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Hypertension and Chronic Bronchitis in Adult Men: Impact and Association of Serum LDL-Cholesterol and cfDNA

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Abstract **Background:** Low Density Lipoprotein Cholesterol (LDL-C) and cell free deoxyribonucleic acid (cfDNA) could be the important factors in the development of hypertension (HTN) and Chronic Bronchitis (CB). In view of inconclusive and controversial reports, we planned to clarify the impact of LDL-C and cfDNA in HTN and CB in adult men. **Methods and Results:** Adult male patients with HTN (n:130) and CB (n:130) compared with normal healthy adult males (n:130) had same range of age (51-60 years) and body mass index (BMI; 18.5-24.9 kg/m^2). LDL-C and cfDNA in CB patients compared with NC did not present any significant variation ($p>0.05$). HTN vs. NC subjects showed significant increased levels for LDL-C (<0.001) and cfDNA (<0.001) in HTN. Furthermore, LDL-C plotted against cfDNA levels for HTN presented significant positive linear correlation ($p<0.001$). Plot of LDL-C against cfDNA in CB and association of all other variables with LDL-C and cfDNA in HTN and CB showed non-significant correlations. **Conclusions:** Present report provides information of the significant impact of increased levels and positive linear correlation of serum LDL-C and cfDNA in adult patients with HTN, possibly involving inflammatory conditions. Increase in BP may increase LDL-C and cfDNA and vice versa via tissue damage and inflammation.

Key Words Hypertension, Chronic Bronchitis, Adult Men, LDL-C, cfDNA

INTRODUCTION

Hypertension (HTN) is quite a common medical condition/ disorder where the force of the blood against artery walls reach to high level. It is one of the multifactorial contributors in the cardiovascular diseases (CVDs) [1]. Whereas the Chronic Bronchitis (CB), a primary type of Chronic Obstructive Pulmonary Disease (COPD) is a long-term inflammatory disorder of respiratory passageways causing productive cough on daily basis for few months continuing to two successive years. It is a primary type of Chronic Obstructive Pulmonary Disease (COPD) [2].

Blood markers in HTN are sodium, potassium, creatinine, estimated glomerular filtration rate (eGFR), other markers related to kidney function, fasting blood glucose (FBG)/or glycated hemoglobin A1C (HbA1c) and lipid profile [3-5]. Some of the other markers for secondary causes are Thyroid-Stimulating Hormone (TSH), aldosterone and renin [6].

Important pathophysiological mechanisms of the occurrence of CB are ciliary dysfunction that destroy the mucociliary escalator, mucus hypersecretion that triggers hypertrophy and hyperplasia in the cartilaginous submucosal glands, airway obstruction/gas mismatch that causes hypoxemia, air-trapping and hypercapnia, airway inflammation/fibrosis causing activation of innate and adaptive immunity, release of pro-inflammatory cytokines leading to edema, hyperplasia in smooth muscles/ peribranchial fibrosis and vascular dysfunction that increases the vascular resistance and may lead to right-sided heart failure [2,7].

There are a number of factors involved in the pathogenesis of CB and HTN. Low Density Lipoprotein Cholesterol (LDL-C) and cell free deoxyribonucleic acid (cfDNA) are the two important risk factors in the occurrence of CB and HTN. However, in view of inconclusive and controversial reports, we planned to determine various variables including age, Basal Body Temperature (BBT), Hemoglobin (Hb), Fasting Blood Glucose (FBG), Hepcidin (Hp), LDL-C and cfDNA. However, the main emphasis in the present study was to assess the impact of the variations and association of LDL-C and cfDNA in hypertension and chronic bronchitis in adult men.

METHODS

The present study was conducted following the ethical considerations of the World Medical Association (WMA) Declaration of Helsinki and accepted/approved by Ethical Committee, College of Medicine, Umm Al-Qura University (UQU), Makkah, Saudi Arabia, Approval Number: "HAPO-02-K-012-2022-01-1085." Furthermore, written consent was taken from each of the participants. Research studies were started on April 26, 2023 and were completed in January 27, 2026 in the nearby hospitals affiliated with UQU.

Sample size was determined using the formula and confirmed by calculator method. Comprehensive history and interviews of the participants were conducted and the information was saved for assessment and analysis. Two groups of patients, HTN and CB, were studied in the present work. A third group served as a Normal Control (NC) group for comparison purpose. Age of all participants was between 51 and 60 years. Participants having less or more age than the mentioned range were not included in the current study. The BMI (kg/m^2) was determined by dividing the body weight (BW) in kilograms of the participants by squared values of body height in meters.

Participants having normal weight BMI (kg/m^2) of 18.5 to 24.9 were included in the present study. Consent of each participant was obtained for collecting information about their disease, previous and present medication, family and their personal background and blood collection. Present study did not involve the overweight and obese participants. Patients having serious disorders (other CVDs, diabetes, stroke, metabolic syndrome (MetS) etc) were not dealt in the present study.

Oral basal body temperature (BBT, °F) was determined employing a Citizen Digital Thermometer CTA303 from Taipei, Taiwan (water resistant, antibacterial and washable). The fasting blood glucose (FBG, mg/dL) test required to take the blood sample at least 10 hours from the last meal. The hepcidin (Hp, ng/mL) was assessed by kit method-Human Hp enzyme-linked immunosorbent assay (ELISA) kit (MyBioSource, Inc, San Diego, CA, United States (US) employing ELISA reader. The hemoglobin (Hb, g/dL) levels were measured using a hematology analyser-Sysmex XN 100i (Sysmex Europe SE, Norderstedbt; Germany).

Some of the common symptoms of chronic bronchitis are shortness of breath specially while doing a physical activity, wheezing, chest pain, production of mucus that is clear, white, green or yellow and occurrence of tiredness or fatigue [2].

Hypertension is clinically diagnosed employing Blood Pressure (BP) cuffs with readings, not by blood tests, though the baseline blood levels of biomarkers are checked to confirm for determining the underlying causes especially the kidney and heart diseases [5].

The HTN is often called as the silent killer since HTN develops noticeable warning/signs rarely leading to a severe manifestation. If the HTN is not treated, it may significantly increase the risk of having cardiac attacks, kidney damages, strokes and other complications.

The BP was determined in mmHg (millimeters of mercury) for systolic BP (SBP) and diastolic BP (DBP) where 120/80,120-129/≤80,130-139/80-89 and ≥140/≥90 are respectively normal BP, elevated BP, stage-1 HTN and stage-2 HTN. The ELISA (enzyme-linked immunosorbent assay) kits were used for determining LDL-C (mg/dL), cfDNA (ng/mL) and other variables in the present study.

SPSS (Statistical Package for Social Sciences, version 24.0 for Windows (SPSS Inc., Chicago, IL, USA) as well as GraphPad Prism (version 6.0), San Diego, CA, USA, were employed for the analyzing the present data. Values in mean±SD were determined and analyzed for obtaining their variation/ difference using unpaired t-test for two tailed values of p. Whereas the associations/ correlations were obtained by drawing the regression lines and finding the R^2 for respective p-values ($p<0.05$ was standardized as a significant variation).

RESULTS

The present study was conducted to find out the impact and association of LDL-cholesterol and cfDNA in adult male patients with hypertension and chronic bronchitis, both groups of patients compared with a group of the normal healthy male participants having same range of age and BMI.

The data of age (years), BBT(°F), BMI (kg/m^2), Hb (g/dL), FBG (mg/dL) and Hp (ng/mL) (Table 1) did not show any significant difference ($p>0.05$) for patients of both groups (HTN and CB) compared with NC. The LDL-C and cfDNA in patients with CB compared with NC also did not present any significant variation ($p>0.05$). The serum LDL-C and cfDNA in HTN patients compared to NC showed significant variation (<0.001) (Table 1).

Serum LDL-C of CB, HTN and NC groups was plotted against other variables of age, BBT, Hb, FBG and Hp that showed non-significant correlation. The LDL-C against cfDNA for HTN group of patients presented significant positive linear correlation ($p<0.001$; Table 2).

Table 1: Characteristic Features and Parameters in Normal Adult Male Healthy Controls and Patients with Hypertension and Chronic Bronchitis

	Normal adult male healthy controls and patients with hypertension and chronic bronchitis				
Parameters	NC	CB	Significance (p) (CB vs. NC)	HTN	Significance (p) (HTN vs. NC)
Age (years)	55.12±2.96	55.13±2.97	0.98	55.23±2.89	0.77
BBT (°F)	98.61±0.68	98.59±0.66	0.81	98.62±0.69	0.91
BMI (kg/m^2)	21.64±2.09	21.63±2.07	0.97	21.69±2.08	0.85
Hb (g/dL)	13.83±1.17	13.83±1.15	0.98	13.84±1.17	0.97
FBG (mg/dL)	91.52±3.28	91.58±3.38	0.88	91.93±4.01	0.37
Hp (ng/mL)	9.49±4.69	9.58±4.74	0.87	9.71±4.85	0.71
LDL-C (mg/dL)	95.78±7.76	97.08±8.06	0.19	103.91±12.98	<0.001
cfDNA (ng/mL)	110.46±64.31	116.16±63.99	0.47	158.73±95.60	<0.001

Table 2: Correlation of LDL-C with Other Parameters in Normal Adult Male Healthy Controls and Patients with Hypertension and Chronic Bronchitis

	Correlation of LDL-C with other parameters in normal adult male healthy controls and patients with hypertension and chronic bronchitis					
	NC		HTN		CB	
Parameters	R^2	P	R^2	p	R^2	p
Age	0.003	0.558	0.002	0.641	0.000	0.824
Hb	0.007	0.351	0.016	0.158	0.005	0.421
FBG	0.005	0.158	0.027	0.064	0.012	0.216
Hp	0.000	0.976	0.001	0.730	0.001	0.715
cfDNA	0.00	0.93	0.80	<0.001	0.00	0.76

Table 3: Correlation of cfDNA with Other Parameters in Normal Adult Male Healthy Controls and Patients with Hypertension and Chronic Bronchitis

	Correlation of cfDNA with other parameters in normal adult male healthy controls and patients with hypertension and chronic bronchitis					
	NC		HTN		CB	
Parameters	R^2	p	R^2	p	R^2	p
Age	0.000	0.990	0.002	0.613	0.001	0.692
Hb	0.000	0.912	0.007	0.332	0.001	0.793
FBG	0.001	0.768	0.017	0.137	0.004	0.501
Hp	0.021	0.098	0.001	0.687	0.017	0.134
LDL-C	0.00	0.93	0.80	<0.001	0.00	0.76

Serum cfDNA of CB, HTN and NC groups was plotted against age, BBT, Hb, FBG and Hp that showed non-significant correlation. The cfDNA against LDL-C for HTN group of patients presented significant positive linear correlation ($p<0.001$; Table 3).

DISCUSSION

Both groups of male adult patients (HTN and CB) compared with a group of normal healthy adult male participants in the present study had same range of age and Body Mass Index (BMI). The LDL-C and cfDNA in patients with CB compared with NC did not present any significant variation ($p>0.05$). The HTN group of patients showed significant variation for LDL-C levels compared to NC levels (<0.001) and cfDNA levels compared to NC levels (<0.001). Furthermore, the LDL-C levels plotted against cfDNA levels for HTN group of patients presented significant positive linear correlation ($p<0.001$). Plot of LDL-C levels against cfDNA levels in CB group and association of all other variables with LDL-c as well as cfDNA in both groups (HTN and CB) of patients showed non-significant correlations.

Our findings mentioned in the above paragraph can be explained with the following reports. It is known that HTN develops inflammation and vice versa and it has been noticed that inflammatory/oxidative stressful conditions are linked to HTN,[8] though the clinical/preclinical studies explain that O_2 generation/systemic oxidative stress are present before the development of significant elevated BP that converts prehypertension (Pre-HTN) to HTN [9]. It was found that elderly people have more incidence of arterial stiffness (AS), HTN and other CVDs involving inflammation [10].

The vascular disorders that relate to endothelial dysfunction [11] have a strong relatedness with inflammatory/oxidative conditions and HTN [12]. Furthermore, in view of the imbalance between vasoconstrictor and vasodilatory activities, the AS occurs that leads to elevation of BP owing to elevated vascular resistance.[13] Nitric oxide increases vasodilation but with the increase in age toward old age and increase in BP, endothelial vasoactive substances are released causing vasodilation of vessels [12,13]. The HTN incidence increases with age [14]. However, the present study was not conducted for age-wise variations and associations. The HTN was higher in men till age 45 years than in women [14] and have similar incidence rate after 46 till 64 and females have more incidence rate than men after 65 [15]. These changes are primarily due to sex hormones, chromosomal features and other sex differences providing protective actions in females [16]. But since the present study was conducted only in adult men, it cannot be compared and explained for gender differences.

The HTN may develop due to a variety of factors including cholesterol [17] and especially the LDL-C [18-20]. Several reports [18-20] provide evidence for the impact of the findings in the current study. The LDL-C concentration and risk of CVDs have an association [21]. Higher concentrations of LDL-C [22-24] and cfDNA in HTN were obtained [25-28]. Elevated blood LDL-C levels besides alterations in other lipid profile variables were revealed in patients with HTN than healthy NC [29].

There are studies showing no significant alteration of LDL-C rather remnant cholesterol in middle aged and elderly patients with HTN [30,31] and no significant change in cfDNA in HTN [26]. It is possible that the HTN patients in the mentioned studies were having mild and varying forms of symptoms and were having other comorbidities that might had influenced the levels of LDL-C and cfDNA.

A number of blood markers are considered important in CB. Some of them are, C-reactive protein (CRP), abnormal high number of red blood cells (RBCs) (polycythemia), high neutrophils, hypoxemia and respiratory acidosis related to arterial blood gas (ABG) and alpha-1 antitrypsin that helps checking the genetic disorder causing emphysema [32]. There are reports that indicate the impact of LDL-C [33] and cfDNA [34] in CB.

Clinical and meta-analyses studies in CB show non-significant differences and associations for LDL-C while comparing with controls [33,35,36] and non-significant difference of cfDNA in CB patients compared to normal healthy controls [37-39]. These studies provide excellent information for interpreting the presently obtained results in patients with HTN and CB.

CONCLUSIONS

The present report provides the information of the significant impact of increased levels and positive linear correlation of serum LDL-C and cfDNA in adult patients with HTN, involving the risk factors, especially the inflammatory conditions. Increase in BP may increase LDL-C and cfDNA and vice versa via tissue damage and inflammation.

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Ethical Considerations

The present study was conducted following the ethical considerations of the WMA Declaration of Helsinki and accepted/approved by Ethical Committee, College of Medicine, Umm Al-Qura University, Makkah, Saudi Arabia; Approval Number: "HAPO-02-K-012-2022-01-1085." Furthermore, written consent was taken from each of the participants.

REFERENCES

[1] Tanase, D.M. *et al.* "Arterial Hypertension and Interleukins: Potential Therapeutic Target or Future Diagnostic Marker?" *International Journal of Hypertension*, 2019. https://doi.org/10.1155/2019/3159283.

[2] Widysanto, A. *et al.* "Chronic Bronchitis." *StatPearls*, StatPearls Publishing, January 2026. Updated February 6, 2025. https://www.ncbi.nlm.nih.gov/books/NBK482437/.

[3] Yang, Y. *et al.* "Dietary Sodium, Potassium Intake, Sodium-to-Potassium Ratio and Risk of Hypertension: A Protocol for Systematic Review and Dose-Response Meta-Analysis of Cohort Studies." *BMJ Open*, vol. 13, no. 2, 2023. https://doi.org/10.1136/bmjopen-2022-065470.

[4] Al Zomia, A.S. *et al.* "Blood Parameter Profiles and Their Clinical Implications in Hypertensive Patients: A Retrospective Chart Review." *Cureus*, vol. 15, no. 8, 2023. https://doi.org/10.7759/cureus.43691.

[5] Elwenspoek, M.M.C. *et al.* "Evidence-Based Blood Tests for Monitoring Adults with Hypertension in Primary Care: Rapid Review, Routine Data Analyses and Consensus Study." *British Journal of General Practice*, vol. 76, no. 769, 2026, pp. 663-672. https://doi.org/10.3399/BJGP.2025.0209.

[6] Del Rey Fernández, A.J. *et al.* "Primary Aldosteronism in Resistant Hypertension Unmasked by a Thiazide-Induced Severe Hypokalaemia." *Anales del Sistema Sanitario de Navarra*, vol. 49, no. 2, 2026. https://doi.org/10.23938/ASSN.1174.

[7] Kanchustambham, V. and B.D. Brown. "Chronic Obstructive Pulmonary Disease (COPD)." *StatPearls*, StatPearls Publishing, January 2026. Updated April 15, 2026, https://www.ncbi.nlm.nih.gov/books/NBK559281/.

[8] Bautista, L.E. *et al.* "Association between C-Reactive Protein and Hypertension in Healthy Middle-Aged Men and Women." *Coronary Artery Disease*, vol. 15, no. 6, 2004, pp. 331-336. https://doi.org/10.1097/00019501-200409000-00006.

[9] Nabha, L. *et al.* "Vascular Oxidative Stress Precedes High Blood Pressure in Spontaneously Hypertensive Rats." *Clinical and Experimental Hypertension*, vol. 27, no. 1, 2005, pp. 71-82. https://doi.org/10.1081/CEH-200044267.

[10] Rosano, C. *et al.* "Aortic Pulse Wave Velocity Predicts Focal White Matter Hyperintensities in a Biracial Cohort of Older Adults." *Hypertension*, vol. 61, no. 1, 2013, pp. 160-165. https://doi.org/10.1161/HYPERTENSIONAHA.112.198069.

[11] Rodríguez-Mañas, L. *et al.* "Endothelial Dysfunction in Aged Humans Is Related with Oxidative Stress and Vascular Inflammation." *Aging Cell*, vol. 8, no. 3, 2009, pp. 226-238. https://doi.org/10.1111/j.1474-9726.2009.00466.x.

[12] Rubio-Ruiz, M.E. *et al.* "Aging in Blood Vessels. Medicinal Agents for Systemic Arterial Hypertension in the Elderly." *Ageing Research Reviews*, vol. 18, 2014, pp. 132-147. https://doi.org/10.1016/j.arr.2014.10.001.

[13] Chrissobolis, S. *et al.* "Oxidative Stress and Endothelial Dysfunction in Cerebrovascular Disease." *Frontiers in Bioscience (Landmark Edition)*, vol. 16, no. 5, 2011, pp. 1733-1745. https://doi.org/10.2741/3816.

[14] Wang, Z. *et al.* "Status of Hypertension in China: Results from the China Hypertension Survey, 2012-2015." *Circulation*, vol. 137, no. 22, 2018, pp. 2344-2356. https://doi.org/10.1161/CIRCULATIONAHA.117.032380.

[15] Ramirez, L.A. and J.C. Sullivan. "Sex Differences in Hypertension: Where We Have Been and Where We Are Going." *American Journal of Hypertension*, vol. 31, no. 12, 2018, pp. 1247-1254. https://doi.org/10.1093/ajh/hpy148.

[16] Everett, B. and A. Zajacova. "Gender Differences in Hypertension and Hypertension Awareness among Young Adults." *Biodemography and Social Biology*, vol. 61, no. 1, 2015, pp. 1-17. https://doi.org/10.1080/19485565.2014.929488.

[17] Ding, D. *et al.* "Cholesterol Profiles and Incident Cognitive Decline among Older Adults: The Shanghai Aging Study." *Age and Ageing*, vol. 50, no. 2, 2021, pp. 472-479. https://doi.org/10.1093/ageing/afaa140.

[18] Nasri, H. and M. Yazdani. "The Relationship between Serum LDL-Cholesterol, HDL-Cholesterol and Systolic Blood Pressure in Patients with Type 2 Diabetes." *Kardiologia Polska*, vol. 64, no. 12, 2006, pp. 1364-1371.

[19] Chiu, S. *et al.* "Comparison of the DASH (Dietary Approaches to Stop Hypertension) Diet and a Higher-Fat DASH Diet on Blood Pressure and Lipids and Lipoproteins: A Randomized Controlled Trial." *The American Journal of Clinical Nutrition*, vol. 103, no. 2, 2016, pp. 341-347. https://doi.org/10.3945/ajcn.115.123281.

[20] Nguyen, L.S. *et al.* "Relation between Baseline LDL-Cholesterol and Cardiovascular Outcomes in High Cardiovascular Risk Hypertensive Patients: A Post-Hoc SPRINT Data Analysis." *International Journal of Cardiology*, vol. 286, 2019, pp. 159-161. https://doi.org/10.1016/j.ijcard.2019.01.048.

[21] Karthikeyan, G. *et al.* "Lipid Profile, Plasma Apolipoproteins and Risk of a First Myocardial Infarction among Asians: An Analysis from the INTERHEART Study." *Journal of the American College of Cardiology*, vol. 53, no. 3, 2009, pp. 244-253. https://doi.org/10.1016/j.jacc.2008.09.041.

[22] Choudhury, K.N. *et al.* "Serum Lipid Profile and Its Association with Hypertension in Bangladesh." *Vascular Health and Risk Management*, vol. 10, 2014, pp. 327-332. https://doi.org/10.2147/VHRM.S61019.

[23] Wu, H. *et al.* "Characteristics of Serum Lipid Levels in Patients with Hypertension: A Hospital-Based Retrospective Descriptive Study." *BMJ Open*, vol. 12, no. 6, 2022. https://doi.org/10.1136/bmjopen-2021-054682.

[24] Zhang, Z. *et al.* "The Relationship between Cholesterol, High-Density Lipoprotein and Glucose Index and Hypertension: A Study Based on Two National Cohorts." *Science Progress*, vol. 108, no. 4, 2025. https://doi.org/10.1177/00368504251396781.

[25] Jeong, D.W. *et al.* "Effect of Blood Pressure and Glycemic Control on the Plasma Cell-Free DNA in Hemodialysis Patients." *Kidney Research and Clinical Practice*, vol. 34, no. 4, 2015, pp. 201-206. https://doi.org/10.1016/j.krcp.2015.09.002.

[26] Polina, I.A. *et al.* "Cell-Free DNA as a Diagnostic and Prognostic Marker for Cardiovascular Diseases." *Clinica Chimica Acta*, vol. 503, 2020, pp. 145-150. https://doi.org/10.1016/j.cca.2020.01.013.

[27] Amaral, L.M. *et al.* "Circulating Total Cell-Free DNA Levels Are Increased in Hypertensive Disorders of Pregnancy and Associated with Prohypertensive Factors and Adverse Clinical Outcomes." *International Journal of Molecular Sciences*, vol. 22, no. 2, 2021. https://doi.org/10.3390/ijms22020564.

[28] Charkiewicz, A.E. "A Proposal for Research Involving New Biomarkers of Hypertension, Lifestyle and Environmental Exposure." *Current Issues in Molecular Biology*, vol. 47, no. 3, 2025. https://doi.org/10.3390/cimb47030206.

[29] Islam, A.K. and A.A. Majumder. "Hypertension in Bangladesh: A Review." *Indian Heart Journal*, vol. 64, no. 3, 2012, pp. 319-323. https://doi.org/10.1016/S0019-4832(12)60096-0.

[30] Chruściel, P. *et al.* "Associations between the Lipid Profile and the Development of Hypertension in Young Individuals-The Preliminary Study." *Archives of Medical Science*, vol. 18, no. 1, 2022, pp. 25-35. https://doi.org/10.5114/aoms.2019.86197.

[31] Esmaeili, B. *et al.* "Remnant Cholesterol, Not LDL Cholesterol, Is Associated with the Risk of Hypertension in the Middle-Aged and Elderly Population: Bushehr Elderly Health Cohort." *Frontiers in Cardiovascular Medicine*, vol. 12, 2025. https://doi.org/10.3389/fcvm.2025.1483778.

[32] Mendy, A. *et al.* "Blood Biomarkers as Predictors of Long-Term Mortality in COPD." *The Clinical Respiratory Journal*, vol. 12, no. 5, 2018, pp. 1891-1899. https://doi.org/10.1111/crj.12752.

[33] Yoo, J. *et al.* "Associations of LDL and HDL Cholesterol with Lung Function Decline and Risk of Airflow Obstruction in a Community-Based Cohort." *Scientific Reports*, vol. 16, no. 1, 2026. https://doi.org/10.1038/s41598-025-31387-2.

[34] Ware, S.A. *et al.* "Cell-Free DNA Levels Associate with COPD Exacerbations and Mortality." *Respiratory Research*, vol. 25, no. 1, 2024. https://doi.org/10.1186/s12931-023-02658-1.

[35] Zafirova-Ivanovska, B. *et al.* "The Level of Cholesterol in COPD Patients with Severe and Very Severe Stage of the Disease." *Open Access Macedonian Journal of Medical Sciences*, vol. 4, no. 2, 2016, pp. 277-282. https://doi.org/10.3889/oamjms.2016.063.

[36] Xuan, L. *et al.* "Association between Chronic Obstructive Pulmonary Disease and Serum Lipid Levels: A Meta-Analysis." *Lipids in Health and Disease*, vol. 17, no. 1, 2018. https://doi.org/10.1186/s12944-018-0904-4.

[37] Szpechcinski, A. *et al.* "Cell-Free DNA Levels in Plasma of Patients with Non-Small-Cell Lung Cancer and Inflammatory Lung Disease." *British Journal of Cancer*, vol. 113, no. 3, 2015, pp. 476-483. https://doi.org/10.1038/bjc.2015.225.

[38] Cha, S. *et al.* "Integration of Circulating Tumor DNA Data Enhances Lung Cancer Prediction in Patients with COPD." *Scientific Reports*, vol. 16, no. 1, 2026. https://doi.org/10.1038/s41598-026-41720-y.

[39] Garcia-Diaz, A. *et al.* "EPIMETRIC: A cfDNA Methylation-Based Algorithm for COPD Diagnosis and Stratification." *Archivos de Bronconeumología*, vol. 62, no. 9, 2026, pp. 635-643. https://doi.org/10.1016/j.arbres.2026.03.016.