Review Article

A Brief Review of Hyper Lipidaemia Disease

Shivanjali S.Lakhapate[1*], Omkar A.Devade[2], Vivek Kumar K.Redasani[3]
[1.]Research Scholar, Department of Pharmacology, YSPM's Yashoda Technical Campus Satara 415011, Maharashtra, India.
2.Department of Pharmacology YSPM's Yashoda Technical Campus Satara 415011, Maharashtra, India.
3.Director and Principal YSPM's Yashoda Technical Campus Satara 415011, Maharashtra, India.
***Corresponding author's E-mail:** shivanjalilmpharm@gmail.com

Received: 20-03-2025; **Revised:** 18-06-2025; **Accepted:** 25-06-2025; **Published online:** 15-07-2025.

ABSTRACT

Hyperlipidaemia is a significant global health concern characterized by elevated plasma lipid levels, including cholesterol, triglycerides, and lipoproteins. It is a major risk factor for cardiovascular diseases such as ischemic heart disease and stroke, contributing to substantial morbidity and mortality worldwide. This comprehensive review highlights the pathogenesis, pathophysiology, classification, risk factors, diagnostic methods, and treatment strategies for hyperlipidaemia. It explores both pharmacological treatments, including statins, fibrates, and PCSK9 inhibitors, and non-pharmacological approaches like dietary modifications, exercise, and herbal remedies. Additionally, the role of specific herbs, including *Colocasia esculenta*, *Tridax procumbens*, *Moringa oleifera*, and others, is discussed for their potential antihyperlipidemic effects. The review underscores the importance of integrative management strategies combining lifestyle changes, conventional therapies, and herbal interventions to effectively address hyperlipidemia and its associated risks.

Keywords: WHO report, Pathophysiology, Types, Risk factor, Diagnosis, Herbs, Treatment.

INTRODUCTION

World health organization report that rate of dyslipidaemia in western pacific (36.7%) and Southeast Asia (30.3%) are significantly lower than observed in Americas (47.7%) and Europe (53.7).[1]

Elevated cholesterol raises the risk of stroke and heart disease. High cholesterol is the cause of one-third of ischemic heart disease worldwide. Raised cholesterol is thought to be responsible for 29.7 million DALYS, or 2% of all DALYS, and 2.6 million fatalities, or 4.5% of all deaths. As a risk factor for ischemic heart disease and stroke, elevated total cholesterol is a significant contributor to the disease burden in both the developed and developing worlds. In 2008, 39% of adults worldwide had elevated total cholesterol (37% of men and 40% of women[2.] One of the major risk factors for the development of cardiovascular diseases like CHD is hyperlipidaemia[3,4,5.]

In 2019, elevated plasma LDL cholesterol levels were associated with an estimated 4.40 million deaths (95% CI: 3.30–5.65 million) and 98.62 million disability-adjusted life years (DALYs), which reflect years lost due to health issues, disabilities, or early death and measure the overall impact of disease. The incidence was found to be higher in men than in women. In Central Europe, the ASDR for ischemic stroke dropped from 24.81 to 14.14 within the same time period, while the ASDR for IHD fell from 143.38 per 100,000 in 1990 to 71.86 in 2019.Slovenia had the lowest ASDR for IHD in Central Europe (27.53), whereas Bulgaria had the highest (108.81). less than 35% of Americans reach the suggested objective levels [6,7.]

Hyperlipidaemia refers to an elevation in one or more types of plasma lipids, which encompass triglycerides, cholesterol, cholesterol esters, and phospholipids, as well as plasma lipoproteins such as very low-density lipoprotein and low-density lipoprotein, accompanied by a decrease in high-density lipoprotein levels[8,9.]

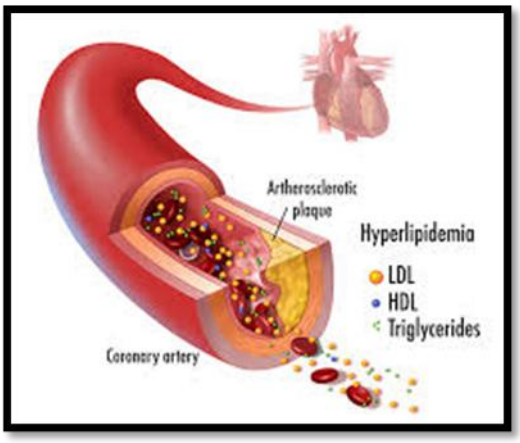

Figure 1: Formation of cholesterol

Generally, hyperlipidemia classified into two distinct subclasses.

1. Elevated cholesterol levels (hypercholesterolemia)
2. Increased triglyceride levels (hypertriglyceridemia)

Pathogenesis of Hyperlipidaemia-

Genetic and environmental factors play a significant role in lipid metabolism. Familial combined hyperlipidemia (FCHL) serves as an important genetic indicator of lipid abnormalities. Individuals with FCHL frequently exhibit more pronounced lipid profile irregularities, characterized by heightened levels of cholesterol and triglycerides. The use of cyclosporine, a widely utilized immunosuppressant,

has been found to intensify these lipid disturbances, particularly among those with pre-existing FCHL. This medication is known to independently elevate LDL cholesterol and triglycerides while reducing HDL cholesterol levels. Although environmental influences such as dietary habits, obesity, and renal graft function are relevant, their effects are generally less significant than those of genetic factors and immunosuppressive treatments. Additionally, other drugs, including beta-blockers, may further deteriorate lipid profiles, and the functional status of the graft can also affect lipid levels. Notably, existing lipid abnormalities prior to transplantation are strong indicators of post-transplant dyslipidemia, highlighting the complex interaction between pre-existing health conditions and therapeutic interventions[10].

Pathophysiology of Hyperlipidaemia-

Triglycerides, phospholipids, and fat-soluble vitamins are also carried in smaller amounts by LDL and HDL, the main lipoprotein transporters of endogenous cholesterol esters. Apolipoproteins, which bind to receptors and act as cofactors for enzymes, are found in the outer layer of lipoproteins and provide lipoproteins their structural foundation. ApoB-100 belongs to the LDL apolipoprotein class, while ApoA-I, ApoA-II, ApoA-IV, ApoA-V, ApoC-III, and ApoE belong to the HDL apolipoprotein class. The dietary and hepatic lipids are transported by lipoproteins to the tissues that need fatty acid storage or energy across the body. HDL, for instance, is responsible for carrying cholesterol from peripheral cells to the gut and liver. HDL uses scavenger receptor class B1 to carry peripheral cholesterol to the liver, where it converts cholesterol esters with TG. Cholesteryl ester transport protein to LDL cells. Hepatic LDL receptor-mediated endocytosis can then remove the cholesterol esters that were transferred to the LDL particles from the bloodstream. After then, the cholesterol may hydrolyze and be eliminated as bile[11]. An inflammatory reaction is triggered when low-density lipoprotein (LDL) particles make their way through the endothelium, the weakened blood vessel walls. Both the LDL levels in the bloodstream and the endothelium's state affect how much LDL can penetrate these walls. The transcription component In order to protect blood arteries, KLF2 reduces inflammation and the possibility that LDL particles will remain in the endothelium lining, which lowers the risk of atherosclerosis. KLF2 expression has been demonstrated to increase with statin therapy, offering further protective advantages[12]. When LDL particles penetrate the endothelium, they may change through processes like glycosylation or oxidation, which intensifies their negative effects and makes it easier for them to build up in the vessel walls[13,14]. This altered LDL draws monocytes, which develop into cholesterol-storing foam cells. This causes inflammation and oxidative stress, which in turn encourages the development of plaque in the arteries. Smooth muscle cells and foam cells work together to form plaque, which narrows arteries and raises the risk of heart attacks and strokes[15].

Classifications of lipoproteins

Chylomicrons (CM),

Very Low-Density Lipoproteins (VLDL),

Low-Density Lipoproteins (LDL),

Intermediate-Density Lipoproteins (IDL),

High-Density Lipoproteins (HDL)[16].

Chylomicrons (cm)

These are The largest particles increased in both their size and density, having a concentration that is directly related to the content of dietary triglycerides.

VLDL

It is called as very low density lipoprotein they are smaller particles that transport more chylomicrons than triglycerides and are produced by the liver. VLDL is carries sterols taken from the liver to various organs and tissues throughout the body. These lipoproteins are composed of a combination of cholesterol and triglycerides[17].

IDL

the action of the lipase enzyme in the capillaries of adipose tissue and muscle, VLDL particles are broken down, resulting in the formation of intermediate density lipoprotein[18].

LDL

As stated by Lee et al. and Galeano et al., low-density lipoproteins are produced in part from intestinal chyle and in part through the lipolysis of very low-density lipoproteins (VLDL). This process is directly associated with coronary heart disease[19].

HDL

High-density lipoprotein (HDL) is called as "good cholesterol." It is produced in the liver and functions to transport cholesterol and various lipids from the tissues back to the liver for breakdown. HDL is called as an antiatherogenic effect[20].

Lipoprotein function

Plasma lipoproteins are important for lipid solubilization in order to transport triglycerides, an Important energy source, which synthesized and absorbed to places of utilization and storage; and to transport cholesterol between different places of absorption, synthesis, catabolism, and elimination[21].

Enzyme involved in lipoprotein metabolism

Lipoprotein lipase

LPL is a versatile enzyme found in endothelial cells of the heart, muscle, adipose tissue, macrophages, and lactating mammary glands. It is essential for the hydrolysis of triglycerides (TG) into two free fatty acids and monoacylglycerol. Additionally, LPL facilitates the receptor-

mediated uptake of lipoproteins, including chylomicron remnants, cholesterol-rich lipoproteins, and free fatty acids[22,23.]

Hepatic lipase (HL)

is a versatile protein that plays a crucial role in the regulation of lipoprotein metabolism. It is produced by hepatocytes and is also present in the adrenal glands and ovaries. HL is responsible for the hydrolysis of phospholipids and triglycerides within plasma lipoproteins. Furthermore, HL influences the delivery of lipids to cells by enhancing the absorption of lipoproteins through cell surface receptors and proteoglycans [24.]

Lecithin cholesterol acyltransferase

Lecithin cholesterol acyltransferase (LCAT) is an essential enzyme involved in HDL metabolism. It facilitates the conversion of free cholesterol into cholesteryl esters, which are subsequently incorporated into the core of lipoproteins, ultimately leading to the formation of mature HDL[25.]

Cholesteryl ester transfer protein (CETP)

Cholesteryl ester transfer protein (CETP), also referred to as plasma lipid transfer protein, is a hydrophobic glycoprotein present in plasma. Its primary function is to promote the transfer of esterified cholesterol esters (CE) from high-density lipoproteins (HDLs) to chylomicrons, VLDL, and LDL, while simultaneously exchanging triglycerides. Individuals with CETP deficiency tend to exhibit higher HDL levels and lower LDL levels[26.]

Microsomal triglyceride protein (MTP)

Microsomal triglyceride protein (MTP functions as a vital lipid transfer protein that catalyzes the transfer of neutral lipids, including triglycerides and cholesterol esters, between the membranes of microsomes isolated from the liver and intestinal mucosa. This protein is indispensable for the assembly of lipoproteins containing apolipoprotein B. Additionally, it has been recognized that MTP plays a significant role in the biosynthesis of glycolipid-presenting molecules and the regulation of cholesterol ester biosynthesis[27.]

Acyl CoA transferase (ACAT)

Acyl CoA transferase (ACAT is a protein located in cellular membranes that catalyzes the conversion of long-chain fatty acyl-CoA and cholesterol into cholesteryl esters. It plays a critical role in regulating cholesterol levels within various tissues, thereby preventing the detrimental accumulation of excess cholesterol in cells. Moreover, ACAT is significant for the formation and release of lipoproteins that contain apolipoprotein-B, particularly in the liver and intestine[28.]

Classification of hyperlipidemia

Hyperlipidemias are categorized according to the Fredrickson classification, which is based on the distribution of lipoproteins. This classification was subsequently endorsed by the World Health Organization (WHO).

Table 1: Classification of hyperlipidemia[29,30.]

Sr.no	Types	Synonyms	Occurrence	Causing agent	Type of lipoprotein increase
1	Type I	Primary hyperlipoproteinemia or Familial hyperchylomicronemia	Very rare	Decreased lipoprotein lipase (LPL)	Chylomicrons
2	Type IIa	Polygenic hypercholesterolaemia or Familial hypercholesterolemia	Less common	LDL receptor deficiency	LDL
3	Type IIb	Familial combined hyperlipidemia	Commonest	Decreased LDL receptor	LDL and VLDL
4	Type III	Familial dysbetalipoproteinemia	Rare	Defect in Apo E 2 synthesis	IDL
5	Type IV	Familial hyperlipidemia	Common	Increased VLDL production and Decreased elimination	VLDL
6	Type V	Endogenous hypertriglyceridemia	Less common	Increased VLDL production and Decreased LPL	VLDL and Chylomicrons

Generally, Hyperlipidaemia classified into two types

Primary

Secondary

Primary Hyperlipidaemia

Primary hyperlipidemia, often referred to as familial hyperlipidemia, arises from a genetic defect. This condition can be classified as monogenic, involving a single gene mutation, or polygenic, involving multiple gene mutations. Typically, primary hyperlipidemia can be categorized into distinct abnormal lipoprotein patterns.

Type I–Raised cholesterol with high triglyceride levels.

Type II–High cholesterol with normal triglyceride levels.

Type III–Raised cholesterol and triglycerides.

Type IV–Raised triglycerides, atheroma and uric acid.

Type V–Raised triglycerides[31,32.]

Secondary hyperlipidemia

Acquired hyperlipidemia, known as secondary hyperlipidemia, is caused by various disorders such as diabetes, glomerular syndrome, chronic alcohol consumption, hypothyroidism, and the use of certain medications like corticosteroids, beta blockers, and oral contraceptives. When combined with high levels of triglycerides, secondary hyperlipidemia can lead to pancreatitis[33.]

Risk factors

Genetic mutation whether single or multiple , lead to the overproduction and inadequate clearance of cholesterol ,triglyceride(TG), low density lipoprotein (LDL) these are classified as non-modified risk factor, also referred as as primary causes primary disorder are prevalent contributors to dyslipidemia in children, although they may not significant impact most cases dyslipidemia in adults[34,35.]

There are two types of risk factors:

Non modified risk factor

modified risk factor

Non modified risk factors

Age, gender and genetics

Unhealthy lifestyle choices are primary contributors to hyperlipidaemia but genetic factor also play role in its development The risk of hyperlipidaemia increases for men after the ages of 45 and for women after 55 due to physiological changes are associated with aging[36,37,38.] As individual age, the efficiency of heart muscle decline which can lead to increase arterial pressure[39.] Women experience rise in cholesterol level following menopause resulting in higher total cholesterol, LDL-C and apolipoprotein B level compared to their premenopausal state while total HDL level decreases Although genetic and predisposition are beyond individual control effective management of hyperlipidemia is still possible through lifestyle modification and medical intervention[40.]

Chronic diseases

Chronic disease that place additional strain on the cardiovascular system can lead to elevated cholesterol level If cholesterol level indicate high level then the cause is unclear a physician may investigate potential underlying condition Possible underlying condition include kidney disorder, liver disease, thyroid dysfunction, pituitary gland abnormalities and diabetes In many instances managing these underlying condition can result in improved cholesterol level Elevated blood sugar level are associated with increase LDL cholesterol and decreased HDL cholesterol High blood sugar level can cause damage to the arterial lining Certain liver disease including cholestatic liver disease and primary biliary cirrhosis heighten the risk of dyslipidemia.

Monitoring and controlling blood sugar level is crucial for maintaining healthy cholesterol level[41,42,43.]

Modified risk factor

Medication-

medication like thiazides, retinoids, estrogen, glucocorticoids they increase and elevate the lipid level so that it causes to the dyslipidemia[44.]

Nutrition

An unhealthy diet increases like wood of hyperlipidemia through two mechanism the composition of diet play significant role , high intake of fat and cholesterol elevate blood lipid level additionally excessive calorie consumption result in surplus calorie being converted and stored as body fat the national cholesterol education programme (NECP)emphasis that weight loss and nutritious diet can reduce level of harmful cholesterol stored in the body managing dietary fiber is crucial for maintain optimal lipid level reducing fat and cholesterol intake is essential for lowering the risk for hyperlipidemia monitoring calorie intake can help prevent the accumulation of excess body fat adopting balanced diet contributes for overall cardiovascular disease lifestyle changes including diet and weight management are vital for improved cholesterol level[45,46,47.]

Physical Activity

Engaging regular physical activity is associated with reduction in bad cholesterol level and increased in good cholesterol level Lack of physical activity contributes weight gain that is why recognized as risk factor for hyperlipidemia Smoking has detrimental effect on blood vessel wall increasing like wood of fatty deposit accumulation So smoking may decreases the level of high density lipoprotein (HDL) cholestero.[48,49.]

Sign and symptoms of hyperlipidemia

Hyperlipidaemia typically exhibiting no symptoms, hyperlipidemia is identified during a routine assessment for atherosclerotic cardiovascular disease illness Possible symptoms include angina (chest discomfort), a heart attack, or a stroke. Extremely high cholesterol levels might cause deposits in tendons or under the skin around eyes[50.]The pancreas, spleen and liver are among the organ that may enlarge blockage of blood vessel in the heart and brain glucose intolerance and obesity are more prevalent the body is covered in pimple like lesion [51.]

Diagnosis examination

Hyperlipidaemia lack specific symptoms and it is Soley identified through blood testing the lipid profile test is utilized for screening this condition, diagnosis typically occur regular health checkups by measuring LDL, HDL, VLDL, and triglyceride levels in the blood[52,53.]

Treatment of hyperlipidemia

Pharmacological therapies are frequently necessary, particularly for patients with a higher risk of ASCVD who have consistent appointment-inspired lifestyle changes. Ezetimibe and statins are the most often prescribed medications for hyperlipidemia. The use of bile acid sequestrants (BAS) is less common. For the best lipid control, PCSK9 inhibitors are frequently used either alone or in conjunction with statins. In addition to PCSK9 inhibitors, new treatments include monoclonal antibodies against angiopoietin-like 3 (ANGPTL3) and apolipoprotein(a) [apo(a)], as well as antisense oligonucleotides that target the manufacture of apolipoprotein B (apoB[54].

Pharmacological treatment of hyperlipidemia[-55-62.]

Table 2: Pharmacological treatment of hyperlipidemia Nonpharmacological treatment for hyperlipidemia

Class	Drug	MOA	Effect
Statins	Atorvastatin, Simvastatin, Rosuvastatin	inhibiting the enzyme HMG-3-CoA, reductase	block the endogenic cholesterol pathway resulting in lower LDL cholesterol serum level
Fibrates	Fenofibrate, Gemifibrozil	activating a nuclear receptor, PPAR-alpha	enhance expression and activity of lipoprotein lipase (LPL), an enzyme that hydrolyzes triglycerides in VLDL and chylomicrons. These medications also reduce the expression of ApoC-III, an inhibitor of LPL; this further promotes the catabolism of triglyceride-rich particles
Bile acid sequestrant	Cholestyramine,	Bind bile acid in gut decreasing cholesterol absorption	Regulate LDL receptor activity
PCSK9 inhibitor	Alirocumab, evolocumab	PCSK9 complex	Hepatocytes produce the protein PCSK9, which attaches to LDL receptors on the surface of liver cells, encouraging their breakdown and decreasing the liver's capacity to eliminate LDLC from the blood.
Sterol absorption inhibitor	Ezetimibe	Inhibit Niemann- Pick C1like 1 (NPC1L1)	Inhibit reabsorption of cholesterol
Niacin	Niacin, nicotinic acid	Reduction in hepatic TG synthesis	Decrease secretion of VLDL and HDL

In order to effectively control hyperlipidemia, lifestyle modifications are essential. Moderate hyperlipidemia can be effectively managed by limiting saturated fat intake and getting regular aerobic exercise, which will significantly improve the lipid profile

Dietary modification

Relying solely on diet may not sufficiently normalize plasma cholesterol levels, as only 15%-20% of blood cholesterol is derived from dietary sources, Nonetheless, dietary changes can complement medical treatments and potentially lower medication dosages. - Patients with hypertriglyceridemia benefit significantly from dietary interventions, which should include lifestyle changes such as weight management and dietary adjustments to effectively address mild to moderate cases. - Effective dietary strategies for managing hyperlipidemia involve reducing overall food intake, limiting saturated fats and cholesterol, opting for lean protein sources, and incorporating beneficial foods like plant sterols and soluble fiber, while also recommending the elimination of alcohol for those with hypertriglyceridemia[63.]

Exercise

Engaging in moderate-intensity physical activity for 30 to 60 minutes, three to five times a week, supports weight control, enhances insulin sensitivity, facilitates the breakdown of triglycerides, and improves lipid profiles. For those with low levels of HDL cholesterol, implementing lifestyle changes such as consistent exercise, maintaining a healthy weight, ceasing tobacco use, and adhering to a balanced diet plays a crucial role in lowering the risk of atherosclerotic cardiovascular disease (ASCVD) and elevating HDL cholesterol levels.

It is also vital to manage additional ASCVD risk factors, including hypertension, smoking, and elevated blood glucose levels, to promote overall cardiovascular health[64.]

Herbal treatment for hyperlipidemia

In contemporary times, herbs are utilized for the treatment of various chronic and acute ailments, including cardiovascular diseases. Historically and presently, plants have served as a vital source of medicinal remedies. Various

methods allow for the consumption of herbs and plants in multiple forms, such as whole herbs, teas, syrups, essential oils, ointments, salves, rubs, capsules, and tablets containing ground or powdered raw herbs or their dried extracts, often resulting in fewer side effects compared to synthetic medications various plant includes

Taro

Scientific name- Colocasia esculenta Family- Araceae taro is also refereed as Alu in Marathi The corms of taro are rich in proteins, carbohydrates, Vitamins, minerals and considered to have some important values in daily human routine. Taro contains carbohydrate and about 11% protein more than potatoes, it also contains 85-87% starch and other nutrients like Vitamin C, thiamine, riboflavin and niacin the chemical constituent present in taro such as flavonoids and triterpenoids which are responsible for antihyperlipidemic activity[65].

Tridax procumbens

Tridax procumbens it is also called as dagadi pala in marathi Tridax procumbens Linn. Belong to (Asteraceae) family is a widely distributed herb found across India, and its extract has traditionally been utilized by rural communities for the treatment of cut wounds due to its anti-inflammatory effects. Research has demonstrated that T. procumbens possesses various beneficial properties, including anti-inflammatory, hepatoprotective, wound healing, antimicrobial, antiseptic, hypotensive, and immunomodulatory effects. The plant contain preliminary phytochemical such as alkaloid ,flavonoids ,triterpenoids which are responsible are antihyperlipidemic activity[66].

Moringa oleifera

Moringa oleifera family- Moringaceae This tropical deciduous tree, which is endemic to the southern Himalayas in northern India, is a perennial tree Moringa oleifera extracts offer a range of nutritional and medicinal advantages, including antioxidant, anti-inflammatory, neuroprotective, hypoglycemic, properties. The beneficial effects of Moringa oleifera are closely linked to its abundant phytochemical constituents, which encompass flavonoids, glucosinolates, isothiocyanates, and phenolic acids which show antihyperlipidemic activity[67].

Camellia sinesis

Camellia sinensis L. (CS) is a perennial shrub classified within the Theaceae family. This plant is cultivated on a commercial scale across numerous countries, with Georgia in the former Soviet Union marking its northernmost range and South Africa and Argentina representing its southernmost limits Camellia sinesis leaves contain various phytochemical constituent which are responsible for showing antihyperlipidemic activity[68].

(Hibiscus cannabinus

Hibiscus cannabinus family –Malvaceae This plant has been historically utilized in traditional folk medicine across Africa and India. It is noted for its composition of various active constituents, including tannins, saponins, polyphenolics, alkaloids, lignans, essential oils, and steroids. The flavonoids in this plant which are responsible for antihyperlipidemic activity[69].

Sesbania grandiflora

Sesbania grandiflora family - Fabaceae Sesbania grandiflora L. is popularly known as “Basna” is an ornamental plant and is found in plains of western Himalayas to Sri Lanka *Sesbania grandiflora* is a folk remedy for bruises, catarrh, dysentry, eyes, fevers, headaches, small pox, sores, sore throat and stomatitis flavonoids and anthocyanins, a heterogenous group of ubiquitous plant polyphenols, have exhibited a variety of pharmacological activities which show antihyperlipidemic activity[70].

Source of Support: The author(s) received no financial support for the research, authorship, and/or publication of this article

Conflict of Interest: The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

REFERENCES

1. Lin CF, et al. Epidemiology of dyslipidemia in the Asia Pacific region. Int J Gerontol. 2018;12(1):2–6. DOI: 10.1016/j.ijge.2018.02.010.
2. Stamler J, Wentworth D, Neaton JD. Is relationship between serum cholesterol and risk of premature death from coronary heart disease continuous and graded? JAMA. 1986;256(20):2823–8. DOI: N/A; PMID: 3773199.
3. Rose G, Shipley M. Plasma cholesterol concentration and death from coronary heart disease: 10-year results of the Whitehall Study. BMJ. 1986;293(6542):306–7. DOI: 10.1136/bmj.293.6542.306.
4. Gotto AM Jr. Risk factor modification: rationale for management of dyslipidemia. Am J Med. 1998;104(2A):6S–8S. DOI: 10.1016/s0002-9343(98)00039-4.
5. Castelli WP. Epidemiology of coronary heart disease: The Framingham study. Am J Med. 1984;76(2):4–12. DOI: 10.1016/0002-9343(84)90952-5.
6. Ramya KR, Batra K. Perception and knowledge of coronary heart disease among adolescents of Kerala. Asian J Nurs Educ Res. 2015;5(3):327. DOI: 10.5958/2349-2996.2015.00067.1.
7. Kaur S. A descriptive study to assess the prevalence of cardiovascular risk factors among adolescents in selected schools of Banga, District Shaheed Bhagat Singh Nagar, Punjab. Asian J Nurs Educ Res. 2016;6(3):361. DOI: 10.5958/2349-2996.2016.00068.9.
8. Kaczorowski J. SNPs and coronary heart disease. Lancet. 2011;377(9763):379. DOI: 10.1016/s0140-6736(11)60124-4.
9. Hypolipidemic activity of Pleurotus Florida against Triton WR 1339-induced hyperlipidemia. Lett Appl NanoBioSci. 2020;10(2):2107–16. DOI: 10.33263/lianbs102.21072116.
10. Aguilar-Salinas CA, Díaz-Polanco A, Quintana E, Macias N, Arellano A, Ramírez E, et al. Genetic factors play an important role in the pathogenesis of hyperlipidemia post-transplantation. Am J Kidney Dis. 2002;40(1):169–77. DOI: N/A; PMID: N/A.

11. Chou D. Harrison's Manual of Medicine, 15th edition. Clin Chem, 2004;50(10):1884-5. DOI: 10.1373/clinchem.2003.030197. PMID: N/A.
12. Endothelial cell dysfunction and the pathobiology of Atherosclerosis. Circ Res, 2025;N/A:N/A. DOI: N/A. PMID: N/A.
13. Libby P, et al. Atherosclerosis. Nature News, 2019;N/A:N/A. DOI: N/A. PMID: N/A.
14. Linton MF. The role of lipids and lipoproteins in atherosclerosis. Endotext [Internet], 2019;N/A:N/A. DOI: N/A. PMID: N/A.
15. Lu H, et al. Renin inhibition reduces hypercholesterolemia-induced atherosclerosis in mice. J Clin Invest, 2008;N/A:N/A. DOI: 10.1172/jci32970. PMID: N/A.
16. Reichen J. Signs and symptoms of liver disease. Textbook Hepatol, 2007;441-50:N/A. DOI: 10.1002/9780470691861.ch5a. PMID: N/A.
17. Global review article on hyperlipidemia. ResGate, 2025;N/A:N/A. DOI: N/A. PMID: N/A.
18. Sundaram M, Yao Z. Recent progress in understanding protein and lipid factors affecting hepatic VLDL assembly and secretion. Nutr Metab, 2010;7(1):35. DOI: 10.1186/1743-7075-7-35. PMID: N/A.
19. Tripathi K. Essentials of Medical Pharmacology. J Pharmacology, 2008;N/A:N/A. DOI: 10.5005/jp/books/10282. PMID: N/A.
20. Costet P. Molecular pathways and agents for lowering LDL-cholesterol in addition to statins. Pharmacol Ther, 2010;126(3):263-78. DOI: 10.1016/j.pharmthera.2010.02.006. PMID: N/A.
21. Ridker PM, et al. HDL cholesterol and residual risk of first cardiovascular events after treatment with potent statin therapy: An analysis from the Jupiter trial. Lancet, 2010;376(9738):333-9. DOI: 10.1016/s0140-6736(10)60713-1. PMID: N/A.
22. Wang H, Eckel RH. Lipoprotein lipase: From gene to obesity. Am J Physiol Endocrinol Metab, 2009;297(2):N/A. DOI: 10.1152/ajpendo.90920.2008. PMID: N/A.
23. Hepatic lipase, lipoprotein metabolism, and atherogenesis. Arterioscler Thromb Vasc Biol, 2025;N/A:N/A. DOI: N/A. PMID: N/A.
24. Gomes FG, et al. Tumor angiogenesis and lymphangiogenesis: Tumor/endothelial crosstalk and cellular/microenvironmental signaling mechanisms. Life Sci, 2013;92(2):101-7. DOI: 10.1016/j.lfs.2012.10.008. PMID: N/A.
25. Durrington P. Cholesteryl ester transfer protein (CETP) inhibitors. Br J Cardiol, 2012;19(3):N/A. DOI: 10.5837/bjc.2012.024. PMID: N/A.
26. Hussain MM, et al. Multiple functions of microsomal triglyceride transfer protein. Nutr Metab, 2012;9(1):14. DOI: 10.1186/1743-7075-9-14. PMID: N/A.
27. Oral EA, Burant C. Leptin and insulin resistance: Good, bad, or still unclear? Am J Physiol Endocrinol Metab, 2009;296(2):N/A. DOI: 10.1152/ajpendo.90914.2008. PMID: N/A.
28. Maeda Y, Kinoshita T. Structural remodeling, trafficking and functions of glycosylphosphatidylinositol-anchored proteins. Prog Lipid Res, 2011;50(4):411-24. DOI: 10.1016/j.plipres.2011.05.002. PMID: N/A.
29. Fredrickson DS. An international classification of hyperlipidemias and hyperlipoproteinemias. Ann Intern Med, 1971;75(3):471-2. DOI: 10.7326/0003-4819-75-3-471. PMID: N/A.
30. Shattat GF. A review article on hyperlipidemia: Types, treatments and new drug targets. Biomed Pharmacol J, 2014;7(2):399-409. DOI: 10.13005/bpj/504. PMID: N/A.
31. Schonfeld G. Inherited disorders of lipid transport. Endocrinol Metab Clin North Am. 1990;19(2):229-257. DOI: 10.1016/s0889-8529(18)30323-2. PMID: N/A.
32. Fredrickson DS, Lees RS. Editorial. Circulation. 1965;31(3):321-327. DOI: 10.1161/01.cir.31.3.321. PMID: N/A.
33. Pharmacotherapy: A Pathophysiologic Approach, 8th edition. Ann Pharmacother. 2011;45(12):1594-1595. DOI: 10.1345/aph.1q315. PMID: N/A.
34. Salvage J. Global institutions – the World Health Organization (WHO). Nurs Stand. 2011;25(35):30. DOI: 10.7748/ns2011.05.25.35.30.b1200. PMID: N/A.
35. Weinreich M, Frishman WH. Antihyperlipidemic therapies targeting PCSK9. Cardiol Rev. 2014;22(3):140-146. DOI: 10.1097/crd.0000000000000014. PMID: N/A.
36. TH A. Assessing awareness, attitude, knowledge of evidence-based medicine among ambulatory care physicians. Austin Public Health. 2021;5(1):N/A. DOI: 10.26420/austinpublichealth.2021.1014. PMID: N/A.
37. Abalkhail BA, et al. Hypercholesterolemia and 5-year risk of coronary heart disease in Jeddah, Saudi Arabia. Prev Med. 2000;31(4):390-395. DOI: 10.1006/pmed.2000.0713. PMID: N/A.
38. Jain A, et al. Psychosocial environment at work: Assessment of WHO regional office for the Eastern Mediterranean. East Mediterr Health J. 2012;18(4):325-331. DOI: 10.26719/2012.18.4.325. PMID: N/A.
39. Friedewald WT, Levy RI, Fredrickson DS. Estimation of LDL cholesterol concentration without ultracentrifuge. Clin Chem. 1972;18(6):499-502. DOI: 10.1093/clinchem/18.6.499. PMID: N/A.
40. Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults. Executive summary of NCEP Adult Treatment Panel III. JAMA. 2001;285(19):2486-2497. DOI: 10.1001/jama.285.19.2486. PMID: N/A.
41. Al-Nozha MM, et al. Smoking in Saudi Arabia and its relation to coronary artery disease. J Saudi Heart Assoc. 2009;21(3):169-176. DOI: 10.1016/j.jsha.2009.06.007. PMID: N/A.
42. Saadi H, et al. Prevalence of diabetes mellitus in Al Ain, UAE. Diabetes Res Clin Pract. 2007;78(3):369-377. DOI: 10.1016/j.diabres.2007.04.008. PMID: N/A.
43. Riley L, et al. WHO stepwise approach to NCD risk factor surveillance. Am J Public Health. 2016;106(1):74-78. DOI: 10.2105/ajph.2015.302962. PMID: N/A.
44. EMHJ Home. World Health Organization. Eastern Mediterranean Health Journal. Available at: https://www.emro.who.int/emh-journal/eastern-mediterranean-health-journal/home.html (Accessed: 15 June 2025).

45. Jackson R, et al. Multiple coronary risk factors in older Kuwaiti males. Nature. 2002;N/A:N/A. DOI: N/A. PMID: N/A.
46. National Cholesterol Education Program (NCEP), Third report of the National Cholesterol Education Program (NCEP) expert panel on detection, evaluation, and treatment of high blood cholesterol in adults (adult treatment panel III) final report. Circulation. Available at: https://pubmed.ncbi.nlm.nih.gov/12485966/ (Accessed: 15 June 2025).
47. Senthilkumar T, Tamilselvi A, Risk factors of cardiovascular disease in adolescents: A systematic review. Asian J Nurs Educ Res. 2021;11(1):151-156. DOI: 10.5958/2349-2996.2021.00039.2.
48. Jackson R, Multiple coronary risk factors in healthy older Kuwaiti males. Eur J Clin Nutr. 2002;56(8):709-714. DOI: 10.1038/sj.ejcn.1601379.
49. Bener A, Diagnosed and undiagnosed diabetes mellitus and its risk factors in a population-based study of Qatar. Diabetes Res Clin Pract. 2009;84(1):99-106. DOI: 10.1016/j.diabres.2009.02.003.
50. Ezeh KJ, Ezeudemba O, Hyperlipidaemia: A review of the novel methods for the management of lipids. Cureus [Preprint]. 2021. DOI: 10.7759/cureus.16412.
51. Grundy SM, Primary prevention of coronary heart disease: Guidance from Framingham. Circulation. 1998;97(18):1876-1887. DOI: 10.1161/01.cir.97.18.1876.
52. Edeoga HO, Okwu DE, Mbaebie BO, Phytochemical constituents of some Nigerian medicinal plants. Afr J Biotechnol. 2005;4(7):685-688. DOI: 10.5897/ajb2005.000-3127.
53. Jugroop M, Critical care nurses' perceptions of caring for patients at a selected hospital in KwaZulu-Natal. [Preprint]. DOI: 10.29086/10413/22833.
54. MW ASA, New insights into the treatment of hyperlipidemia: Pharmacological updates and emerging treatments. Cureus. Available at: https://pubmed.ncbi.nlm.nih.gov/38919858/ (Accessed: 16 June 2025).
55. Sirtori CR, The pharmacology of statins. Pharmacol Res. 2014;88:3-11. DOI: 10.1016/j.phrs.2014.03.002.
56. Schoonjans K, Staels B, Auwerx J, Role of the peroxisome proliferator-activated receptor (PPAR) in mediating the effects of fibrates and fatty acids on gene expression. J Lipid Res. 1996;37(5):907-925. DOI: 10.1016/s0022-2275(20)42003-6.
57. Fruchart JC, Peroxisome proliferator-activated receptor-alpha (PPARα): At the crossroads of obesity, diabetes, and cardiovascular disease. Atherosclerosis. 2009;205(1):1-8. DOI: 10.1016/j.atherosclerosis.2009.03.008.
58. Bou Malham S, Goldberg AC, Cardiovascular risk reduction: The future of cholesterol-lowering drugs. Curr Opin Pharmacol. 2016;27:62-69. DOI: 10.1016/j.coph.2016.01.007.
59. Rakipovski G, Hovingh GK, Nyberg M, Proprotein convertase subtilisin/kexin type 9 inhibition as the next statin? Curr Opin Lipidol. 2020;31(6):340-346. DOI: 10.1097/mol.0000000000000718.
60. Spolitu S, Proprotein convertase subtilisin/kexin type 9 and lipid metabolism. Curr Opin Lipidol. 2019;30(3):186-191. DOI: 10.1097/mol.0000000000000601.
61. Ezetimibe. Ezetimibe added to statin therapy after acute coronary syndromes. New Engl J Med. Available at: https://www.nejm.org/doi/full/10.1056/NEJMoa1410489. Accessed June 16, 2025.
62. KV ML. Mechanism of action of niacin. Am J Cardiol. Available at: https://pubmed.ncbi.nlm.nih.gov/18375237/. Accessed June 16, 2025.
63. Chait A, Robertson HT, Brunzell JD. Chylomicronemia syndrome in diabetes mellitus. Diabetes Care. 1981;4(3):343-348. DOI: 10.2337/diacare.4.3.343.
64. Berberich AJ, Hegele RA. A modern approach to dyslipidemia. Endocr Rev. 2021;43(4):611-653. DOI: 10.1210/endrev/bnab037.
65. Lad SS, Kolhe SU. Evaluation of antihyperlipidemic potential of aqueous corm extract of Colocasia esculenta in experimental model of rats. Pharmacol Res Mod Chin Med. 2023;9:100307. DOI: 10.1016/j.prmcm.2023.100307.
66. Petchi RR, Parasuraman S, Vijaya C. Antidiabetic and antihyperlipidemic effects of an ethanolic extract of the whole plant of Tridax procumbens (Linn.) in streptozotocin-induced diabetic rats. J Basic Clin Pharm. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3979266/. Accessed June 16, 2025.
67. Himi HZ, Rahman MM, Hasan SA, Rose L, Zaman TS, Chowdhury MM. An evaluation of anti-hyperlipidemic activity of ethanolic extract of Moringa oleifera on high-fat-induced hyperlipidemic rat model. Int J Biochem Res Rev. 2024;33(4):33-39.
68. Antihyperlipidemic activity of Camellia sinensis leaves in Triton WR-1339 induced albino rats. Available at: https://www.researchgate.net/publication/350374405_Antihyperlipidemic_activity_of_Camellia_sinensis_leaves_in_Triton_WR-1339_induced_albino_rats. Accessed June 16, 2025.
69. Antihyperlipidemic activity of Camellia sinensis leaves in Triton WR-1339 induced albino rats. Available at: https://www.researchgate.net/publication/350374405_Antihyperlipidemic_activity_of_Camellia_sinensis_leaves_in_Triton_WR-1339_induced_albino_rats. Accessed June 16, 2025.
70. Effect and evaluation of anti-hyperlipidemic activity of methanolic extract of Sesbania grandiflora in Triton-X 100 induced hyperlipidemic rats. Available at: https://sifisheriessciences.com/journal/index.php/journal/article/view/1747/1792. Accessed June 16, 2025.