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Serum C-Reactive Protein Levels in Hypertensive Patients in Aceh: An Ethnic-Based Study

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Abstract

Inflammation is a key factor in the pathophysiology of hypertension. One of the inflammatory biomarkers that can be used to gauge the level of systemic inflammation in hypertensive patients is C-reactive protein (CRP). This study investigated the role of CRP among hypertensive patients in Aceh according to ethnic background. This study adopted an observational analytical design. A total of 120 participants were enrolled in the study, comprising 90 hypertensive patients from three ethnic groups (Gayo, Aneuk Jamee, and Acehnese), with 30 participants in each ethnic group, and 30 normotensive individuals who served as the control group. The Kruskal-Wallis test was used to assess intergroup variations in CRP concentrations, while the Spearman's rho correlation was used to examine the association of CRP levels among hypertensive subjects across ethnic groups in Aceh, as well as comparisons with normotensive controls. Among participants, 54% had normal CRP levels, whereas 46% had elevated levels. Mean CRP concentrations were higher in female than in males; however, this difference did not reach statistical significance ($p = 0.061$). Stratification by ethnic group revealed a statistically significant variation in mean CRP levels ($p = 0.001$), with the highest values observed among the Aneuk Jamee group. Nevertheless, no significant correlation was identified between CRP levels and the occurrence of hypertension across ethnic groups in Aceh ($p > 0.05$). C-reactive protein (CRP) levels varied among Aceh's ethnic groups, but there was no discernible correlation with the prevalence of hypertension. These results imply that the regulation of inflammatory processes in people with hypertension may be influenced by non-ethnic factors.

Keywords: *C-Reactive Protein, Hypertension, Ethnic.*

INTRODUCTION

Hypertension, being one of the most common diseases, affects both developed and developing countries, Indonesia included (Peltzer & Pengpid, 2018). Based on the 2007 Basic Health Research report, hypertension was the 3rd most common cause of deaths in the country (Hussain et al., 2016). The most recent report, the 2023 Indonesian Health Survey, shows how in people aged 18 and above, hypertension is present in 30.8% of the population, and 22.6% is the reported case in Aceh Province (Kementerian Kesehatan Republik Indonesia, 2023). The Acehnese (Ureuëng Acèh) are the original residents living along the coasts and in some parts of the Aceh Province. Most are followers of Islam, and the Acehnese language, which is part of the Western Malayo-Polynesian family and related to Cham, is central to their culture. The Acehnese has a rich cultural

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tradition that is especially visible during rituals and ceremonies. The trend of these rituals is the consumption of mass amounts of carbohydrates, proteins, and fats and low amounts of dietary fibre. This may heighten the risk of contracting ailments such as hypertension and other non-communicable diseases.

Dietary habits impact immunological function. The consumption of unhealthy foods such as those rich in protein, carbs, and fats and low in fiber disrupts immune system homeostasis and promotes metabolic and inflammatory diseases. Excessive or imbalanced nutritional consumption causes immune polarization and alters the activity of immune cells, thereby increasing the risk of developing chronic inflammatory diseases (Jia et al., 2025). Eating too many refined carbohydrates raises blood glucose levels, causes oxidative stress, elevates blood levels of inflammatory cytokines such as IL-6 and TNF-α, impairs neutrophil and macrophage function, and alters gut microbiota composition (Estevão et al., 2026; Forgie et al., 2019). Diets high in saturated fats initiate inflammation by activating the NF-κB pathway, and this inflammatory response causes macrophage activation, chronic low-grade inflammation, and a decrease in the variety of gut microbiota (Qiu et al., 2022). Excessive consumption of salt promotes the development of Th17 pro-inflammatory cells, which in turn activates macrophage-mediated inflammation and inhibits the Tregs (Li et al., 2022). These dietary habits collectively disturb immunological homeostasis and increase chronic inflammation, increasing susceptibility to immune-mediated diseases, including hypertension.

Hypertension relates very closely to vascular inflammation. Chronic hypertension causes inflammatory responses such as increased release of the adhesion molecules, growth factors, and proinflammatory cytokines (Dinh et al., 2017). Inflammation of the blood vessels can also impair the performance of the endothelial cells. Those cells are the innermost ones that regulate blood vessel contraction and relaxation. The inflammation of blood vessels will also increase the levels of the inflammation-modifying substances, such as Interleukin-6 (IL-6), CRP, and tumor necrosis factor-alpha (TNF-α), that can impair the endothelial cells and increase vascular inflammation and, therefore, raise blood pressure (Gabriel et al., 2025).

C-reactive protein (CRP) is a frequently used inflammation biomarker in clinical practice, known for its ability to detect changes in systemic inflammation. The liver produces CRP in response to inflammation. The measurement of CRP levels in the blood is a useful tool for diagnosing, monitoring, and managing various medical conditions related to inflammation. It is important to highlight that a higher level of CRP is not exclusive to one medical disorder and must be reviewed in conjunction with clinical symptoms, physical examination, and additional tests in order to make an accurate diagnosis and develop a treatment strategy (Hage, 2014; Singh et al., 2026).

The relationship between CRP levels and hypertension continues to be explored because of its complex biological mechanisms. Elevated CRP levels have been consistently associated with hypertension; however, this relationship is influenced by the presence of comorbid conditions, including cardiovascular disease, infections, and other systemic disorders (He et al., 2022). A more comprehensive understanding of the relationship between inflammation and hypertension, especially within populations characterized by distinct cultural attributes such as the Acehnese community, is essential for the advancement of more effective strategies for prevention and management.

METHODS

The research was conducted in Aceh Province for 9 months (April 2022 to Januari 2023). The total number of participants was 120 patients referred from the regional hospital to Zainoel Abidin Hospital. The study comprised 90 hypertensive patients from three ethnic groups (Gayo, Aneuk Jamee, and Acehnese), with 30 participants in each

ethnic group, and 30 normotensive individuals who served as the control group. The measurement of CRP serum was obtained in the clinical pathology laboratory at Zainoel Abidin Hospital. CRP serum data among 3 ethnic groups was analyzed using a Kruskal-Wallis test. The relationship of CRP levels among hypertensive subjects across different ethnic groups in Aceh, as well as with non-hypertensive controls, was examined using Spearman's rho correlation (r = 1).

Materials and equipments

The study was conducted using a centrifuge, vortex mixer, strip plate, syringe, tourniquet, gloves, slide test kit, micropipettes with yellow and blue tips, stirrer, and rotator. The materials used included blood serum, CRP latex reagent, 0.9% sodium chloride (NaCl), 96% ethanol, phosphate-buffered saline (PBS), and distilled water.

Implementation procedure

The procedure consisted of pre-analytical and analytical phases. During the pre-analytical phase, all required materials and equipment were prepared before venous blood specimens were collected and processed to obtain serum samples. In the analytical phase, qualitative CRP testing was first performed. The CRP latex reagent was gently mixed before being dispensed onto the designated circles of a slide containing one drop (50 μL) each of serum, positive control (PC), and negative control (NC). One additional drop of CRP latex reagent was added to each circle, after which the slide was rotated at 100 rpm for 2 minutes to facilitate proper mixing. The reaction was then observed under adequate illumination. Agglutination was interpreted as a positive CRP result, indicating a CRP concentration of ≥6 mg/L.

Samples yielding positive qualitative results were subsequently subjected to semi-quantitative analysis using a serial dilution method to determine the CRP titre. Initially, 50 μL of 0.9% sodium chloride (NaCl) was dispensed into six circles on a slide. A volume of 50 μL of serum was added to the first circle and mixed thoroughly to produce a twofold dilution. An amount of 50 μL of the mixture was transferred sequentially from one circle to the next to obtain fourfold, eightfold, sixteenfold, and thirty-twofold dilutions. If agglutination remained positive in the fifth circle, 50 μL of the suspension was transferred to the sixth circle as a stock. One drop of CRP latex reagent was then added to each circle, and the slide was rotated at 100 rpm for 2 minutes. Following incubation, the reactions were observed under adequate illumination. The CRP titre was determined by multiplying the highest dilution that exhibited agglutination by 6 mg/L.

RESULTS

A total of 120 participants were enrolled, comprising hypertensive patients from the Gayo, Aneuk Jamee, and Acehnese ethnic groups, as well as normotensive individuals who served as the control group. The characteristics of the study population are presented in Table 1.

Table 1. The characteristics of CRP serum in Aceh

Variable	N	Mean (mg/L)	SD	Min	Max	P-value
C-RP Serum						
-Normal (<6 mg/L)	65 (54,2%)					
-Abnormal (≥6 mg/L)	55 45,8%					

Sex						
- Male	60	2,40	1,46	0,96	9,59	0,061
- Female	60	2,88	1,48	1,14	8,35	
Ethnic						
- Gayo	30	5,17	5,31	0,10	13,10	0.001
- Aneuk Jamee	30	7,27	5,96	0,30	16,10	
- Acehnese	30	6,13	5,69	0,20	14,50	
Control group	30	4,96	5,11	0,10	12,60	

Note: SD: Standard Deviation; Min = Minimum; Max = Maximum

Table 1 indicates that 54,2% of samples displayed normal (non-infectious) CRP levels, while 45,8% exhibited elevated (infectious) levels. Male and female participants were equally represented, with each group comprising 60 individuals. The average CRP level for females was 2.88 mg/L, exceeding the average level for males at 2.40 mg/L. This difference was not statistically significant, as shown by a p-value of 0.061. The Aneuk Jamee group exhibited the highest mean CRP level at 7.27 mg/L, succeeded by the Acehnese at 6.13 mg/L and the Gayo group at 5.17 mg/L. The differences were statistically significant (p = 0.001).

Table 2 The correlation of serum CRP levels among hypertensive patients across Three ethnic groups and the control group

Variable		**N**	**Coefficient Correlation (r)**	**p-value**
Gayo	Aneuk Jamee	30	-0,004	0,983
	Acehnese	30	-0,003	0,989
	Control	30	0,470	0,714
Aneuk Jamee	Acehnese	30	-0,178	0,347
	Control	30	0,183	0,663
Acehnese	Control	30	-0,126	0,893

Table 2 shows the relationship between hypertension among subjects from different ethnic groups in Aceh based on CRP titre quantities using Spearman's rho correlation test. In general, there was no significant correlation in CRP levels among hypertensive patients across ethnic groups in Aceh, nor when compared to the control group (p > 0.05). The Gayo group showed no significant correlation with the Aneuk Jamee group (r = -0.004; p = 0.983), the Acehnese group (r = -0.003; p = 0.989), or the control group (non-hypertensive individuals) (r = 0.470; p = 0.714). Similarly, the Aneuk Jamee group showed no significant link with the Acehnese group (r = -0.178; p = 0.347) or the control group (r = 0.183; p = 0.663). The Acehnese group exhibited no significant connection with the control group (r = -0.126; p = 0.893).

DISCUSSION

Several variables promote hypertension in Aceh, including genetic susceptibility, poor lifestyle behaviors (such as high salt and fat intake, physical inactivity, and smoking), stress, and comorbidity like diabetes and kidney disorders (Masyudi et al., 2022). The socio-cultural life of the Acehnese community remains strongly influenced by

traditional practices, particularly in ceremonial events that involve the consumption of foods high in carbohydrates, fats, proteins, and salt and low in fiber. These dietary patterns elevate the risk of hypertension. A study in Aceh Tamiang found that eating too much salt was one of the main risk factors for cardiovascular disease, along with sex and smoking history (Fitri et al., 2024). A case–control study indicated that age, family history, obesity, physical activity, salt and coffee consumption, stress, and medication adherence significantly affected the prevalence of uncontrolled hypertension in Central Aceh (Nadapdap et al., 2021). No specific studies have directly linked ethnicity in Aceh to hypertension, an approach based on inflammatory biomarkers such as CRP is important for understanding disease mechanisms, particularly in relation to systemic and cardiovascular diseases.

Hypertension is a multifactorial condition characterized by complex interactions between numerous biological mechanisms, including dysregulation of blood pressure management, endothelial dysfunction, electrolyte imbalance, insulin resistance, and chronic inflammation. Endothelial dysfunction leads to hypertension by disrupting the equilibrium between vasodilatory agents, such as nitric oxide, and vasoconstrictive agents, such as endothelin-1, thereby elevating peripheral vascular resistance. The oxidative stress and inflammatory mediators are triggered by insulin resistance and chronic inflammation, which worsens endothelial function and accelerates the development of hypertension (Gallo et al., 2022; Guzik et al., 2024). The renin-angiotensin-aldosterone system (RAAS) plays a crucial role in raising blood pressure through vasoconstriction and fluid retention. Angiotensin II, the main component of RAAS, significantly contributes to increased blood pressure, as well as inflammation, oxidative stress, and changes in blood vessel structure, all of which worsen hypertension (Masi et al., 2019).

The chronic inflammation in hypertension is closely associated with a higher level of inflammation biomarkers, including CRP. Hypertension involves RAAS activation, oxidative stress, and endothelial dysfunction that trigger the release of inflammation mediators into circulation. The rise of this biomarker indicates systemic inflammation, which contributes to the worsening of endothelial dysfunction and increases the risk of cardiovascular complications. This fact shows that hypertension and CRP are strongly related (Hage, 2014; Singh et al., 2026).

The study's findings demonstrated the mean CRP level was higher in the Aneuk Jamee ethnic group, followed by Acehnese and Gayo. The statistical analysis revealed a substantial difference among the three ethnicities. This result is caused by variations in demographic characteristics related to ethnicity, such as genetic factors, eating habits, environment, and socio-cultural differences. Other factors such as age, sex, and comorbidity can also influence the results (Sanghera et al., 2019). There is still no scientific evidence that proves ethnic influences on hypertension (Norris, 2009). A cohort study indicated that the difference in CRP among ethnicities was predominantly affected by social and environmental factors rather than genetics (Nagar et al., 2021).

Kong and colleagues (2012) found that genetic differences, particularly polymorphisms in the CRP gene, influence circulating CRP levels, which serve as an inflammation marker. Higher CRP levels have been linked to increased blood pressure and a greater likelihood of developing hypertension. A direct connection between genetic variation in the CRP gene and the development of hypertension has not been established. This implies that genetic factors primarily modulate the inflammatory response, rather than directly causing hypertension (Kong et al., 2012). These findings support the idea that hypertension is a multifaceted condition, resulting from a complex interaction of genetic and environmental influences.

Socio-environmental aspects such as traditional eating habits and lifestyle can increase the risk of hypertension and also influence inflammation among ethnicities (Furman et al., 2019). High consumption of saturated fatty acids had been identified as a component that plays a role in increasing inflammation markers, whereas unsaturated fatty acids had the opposite effect (Peña-Orihuela et al., 2013). Food with high fibre and low fat has been proven to lower inflammation markers and is also associated with lowering blood pressure (Steinberg et al., 2017). High consumption of fruits, vegetables, and healthy fat is also related to the lower level of CRP and lower risk of various non-communicable diseases (Widmer et al., 2015). A dietary pattern characterized by high consumption of processed meats and refined carbohydrates is associated with increased inflammatory markers and a higher risk of various chronic diseases (Barbaresko et al., 2013). Eating habits play a major role in modulating inflammation and also contribute to hypertension and other cardiovascular risks.

There were some differences in CRP levels between ethnic groups, but the statistical analysis did not find a significant link between CRP and ethnic background in patients with hypertension. This suggests that inflammation in hypertension is not directly determined by ethnicity but is instead shaped by a more complex interaction of biological and environmental factors. Attributing inflammation in hypertension solely to specific ethnic groups may be too simplistic and cannot be generalized. A more comprehensive understanding is needed to better understand the differences in CRP levels among ethnic groups in Aceh and the factors that contribute to these variations.

While the three ethnic groups in this study display different CRP levels, this is not only biologically based. They have different cultural practices, which include different food choices, as well as different environmental exposures. The outcomes of health are comprised of the interactions of different factors, particularly of a social and behavioral nature and the environment. The social-ecological model acknowledges the multifactorial influences on dietary behaviors, including cultural traditions, family practices, food availability, and socioeconomic conditions (Anyanwu et al., 2022). Traditional Acehnese dishes are characterized by high carbohydrate content, coconut milk, salted fish, and seasonings high in sodium and low in dietary fiber. These dietary patterns have been associated with chronic low-grade inflammation through increased oxidative stress, alterations in the composition of the gut microbiota, disruption of the intestinal barrier, and increased production of pro-inflammatory cytokines. These mechanisms may partly explain the high CRP levels observed in the Acehnese population.

There are some limitations in this study. CRP levels were measured through a latex agglutination assay, which exhibits lower sensitivity than a high-sensitivity CRP (hs-CRP) or ELISA assays. Even though the latex agglutination assay is sufficient for measuring significant inflammation, its detection limit of 6 mg/L is too high for finding small elevations of CRP that occur during chronic low-grade inflammation. Therefore, this study likely did not fully capture the low-grade inflammatory processes implicated in the pathogenesis of hypertension. The study may have overlooked subclinical inflammatory variability of ethnicity and diet. Further research should be conducted with hs-CRP or other high-sensitivity methods to measure the impacts of low-grade inflammation, diet, and ethnicity on hypertension more comprehensively.

CONCLUSION AND RECOMMENDATION

The level of CRP in hypertensive patients in Aceh Province differs among ethnic groups, with statistically significant variations. The Aneuk Jamee group had the highest level of CRP compared to the Acehnese and Gayo groups. There are no significant relationships between the level of CRP and ethnic background, neither in patients with

hypertension nor with healthy individuals. This implies that while CRP levels vary by ethnicity, they don't directly contribute to the development of hypertension. The occurrence of hypertension may be influenced by a combination of various factors, including biological, lifestyle, and environmental factors.

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