Review article

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Lipoprotein(a): An update on its role in human health and disease

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ABSTRACT

Over the past few years, there has been an undiminished interest on lipoprotein(a) [Lp(a)]. High Lp(a) levels have been proposed as an independent causal risk factor for atherosclerotic cardiovascular disease (CVD). The main question that remains to be answered, however, is the potential clinical benefit of Lp(a) reduction. This will contribute to the enrichment of our knowledge on the exact pathophysiological role of this lipoprotein. This narrative review aims to summarize currently available data on the structure, metabolism, and pathogenicity of Lp(a).

KEY WORDS: *Lipoprotein(a), Apolipoprotein(a), Oxidized Phospholipids, Lipoprotein-associated phospholipase A2, Autotaxin, Monocyte chemoattractant protein-1, Atherogenesis, Calcific aortic valve stenosis, Thrombosis*

INTRODUCTION

Lipoprotein(a) [Lp(a)] was first discovered by the Norwegian physician Kare Berg almost 6 decades ago. It is a lipoprotein particle found in plasma consisting of a low-density lipoprotein (LDL) particle with an apolipoprotein(a) [apo(a)] moiety covalently bound to its apolipoprotein B-100 (apoB-100) component[1-3]. High Lp(a) levels are inherited in 90% of cases[4]. Lp(a) exerts inflammatory, thrombotic and atherogenic properties and seems to represent an independent cardiovascular risk factor[1-4]. Lp(a) mediates atherogenesis through mechanisms linked to its LDL and apo(a) components and associated oxidized phospholipids (OxPLs), of which Lp(a) is their major lipoprotein carrier[5]. Elevated Lp(a) plasma concentrations may predict the presence and progression of coronary heart disease (CHD), femoral and carotid artery disease[6]. Furthermore, Lp(a) levels seem to increase following acute coronary syndrome and percutaneous coronary intervention, due to its role as a positive acute-phase reactant. High Lp(a) levels, may predict death, myocardial infarction, stroke and need for revascularization in unselected populations, as well[6]. They also correlate with an amplified risk of aortic valve stenosis and peripheral artery disease[6]. Notably, there are currently no available treatments for potent reduction of high Lp(a) levels. In this narrative review, we present an update on the metabolism, physiology, and pathophysiology of Lp(a).

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METHODS

Relevant studies were identified by searching MEDLINE, EMBASE and CENTRAL databases up to 31 August 2021 using the following terms: lipoprotein(a), apolipoprotein(a), Lp-PLA2, oxidized phospholipids, cardiovascular risk, atherogenesis, calcific aortic valve stenosis, thrombosis. Reference lists from these articles were also scrutinized.

Structure and metabolism of Lp(a)

Lp(a) consists of an LDL-like particle, in which the apoB-100 is linked by a single disulphide bridge to a unique plasminogen-like glycoprotein, known as apolipoprotein(a). (Figure) Lp(a) exerts inflammatory, oxidative, thrombotic, atherogenic and antifibrinolytic properties[1-3].

Lp(a) synthesis occurs exclusively in the liver. Approximately 90% of circulating Lp(a) levels are inherited and strongly determined by a single gene, the *LPA* gene[7]. The *LPA* gene is evolutionarily derived from and highly homologous to the plasminogen (PLG) gene[8,9]. The *PLG* gene encodes 5 unique kringle domains and an active protease domain that is activated to plasmin by tPA (tissue-type plasminogen activators). The *LPA* gene, and therefore apo(a), does not contain kringles I-III, but does contain kringle IV (KIV), KV and a protease domain. This protease domain is catalytically inactive and, thus, it cannot be converted to a plasmin-like molecule because of amino acid substitutions at the site of cleavage of plasminogen activators[10]. Furthermore, because of multiple duplication events during evolution, the *LPA* gene has accumulated 10 copies of KIV that are each unique in amino acid sequence except for KIV2. KIV contains 1 copy of KIV1 and KIV3-10, but variable copies of KIV2, ranging from 1 to >40 on each allele. KIV2 repeats may differ in nucleic acid sequence but are identical in amino acid sequence[10]. Consequently, the different repeats of KIV2 in apo(a) account for the various size polymorphisms of this apolipoprotein. Besides the apo(a) isoform size, however, other genetic variants have an impact on Lp(a) levels for a given isoform. Functional single nucleotide polymorphisms (SNPs) within the *LPA* KIV2-encoding region (+4733G>A, +4925G>A, R21X, rs41272114, rs3798220) cooperate in determining Lp(a) variance and induce low Lp(a) concentrations[11-15]. This moderate but lifelong genetic Lp(a) reduction translates to noticeable CHD risk reduction, as well[11,14,15]. KIV9 contains an unpaired cysteine residue, which is attached by a disulfide bridge to a cysteine residue of

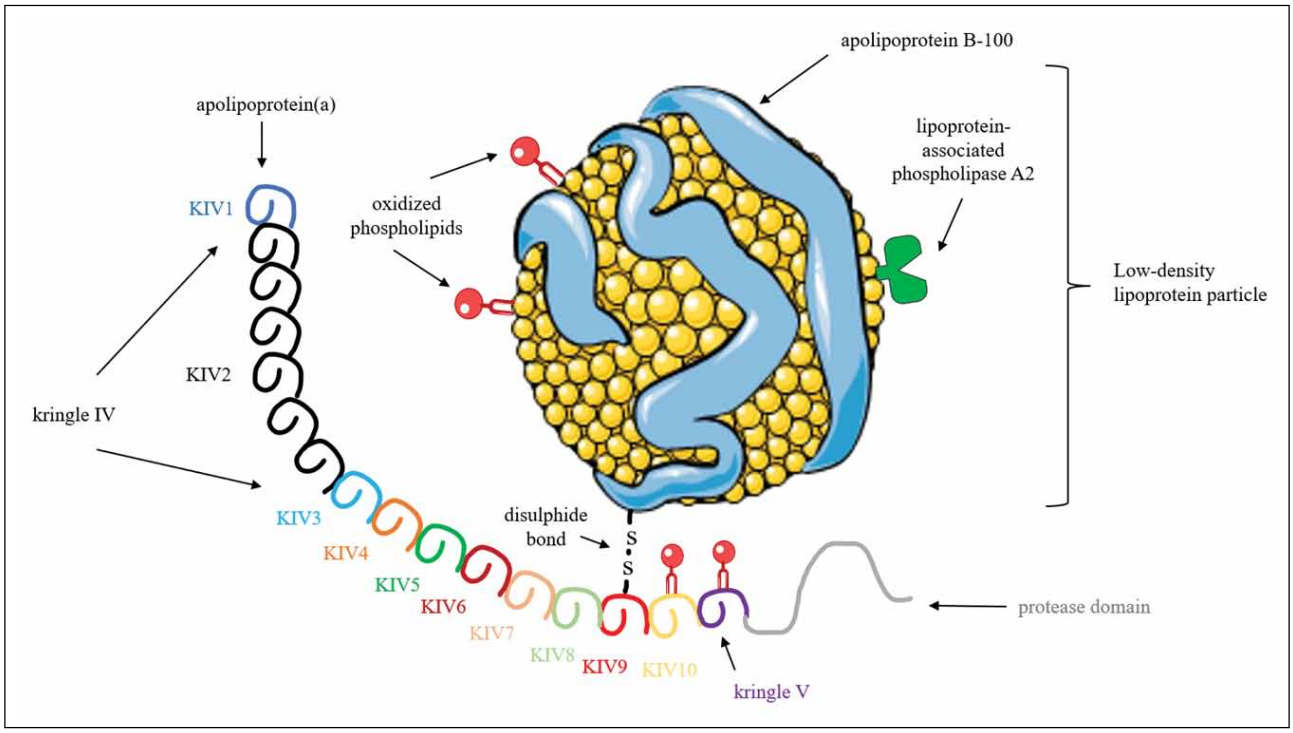

FIGURE. Structure of lipoprotein(a). Lipoprotein(a) [Lp(a)] consists of a low-density lipoprotein-like particle, in which the apolipoprotein B-100 is linked by a single disulphide bond to a glycoprotein, known as apolipoprotein(a). Apolipoprotein(a) contains 10 copies of kringle IV (KIV), KV and a catalytically inactive protease domain. KIV contains 1 copy of KIV1 and KIV3-10, but variable copies of KIV2, ranging from 1 to >40 on each allele. Up to 90% of all oxidized phospholipids found in human lipoproteins are carried on Lp(a) and subjected to degradation by lipoprotein-associated phospholipase A2.

apoB-100, located near the binding site of LDL to its receptor[16-18]. Specific functionalities relevant to the assembly and molecular pathology of Lp(a) are attributable to lysine-binding sites (LBSs), which are present in some of the KIV domains of apo(a). The lysine-binding site in KIV10 is considered to be strong and those in KIV5-KIV8 weak[19]. The strong lysine-binding site in KIV10 is thought to mediate binding of apo(a)-Lp(a) to fibrin, cell surface receptors and extracellular matrix proteins[18,20]. On the other hand, those in KIV5-KIV8 participate in the non-covalent interactions with apoB100 that precede disulfide bond formation[21,22]. Importantly, KIV10 also contains the site to which a proinflammatory oxidized phospholipid (OxPL) is covalently attached[23,24].

As mentioned above, plasma Lp(a) levels vary widely between individuals and are largely determined by their apo(a) size[13]. There is an inverse relationship between the number of KIV2 repeats of apo(a) and the level of Lp(a) in plasma[25]. Unlike other traditional lipoproteins, lifestyle changes have little impact on Lp(a) levels[1,4]. Furthermore, Lp(a) levels are stable over time. Thus, Lp(a) levels need only be measured once, unless a secondary cause is suspected or specific treatment is instituted[1,4].

Unfortunately, little is known about the dominant sites and processes accountable for the removal of Lp(a) from circulation. Scientists debate between liver and kidneys as the dominant clearance site. Spleen and muscles may also play a modest role in the clearance process[7]. Multiple receptors for Lp(a) have been identified, with the best evidence available for the LDL receptor (LDLR)[26-29], various plasminogen receptors[29,30] and scavenger receptor class B member 1 (SRB1)[31]. Lp(a) concentrations may vary with ethnicity and gender[4]. Traditional thresholds for elevated Lp(a) concentrations are > 30 mg/dL (>75 nmol/L), with about 20% of the population having Lp(a) concentrations > 50 mg/dL (120 nmol/L)[1,32].

Physiological functions of Lp(a)

The physiological role of Lp(a) in humans is still not fully elucidated. Individuals with extremely low levels of plasma Lp(a) present with no disease or deficiency syndromes[33]. In a large, contemporary, general population cohort low levels of Lp(a) and corresponding *LPA* genotypes did not associate with any major disease groups, including cancer, cancer subtypes and infections. For cardiovascular disease (CVD) was even found that observationally and genetically low levels of Lp(a) are associated with decreased risk of myocardial infarction, aortic valve stenosis, and ischaemic stroke[34]. Several studies have reported that Lp(a) plays a significant role in inhibiting angiogenesis and tumor growth[35-37]. Lp(a) due to its homology with PLG may function as an anti-neoplastic protein. It may decrease the activation of the proteases, which are mandatory for the activation of matrix metalloproteinases (MMPs) and the subsequent activation of angiogenesis[33]. Moreover, many investigators have reported the positive role of Lp(a) in wound healing and tissue repair, by limiting bleeding at sites of injury and delivering cholesterol for cell replenishment[33,38,39]. Indeed, Lp(a) accumulates in endothelial injuries, binds to several components of the vessel wall and sub-endothelial matrix, stimulates chemotactic activation of monocytes/macrophages and modulates angiogenesis. All these effects are mediated by apo(a)[33].

As previously described, apo(a) isoforms share substantial structural and functional homology with PLG, the principal component of the fibrinolytic pathway, which is converted to plasmin for fibrinolysis[35]. This homology allows apo(a) to compete with PLG for fibrin affinity sites[40]. Additionally, Lp(a) attenuates PLG activation to plasmin by the tissue Plasminogen Activator (tPA) in the presence of fibrin[41]. Thus, Lp(a) seems to inhibit fibrinolysis. However, there is little evidence to support such a role in vivo. Many studies have reported that Lp(a) levels increase in patients with acute pathologies, such as myocardial infarction, inflammatory bowel disease, and gallbladder fistula[33,42-44]. It is hypothesized that under certain settings, after myocardial infarction for example, Lp(a) acts as a positive acute-phase reactant[33,45]. This is why inflammatory status should always be considered when interpreting plasma Lp(a) concentrations[33,46,47]. In contrast, Lp(a) may behave as a negative acute-phase reactant in cases of serious burns and severe infection, such as visceral leishmaniasis or sepsis[48-50].

OxPLs play a fundamental role in the early stages of atherosclerosis[5,51]. It has been suggested that a normal physiologic role of Lp(a) may be to bind and transport such proinflammatory OxPLs. Because of its high content with lipoprotein-associated phospholipase A2 (Lp-PLA2), which hydrolyzes OxPLs, Lp(a) may also mediate their clearance. This occurs through the formation of a covalent bond between the KIV10 and KV of the apo(a) fragment of Lp(a) and OxPLs[5,51].

The pathogenicity of lipoprotein(a)

Convincing evidence has emerged from pathophysiological, epidemiological, and genetic studies on the causality of high serum Lp(a) levels as a potent risk factor for CHD, transient ischaemic attack, ischaemic stroke or recurrent stroke in patients younger than 60 years, peripheral artery disease, chronic kidney disease, heart failure, venous thromboembolism, calcific aortic valve stenosis, as well as retinopathy in patients with diabetes[1,4,52-56].

Moreover, Mendelian randomization and genome wide association studies seem to support the role of Lp(a) as an independent cardiovascular risk factor[1,4,52]. Indeed, cardiovascular risk assessment with Lp(a) at middle-age may include direct Lp(a) measurement or an *LPA* genetic risk score, comprising 43 variants at the *LPA* gene[57]. *LPA* genetic risk score is able to discriminate people with the hyper-Lp(a) phenotype (i.e., high Lp(a) levels) and high risk for CAD even among closely related family members[57]. Hyper-Lp(a) phenotype frequently co-exists with other risk factors for CVD, such as familial hypercholesterolaemia or apolipoprotein E4-allele[58-60]. Indeed, hyper-Lp(a) phenotype is a frequent finding in FH subjects, especially in the presence of CHD[58-60].

Individuals with heterozygous familial hypercholesterolaemia (HeFH) have almost 2.5-fold increased Lp(a) levels compared with controls[61]. It is suggested that Lp(a) has a binding affinity to LDLR but less than LDL due to apo(a) mask. Thus, its clearance may be decreased in HeFH patients[62]. Also, Lp(a) levels have been proposed as a marker of restenosis after percutaneous transluminal coronary angioplasty, saphenous vein bypass graft atherosclerosis and accelerated coronary atherosclerosis of cardiac transplantation[63].

Moreover, various inflammatory conditions, such as rheumatoid arthritis, systemic lupus erythematosus, acquired immunodeficiency syndrome and pulmonary arterial hypertension are associated with high Lp(a) levels[64]. Particularly, in cases of rheumatoid arthritis interleukin-6 receptor blockade by tocilizumab reverses high Lp(a) levels. This suggests that interleukin-6 may have a potential role in regulating Lp(a) plasma levels[64]. Differences in Lp(a) levels have also been observed in pregnancy, another inflammatory condition[65]. Apart from inflammation, Lp(a) correlates inversely with bile acid levels in plasma in patients with biliary obstructions. It has been revealed that the activation of the Farnesoid X Receptor by bile acids suppresses *LPA* mRNA transcription and therefore regulates plasma Lp(a) levels[66].

Paradoxically, low levels of Lp(a) could be associated with increased risk of diabetes mellitus or bleeding[34]. One hypothesis is that the increased risk for diabetes results from the harmful trapping of large apo(a) isoforms in hepatocytes or other cells, and thus not from the low levels per se[34]. However, it remains possible that some patients with low Lp(a) levels could have increased risk for diabetes or bleeding because of some unidentified genetic or acquired predisposing cofactor that acts synergistically with low Lp(a)[34].

Regarding pathophysiological mechanisms, Lp(a) may act via its LDL-like component[67,68]. Indeed, in some patients, a substantial fraction of LDL-cholesterol may be transported by Lp(a) particles rather than the archetypical LDL particle[69]. The LDL-like component of Lp(a) undergoes different types of modification after entry into the vessel wall[67,68]. The atherogenic actions of LDL in the arterial tissue include the formation of macrophage-derived foam cells upon phagocytic uptake of aggregated LDL particles, or LDL in which lipid and/or protein components have undergone covalent modification, triggering uptake by scavenger receptors[70]. Also, they include the release of bioactive proinflammatory lipids exerting both local and systemic actions, the formation of extracellular lipid deposits, and induction of an adaptive immune response with the activation of antigen-specific T-cell responses and antibodies[70]. Additionally, LDL particles induce an innate immune response in the arterial wall, that involves damage associated molecular patterns (DAMPs). In turn, these DAMPs promote recruitment of immuno-inflammatory cells, such as monocyte-macrophages, neutrophils, lymphocytes, and dendritic cells, leading to local and potentially chronic inflammation. Cell death by apoptosis or necrosis can then be induced, thereby contributing to necrotic core formation[70].

Moreover, Lp(a) may act via the antifibrinolytic/prothrombotic effects of apo(a). Apo(a) is highly homologous to PLG and its binding to plasminogen binding sites prevents interaction between PLG and tPA. If tPA cannot cleave plasminogen to plasmin, then fibrin clots cannot be dissolved[71]. Lp(a) also increases the production and activity of tissue plasminogen activator inhibitor-1 (PAI-1)[72]. Nonetheless, it is a competitor with both PLG and tPA for binding sites on fibrin, which subsequently promote a thrombotic state by preventing plasmin-mediated clot lysis. Indeed, smaller apo(a) isoforms display higher affinity binding to fibrin[73]. Thrombosis may be augmented by Lp(a) binding and then inhibiting tissue factor pathway inhibitor (TFPI), which is a potent inhibitor of the tissue factor mediated coagulation cascade[74]. Also, Lp(a) has been demonstrated to regulate platelet activation and aggregation triggered by various agonists, as well as to associate with others prothrombotic proteins, such as α2-macroglobulin (α plasmin inhibitor) and serine proteinase inhibitor A1 (SERPINA, a tPA inhibitor)[75].

Lp(a) is susceptible to oxidative stress, leading to the formation of pro-inflammatory and pro-atherogenic OxPLs, found on apoB, apo(a), and its lipid phase[1,76]. OxPLs induce proinflammatory signaling in endothelial cells, smooth muscle cells, monocytes, macrophages, dendritic cells, and platelets[77-80]. They also mediate plaque-destabilizing processes, and as they are present in higher quantities (70-fold) in plaque than in plasma, are capable of stimulating proinflammatory genes leading to vascular inflammation[77-80]. Additionally, OxPLs are pro-apoptotic

in high concentrations, accumulate in atherosclerotic lesions and play an important role in atherosclerosis[77-80]. High Lp(a) and OxPLs of Lp(a) levels, through their pro-inflammatory and procalcific activity on valvular interstitial cells, are causally associated with increased valve calcification in elderly patients with advanced aortic stenosis, a faster hemodynamic progression of aortic stenosis, and increased risk of aortic valve replacement and death[81,82]. OxPL plasma levels correlate more strongly with high Lp(a) levels and small apo(a) isoforms, or with the presence of *LPA* SNPs rs3798220 and rs10455872, which are also correlated with high Lp(a) levels[83,84] .This association of OxPLs with small Lp(a) particles may at least partially explain their enhanced atherogenicity and association with higher CVD risk as compared with large ones[85]. Nevertheless, up to 90% of all OxPLs found in human lipoproteins are carried on Lp(a), which is not necessarily oxidized. Thus, OxPLs may impart additional and potent proinflammatory properties to Lp(a) and play a key role in Lp(a) functionality[5,23]. OxPLs are degraded into lysophosphatidylcholine (lyso-PC) and oxidized free fatty acids, which also manifest proinflammatory and proatherogenic effects by Lp-PLA$_2$. Lp-PLA2, among other lipoproteins, is associated with Lp(a)[85] .However, the Lp-PLA2 associated with small apo(a) isoforms has a lower catalytic efficiency compared with the Lp-PLA2 associated with larger apo(a) isoforms. This could be another factor that favors the sequestration of plasma OxPLs on small apo(a) isoforms, and therefore the strong correlation between small apo(a) isoforms and high OxPL levels in plasma[85].

Another biological property of Lp(a) that makes it a proatherogenic and a proinflammatory lipoprotein, is monocyte chemoattractant protein-1 (MCP-1). MCP-1 is a major chemokine involved in the development of atherosclerosis via monocyte recruitment to the vascular wall[86]. Lp(a) in plasma may serve as a carrier for MCP-1, and OxPLs are major determinants of the MCP-1 binding[86]. Once Lp(a) has entered the arterial intima with its associated MCP-1, it may subsequently enhance the trafficking of monocytes to the vascular wall, and thereby exacerbate lesion progression[86]. Furthermore, Lp(a) promotes the adhesion and transendothelial migration of monocytes, through the interaction of apo(a) with the b2-integrin Mac-1[87].

Last but not least, autotaxin (ATX) is another important molecule associated with Lp(a). ATX preferentially transported by Lp(a) catalyzes the hydrolysis of lyso-PC into lysophosphatidic acid (lyso-PA)[88]. As mentioned previously, lyso-PC is formed by hydrolysis of OxPLs, mediated by the Lp(a)-associated Lp-PLA2[85]. Lyso-PA stimulates complex intracellular signaling pathways. As a result, it generates various cellular responses, such as inflammatory cytokine release, monocyte attraction and adhesion, abnormal endothelial cell behavior, endothelial permeability, and LDL uptake for plaque formation and participates in different pathophysiological conditions. Inflammation, atherogenesis and calcific aortic valve stenosis are among them[88,89].

All these pathophysiological mechanisms of Lp(a), including proatherogenic, proinflammatory and antifibrinolytic mechanisms, probably contribute to cardiovascular risk in various but different extent in all age groups[90]. However, it is proposed that specific properties may predominate and manifest clinically in different age groups, with antifibrinolytic effects mainly in children, proinflammatory effects in young adults, and proatherogenic effects in the elderly[90].

Effect of hypolipidemic treatment on Lp(a)

There are neither known non-pharmacologic methods, nor any specific pharmacological approaches able to lower Lp(a) concentrations to the extent proposed to achieve cardiovascular benefits[91].

The effects of currently used therapeutic agents on circulating levels of Lp(a) are not well understood. Some of them, however, have a limited but clear effect on Lp(a). Lipoprotein apheresis is highly effective in reducing Lp(a) levels (25-40%)[92]. Both statins[93] and low-saturated fat diets[94] raise Lp(a) levels by approximately 10-30%. On the other hand, fibrates[95], and most hormones (except growth hormone)[32,96] may reduce Lp(a) levels. Niacin[97], mipomersen[98], lomitapide[99], proprotein convertase subtilisin kexin 9 (PCSK9)[100-102] and (cholesteryl transfer protein) CETP inhibitors[103], aspirin[32], antibodies to interleukin-6[32], nutraceuticals[104-107], tibolone[108] and ezetimibe[109], also, decrease Lp(a) levels. Vitamin C[110] and bile acid sequestrants[111] have a neutral effect on plasma Lp(a) levels.

In the era of RNA-based therapies, novel medicines aimed at substantially lowering Lp(a) levels, using antisense oligonucleotides (ASOs) and small interfering RNAs (siRNA), are currently in clinical development[91]. ASOs targeting apo(a) have shown much promise with reductions up to 92.4% in Lp(a) in a dose dependent fashion and a favorable safety profile[3,112,113]. AMG 890 (olpasiran), a siRNA, reduced Lp(a) with observed maximal percent reductions of >90% in a phase I study[114].

In the following table, we review the established and emerging therapeutic agents that affect Lp(a) levels. (Table)

Conclusion and future perspective

Lp(a) offers a fresh look at atherosclerotic CVD, as high Lp(a) levels seem to be associated with an increased risk of CVD. On the contrary, the role of low Lp(a) levels

TABLE. Current and emerging Lipoprotein(a)-lowering therapies

Lipoprotein(a)-lowering therapy	Lipoprotein(a) effect
Lipoprotein apheresis	Acute decrement of 70% to 75%, but regular apheresis can translate into a mean Lp(a) reduction between 25% to 40%.
Statins	Most statins may increase Lp(a) on average 8% to 24%, although significant heterogeneity in response is present.
Low-saturated fat diets	Potential increment between 10% to 20%.
Fibrates	Potent reduction between 10% to 40%. However, they are not the drugs of choice for managing Lp(a) elevations.
Sex hormone therapies (e.g. estrogen)	Lp(a) reduction by approximately 20%. However, hormone replacement therapy cannot be recommended for the sole purpose of lowering Lp(a).
Tibolone	Lp(a) reduction between 13,2% and 29%.
Vitamin C	Neutral effect on Lp(a) plasma levels.
Bile acid sequestrants	Neutral effect on Lp(a) plasma levels.
Nicotinic acid (niacin)	Potential Lp(a) lowering effect between 20% to 30%, but it is limited by side effects.
Ezetimibe	As monotherapy provides a modest 7% reduction in Lp(a) levels.
Mipomersen	20%-40% reduction, although the product is not clinically available.
Lomitapide	17% reduction.
Inhibitors of cholesteryl transfer protein (CETP inhibitors)	25%-40% reduction, although not approved for clinical use.
Thyromimetic eprotirome	Lp(a) decrement between 20% to 30%, although not approved for clinical use (investigational agent).
Aspirin	Modest reduction up to 30%.
Antibodies to interleukin-6	Modest reduction up to 30%.
Nutraceuticals (L-carnitine, coenzyme Q10, xuezhikang)	Potential Lp(a)-lowering effects between 10% to 30%.
Proprotein convertase subtilisin kexin 9 (PCSK9) inhibitors: • Monoclonal antibodies: evolocumab, alirocumab • Antisense: inclisiran	 • Mean reduction of Lp(a) levels between 14% to 30%. • Mean reduction of Lp(a) levels between 15% to 25%.
Antisense oligonucleotides (ASOs): • ISIS-Apo(a)RX • IONIS-Apo(a)RX • IONIS-Apo(a)LRX (pelacarsen=TQJ230)	 • Mean percentage decreases in plasma Lp(a) concentrations of 40% to 78%. • Mean percentage decreases in plasma Lp(a) concentrations of 67% to 72%. • Lp(a) reductions up to 92%.
Small interfering RNAs (siRNAs): • Olpasiran (AMG890)	 • Observed maximum reduction of >90%.

in humans is still not fully elucidated. Several mechanisms to explain the atherogenicity of Lp(a) have been proposed so far, including primarily its LDL and apo(a) components and associated OxPLs. However, since we have no commercially available drugs that selectively reduce high Lp(a) levels, it is not possible to draw safe conclusions on the clinical importance for reducing Lp(a) as well as for the exact pathophysiological role of this lipoprotein.

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Conflict of Interest

The authors have no conflicts of interest related to this publication.

ΠΕΡΙΛΗΨΗ

Λιποπρωτεΐνη(α): Σύγχρονη ανασκόπηση για τον ρόλο της στην ανθρώπινη φυσιολογία και παθολογία

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Τα τελευταία χρόνια, παρατηρείται ένα αμείωτο ενδιαφέρον για τη λιποπρωτεΐνη(α). Τα αυξημένα επίπεδα αυτής της λιποπρωτεΐνης έχουν προταθεί ως ανεξάρτητος αιτιολογικός παράγοντας κινδύνου για την εμφάνιση αθηρωμάτωσης και παθήσεων του καρδιαγγειακού συστήματος. Το κύριο ερώτημα που μένει να απαντηθεί, ωστόσο, είναι το κλινικό όφελος, που πιθανά θα προκύψει, από τη μείωση των επιπέδων της λιποπρωτεΐνης(α). Η απάντηση σε αυτό το ερώτημα θα συμβάλλει, μεταξύ άλλων, και στον εμπλουτισμό των γνώσεών μας για τον ακριβή παθοφυσιολογικό της ρόλο. Στο παρόν άρθρο, συνοψίζουμε και παρουσιάζουμε την υπάρχουσα βιβλιογραφία αναφορικά με τη δομή, το μεταβολισμό καθώς και την παθογένεια της λιποπρωτεΐνης(α).

ΛΕΞΕΙΣ ΚΛΕΙΔΙΑ: *Λιποπρωτεΐνη(α), Απολιποπρωτεΐνη(α), Οξειδωμένα Φωσφολιπίδια, Σχετιζόμενη με λιποπρωτεΐνες φωσφολιπάση Α2, Αυτοταξίνη, Χημειοτακτική πρωτεΐνη-1 των μονοκυττάρων/μακροφάγων, Αθηρογένεση, Στένωση αορτικής βαλβίδας, Θρόμβωση*

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