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Association of Serum Lipids with High Blood Pressure among Diabetic Patients

Dr. Md. Sharif Hossain[1], Dr. Rajee Mahmud Talukder[2], Dr. Md. Enamul Haque[3], Dr. Md. Masum[4], Dr. Fathima Sultana[5], Dr. Md. Sarowar Uddin Milon[6]

Abstract

Background: The intricate interplay between serum lipid levels and high blood pressure in diabetic patients has emerged as a critical nexus in contemporary medical research. As diabetes poses a multifaceted challenge to cardiovascular health, understanding the nuanced relationship between serum lipids and hypertension becomes imperative. This study delves into the intricate dynamics, exploring how variations in lipid profiles may influence blood pressure regulation in diabetic individuals. Unraveling these associations holds the key to developing targeted interventions that mitigate the heightened cardiovascular risks faced by diabetic patients, paving the way for more effective management and improved overall health outcomes.

Aim of the study: This study aimed to evaluate the association of serum lipids with high blood pressure among diabetic patients.

Methods: This observational study occurred at the Department of Medicine in National Institute of Cardiovascular Disease (NICVD), Dhaka, Bangladesh. The study included a cohort of 123 individuals diagnosed with diabetes. The research spanned one year, commencing from January 2021 to December 2021.The research included comprehensive assessments, blood pressure checks, and blood sample collection. Inclusion criteria covered type-1 and type-2 diabetic patients, while exclusion criteria excluded children, pregnant diabetic women, those with end-stage renal disease, on dialysis, or with active hepatic disease. Hypertension was defined as blood pressure ≥140/90. Fasting blood samples measured cholesterol levels. Data analysis utilized IBM SPSS Statistics, and statistical significance was set at $p<0.05$. The study aimed for 90% statistical power, presenting data as percentages with mean±SD and 95% confidence intervals.

Results: This study analyzes a diabetic patient cohort's demographic and health characteristics. Of 123 participants, 56.09% were male, 82.93% had Type-2 diabetes, and 68.18% lacked hypertension. Lipid analysis revealed abnormal levels in 64.55%. Descriptive statistics include a mean age of 49.84 years and a diabetes duration of 13.37±4.58 years. Correlation analysis shows positive links between blood pressure and various lipids. Regression models indicate significant associations between systolic/diastolic blood pressure and triglycerides, cholesterol, LDL-C, HDL-C, and Non-HDL-C. These findings emphasize the intricate relationship between blood pressure and lipid levels in diabetic patients.

Conclusion: This study reveals a significant association between serum lipid levels and high blood pressure in diabetic patients. Elevated lipids may serve as a predictive factor for hypertension in this population. Understanding these links is crucial for targeted interventions to mitigate cardiovascular risks and improve overall health outcomes in diabetic individuals.

Affiliation:

[1]Assistant Registrar, Department of Medicine, National Institute of Cardiovascular Disease (NICVD), Dhaka, Bangladesh

[2]Associate Professor, Department of Medicine, Medical College for Women and Hospital, Dhaka, Bangladesh

[3]Assistant Professor, Department of Medicine, Medical College for Women and Hospital, Dhaka, Bangladesh

[4]Medical Officer, Bangabandhu Sheikh Mujib Medical University (BSMMU), Dhaka, Bangladesh

[5]Microbiologist, National Institute of Cardiovascular Disease (NICVD), Dhaka, Bangladesh

[6]Phase A resident (endocrinology), Bangabandhu Sheikh Mujib Medical University (BSMMU), Dhaka, Bangladesh

***Corresponding author:**
Nura A Mohamed. Biomedical Research Center, Qatar University, Doha P.O. Box 2713, Qatar.

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Introduction

High blood pressure, also known as hypertension, is a prevalent comorbidity in individuals with diabetes, posing a significant challenge for healthcare professionals [1]. The interaction between diabetes and hypertension is intricate, with both conditions influencing and exacerbating each other's progression. Ongoing research is dedicated to comprehending the complex relationship between serum lipid levels and the onset of high blood pressure in diabetic patients. Dyslipidemia is a common feature of diabetes and has been linked to cardiovascular complications [2]. Essential hypertension is often asymptomatic and goes undetected, earning it the moniker "silent killer." Uncontrolled hypertension can lead to organ damage throughout the body. Dyslipidemia and hypertension stand out as the primary risk factors for coronary artery disease (CAD). Both hypertension and hypercholesterolemia (or dyslipidemia) individually increase the risk of CAD, and their combined impact is shown to be multiplicative. Blood pressure also significantly influences the rate of atheroma formation in human subjects. Isolated systolic hypertension, prevalent in elderly subjects, is attributed to atherosclerosis-induced staining of the aorta and major arteries. Autopsy studies on human coronary arteries and aortas from various regions worldwide have concluded that atherosclerosis is more extensive and severe in hypertensive patients than in normotensive individuals [3-5]. The association between serum lipids and high blood pressure in the context of diabetes holds paramount importance due to the heightened risk of cardiovascular events in this population [6]. Studies propose that alterations in lipid profiles, including elevated levels of triglycerides and low-density lipoprotein cholesterol (LDL-C), may contribute to the development of hypertension in individuals with diabetes [7]. Additionally, disturbances in lipid metabolism can adversely affect vascular function and worsen insulin resistance, complicating the management of both conditions. Untreated hypertension has various adverse effects on the human body, including end-organ damage. Both high blood pressure and elevated serum lipids are major risk factors for the development of ischemic heart disease (IHD) or CAD, and their progression is accelerated among people with diabetes. Furthermore, these metabolic abnormalities are associated with macrovascular and microvascular complications of type 2 diabetes and are risk factors for atherosclerosis in children and young adults [8-11]. Recent research literature affirms that diabetes mellitus is a cardiovascular risk equivalent, as confirmed by the Framingham study and other landmark studies [12,13]. Diabetic dyslipidemia is characterized by elevated triglyceride levels, elevated low-density lipoprotein cholesterol (LDL-C), and low high-density lipoprotein cholesterol (HDL-C) levels [14]. New guidelines recommend targeting non-HDL cholesterol to reduce cardiovascular morbidity and mortality. While Albrink demonstrated in 1963 that triglycerides were a significant atherosclerotic risk in diabetes, recent trials indicate that lowering triglyceride levels does not significantly reduce the primary endpoint of major coronary events. This evidence is supported by the Fenofibrate Intervention and Event Lowering in Diabetes (FIELD) study. Therefore, high-density lipoprotein (HDL-C) serves as a strong inverse covariate of triglycerides, and the management of dyslipidemia must consider both HDL-C and Non-HDL-C [15,16]. Historically, some research trials sought to establish a positive relationship between serum total cholesterol and blood pressure [17,18,19]. However, their results were inconsistent, and these trials concluded that these associations were insignificant. Some studies have shown positive correlations [20,21], but they were not conducted on diabetic subjects and did not develop statistical regression models for serum lipids and blood pressure. The current study aims to identify associations and significant correlations between serum lipids (total cholesterol, LDL-C, HDL-C, Non-HDL-C, and triglycerides) and to develop statistical regression models and linear equations predicting or calculating systolic and diastolic blood pressure elevations based on increased serum lipids among diabetic patients.

Methodology

This observational study occurred at the Department of Medicine in National Institute of Cardiovascular Disease (NICVD), Dhaka, Bangladesh. The study included a cohort of 123 individuals diagnosed with diabetes. The research spanned one year, commencing from January 2021 to December 2021

. During this period, comprehensive histories and physical examinations were conducted, and blood pressure was assessed using standardized methods.

Inclusion criteria:

- Patients with type-1 diabetic.
- Patients with type-2 diabetic.

Exclusion criteria:

- Children (age<13 years).
- Pregnant diabetic women.
- Patients with end-stage renal disease (ESRD).
- Patients on dialysis and with active hepatic disease.

A blood pressure equal to or greater than 140/90 was categorized as "hypertension." Fasting blood samples were collected after at least 12 hours, typically in the early morning. The levels of low-density lipoprotein cholesterol,

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total cholesterol, LDL, and HDL (measured in mg/dl) were determined using enzymatic procedures. Patient data were subjected to analysis using IBM SPSS Statistics, version 20, designed for Microsoft Windows. Standard medical statistical methods were employed for all statistical tests. The data were presented as percentages with mean±SD and 95% confidence intervals for the variables. The study was structured to achieve a statistical power of 90% for detecting significant changes. All p-values were two-sided, and those below 0.05 were deemed statistically significant.

Results

The demographic and other characteristics of the diabetic patient cohort are summarized in Table 1. Most of the 69(56.09%) patients were male, and the rest 54(43.91%) were female. Regarding the type of diabetes, the majority of 102(82.93%) individuals had Type-2 diabetes, and 21(17.07%) individuals had Type-1 diabetes. 75(68.18%) individuals did not exhibit hypertension, whereas 48(43.64%) individuals were hypertensive. The lipid status analysis indicated that 71 individuals (64.55%) had abnormal lipids, while 52 (47.27%) displayed normal lipid levels. In Table 2, the descriptive statistics for various variables are presented. The mean age of the participants is 49.84 years, with a standard deviation of 13.44 years. The Mean±SD of diabetes duration is reported as 13.37±4.58 years. The mean triglyceride level is 155.46 mg/dl, and the standard deviation is 84.26 mg/dl. Blood pressure parameters are also included, with the Mean±SD of systolic blood pressure being 127.37±15.47mmHg and the Mean±SD of systolic blood pressure being 78.57±8.76 mm Hg. Table 3 presents the study population's serum lipid levels with and without hypertension. For participants with hypertension, the mean total cholesterol level is 195 mg/dl (SD=47; 95% CI: 191 to 196), while those without hypertension exhibit a slightly lower mean of 184 mg/dl (SD=57; 95% CI: 181 to 190). Similar patterns are observed for triglycerides, with the hypertensive group having a mean of 163 mg/dl (SD=95; 95% CI: 157 to 170), compared to 151 mg/dl (SD=88; 95% CI: 147 to 160) in the non-hypertensive group. Regarding LDL-C, individuals with hypertension show a higher mean level of 124 mg/dl (SD=56; 95% CI: 118 to 126), in contrast to the non-hypertensive group with a lower mean of 114 mg/dl (SD=45; 95% CI: 94 to 104). The HDL-C levels are marginally lower in the hypertensive group, with a mean of 41 mg/dl (SD=14; 95% CI: 42 to 38), compared to 42 mg/dl (SD=24; 95% CI: 41 to 45) in the absence of hypertension. Non-HDL-C follows a similar trend, with a higher mean of 152 mg/dl (SD=50; 95% CI: 147 to 154) in the hypertensive group and a lower mean of 146 mg/dl (SD=46; 95% CI: 141 to 148) in the non-hypertensive group. Table 4 presents the correlation analysis between serum lipids and systolic blood pressure. The results indicate a positive correlation between systolic blood pressure and triglycerides ($r = 0.389$, $p < 0.0001$), total cholesterol ($r = 0.387$, $p < 0.001$), LDL-C ($r = 0.361$, $p < 0.01$), HDL-C ($r = 0.359$, $p < 0.01$), and Non-HDL-C ($r = 0.42$, $p < 0.0001$). The correlation between lipid and diastolic blood pressure is shown in Table 5. The correlation between diastolic blood pressure and triglycerides yielded a coefficient of 0.398 ($p < 0.0001$), indicating a statistically significant positive correlation. Similarly, there was a significant positive correlation between diastolic blood pressure and total cholesterol (coefficient=0.384, $p<0.001$); also, diastolic blood pressure has correlations with low-density lipoprotein and high-density lipoprotein cholesterol. Table 6 presents the regression models for systolic blood pressure (BP) and various serum lipids of the study population. Notably, a statistically significant association was observed between serum triglyceride levels and systolic BP, as indicated by an F-value of 13.29, a T-value of 163.04, and a p-value of less than 0.0001. Similarly, significant associations were found for serum cholesterol, LDL-C, HDL-C, and Non-HDL-C with systolic BP, as evidenced by F-values of 11.72, 4.88, 5.41, and 19.71, T-values of 75.14, 111.67, 124, and 90.27, respectively, all with p-values below 0.0001. Table 7 presents the regression models for diastolic blood pressure (BP) and serum lipids. Specifically, the model involving serum triglyceride and diastolic BP exhibits a substantial F-value of 26.76, underscoring a significant relationship with a corresponding T-value of 181.5 and a p-value less than 0.0001. Similarly, the models for serum cholesterol, LDL-C, HDL-C, and Non-HDL-C about diastolic BP also yield statistically significant F-values of 11.2, 3.5, 7.4, and 19.6, respectively, all accompanied by considerably high T-values and p-values below 0.0001.

Table 1: Demographic and other characteristics of diabetic patients (N=123)

Parameters	Frequency (n)	Percentage (%)
Gender distribution		
Male	69	56.09
Female	54	43.91
Type of diabetes		
Type-1	21	17.07
Type-2	102	82.93
Status of hypertension		
Hypertensive	48	43.64
Non-hypertensive	75	68.18
Lipid status		
Abnormal lipids	71	64.55
Normal lipids	52	47.27

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Table 2: Variables with descriptive statistics (Mean±SD)

Variables	Mean ± SD
Age (year)	49.84 ± 13.44
Diabetes duration (year)	13.37 ± 4.58
Triglycerides (mg/dl)	155.46 ± 84.26
Total cholesterol (mg/dl)	187.73 ± 52.91
LDL-C (mg/dl)	117.73 ± 47.77
HDL-C (mg/dl)	43.17 ± 16.37
Non-HDL-C (mg/dl)	149.37 ± 47.59
Systolic blood pressure (mm Hg)	127.37 ± 15.47
Diastolic blood pressure (mm Hg)	78.57 ± 8.76

Table 3: Serum lipids levels with hypertension state (Mean ± SD; 95% CI) (N=123)

Serum lipids	Hypertension status with serum lipids(mg/dl)				p-value
	Present		Absent		
	Mean ± SD	95% CI	Mean ± SD	95% CI	
Total cholesterol	195 ± 47	191 to 196	184 ± 57	181 to190	<0.001
Triglycerides	163 ± 95	157 to 170	151 ± 88	147 to160	<0.001
LDL-C	124 ± 56	118 to 126	114 ± 45	94 to 104	<0.001
HDL-C	41 ± 14	42 to 38	42 ± 24	41 to 45	<0.001
Non-HDL-C	152 ± 50	147 to 154	146 ± 46	141 to148	<0.001

Table 4: Correlation between serum lipids and systolic blood pressure (N=123)

Variable tested for correlation	Pearson's correlation coefficient	p-value
Systolic BP and triglycerides	0.389	< 0.0001
Systolic BP and total cholesterol	0.387	< 0.001
Systolic BP and LDL-C	0.361	<0.01
Systolic BP and HDL-C	0.359	<0.01
Systolic BP and Non-HDL-C	0.42	<0.0001

Table 5: Correlation between lipids and diastolic blood pressure (N=123)

Variable tested for correlation	Pearson's Correlation Coefficient	p-value
Diastolic BP and triglycerides	0.398	<0.0001
Diastolic BP and T cholesterol	0.384	<0.001
Diastolic BP and LDL-C	0.348	<0.01
Diastolic BP and HDL-C	0.365	<0.01
Diastolic BP and Non-HDL-C	0.421	<0.0001

Table 6: Regression models for systolic blood pressure and serum lipids (N=123)

Variables	F-value	T-value	p-value
Serum Triglyceride and systolic BP	13.29	163.04	<0.0001
Serum cholesterol and systolic BP	11.72	75.14	<0.0001
Serum LDL-C and systolic BP	4.88	111.67	<0.0001
Serum HDL-C and systolic BP	5.41	124	<0.0001
Serum Non-HDL-C and systolic BP	19.71	90.27	<0.0001

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Table 7: Regression models for diastolic blood pressure and serum lipids (N=123)

Variables	F-value	T-value	p-value
Serum triglyceride and diastolic BP	26.76	181.5	<0.0001
Serum cholesterol and diastolic BP	11.2	84.3	<0.0001
Serum LDL-C and diastolic BP	3.5	126.6	<0.0001
Serum HDL-C and diastolic BP	7.4	141.3	<0.0001
Serum Non-HDL-C and diastolic BP	19.6	101.1	<0.0001

Discussion

The comprehensive management of dyslipidemia plays a crucial role in the overall care of individuals with diabetes. In routine clinical practice, physicians typically focus on LDL-C as a primary target. However, recent recommendations suggest that targeting non-HDL-C is also important. Non-HDL-C can be calculated by subtracting HDL-C from total cholesterol, providing a more accurate indicator of overall harmful cholesterol and a risk factor for coronary artery disease (CAD). Both the National Cholesterol Education Program (NCEP) and the American Diabetes Association (ADA) endorse a target LDL-C level of 200 mg/dl. This underscores the significance of non-HDL-C as a potential marker of dyslipidemia [22,23]. Screening diabetic patients for dyslipidemia during initial and follow-up visits is crucial, as serum lipids contribute to elevated blood pressure and increase the risk of CAD. Our study, for the first time in medical research history, established correlations between serum lipids, including non-HDL-C, and blood pressure in diabetic patients. The highest correlations were observed between non-HDL-C and systolic/diastolic blood pressures (r=0.414 and r=0.415, respectively, with p, respectively). Linear equations derived from our research indicate that elevated serum triglycerides (e.g., 300 mg/dl) can raise systolic blood pressure to 131 mmHg, and LDL-C levels of 180 mg/dl can lead to blood pressure elevations up to approximately 129.5 mm Hg. This predictive technique highlights the potential for significant blood pressure elevations due to chronic exposure to high serum lipids. Moreover, our statistical analysis suggests that increasing HDL-C levels are associated with reduced systolic and diastolic blood pressure. Dyslipidemia and high non-HDL-C cholesterol are also linked to hypothyroidism among diabetic patients, emphasizing the need for regular screening and follow-up. Research trials have shown associations between dyslipidemia and nephropathy, emphasizing the importance of early detection in primary care clinics [24,25]. Additionally, hypertension in diabetic patients is associated with CAD, cerebrovascular disease (CVA), and other diabetes-related complications. Efforts to reduce elevated blood pressure through available medications are crucial, as tight blood pressure control has demonstrated reductions in morbidity, mortality, and diabetes-related complications [26-29]. Routine screening for dyslipidemia is essential in diabetic patients, given its association with CAD or ischemic heart disease and high morbidity and mortality rates. Insulin resistance is linked to dyslipidemia and high triglycerides, necessitating aggressive treatment with statins when detected [30-32]. In diabetology clinics, the management of type-1 and type-2 diabetic patients involves distinct strategies. Basal-bolus insulin is recommended for type-1 diabetes, while type-2 diabetes can be managed with oral agents alone or in combination with insulin. Metformin is particularly recommended for type-2 diabetes due to its cardiovascular protective effects and positive impact on insulin sensitivity and serum lipids, as supported by research studies [33-35]. Adherence to established guidelines for diabetes management and its complications is crucial [36,37]. Our groundbreaking research has unveiled significant correlations, associations, and regression models/linear mathematical equations between serum lipids (including non-HDL-C) and blood pressure (or HTN). Confirmatory research at the multi-centre level and randomized controlled trials are warranted to validate our findings.

Limitation of the study

The study's limitations include a cross-sectional design, preventing the establishment of causal relationships. The reliance on self-reported data may introduce recall bias. The sample, confined to diabetic patients, limits generalizability to the broader population. Additionally, the study does not explore confounding variables, potentially impacting the accuracy of observed associations. Moreover, the study does not consider variations in treatment regimens, potentially influencing lipid profiles and blood pressure. These limitations highlight the need for cautious interpretation and suggest avenues for future research to enhance the understanding of the complex interplay between serum lipids and high blood pressure in diabetic individuals.

Conclusion & Recommendation

In conclusion, our study establishes a significant association between serum lipids and high blood pressure in diabetic patients. Elevated levels of cholesterol and triglycerides were found to correlate with increased blood pressure, underscoring the intricate interplay between lipid metabolism and hypertension in this population. These

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findings emphasise the importance of comprehensive cardiovascular risk management in diabetic individuals, highlighting the potential role of lipid-lowering interventions in preventing or managing hypertension. Further research is warranted to elucidate the underlying mechanisms and to guide targeted therapeutic strategies for optimizing cardiovascular outcomes in this vulnerable patient group.

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