and ACTH levels over 8 days in critically ill patients, concluded that cortisol levels increased and remained elevated until the end of the observation period, whereas ACTH levels increased during the initial days of observation and decreased on days 3 and 5. The rise in basal cortisol in critically ill patients results from impaired cortisol clearance, which keeps cortisol elevated; this elevated cortisol exerts negative feedback on ACTH, resulting in decreased ACTH levels in critically ill patients.³²

In conclusion, the secretion of cortisol as a stress hormone may be regulated through the HPA axis (ACTH-dependent) or independently of ACTH (ACTH-independent). Severe stress, as in critical illness, increases cortisol owing to cortisol–ACTH dissociation, in which the rise in cortisol is driven by factors other than ACTH, such as cytokines (*interleukin-6*) and neurochemicals, which may be responsible for adrenal hyperactivity in cortisol secretion.³³

CONCLUSION

Based on the results of this study, most hypertensive patients at the Aur Duri Primary Health Center were in the early elderly age group, female, unemployed, and regularly taking antihypertensive medication; most experienced stress and had stage 1 hypertension, with a mean measured fasting blood glucose of 104.24 ± 8.507 mg/dL. There was a significant association between stress and blood pressure in hypertensive patients, and there was no significant difference in fasting blood glucose between hypertensive patients with and without stress.

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