lipidology

MDPI

Review

The Crosstalk Between Non-Coding RNAs and Lipid Metabolism in Chronic Disease Progression

Zoofa Zayani [1], Arash Matinahmadi [2], Alireza Tavakolpournegari [3], Seyedeh Safoora Moosavi [3] and Seyed Hesamoddin Bidooki [4,*]

[1] Centre for Modern Interdisciplinary Technologies, Nicolaus Copernicus University, 87-100 Torun, Poland; zoofa.zayani@doktorant.umk.pl
[2] Department of Cellular and Molecular Biology, Nicolaus Copernicus University, 87-100 Torun, Poland; arash.matinahmadi@doktorant.umk.pl
[3] Centre Armand-Frappier Santé Biotechnologie, Institut National de la Recherche Scientifique (INRS), Laval, QC H7V 1B7, Canada; alireza.tavakolpournegari@inrs.ca (A.T.); safoora.moosavi@inrs.ca (S.S.M.)
[4] Department of Biochemistry and Molecular and Cellular Biology, Faculty of Veterinary Medicine, Health Research Institute of Aragon, University of Zaragoza, 50013 Zaragoza, Spain
* Correspondence: sbidooki@unizar.es

Abstract

In the last twenty years, an increasing volume of research has characterized lipids as dynamic signaling molecules that play essential roles in various physiological and pathological processes, especially concerning chronic diseases such as cardiovascular disorders, diabetes, liver disease, neurodegeneration, cancer, obesity, diabetic and chronic kidney diseases and atherosclerosis. Dysregulation of lipid synthesis and storage, lipolysis, fatty acid oxidation, lipid signaling pathways, and organelle-specific lipid modifications, including mitochondrial phospholipid remodeling and endoplasmic reticulum stress induced by saturated fatty acids, are recognized as contributors to the initiation and progression of this pathogenesis. Concurrently with the increasing comprehension of lipid metabolism, the last decade has seen progress in the understanding of genome control, especially with non-coding RNAs (ncRNAs). MicroRNAs, long non-coding RNAs, and circular RNAs, as ncRNAs, are essential modulators of gene expression at the epigenetic, transcriptional, and post-transcriptional levels that affect a number of lipid metabolism-related processes, such as fatty acid synthesis and oxidation, cholesterol homeostasis, and lipid droplet dynamics. Therapeutically, ncRNAs hold considerable promise owing to their tissue specificity and modularity, with antisense oligonucleotides and CRISPR-based editing currently under preclinical evaluation. In this context, we review recent studies exploring the interplay between ncRNAs and the regulatory networks governing lipid metabolism, and how disruptions in these networks contribute to chronic disease. This emerging paradigm underscores the role of ncRNA–lipid metabolism interactions as central nodes in metabolic and inflammatory pathways, highlighting the need for a holistic approach to therapeutic targeting.

Keywords: lipid metabolism; ncRNA; miRNAs; lncRNAs; CircRNAs; liver; adipose tissue; brain; vasculature; kidney; chronic diseases

check for updates

Academic Editor: Gerhard Kostner

Received: 9 September 2025
Revised: 15 October 2025
Accepted: 18 October 2025
Published: 21 October 2025

Citation: Zayani, Z.; Matinahmadi, A.; Tavakolpournegari, A.; Moosavi, S.S.; Bidooki, S.H. The Crosstalk Between Non-Coding RNAs and Lipid Metabolism in Chronic Disease Progression. *Lipidology* **2025**, *2*, 19. https://doi.org/10.3390/lipidology2040019

Copyright: © 2025 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

1. Introduction

Lipid metabolism, the complex network of processes governing the synthesis, breakdown, and utilization of various lipids such as fatty acids, triglycerides, phospholipids, and cholesterol, is fundamental to cellular health, energy balance, and signaling [1]. Lipid

metabolism has already been observed as operating in a confined manner, focused on the storage and release of energy, but is now widely perceived as a dynamic network that plays important roles in signaling, maintaining the integrity of cellular membranes, and systemic homeostasis [2,3]. Over the past two decades, an expanding body of research has redefined lipids as dynamic signaling molecules with critical roles in a variety of physiological and pathological processes, particularly in the context of chronic diseases [4,5]. Dysregulation of lipid metabolism contributes to a wide range of chronic diseases, including cardiovascular disorders, diabetes, liver disease, neurodegeneration, cancer, obesity, and atherosclerosis [6]. Dysregulation of lipid synthesis and storage, lipolysis, fatty acid oxidation, and lipid signaling pathways, are now known to be involved in the initiation and progression of such pathogenesis [7]. In the past, research concentrated on the classical pathways, i.e., fatty acid synthesis, β-oxidation, and cholesterol transport controlled by enzymes (i.e., acetyl-CoA carboxylase, HMG-CoA reductase) and by receptors (i.e., low-density lipoprotein (LDL) receptor) [8]. Nevertheless, progress in systems biology has revealed a more intricate landscape, where lipid metabolism intersects with inflammation, oxidative stress, and inter-organ crosstalk [9]. For example, lipotoxicity due to ectopic lipid deposition in non-adipose tissues causes insulin resistance generated by ceramides and diacylglycerols [10], and oxidized LDL particles exaggerate endothelial dysfunction in atherosclerosis [11]. Furthermore, organelle-specific lipid alterations, such as mitochondrial phospholipid re-modelling [12] or endoplasmic reticulum (ER) stress [13] derived from saturated fatty acids [14], are now believed to contribute to disease pathogenesis [15]. This new paradigm has highlighted lipid metabolism as a center for many metabolic and inflammatory pathways, necessitating a holistic approach to therapeutic targeting [16].

In parallel with the growing understanding of lipid metabolism, the past decade has witnessed advances in the understanding of genome regulation, particularly regarding non-coding RNAs (ncRNAs) [17]. MicroRNAs (miRNAs), long non-coding RNAs (lncRNAs), and circular RNAs (circRNAs), as ncRNAs, are now recognized as crucial regulators of gene expression at the epigenetic, transcriptional, and post-transcriptional levels [18–20]. Studies have demonstrated that ncRNAs modulate various aspects of lipid metabolism, including fatty acid synthesis and oxidation, cholesterol homeostasis, and lipid droplet dynamics [21]. For example, specific miRNAs such as miR-33 and miR-122 have been shown to regulate cholesterol efflux and fatty acid metabolism, respectively [22]. LncRNAs, through diverse mechanisms involving chromatin remodeling, transcriptional interference, and miRNA sponging, also exert profound effects on lipid metabolic pathways [23]. lncRNA-LeXis modulates hepatic lipogenesis by sequestering the transcriptional coactivator *Med1* [24], or lncRNA-ANRIL is associated with atherosclerosis risk [25]. CircRNAs add an additional layer of complexity by acting as molecular sponges for miRNAs, interacting with RNA-binding proteins, and potentially encoding functional peptides [26]. Beyond intracellular roles, ncRNAs mediate inter-organ communication via exosomes, e.g., adipocyte-derived miR-99b suppresses hepatic *FGF21* expression, exacerbating metabolic syndrome [27]. Therapeutically, ncRNAs offer promise due to their tissue-specificity and modularity, with antisense oligonucleotides and CRISPR-based editing in preclinical testing [28]. However, challenges such as limited delivery efficiency and off-target effects persist [29]. In this regard, we summarize recent studies to understand the crosstalk between ncRNAs and the regulatory networks that control lipid metabolism, and how these networks become dysregulated in chronic disease.

2. Mechanisms and Dysregulation of Lipid Metabolism in Chronic Disease

The type and quantity of dietary lipids consumed are foundational determinants of cellular health and disease risk, impacting membrane composition and subsequent stability.

An excess intake of saturated fatty acids can promote lipotoxicity and mitochondrial dysfunction, while the health benefits of polyunsaturated fatty acids (PUFAs), such as $\omega - 3$ and $\omega - 6$ families, stem from their critical role in maintaining the structure and fluidity of the phospholipid bilayer [30]. However, the high degree of unsaturation in PUFAs renders them uniquely vulnerable to lipid peroxidation, a degradative process initiated by reactive oxygen species (ROS). This results in the formation of numerous highly reactive PUFA metabolites, including malondialdehyde and 4-hydroxynonenal, which are potent electrophiles and signaling molecules [31]. These reactive PUFA metabolites inflict damage in two critical domains. First, they directly compromise the function of the cell bilayer by forming covalent adducts with membrane proteins and altering lipid packing, thereby disrupting membrane fluidity and essential signaling pathways [32]. Second, and more profoundly, these lipid-derived reactive species serve as endogenous genotoxic agents. Once they infiltrate the nucleus, they induce DNA damage through base modifications and the formation of DNA-adducts, significantly increasing the frequency of strand breaks and ultimately leading to genome instability [33,34]. Therefore, a complete understanding of lipid-associated diseases must encompass this pathway: from imbalanced dietary fat intake to membrane degradation, reactive metabolite generation, and the resultant threat to genomic integrity.

In chronic diseases, dysregulation of lipid pathways can contribute to lipotoxicity if excessive free fatty acids (FFAs) or cholesterol accumulate in tissues and impair function, as well as chronic inflammation that is driven by pro-inflammatory lipid mediators such as oxidized LDL or ceramides [35]. Mitochondrial dysfunction, ectopic lipid deposition, and dysregulated lipid signaling underscore the interconnectedness of chronic diseases. This paradigm serves to implicate lipid metabolism not as an afterthought of metabolism, but rather as a commanding orchestrator of chronic disease (Figure 1).

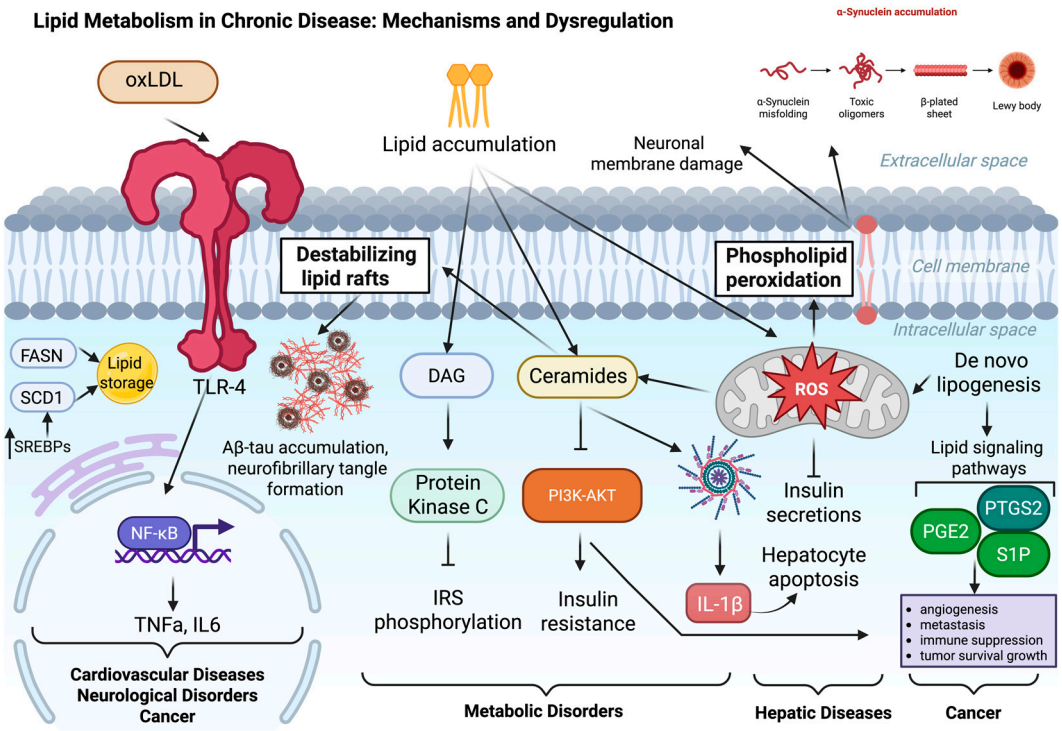


Figure 1. Mechanistic insights into lipid metabolism and its dysregulation in chronic disease.

2.1. Cardiovascular Diseases

Atherosclerosis, the pathological cornerstone of cardiovascular disease (CVD), develops through lipid accumulation in arterial walls, where LDL cholesterol infiltrates the

endothelial layer, triggering inflammation and initiating plaque formation [36]. Once LDL particles penetrate the arterial intima, they undergo oxidative modification, becoming oxidized LDL (oxLDL), which recruits macrophages that engulf these lipids, transforming into foam cells, a defining feature of atherosclerotic plaques. This process is exacerbated by lipid peroxidation, where ROS modify LDL, making it more atherogenic. The resulting oxLDL acts as a damage-associated molecular pattern (DAMP), binding to Toll-like receptor 4 (TLR4) on macrophages, which activates nuclear factor kappa B (NF-κB) signaling and induces the release of pro-inflammatory cytokines such as TNFα and IL-6, perpetuating vascular inflammation [37]. In contrast, high-density lipoprotein (HDL) exerts a protective role by facilitating reverse cholesterol transport, mobilizing excess cholesterol from peripheral tissues, including arterial lesions, to the liver for excretion [38,39]. However, dyslipidemia, characterized by elevated triglycerides (TGs) and lipoprotein A, exacerbates vascular damage [40]. Genetic predispositions, such as LDL receptor mutations that hinder LDL clearance [41], or dysregulation of lipid-modulating enzymes like lipoprotein lipase (essential for TG breakdown) [42] and cholesteryl ester transfer protein (CETP) (which mediates cholesterol exchange between lipoproteins) [43], amplify these risks. These genetic factors intersect with lifestyle choices, particularly diets high in saturated fats and sugars, to worsen lipid imbalances [44]. Therapeutic strategies aimed at reducing lipid accumulation and inflammation include weight loss to decrease lipid burden, drugs like proprotein convertase subtilisin kexin type 9 (PCSK9) inhibitors (for cholesterol management) [45], repurposing metabolic regulators (e.g., Peroxisome proliferator-activated receptors (PPAR-γ) agonists to enhance adipose lipid storage [46], ceramide synthesis inhibitors to reduce toxic lipid intermediates, TLR4 inhibitors to dampen inflammation, and antioxidants to mitigate oxidative stress and lipid peroxidation [47], offering potential avenues to mitigate CVD progression (Figure 1). This synergy between inherited susceptibilities and environmental influences underscores the complex gene-environment interplay driving CVD.

2.2. Obesity and Type 2 Diabetes

Obesity and type 2 diabetes mellitus (T2DM) are driven by a pathological interplay between ectopic lipid deposition and insulin resistance [48]. In obesity, dysfunctional adipose tissue becomes overwhelmed, leading to the spill-over of FFAs into non-adipose organs such as the liver, skeletal muscle, and pancreas [49]. This ectopic lipid accumulation triggers lipotoxicity, where lipid intermediates like diacylglycerol (DAG) and ceramides disrupt insulin signaling. DAG activates protein kinase C (PKC), impairing insulin receptor substrate (IRS) phosphorylation, while ceramides inhibit PI3K-Akt pathways, reducing glucose uptake and promoting insulin resistance (Figure 1) [50,51]. Additionally, ceramides activate the *NLRP3* inflammasome, leading to the production of IL-1β, which further exacerbates insulin resistance and contributes to pancreatic β-cell dysfunction [52]. Lipotoxicity also induces mitochondrial dysfunction and ER stress, culminating in β-cell apoptosis and reduced insulin secretion [53,54]. Chronic nutrient overload overwhelms mitochondrial capacity, resulting in incomplete fatty acid oxidation and the accumulation of toxic lipid intermediates, which increase ROS production and oxidative stress, further impairing metabolic function [55,56]. Adipose-derived hormonal imbalances, such as leptin resistance and reduced adiponectin levels, promote hyperphagia and diminish insulin-sensitizing effects, while pro-inflammatory cytokines (e.g., TNFα, IL-6) fuel systemic inflammation, entrenching insulin resistance (Figure 1) [57,58]. The convergence of ectopic lipids, impaired insulin action, β-cell failure, and chronic inflammation creates a self-perpetuating metabolic crisis, underscoring the centrality of lipid dysregulation in obesity and T2DM pathogenesis.

2.3. Metabolic Dysfunction–Associated Steatotic Liver Disease (MASLD)

MASLD begins with hepatic steatosis, where excessive lipid accumulation arises from upregulated De Novo lipogenesis (DNL), the liver's synthesis of new fats from carbohydrates, coupled with impaired fatty acid oxidation and defective secretion of very low-density lipoproteins (VLDL), which normally export triglycerides [59]. This ectopic lipid deposition, driven by Golgi and adipose tissue dysfunction and lipid overflow, leads to lipotoxicity, where toxic lipid intermediates like ceramides and cholesterol crystals activate inflammatory and fibrotic pathways [60,61]. Genetic variants, such as the *PNPLA3 I148M* (a common genetic variation that significantly increases the risk of MASLD), exacerbate lipid retention and oxidative stress by disrupting lipid droplet remodeling. Mitochondrial dysfunction further impairs fatty acid breakdown, resulting in incomplete oxidation and overproduction of ROS, which drive lipid peroxidation and hepatocyte damage [62–64]. Oxidative stress, combined with lipotoxicity from FFAs and cholesterol crystals, activates Kupffer cells and hepatic stellate cells, triggering inflammatory cytokines (e.g., TNFα, IL-6) and fibrotic pathways (e.g., TGF-β) (Figure 1) [65,66]. Specifically, cholesterol crystals stimulate the NLRP3 inflammasome, leading to IL-1β release and hepatocyte apoptosis [67], accelerating the progression from steatosis to Non-alcoholic steatohepatitis (NASH). These processes culminate in inflammation, hepatocyte ballooning, and fibrosis, potentially leading to cirrhosis or hepatocellular carcinoma (Figure 1) [68]. The interplay of metabolic overload, genetic predisposition, and oxidative damage underscores MASLD as a lipid-driven disorder with systemic metabolic implications.

2.4. Neurological Disorders

The brain's lipid-rich composition, essential for myelination, synaptic plasticity, and neuronal signaling, makes it susceptible to lipid dysregulation, a key driver of neurodegenerative diseases like Alzheimer's (AD) and Parkinson's (PD) [69]. In AD, the apoE4 allele impairs cholesterol transport and lipid homeostasis, promoting amyloid-beta (Aβ) aggregation by reducing Aβ clearance and increasing plaque formation [70]. Sphingolipid imbalances, particularly ceramide accumulation, destabilize membrane microdomains (lipid rafts), altering amyloid precursor protein (APP) processing and enhancing neurotoxic Aβ production. Moreover, ceramides directly induce neuronal apoptosis and impair synaptic function, exacerbating cognitive decline [71,72]. Oxidative stress exacerbates phospholipid peroxidation, generating reactive aldehydes that damage neuronal membranes and organelles, while oxidized lipids in lipid rafts facilitate pathological Aβ-tau interactions, accelerating neurofibrillary tangle formation [73]. Additionally, oxidized lipids and Aβ peptides act as DAMPs and TLRs on microglia, which trigger NF-κB signaling and pro-inflammatory cytokine release, sustaining chronic neuroinflammation (Figure 1) [74]. In PD, lipid peroxidation products, such as oxidized dopamine derivatives and PUFAs, promote α-synuclein misfolding and aggregation into Lewy bodies, which disrupt synaptic function and cause dopaminergic neuron death. These processes are amplified by mitochondrial dysfunction and impaired antioxidant defenses, linking lipid peroxidation to oxidative damage and neuroinflammation [75,76]. These shared pathways of lipid dysregulation, oxidative stress, inflammation, and mitochondrial impairment highlight the potential for unified therapeutic strategies across neurodegenerative disorders.

2.5. Cancer

Cancer cells reprogram lipid metabolism to fuel uncontrolled growth, using lipids for structural components for membranes, signaling molecules, and energy sources [77]. Hyperactivation of sterol regulatory element-binding proteins (SREBPs), which reside in the ER, drives DNL, upregulating enzymes like fatty acid synthase (FASN) [78] and stearoyl-

CoA desaturase-1 (SCD1) that synthesize and desaturate fatty acids, for lipid storage in lipid droplets for future energy needs [79]. These lipid droplets also buffer oxidative stress and support membrane synthesis during rapid proliferation [80–82]. Lipid signaling pathways, via bioactive lipids like sphingosine-1-phosphate (*S1P*) and Prostaglandin-Endoperoxide Synthase 2 (*PTGS2*), promote angiogenesis, metastasis, and immune suppression. *PGE2*, alongside the PI3K-Akt-mTOR axis, enhances tumor survival, growth, and resistance to apoptosis (Figure 1) [83]. Lipid-derived molecules like lysophosphatidic acid (LPA) and S1P activate pro-tumorigenic pathways, fostering immune evasion and metastatic spread [84]. Furthermore, lipid-laden tumor-associated macrophages (TAMs) adopt pro-tumorigenic phenotypes through TLR-driven pathways, supporting cancer progression and therapy resistance [85]. Cancer cells exhibit metabolic flexibility by scavenging exogenous lipids from the microenvironment, including adipocyte-derived fatty acids in breast cancer, to fuel growth [86] or lipid-rich extracellular vesicles from stromal cells [87]. This adaptability allows tumors to thrive under nutrient-poor conditions while evading therapies [88]. The interplay between intrinsic lipogenic reprogramming and microenvironmental lipid exploitation underscores lipid metabolism as a therapeutic vulnerability, with inhibitors targeting FASN, SREBPs, or lipid signaling pathways emerging as promising strategies to disrupt cancer progression (Figure 1).

3. NcRNAs as Regulators of Lipid Metabolism in Chronic Diseases

Recent high-throughput transcriptomic analyses have shown that up to 90% of eukaryotic genomic DNA is transcribed. However, only 1–2% of these transcripts encode proteins, while the vast majority are ncRNAs [89]. These RNAs are categorized by size and function: small ncRNAs such as miRNAs, which silence mRNAs via base-pairing; small interfering RNAs (siRNAs), involved in RNA interference [90]; and Piwi-interacting RNAs (piRNAs), which suppress transposons and lncRNAs, which scaffold chromatin modifiers (e.g., X-inactive specific transcript (XIST) in X-chromosome inactivation) or organize nuclear structures [91] and circRNAs, formed by back-splicing, act as miRNA sponges (e.g., CDR1as/miR-7) or modulate transcription (Figure 2) [92]. By interacting with DNA, RNA, proteins, or epigenetic machinery, ncRNAs fine-tune cellular homeostasis, development, and disease, with dysregulation linked to cancer, neurodegeneration, and cardiovascular disorders [93]. Their evolutionary conservation and clinical potential as biomarkers or therapeutic targets underscore their biological significance, redefining our understanding of genomic regulation beyond protein-coding genes.

3.1. MiRNAs

MiRNAs are small, conserved ncRNAs, transcribed as primary miRNAs (pri-miRNAs) and processed by Drosha-DGCR8 in the nucleus and Dicer in the cytoplasm into mature miRNAs [94,95]. They primarily regulate gene expression post-transcriptionally by incorporating into the RNA-induced silencing complex (RISC) and binding complementary sequences in the 3′ untranslated region (3′UTR) of target mRNAs, leading to translational repression or mRNA degradation [96]; for example, oncogenic miR-21 silences tumor suppressors like *PTEN*, promoting cancer progression [97–99]. A single miRNA can target hundreds of mRNAs, forming extensive regulatory networks essential for development, cell differentiation, proliferation, apoptosis, and metabolism [100]. Additionally, miRNAs influence epigenetic regulation by targeting enzymes like DNMT3B, a DNA methyltransferase; their downregulation in cancers leads to DNMT3B overexpression, causing hypermethylation of CpG islands in tumor suppressor gene promoters, silencing genes critical for cell cycle control and apoptosis, while miRNA-mediated suppression of DNMT3B can restore hypomethylation to reactivate these genes [101,102].

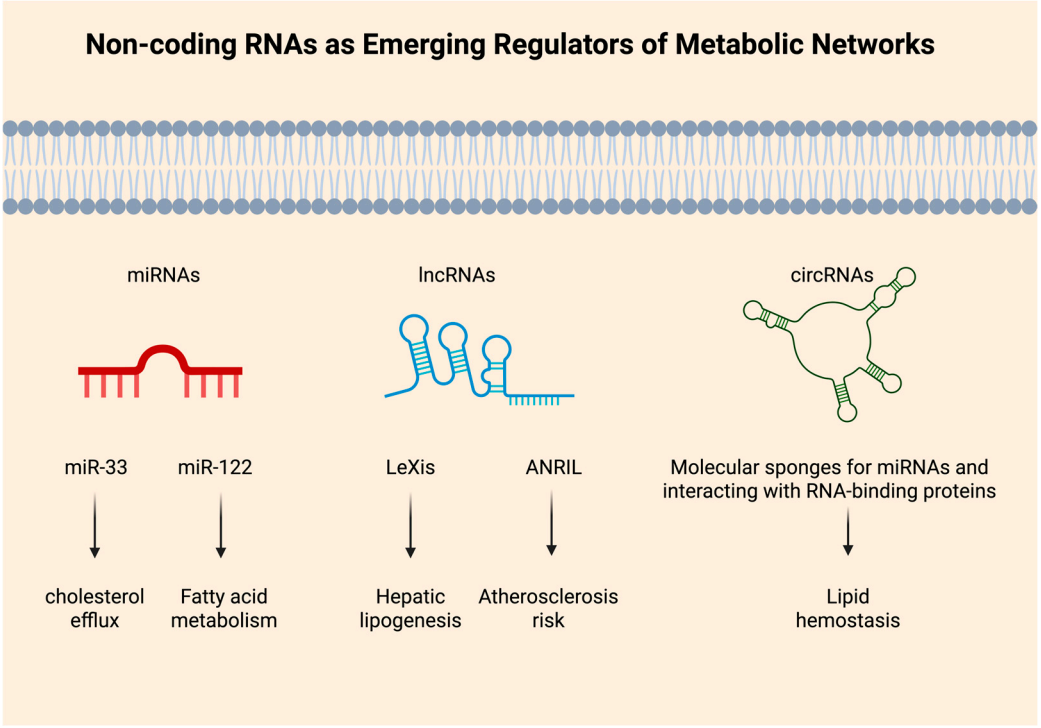


Figure 2. Regulatory roles of ncRNAs in lipid metabolism.

miRNAs critically regulate lipid metabolism by targeting multiple genes simultaneously [103]. They bind to mRNAs, repressing key enzymes (e.g., HMG-CoA reductase (HMGCR), FASN) [104], lipid transporters (e.g., ABCA1, CD36) [105,106], and transcription factors (e.g., PPARα, SREBP-1c) [107,108] involved in lipid synthesis, oxidation, and trafficking. In chronic diseases like atherosclerosis, T2D, MASLD, and AD, dysregulated miRNA expression disrupts lipid homeostasis, driving lipid accumulation, inflammation, and disease progression. Table 1 examines miRNAs as regulators of lipid metabolism and their specific roles in chronic diseases.

Table 1. MiRNAs involved in lipid metabolism.

miRNA	Target	Effect	Disease	References
miR-27b	*HMGCR*	Cholesterol synthesis	MASLD	[109,110]
miR-27a	Peroxisome Proliferator-Activated Receptor Gamma (*PPARγ*)	Triglyceride accumulation, Adipogenesis	T2D, MASLD	[111,112]
miR-21	Secreted Frizzled-Related Protein 5 (*SFRP5*), vascular cell adhesion molecule 1 (*VCAM-1*), Peroxisome Proliferator-Activated Receptor Alpha (*PPARα*), *PTEN/AKT* signaling, *TNFα*, *IL-6*	Liver lipid-induced inflammation and fibrosis, decrease fatty acid oxidation, and increase lipid accumulation and Lipogenesis	MASLD/NASH, Atherosclerosis, T2D, DKD	[113–120]
miR-122	*SREBP-1c*, Carnitine palmitoyltransferase 1A (*CPT1A*), *PPARα*	Promotes DNL by targeting suppressors of lipogenesis, increases VLDL production, and causes hypertriglyceridemia	MASLD/NASH, T2D	[108,121–123]

Table 1. *Cont.*

miRNA	Target	Effect	Disease	References
miR-33a/b	*CPT1A*, ATP-binding cassette transporter A1 and G1 (*ABCA1*, *ABCG1*)	Represses fatty acid oxidation, reduces cholesterol, and Aβ efflux	Atherosclerosis, AD	[124–127]
miR-223	Scavenger Receptor Class B Type 1 (*SCARB1* or *SR-B1*), *ABCA1*	Dysregulation of HDL cholesterol uptake and inflammation	Atherosclerosis, CVD, MASLD	[128–131]
miR-20a-5p	*CD36*	Lipid uptake and storage	MASLD, T2D, CVD	[132–134]
miR-34a	Sterol Regulatory Element Binding Transcription Factor 1 (*SREBF1*), *PPARα*	Increases lipogenesis, less mitochondrial and peroxisomal fatty acid oxidation	MASLD/NASH, T2D, AD	[135–138]
miR-10b	*PPARα*, transforming growth factor beta 1 (*TGF-β1*)	Fatty acid oxidation and lipid accumulation	MASLD	[139,140]
miR-96	Adipose Triglyceride Lipase (*ATGL*), *ABCA1*, *SREBP2*	Represses intramuscular lipolysis, fatty acid oxidation, and uptake of HDL-associated cholesteryl esters	Atherosclerosis	[141–143]
miR-144	*ABCA1*	Decrease cholesterol efflux and HDL levels	Atherosclerosis	[144,145]
miR-155	*ABCA1*, Liver X Receptor α (*LXRα*)	Decrease cholesterol efflux and HDL formation	Atherosclerosis, T2D, AD	[146–150]
miR-29	*HMGCR*, *SREBP-1c*, Insulin Receptor Substrate 1 (*IRS1*), *AKT3*, *PPARδ*, *GSK3β/SIRT1*	Impairs insulin signaling, decreases fatty acid synthesis, and cholesterol production	MASLD/NASH, T2D, DKD	[151–155]
miR-143	oxysterol-binding protein-related protein 8 (*ORP8*), *IRS1*, *MAP2K5–ERK5*	Impairs insulin signaling, Adipogenesis	Atherosclerosis, T2D	[156–158]
miR-375	Adiponectin Receptor 2 (*AdipoR2*)	Decreases lipid oxidation	MASLD, T2D	[159–161]
miR-320	*IRS1*, *CD36*	Increase lipid accumulation	MASLD, T2D	[162,163]
miR-192	*SREBF1*, *SCD1*, *PPARα*	Increase lipid accumulation	MASLD/NASH, T2D	[164–166]
miR-106b	*ABCA1*, *PTEN*	Impairs cholesterol efflux	Atherosclerosis, AD, MASLD	[167–169]
miR-146a	Mediator complex subunit 1 (*MED1*), Tumor necrosis factor receptor-associated factor 6 (*TRAF6*)	Increase lipid accumulation	MASLD, AD, Atherosclerosis	[170–173]
miR-125	ELOVL fatty acid elongase 6 (*Elovl6*), *NF-κB* signaling, Sphingosine Kinase 1 (*SphK1*)	Increase lipid accumulation and inflammation	T2D, MASLD, AD	[174–176]

Table 1. *Cont.*

miRNA	Target	Effect	Disease	References
miR-137	AMP-activated protein kinase (*AMPKα*), Calcium channel subunit (*CACNA1C*), *PTGS2*	Decrease lipid accumulation, decrease inflammation,	MASLD, AD	[177,178]
miR-210	Insulin-like Growth Factor 2 (*IGF2*), Suppressor of Cytokine Signaling 1 (*SOCS1*)	Decrease lipid accumulation and inflammation,	Atherosclerosis, T2D	[179,180]
miR-124	Preadipocyte factor-1 (*Pref1*), *SREBP2*	Regulates triglyceride contents in hepatocytes, Lipid droplet formation	MASLD, Atherosclerosis	[181–184]
miR-130b	*PPARγ*, *TNFα*	Inflammation in adipose tissue and insulin sensitivity	Obesity, T2D	[185,186]
miR-126	*SCARB1*, hypoxia-inducible factor 1α (*HIF1α*)	Suppressing vascular inflammation	CVD	[187]
miR-148a	LDL receptors (*LDLR*), *ABCA1*	Regulates LDL-cholesterol uptake	Atherosclerosis	[188,189]
miR-103	Caveolin-1 (*CAV1*), *SFRP4*	Decreases adipocyte size and enhances insulin-stimulated glucose uptake	MASLD/NASH, T2D	[190,191]
miR-107	*CAV1*	Decreases adipocyte size and enhances insulin-stimulated glucose uptake	MASLD/NASH, T2D	[190]
miR-145	*TNFα*, *NF-κB*	Inflammation in adipose tissue	Obesity, Atherosclerosis	[192]
miR-7	*LXR*, *ABCA1*, 24-dehydrocholesterol reductase (*DHCR24*)	Regulates cholesterol efflux	AD, T2D	[193]

3.2. LncRNAs

LncRNAs are transcripts longer than 200 nucleotides, lacking significant open reading frames, and exhibit high sequence and structural diversity with tissue-specific and developmental stage-specific expression [194]. They regulate gene expression through multiple mechanisms: at the transcriptional level, lncRNAs can function as scaffolds for chromatin-modifying complexes such as Polycomb Repressive Complex 2 (*PRC2*) or interact with transcription factors and RNA polymerase II. For example, lncRNA-XIST recruits PRC2 to deposit repressive H3K27me3 marks, facilitating X-chromosome inactivation in females [195], while lncRNA-PANDA sequesters the transcription factor *NF-YA* to suppress pro-apoptotic gene expression during cellular stress responses [196]; post-transcriptionally, by modulating mRNA stability, translation, or splicing, such as lncRNA-NORAD, which binds PUMILIO proteins to stabilize pro-survival mRNAs during stress [197]; epigenetically, lncRNA-ANRIL promotes cancer by recruiting the *PRC1* and *PRC2* complexes to the *INK4/ARF* gene region, leading to the silencing of tumor suppressor genes such as $p16^{INK4a}$ and $p14^{ARF}$ through H3K27m3 and H2A ubiquitination [25,198]. Additionally, some lncRNAs regulate gene expression by acting as microRNA sponges, a mechanism known as competing endogenous RNA (ceRNA) activity. For example, lncRNA-H19 produces

miR-675 and can also bind (sponge) it to protect the tumor suppressor RB (retinoblastoma protein). However, when lncRNA-H19 is overexpressed in cancer, excess miR-675 is released, which can suppress RB and contribute to tumor progression [199,200].

LncRNAs are pivotal regulators of lipid homeostasis, orchestrating lipid biosynthesis, storage, and signaling through transcriptional, post-transcriptional, and epigenetic mechanisms [201]. By interacting with RNA-binding proteins, miRNAs, or chromatin-modifying complexes, lncRNAs modulate key regulators like *SREBP-1c*, *PPARs*, and liver X receptors (*LXR*), balancing lipid synthesis and catabolism [202]. Dysregulation of lncRNAs disrupts this equilibrium, driving lipid accumulation, inflammation, and metabolic dysfunction in chronic diseases (Table 2) [203]. Their roles as molecular scaffolds or signaling modulators position lncRNAs as critical players in disease pathogenesis and promising therapeutic targets or biomarkers.

Table 2. LncRNAs involved in lipid metabolism.

lncRNA	Target	Effect	Disease	References
lnc-LeXis	RNA-binding protein RALY	Increases the hepatic cholesterol	MASLD/NASH	[204,205]
lnc-LSTR	*TDP-43*, *Cyp8b1*	Regulates bile acid composition, which influences lipid absorption and metabolism	Atherosclerosis	[206,207]
lnc-MALAT1	*ABCA1*, miRNA-17-5p, *PPARα/CD36*, miR-206, miR-382-3p	Inhibits glucose uptake and lipogenesis, increases cholesterol accumulation	Atherosclerosis, MASLD, T2D, DKD	[208–212]
lnc-H19	MLX-interacting protein-like (*MLXIPL*), *mTORC1*, *PPARγ*, miR-130b-3p	Increases lipid synthesis and accumulation, adipogenesis	MASLD, Atherosclerosis, DKD	[213–215]
lnc-ANRIL	Cyclin-dependent kinase inhibitor (*CDKN2A/B*), *PRC1/2*, *NF-κB*, *ADIPOR1*, *VAMP3*, *C11ORF10*	Impair cholesterol efflux, glycolipid metabolism	Atherosclerosis	[216–219]
lnc-BLNC1	Early B-cell factor 2 (*EBF2*), uncoupling protein 1 (*UCP1*), *SREBP1c*	Exacerbate insulin resistance, lipid accumulation, and adipogenesis	MASLD, T2D	[220–222]
lnc-MEG3	mir-21, Low-density lipoprotein receptor-related protein 6 (*LRP6*), Sirtuin 6 (*SIRT6*), *FOXO1*, Acetyl-CoA Carboxylase 1 (*ACC1*)	FFA-induced lipid accumulation	MASLD, T2D	[223–226]
lnc-LINC00473	*UCP1*, Cyclic adenosine monophosphate (*cAMP*), Perilipin 1 (*PLIN1*)	Lipolysis, respiration process, and mitochondrial oxidative metabolism	T2D	[227,228]
lnc-ADINR	*c/EBPα*, histone methyltransferase complex (*MLL3/4*), *PA1*	Adipogenesis	Obesity	[229,230]

Table 2. *Cont.*

lncRNA	Target	Effect	Disease	References
lnc-NEAT1	*ATGL*, CCAAT/enhancer-binding protein α (*CEBPα*), *PPARγ*, miR-140, AMPK/SREBP-1 signaling, miR-146a-5p/*ROCK1*	Adipogenesis, lipolysis	MASLD, Atherosclerosis, AD	[231–236]
lnc-CHROME	miR-27b, miR-33a/b, miR-128, *ABCA1*	Cholesterol secretion and HDL synthesis,	Atherosclerosis	[237,238]
lnc-TUG1	miR-204/SIRT1, *PPARα*	Fatty acid β-oxidation	Obesity, T2D	[239–241]
lnc-Dnm3os	*NF-κB*, Nucleolin	Glucose uptake and increasing free fatty acid, inflammation-induced lipid accumulation	T2D	[242]
lnc-HI-LNC45	Unknown	β-cell dysfunction	T2D	[243,244]
lnc-SNHG1	Glutathione peroxidase 4 (*GPX4*), Nuclear factor erythroid 2-related factor 2 (*NRF2*), Nuclear Receptor Coactivator 4 (*NCOA4*), *CD98*, Polypyrimidine tract-binding protein 1 (*PTBP1*), miR-7/*NLRP3*,	Fatty acid β-oxidation, ferroptosis, adipogenic differentiation	PD	[245–247]
lnc-NRON	*PER2/Rev-Erbα/FGF21*, *AMPK*	Hepatic lipid homeostasis enhances adipose function via triacylglycerol hydrolysis	MASLD, T2D, Atherosclerosis	[248–251]
lnc-UCA1	*PPARα*, miR-30a-3p, retinoid X receptor α (*RXRα*), miR-143-3p, miR-214	Promotes lipid accumulation, mitochondrial dysfunction	T2D, MASLD, PD	[252–255]
lnc-MIAT (GOMAFU)	*IL-1β*, *IL-6*, and Tumor necrosis factor alpha (*TNFα*), *HIF1α*, *FOXO1*, miR-139-5p	Increases lipid content and reduces collagen content in the plaques, microvascular dysfunction, and promotes hepatic insulin resistance	Atherosclerosis, CVD, T2D	[256–259]
lnc-Gm15622	*SREBP-1c*, miR-742-3p	Lipid accumulation in hepatocytes	MASLD	[260]
lnc-HNF4A-AS1	Methyltransferase-like 3 (*METTL3*)	Regulates intracellular polyunsaturated fatty acids (PUFA)	MASLD	[261]

3.3. CircRNAs

CircRNAs are covalently closed-loop structures formed by back-splicing of pre-mRNAs, comprising exons, introns, or both, and lack 5′ caps and 3′ tails, making them resistant to exonuclease degradation and highly stable. They regulate gene expression by acting as miRNA sponges, such as *CDR1as* (*ciRS-7*), which sequesters miR-7 to protect mRNA targets involved in brain development and neurodegeneration [262], or as protein

scaffolds, like circFOXO3 (Forkhead box protein O3) which binds the E3 ubiquitin ligase MDM2 to stabilize the tumor suppressor FOXO3, enhancing stress resistance in cardiomyocytes [263]. Some circRNAs, like circEIF3J, bind RNA polymerase II at gene promoters to stabilize the transcription initiation complex and enhance host gene expression [264]. Emerging evidence suggests certain circRNAs can be translated into peptides via Internal Ribosome Entry Site (IRES) elements [265]. They are implicated in neuronal development, synaptic function, and cancer, with their stability and tissue-specific expression making them promising biomarkers.

CircRNAs are stable, covalently closed RNA molecules that regulate lipid metabolism and contribute to chronic diseases [266]. CircRNAs act as miRNA sponges, molecular scaffolds, and transcriptional regulators, modulating lipid enzymes, transporters, and gene expression [267]. By sequestering miRNAs, scaffolding proteins, or enhancing transcription, they fine-tune lipid biosynthesis, cholesterol efflux, and adipogenesis [268,269]. Dysregulation of circRNAs disrupts lipid homeostasis, promoting lipid accumulation, inflammation, and disease progression, making them promising biomarkers and therapeutic targets for lipid-driven pathologies (Table 3) [270].

Table 3. CircRNAs involved in lipid metabolism.

circRNA	Target	Effect	Disease	References
circRNA-0046367 circRNA-0046366	miR-34a/*PPARα*	β-oxidation of fatty acids	MASLD/NASH	[271–273]
circRNA-0001452 circRNA-0001453 circRNA-0001454	miR-466i-3p, miR-669c-3p, *AMPK*	Promotes the transcription and translation of lipogenic genes	MASLD	[274]
circRNA-0071410	miR-9-5p	Fibrosis development	MASLD/NASH	[272,275]
circRNA-SCD1	*JAK2/STAT5*	Hepatic lipid droplet formation	MASLD	[276,277]
circRNA-ABCA1	miR-140-3p/*MAP2K6*	Promotes cholesterol efflux to apolipoprotein A-I (apoA-I), β-oxidation of fatty acids	CVD, Atherosclerosis	[278–280]
circRNA-ANRIL	*INK4/ARF*, pescadillo homologue 1 (*PES1*)	Glycolipid metabolism, plaque growth	Atherosclerosis	[219,281–283]
circRNA-HIPK3	miR-192-5p, *FOXO1*, miR-190b, miR-106a-5p/*MFN2*	Effect of oleate on adipose deposition, Insulin resistance	Atherosclerosis, T2D, MASLD	[272,284–287]
circRNA-021412	miR-1972, Lipin 1 (*LPN1*)	Promotes liver steatosis and inflammation	MASLD	[288–290]
circRNA-SAMD4A	miR-138-5p/*EZH2*	Dysregulated adipogenesis and insulin signaling	Obesity	[291]
circRNA-LARP1B	*cAMP/PKA* signaling, Phosphodiesterase 4C (*PDE4C*)	Promotes lipid accumulation	Atherosclerosis	[292,293]
circRNA-ACC1	miR-338-3p, *AMPK-ABCA1/ABCG1*	β-oxidation of fatty acids	MASLD	[294,295]

Table 3. *Cont.*

circRNA	Target	Effect	Disease	References
circRNA-FUT10	*let-7c/let-e*, *PPAR1β*	Inhibit the differentiation of adipocytes	Obesity, T2D	[296]
circRNA-0000660	miR-693, Insulin-like Growth Factor Binding Protein 1 (*IGFbp1*)	Liver lipid accumulation	Obesity	[297]
circRNA-0003546	miR-326, *PDE3B*	Increases Lipid efflux	Atherosclerosis	[298]
circRNA-0092317	miR-543, miR-326, *PDE3B*	Increases Lipid efflux	Atherosclerosis	[298]
circRNA-ARF3	miR-103, TNF receptor-associated factor 3 (*TRAF3*)	Inflammation in adipose tissue	Obesity	[299]

3.4. Other Subclasses of ncRNAs

Beyond miRNAs, lncRNAs, and circRNAs, several specialized ncRNA subclasses contribute to gene regulation. Small nucleolar RNAs (snoRNAs) guide site-specific chemical modifications, such as 2′-O-methylation and pseudouridylation, in ribosomal RNAs (rRNAs) and small nuclear RNAs (snRNAs), ensuring proper ribosome assembly, with dysregulation linked to ribosomopathies like Prader–Willi syndrome [300]. PiRNAs, slightly longer than miRNAs, partner with PIWI-clade Argonaute proteins to silence transposable elements in germline cells, securing genomic stability and fertility through epigenetic regulation, with aberrant expression implicated in cancers and infertility [301,302]. snRNAs, such as U1 and U2, are core spliceosome components, directing precise intron removal during pre-mRNA splicing to generate mature transcripts [303]. Enhancer RNAs (eRNAs), transcribed from active enhancer regions, promote chromatin looping or recruit transcriptional coactivators like the Mediator complex to amplify target gene expression, influencing cell identity and disease states like cancer [304]. These subclasses fine-tune RNA processing, genome defense, and transcriptional activation, collectively shaping cellular function and adaptability, with dysregulation contributing to chronic diseases like cancer and infertility.

4. NcRNA-Lipid Interaction Networks Across Organ Systems

NcRNAs form multi-tiered interaction networks that maintain systemic lipid homeostasis. These networks operate inter-organically, enabling crosstalk between the liver, adipose tissue, brain, and vasculature [305], while intra-organically fine-tuning tissue-specific responses by intersecting with inflammatory and oxidative stress pathways [306]. This integration allows ncRNAs to synchronize metabolic flux, inflammation, and redox signaling across organs, thereby preserving physiological equilibrium or, upon dysregulation, propagating diseases like MASLD, obesity, and cardiovascular disorders through amplified lipotoxicity and impaired lipid trafficking [220,307].

Systemic lipid crosstalk relies on circulating ncRNA–lipid complexes, where ncRNAs, primarily miRNAs, are trafficked via extracellular vesicles (EVs) (e.g., exosomes, microvesicles) or directly bound to lipoproteins (e.g., HDL), acting as endocrine messengers that transmit metabolic signals across organs [308,309]. Hepatocyte-derived EVs, enriched in miRNAs like miR-122 (constituting 70% of hepatic miRNAs) and miR-192, are internalized by adipocytes to suppress *PPARα* and *AdipoR1*, reducing lipid oxidation and altering adipokine secretion (e.g., adiponectin, leptin) [122,310,311], while adipose tissue

releases EVs carrying miR-27 or miR-130b to inhibit hepatic *PPARγ*, curbing lipogenesis and VLDL assembly, establishing a bidirectional liver-adipose axis [312]. Beyond EVs, lipoprotein-ncRNA complexes exhibit cargo specificity: HDL transports miR-223 and miR-126 to endothelial cells, promoting *ABCA1/G1*-mediated cholesterol efflux and suppressing vascular inflammation [131,187], whereas LDL-bound miR-148a enhances lipid uptake by targeting *LDLR* [189]. Dysregulation of this network illustrates how ncRNA-lipid shuttling synchronizes inter-organ metabolism but propagates disease when disrupted.

4.1. Liver

The liver orchestrates lipid homeostasis through hierarchically organized ncRNA networks that precisely control synthesis, oxidation, and lipoprotein export [313]. MiRNAs like miR-33a/b (embedded in *SREBP2/1* introns) suppress *ABCA1* and *ABCG1* to limit cholesterol efflux, simultaneously inhibiting *CPT1A* and *HADHB* to repress fatty acid β-oxidation, thereby promoting lipid retention [125–127]. LncRNAs exert epigenetic control: *HNF4A-AS1* binds to *METTL3*, promoting m6A modification of *DECR1* mRNA. This modification facilitates *YTHDF3*-mediated degradation of *DECR1*, reducing its expression. When *HNF4A-AS1* is downregulated, *DECR1* expression increases, which lowers intracellular PUFA levels and confers resistance to sorafenib-triggered ferroptosis in hepatocellular carcinoma [261,314]. The downregulation of *MEG3* in vitro and vivo models of MASLD showed a negative correlation with lipogenesis-related genes [226]. CircRNAs fine-tune these networks via competitive sponging; circRNA_0046367 (downregulated in steatosis) adsorbs miR-34a, preventing its repression of *SIRT1* and *PPARα*, thereby boosting β-oxidation of fatty acids (Figure 3) [205].

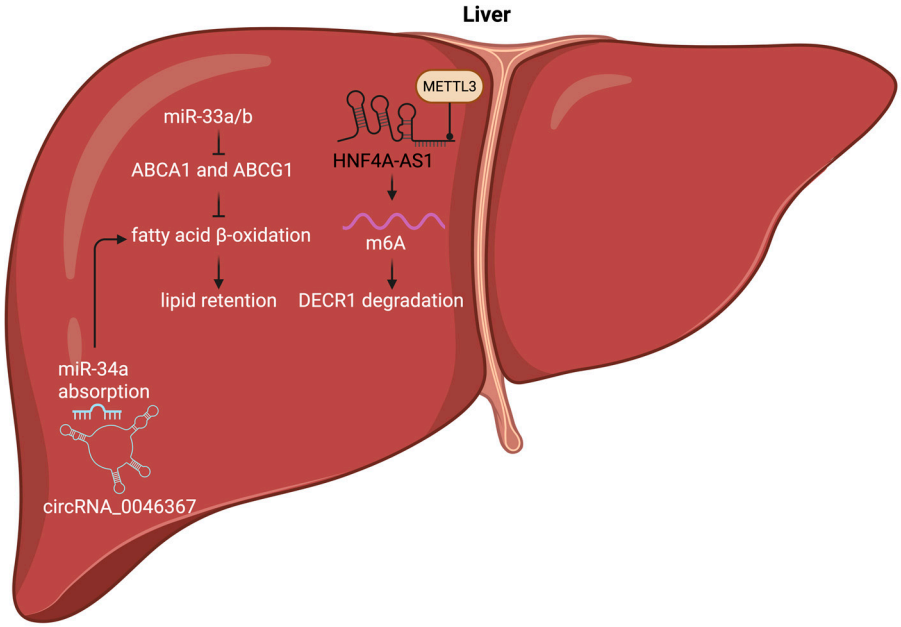


Figure 3. NcRNA–lipid interaction networks across liver.

4.2. Adipose Tissue

Adipose tissue employs a sophisticated ncRNA regulatory framework to govern adipogenesis, lipid storage dynamics, and systemic metabolic crosstalk (Figure 4) [315]. MiRNAs such as miR-143 regulate adipogenesis by modulating the *MAP2K5-ERK5* signaling [156]. In adipocytes, suppression of miR-103/107 leads to increased caveolin-1 expression, which stabilizes the insulin receptor, enhances insulin signaling, reduces adipocyte size, and improves insulin-stimulated glucose uptake. These results highlight the critical role of miR-103/107 in regulating insulin sensitivity and suggest a potential therapeutic target for type

2 diabetes and obesity [190,191]. MiR-145 promotes TNF-α production, and it induces inflammation by activating *NF-κB* in human adipose tissue [192]. LncRNAs orchestrate chromatin remodeling: lncRNA-ADINR plays an important role in regulating the differentiation of human mesenchymal stem cells into adipocytes by modulating *C/EBPα*. *ADINR* regulates the differentiation of human mesenchymal stem cells into adipocytes by controlling *C/EBPα* expression in a cis-acting manner [230]. On the other hand, lncRNA-Blnc1 enhances thermogenic gene activation in brown adipocytes by assembling a ribonucleoprotein complex with *hnRNPU* and *EBF2* [221]. CircARF3 acts as a sponge for miR-103, relieving its inhibition on TRAF3 and thereby increasing *TRAF3* expression. Through this mechanism, circARF3 promotes mitophagy and reduces inflammation in adipose tissue [299]. Crucially, adipose-derived exosomal ncRNAs mediate inter-organ signaling, obese adipocytes release exosomes enriched in miR-27a (targeting hepatic *PPARγ*), and miR-27a secreted into circulation by adipose tissue may regulate insulin resistance in skeletal muscle [111]. MiR-130b suppresses *PPARγ*, thereby influencing macrophage polarization, promoting adipose tissue inflammation, and impairing insulin sensitivity [186]. Dysregulation in obesity triggers pathogenic feedback loops; the expression of miR-155 plays a role in the link between adipose tissue dysfunction and the development of obesity associated disorders, including T2D [186]. This ncRNA-driven dysfunction promotes ectopic lipid deposition, insulin resistance, and meta-inflammation, positioning adipose ncRNAs as both biomarkers and therapeutic targets for metabolic syndrome.

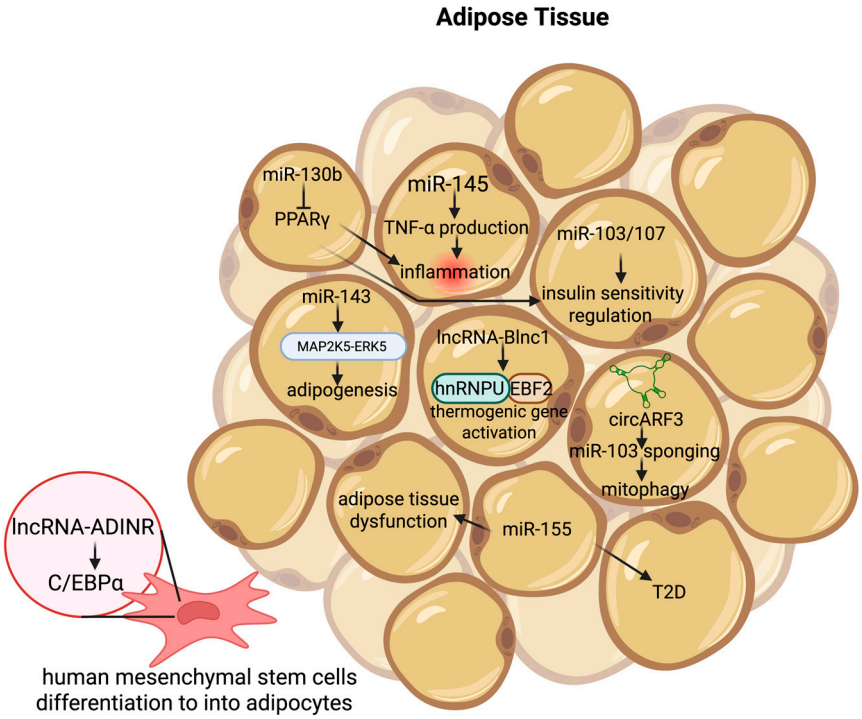


Figure 4. NcRNA–lipid interaction networks across adipose tissue.

4.3. Brain

The brain holds nearly 25% of the body's total cholesterol, with about 70–80% localized in myelin, where it plays an essential role in insulation [316]. MiRNAs such as miR-33 overexpression disrupts cholesterol efflux and elevates extracellular Aβ levels by enhancing its secretion and reducing its clearance in neural cells [124]. MiR-124 regulates *SREBP2* levels and lipid droplet formation in microglia [184]. Knockdown of lncRNA-*NEAT1* prevents post-stroke lipid droplet agglomeration in microglia by regulating autophagy [236]. MiR-155/*MafB* axis also contributes to dyslipidemia and atherosclerosis in cerebrovascular

disease, which is one of the AD-related modifiable risk factors [150]. MiR-7 controls cholesterol biosynthesis through posttranscriptional regulation of *DHCR24* expression in AD [193]. These disruptions position ncRNA–lipid crosstalk as a pivotal axis in neurodegenerative pathogenesis and a potential biomarker/therapeutic target (Figure 5).

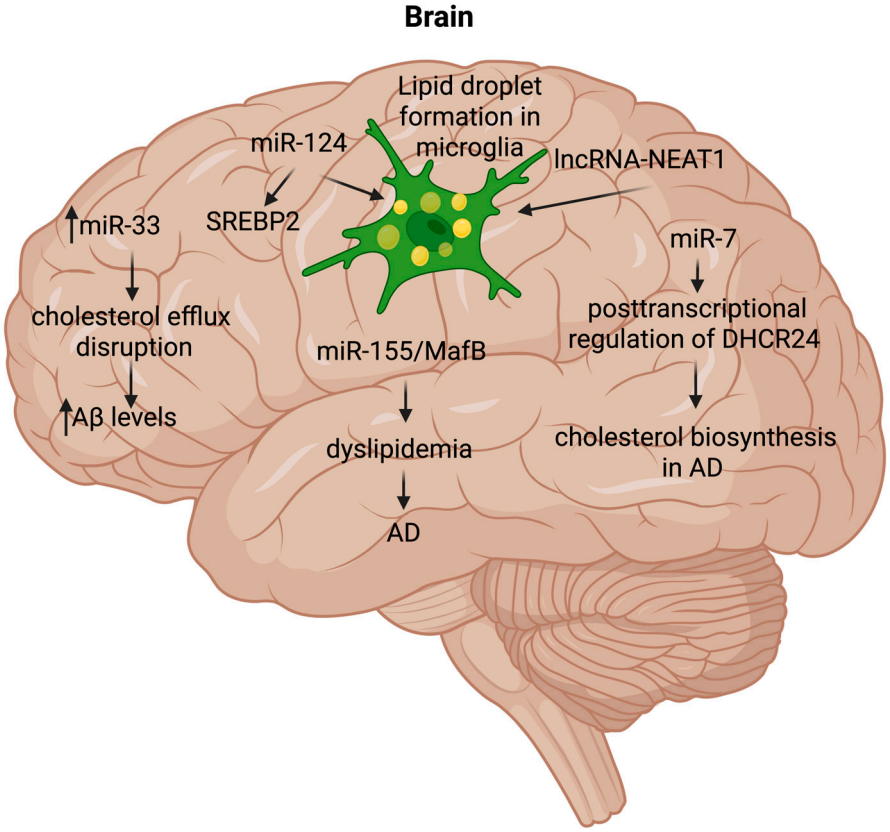


Figure 5. NcRNA–lipid interaction networks across brain.

4.4. Vasculature

NcRNA networks act in a cell-type-dependent manner within the vasculature, where endothelial cells (ECs) and vascular smooth muscle cells (VSMCs) rely on different ncRNA sets to regulate lipid metabolism, preserve barrier function, and control inflammation, thereby maintaining vascular protection while counteracting atherosclerosis (Figure 6) [317]. Endothelial miRNA, like miR-223-3p, modulates cholesterol metabolism through directly or indirectly targeting genes related to cholesterol transport, biosynthesis, and efflux. Both HDL-carried miR-223-3p and hepatocyte-expressed miR-223-3p could execute the regulatory function. MiR-223-3p could inhibit the expression of *SR-BI*, while the inhibition could lead to reduced uptake of HDL-carried miR-223-3p from plasma, so this loop regulation may be one of the mechanisms helping to maintain the cholesterol homeostasis at the cellular or systemic level [129]. Diet-induced hypercholesterolaemia alters the miRNA composition of HDL, resulting in increased levels of miR-126, which can be transferred to ECs and disrupt essential vascular processes [187]. In VSMCs, MiR-145-5p modulated lipid metabolism and M2 macrophage polarization by targeting *PAK7* and regulating β-catenin signaling in hyperlipidemia, which may provide a potential biomarker for the treatment of hyperlipidemia-induced cardiovascular diseases [318]. LncRNA-H19 induces lipid metabolic disorders in foam cells by suppressing lipid metabolism and increasing lipid accumulation, which contribute to the progression of atherosclerosis and participate in vascular physiopathology and angiogenesis [215]. Moreover, lncRNA-ANRIL modulates vascular endothelial function and affects macrophage cholesterol handling, linking it to

both atherosclerosis progression and impaired lipid metabolism [216]. CircRNA-ABCA1 is up-regulated in atherosclerotic aortic vessels and H_2O_2-treated ECs. It has potential regulatory effects on atherosclerosis and vascular endothelial injury by targeting miR-30d-3p-TP53RK and miR-140-3p-MKK6 axis and their downstream signaling pathways [279]. CircRNA-ABCA1 promoted cholesterol biosynthesis by regulating miR-140-3p/HMGCR and *HMGCS1* axis. It is worth mentioning that *ABCA1* promotes cholesterol efflux to apolipoprotein A-I (*apoA-I*) to suppress foam cell formation [278].

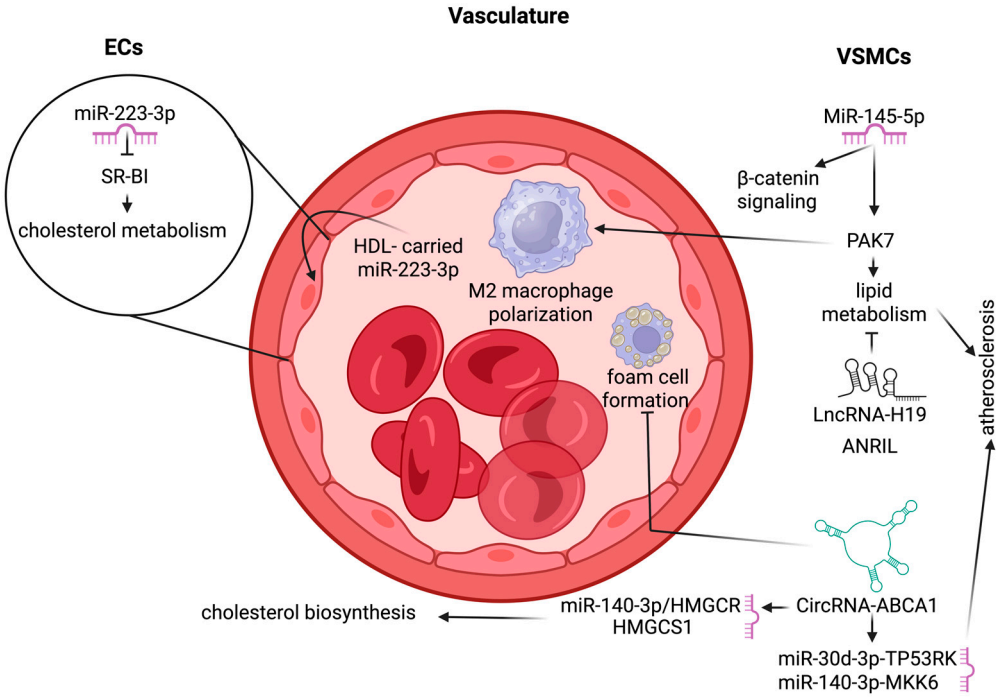


Figure 6. NcRNA–lipid interaction networks across vasculature.

4.5. Kidney

Recent studies have highlighted that ncRNAs are not only involved in hepatic or vascular lipid dysfunction but also play central roles in renal injury associated with metabolic disorders. For instance, miR-21 is upregulated in diabetic nephropathy (DN), and its silencing ameliorates mesangial expansion, interstitial fibrosis, podocyte loss, inflammatory gene expression, and albuminuria in diabetic mouse models [319]. In human patients, serum miR-21 correlates with structural and functional markers of DN (e.g., GBM thickening, albumin-creatinine ratio) [320]. Another miRNA, miR-29b, shows increased urinary levels in early Diabetic kidney disease (DKD) and is negatively associated with renal function. Its overexpression exacerbates podocyte injury via suppression of mitochondrial biogenesis regulator *PGC-1α*, while inhibition of miR-29b preserves podocyte integrity in mouse DKD models [321]. On the lncRNA side, *MALAT1* is significantly upregulated in peripheral blood mononuclear cells of DKD patients and correlates with albuminuria, urinary β_2- and α_1-microglobulin, creatinine, and *HbA1c* [322]. In renal tubular epithelial cells under high glucose, *MALAT1* promotes injury via interactions with *LIN28A* and *Nox4*, affecting the AMPK/mTOR pathway. Its knockdown reduces apoptosis, reactive oxygen species, and inflammatory cytokine secretion [323]. LncRNA-p21 is induced in renal tubule cells under lipotoxic conditions (high-fat diet or palmitic acid exposure), its tubule-specific deletion reduces oxidative stress, inflammation, apoptosis, and histologic kidney injury despite ongoing hyperlipidemia [324]. LncRNA H19, alleviates renal tubulointerstitial fibrosis via reducing lipid accumulation and triglyceride content through modulating the miR-130a-3p/*ACSL1* axis in mouse kidneys and in vitro [325]. These examples together strengthen

the argument that lipid-metabolic dysregulation mediated by ncRNAs plays a substantial role in DKD and chronic kidney disease pathogenesis and offers both mechanistic insight and potential biomarkers/therapeutic targets (Figure 7).

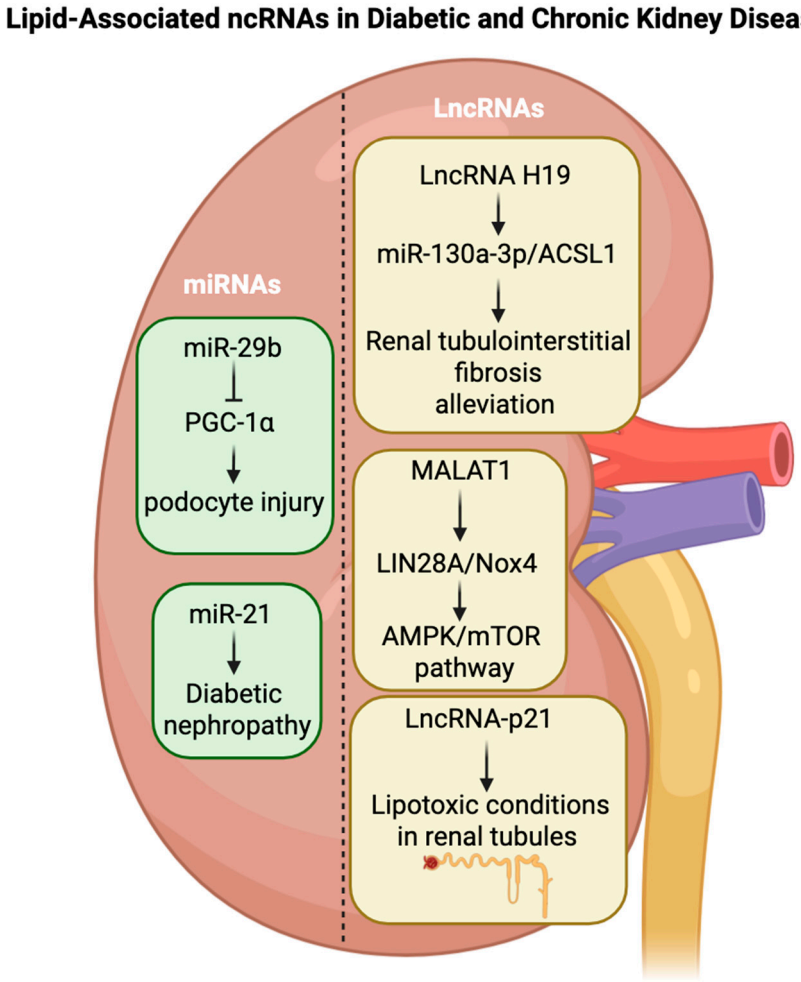


Figure 7. Lipid-associated ncRNAs in diabetic and chronic kidney diseases.

4.6. Cross-Study Comparative Analysis of ncRNA–Lipid Associations Across Organ Systems

A cross-study comparison highlights that a set of ncRNAs recur across cardiovascular, metabolic, and hepatic diseases and that these molecules often converge on a few shared lipid-handling hubs. In CVDs, the association between lipids and ncRNAs manifests prominently through dysregulated cholesterol homeostasis and inflammatory signaling. For instance, miR-33a/b targets *ABCA1* and *ABCG1* to inhibit cholesterol efflux, promoting foam cell formation and plaque progression in atherosclerosis [22,126,127]. Similarly, lncRNA-MALAT1 exacerbates lipid accumulation by sponging miR-206, leading to endothelial dysfunction and vascular inflammation [212]. In contrast, hepatic disorders like MASLD show overlapping yet distinct cross-talk, where miR-122 enhances DNL by suppressing *PPARα*, resulting in triglyceride buildup and steatosis [22,121–123]. Cross-comparisons reveal that while CVD studies emphasize oxLDL-driven ncRNA alterations (e.g., miR-155 inhibiting *ABCA1*) [148,211], hepatic research highlights FFA-induced endoplasmic reticulum stress modulating ncRNAs like lnc-MEG3, which reduces lipid accumulation via SIRT6/FOXO1 pathways [223,225]. This suggests a shared inflammatory lipid mediator role, such as ceramides, but with tissue-specific outcomes: vascular plaque instability in CVD versus hepatocyte ballooning in MASLD.

Metabolic changes in obesity and T2D underscore the lipids-ncRNAs interplay through insulin resistance and ectopic lipid deposition, often compared to hepatic pathologies for their interconnected pathways. miR-27a targets *PPARγ* to promote triglyceride accumulation in adipocytes [111], mirroring its role in hepatic DNL upregulation in MASLD models [112] where it correlates with increased VLDL secretion and hypertriglyceridemia. LncRNA-BLNC1, by enhancing *SREBP1c* activity, drives adipogenesis and insulin resistance in obese tissues, a mechanism echoed in diabetic hepatic steatosis via similar SREBP-mediated lipogenesis [122]. However, cross-study analyses highlight divergences: metabolic-focused research, such as in high-fat diet, links ceramide accumulation to ncRNA dysregulation (e.g., miR-34a inhibiting *PPARα* and leads to less mitochondrial and peroxisomal fatty acid oxidation), fostering systemic inflammation [52,136], whereas hepatic studies emphasize cholesterol crystal activation of *NLRP3* inflammasomes via ncRNAs like circRNA-0046367 [60,61,67,205]. This cross-talk convergence points to exosomal ncRNA transfer (e.g., adipocyte-derived miR-130b suppressing hepatic *PPARγ*) [186,308,312], amplifying metabolic-hepatic feedback loops, yet metabolic disorders exhibit broader interorgan effects compared to localized hepatic fibrosis.

Neurological disorders, such as AD, reveal a unique lipids-ncRNAs association centered on sphingolipid imbalances and oxidative stress, providing a comparative lens to cardiovascular and metabolic pathologies [71–73]. MiR-33a/b, implicated in CVD for repressing fatty acid oxidation, similarly reduces Aβ efflux in AD by targeting *ABCA1*, leading to amyloid plaque formation akin to atherosclerotic plaques [124–126]. LncRNA-NEAT1 modulates lipid droplet dynamics in microglia, promoting neuroinflammation via miR-146a sponging, a pathway paralleling its role in MASLD lipid accumulation but differentiated by brain-specific myelin disruption [232,233,236]. Overall, these associations highlight ncRNAs as central hubs in lipid-mediated chronic disease progression, with shared mechanisms (e.g., PPAR modulation) but divergent endpoints, vascular inflammation in CVD, insulin resistance in metabolic/hepatic conditions, and neuronal apoptosis in neurological disorders, underscoring the need for integrated therapeutic strategies.

5. Therapeutic Targeting Strategies, Biomarker Potential and Delivery Technologies of ncRNAs in Lipid-Related Chronic Diseases

NcRNAs play pivotal roles in regulating lipid metabolism, positioning them as promising tools for diagnostics and treatments in chronic conditions like atherosclerosis, MASLD/NASH, and obesity. Their stability in biofluids, often protected by EVs or HDL particles, enables non-invasive detection of disease-specific signatures [326]. The therapeutic potential of ncRNAs stems from their central roles in lipid metabolism, inflammation, and vascular homeostasis. Manipulating their expression can reverse disease phenotypes in preclinical models, providing a foundation for novel interventions. For instance, liver-specific miR-122 knock-out rapidly develops NASH because of enhanced lipogenesis, alterations in lipid secretion, and increased TNF-α secretion [108], or lncRNA-MALAT1 silencing upregulated the expression of *SR-A* in oxLDL-stimulated macrophages. SR-A-mediated uptake of modified LDL by macrophages leads to deposition of cholesterol and foam cell formation during atherogenesis [211]. ncRNAs' dynamic changes enable real-time monitoring of progression or therapy response. Despite hurdles like delivery challenges, off-target effects, and ncRNA network complexity, these approaches herald precision medicine for lipid disorders.

5.1. Therapeutic Targeting Strategies

5.1.1. Antisense Oligonucleotides (ASOs) and antagomiRs

ASOs and their miRNA-specific subclass, antagomiRs, represent a powerful therapeutic strategy to precisely inhibit pathogenic ncRNAs driving lipid disorders [327,328]. These synthetic, chemically modified nucleic acid analogs are designed to bind complementary target ncRNA sequences via Watson–Crick base pairing [329]. For instance, miR-33 antagomirs represented a promising gene therapy system for lipid metabolic disorders. MiR-33 antagomirs can significantly decrease lipid deposition in the liver and treat MASLD [330]. In acute bronchial asthma, inhibition of miR-21 with an antagomir reduced allergic airway inflammation by blocking Th2 cell activation, indicating the potential of this antagomir as a therapeutic approach for asthma [331]. A study demonstrated that conditional silencing with a cholesterol-conjugated antagomir (antagomir-126) effectively suppressed miR-126 expression in endothelial cells and lung tissue, confirming the utility of lipid-based delivery for miRNA inhibition. Loss of miR-126 activity was associated with reduced capillary density and impaired endothelial outgrowth, effects attributable to the derepression of angiogenesis inhibitors such as *Spred-1* and *PIK3R2* [332]. In recent years, several ncRNA-based therapeutics have advanced into human clinical trials, especially siRNA and ASO modalities targeting lipid regulators. One of the most prominent examples is Inclisiran (a GalNAc-conjugated siRNA targeting *PCSK9*), which in two phase III trials reduced LDL-C by ~52.6% relative to placebo in patients with elevated LDL cholesterol [333]. In long-term follow-up, inclisiran has shown a durable lipid-lowering effect and favorable safety over multiple years [334]. Another example is Vupanorsen, an ASO directed against ANGPTL3 mRNA (GalNAc-conjugated). In phase II studies, it effectively lowered triglycerides and atherogenic lipoproteins in patients with metabolic and lipid disorders [335,336]. However, concerns about hepatic fat accumulation and liver enzyme elevations limited further development [337]. To overcome some of those limitations, newer siRNA agents have entered trials. For instance, Zodasiran, a hepatic siRNA targeting *ANGPTL3*, in the *ARCHES-2* (phase IIb) study led to dose-dependent reductions in triglycerides (up to –63%), LDL, non-HDL, and apoB in patients with mixed hyperlipidemia, without a significant rise in liver fat [338,339]. In parallel, Plozasiran (ARO-APOC3), a hepatocyte-targeted siRNA against *APOC3*, demonstrated in the SHASTA-2 trial (phase IIb) robust reductions in fasting triglycerides (~–57% at higher doses) in patients with severe hypertriglyceridemia [340–343]. Another attractive target is Lipoprotein(a) [Lp(a)]. The siRNA Olpasiran has shown potent Lp(a) lowering: in a randomized clinical trial, it significantly reduced Lp(a) levels in patients with established cardiovascular disease [344,345]. Complementing siRNAs, classic ASOs targeting LPA also persist in development. For example, Pelacarsen, an ASO against LPA, has shown substantial Lp(a) reduction in phase II, and is now being tested in the Lp(a)HORIZON trial to evaluate the impact on major cardiovascular events [346,347]. Together, these studies underscore the therapeutic versatility of ASOs, antagomirs and siRNA-based therapy, demonstrating their potential to modulate diverse disease pathways ranging from lipid metabolism to inflammation and angiogenesis.

5.1.2. MiRNA Mimics and Inhibitors

Restorative strategies using miRNA mimics offer a complementary approach to antisense inhibition for ncRNA-based therapeutics. These synthetic, double-stranded RNA molecules are engineered to replace the function of tumor-suppressive, metabolic diseases, or anti-steatotic miRNAs that become downregulated in disease states [348]. For instance, the study investigated the therapeutic potential of using a miR-122 mimic and/or a miR-221 inhibitor as a novel treatment approach for hepatocellular carcinoma in an animal model.

When administered together, these molecules enhanced the individual therapeutic effects by specifically regulating *SENP1* and *ARF4*. This dual strategy was shown to suppress tumor cell growth and angiogenesis, while at the same time promoting both apoptosis and necrosis in cancer cells [349]. In vascular endothelial cells, introducing either a miR-223 mimic or a miR-223 inhibitor altered Tissue Factor (TF) expression at both the mRNA and protein levels. These findings demonstrate that miR-223 negatively regulates TF expression, revealing a new molecular mechanism in the control of the coagulation cascade and offering insight into potential protection against thrombogenesis during atherosclerotic plaque rupture [350]. Collectively, these findings highlight the promise of miRNA mimics and inhibitors as therapeutic tools, capable of restoring protective miRNA functions to regulate tumor progression, metabolic imbalance, angiogenesis, and vascular homeostasis.

5.1.3. Multi-Omics and Gene-Editing Approaches

The regulatory interactions between ncRNAs and lipid metabolism are multifaceted and span transcriptional, post-transcriptional, and metabolic levels. To disentangle these connections, multi-omics strategies, notably combining transcriptomics with lipidomics or proteomics, have been increasingly employed to identify ncRNA–lipid correlations. For example, in the context of cholesterol homeostasis, the lncRNA LeXis is induced by LXR signaling and acts as a feedback regulator of cholesterol biosynthesis, thereby linking lipid-sensing pathways with non-coding transcriptome control [351]. On the miRNA side, miR-33 has been well characterized; it suppresses expression of *ABCA1* and *ABCG1*, thus inhibiting cholesterol efflux to HDL and contributing to cellular cholesterol retention [352]. Although direct applications of CRISPR-based editing on ncRNAs in lipid disease models remain scarce, a few key studies illustrate the feasibility of such approaches. For instance, CRISPR/Cas9-mediated knockout of miR-24 in primary mammary epithelial cells led to reductions in cholesterol and monounsaturated fatty acids, along with modulation of lipid biosynthesis genes like *FASN* and *INSIG1* [353]. On the technical front, dual-guide RNA (dgRNA) CRISPR strategies have been developed for efficient and specific deletion of miRNA regions without off-target disruption of homologous miRNAs [354].

5.2. Biomarker Potential

Numerous studies have demonstrated that ncRNAs detectable in biofluids (plasma, serum) serve as promising non-invasive biomarkers in disorders of lipid metabolism. For example, miR-122 is significantly elevated in the plasma of patients with liver disease, correlating with alanine aminotransferase and histologic damage [355,356]. In MASLD cohorts, miR-122-5p, along with miR-21, miR-126-5p, and miR-151a-3p, is higher in individuals with steatosis and correlates with hepatic fat content and liver stiffness [357]. Similarly, miR-34a shows elevated serum levels in patients with MASLD/NASH compared to healthy controls or patients with other liver diseases; its levels correlate with the severity of steatosis and inflammatory activity, and the diagnostic accuracy area under the receiver-operator characteristic curve (AUC) is promising [358–360]. On the lncRNA side, circulating lncRNA ENST00000416361 demonstrates notable upregulation in the plasma of patients with coronary artery disease (CAD), approximately 2.3 times higher than in healthy subjects, and exhibits a receiver operating characteristic (ROC) AUC of 0.79, supporting its potential utility as a non-invasive diagnostic biomarker for CAD [361]. Another lncRNA, CoroMarker, present in EVs, shows high stability in plasma and strong diagnostic performance for CAD (AUC ~ 0.92) independent of classical risk factors [362,363]. Low lncRNA LeXis, which regulate cholesterol homeostasis, independently associate with NASH diagnosis in patients with NAFLD. Therefore, circulating lncRNA LeXis could be a potential non-invasive diagnostic biomarker for NASH [24]. lncRNA CHROME, which

is elevated in the plasma and atherosclerotic plaques of individuals with CAD, regulates cellular and systemic cholesterol homeostasis [242]. These findings support the utility of ncRNAs both as diagnostic biomarkers (steatosis, NASH, dyslipidemia, CAD) and for monitoring disease progression or response to therapy, complementing existing lipid and liver function markers.

5.3. Delivery Technologies

Overcoming the delivery barrier is paramount for translating ncRNA therapeutics into clinical reality, as naked RNA molecules are rapidly degraded by nucleases, exhibit poor cellular uptake, and lack tissue specificity. Some of the advanced delivery systems described below overcome these limitations by employing sophisticated engineering approaches.

5.3.1. Lipid Nanoparticles (LNPs)

Encapsulation of a miR-122 mimic in LNP-DP1 effectively increased miR-122 levels in tumor cells, suppressed tumor progression in vivo, and demonstrated superior delivery efficiency compared to conventional approaches [364]. In addition, a study explored the use of PEGylated lipid nanoparticles (PEG-LNPs) for delivering anti-adipogenic miRNAs as a potential therapy for obesity and type 2 diabetes. Loading miR-27a suppressed adipogenesis by downregulating *PPARγ* and reducing lipid droplet formation, while miR-26a promoted browning of white adipocytes through *UCP1* upregulation. These findings demonstrate that targeted miRNA delivery via PEG-LNPs may provide a novel strategy to modulate adipose tissue function in metabolic diseases [365]. Nanoliposome-mediated delivery has also been employed as an ideal nano-scale delivery system for cancer diagnosis and therapy. Nanoliposomes are synthetic lipid-based nanoparticles engineered to encapsulate and deliver therapeutic agents, including ncRNAs. Unlike EVs, which are naturally secreted, nanoliposomes provide a controllable and versatile platform for targeted drug delivery [366]. Cationic nanoliposomes were developed as carriers for miR-1296 to overcome delivery barriers in triple-negative breast cancer (TNBC). The nanoliposomes showed high encapsulation efficiency, effective cellular uptake, and cytoplasmic localization of miR-1296, leading to reduced viability of TNBC cells through apoptosis and enhanced sensitization to cisplatin [367].

5.3.2. GalNAc-Conjugates

A type of delivery system used in RNAi therapeutics, particularly for targeting liver cells. They utilize the sugar molecule N-acetylgalactosamine (GalNAc) to bind to the asialoglycoprotein receptor (ASGPR) on liver cells, facilitating efficient cellular uptake of the therapeutic molecule, such as siRNA. This targeted delivery enhances the effectiveness of RNAi, a process that silences specific genes, for treating various liver-related diseases [368]. For instance, a study optimized in vitro models to replicate inclisiran (a representative GalNAc–conjugated siRNA) metabolism in vivo, identifying rat serum/plasma, liver homogenates, liver tritosomes, and plated hepatocytes as effective systems. These models closely mimic liver metabolism and nuclease activity, providing valuable tools for studying GalNAc-conjugated siRNA therapeutics and supporting the optimization of siRNA drug development [369]. GalNAc-conjugated siRNA (ANGsiR10) was developed to silence *ANGPTL3*, a key regulator of lipid metabolism. The GalNAc modification enables targeted delivery to hepatocytes via the asialoglycoprotein receptor, enhancing potency and durability. In vitro and in vivo studies showed that ANGsiR10 effectively reduced *ANGPTL3* expression, resulting in marked and sustained decreases in plasma triglycerides and cholesterol. These findings highlighted the therapeutic potential of GalNAc-siRNA conjugates for long-acting management of dyslipidemia and liver diseases [370].

5.3.3. Engineered EVs

EVs are nanoscale particles that can be categorized into subtypes such as exosomes, ectosomes, microvesicles, and apoptotic bodies. They are secreted by a wide range of cell types, including immune cells, mesenchymal stem cells, endothelial, epithelial, and various cancer cells. EVs naturally carry diverse biomolecules, such as proteins, DNA, mRNA, miRNAs, and lncRNAs. They have been detected in multiple body fluids, including plasma, serum, saliva, cerebrospinal fluid, breast milk, urine, and semen. By being released into these fluids, EVs serve as key mediators of intercellular communication [371]. EVs are being explored as delivery systems for miRNA therapeutics through two main approaches: endogenous loading, where RNA is incorporated during EV formation, and exogenous loading, where RNA is introduced after EV isolation. In one study, HEK293T cells were engineered to load pre-miR-199a into EVs via a TAT–TAR interaction, which increased packaging efficiency by about 65-fold while preserving proper maturation into functional miRNA. Despite this improvement, the overall yield remained very low (~0.003 copies per EV), meaning billions of EVs were needed to observe transfer, and the delivered miRNA levels were too low to affect target gene expression in recipient cells [371]. Exosome-mediated delivery, as an EV-based delivery, was examined by miRNA-155 mimicker or inhibitor and found to have a significant biological response in hepatocytes and macrophages. B cell-derived exosomes can function as vehicles to deliver exogenous miRNA-155 mimic or inhibitor into hepatocytes or macrophages, respectively [372]. Engineered EVs have also been shown to efficiently deliver siRNAs into stem cells and in vivo models with minimal toxicity, supporting their potential for stem cell engineering and RNA-based gene therapies [373]. These findings highlight the potential of EVs as versatile carriers for therapeutic ncRNAs, though their efficiency and consistency in cargo loading remain key challenges to overcome.

5.3.4. Aptamer-Functionalized Systems

Aptamers are single-stranded RNA or DNA molecules that form hairpin and additional secondary structures determined by specific sequences to achieve target recognition. Aptamer-guided delivery systems are emerging as promising strategies for non-coding RNA (ncRNA) therapy. For instance, in castration-resistant prostate cancer, a 19-nt RNA aptamer (EpDT3) that specifically binds to cancer cells that overexpress EpCAM on the cell surface and are endocytosed after binding to the molecule, was conjugated to poly (amidoamine) (PAMAM) dendrimers to facilitate efficient delivery of the tumor suppressor lncRNA-MEG3 (pMEG3). The resulting PAMAM-PEG-EpDT3/pMEG3 nanoparticles enhanced cellular uptake through aptamer-mediated endocytosis and showed superior antitumor efficacy compared to non-aptamer-modified nanoparticles. Both in vitro and in vivo experiments confirmed that aptamer functionalization significantly improves ncRNA delivery and therapeutic outcomes [374]. In clear cell renal cell carcinoma (ccRCC), AS1411 aptamer-modified lipid nanoparticles (AS1411/LNP) were used to deliver siRNA targeting circPDHK1. This aptamer-guided system improved tumor-specific uptake, prolonged circulation, and effectively reduced circPDHK1 levels, leading to inhibition of proliferation, migration, and mTOR-AKT signaling in ccRCC cells, with minimal off-target toxicity [375]. These studies collectively demonstrate that aptamer-functionalized delivery platforms offer a versatile and effective approach for targeted ncRNA therapy across diverse cancers.

6. Conclusions

In conclusion, ncRNAs orchestrate multi-layered interaction networks that sustain systemic lipid homeostasis. These networks function inter-organically, mediating crosstalk between the liver, adipose tissue, brain, vasculature and kidney, while intra-organically

fine-tuning tissue-specific responses through interactions with inflammatory and oxidative stress pathways. This integration enables ncRNAs to synchronize metabolic flux, inflammation, and redox signaling across organs, thereby preserving physiological equilibrium or, upon dysregulation, propagating diseases such as MASLD, obesity, and cardiovascular disorders through amplified lipotoxicity and impaired lipid trafficking. MiRNAs are key regulators of lipid metabolism, exerting control by simultaneously targeting multiple genes. They bind to mRNAs and repress the expression of enzymes (e.g., HMG-CoA reductase [HMGCR], FASN), lipid transporters (e.g., ABCA1, CD36), and transcription factors (e.g., *PPARα*, *SREBP-1c*) that govern lipid synthesis, oxidation, and trafficking. In chronic diseases such as atherosclerosis, T2D, MASLD, and AD, dysregulated miRNA expression disrupts lipid homeostasis, leading to lipid accumulation, inflammation, and progressive pathology. LncRNAs regulate lipid metabolism by interacting with RNA-binding proteins, miRNAs, and chromatin-modifying complexes, thereby modulating key transcriptional regulators such as *SREBP-1c*, *PPARs*, and *LXR*. Through these interactions, they fine-tune the balance between lipid synthesis and catabolism. When dysregulated, lncRNAs disrupt this equilibrium, promoting lipid accumulation, inflammation, and metabolic dysfunction in chronic diseases. CircRNAs regulate lipid metabolism by functioning as miRNA sponges, molecular scaffolds, and transcriptional regulators. Through these roles, they modulate lipid-metabolizing enzymes, transporters, and transcriptional programs, thereby fine-tuning lipid biosynthesis, cholesterol efflux, and adipogenesis. Dysregulation of circRNAs disrupts lipid homeostasis, driving lipid accumulation, inflammation, and the progression of metabolic diseases. Finally, ncRNAs regulate lipid metabolism and are promising biomarkers and therapeutic targets for disorders like atherosclerosis, MASLD, and obesity. They influence lipid balance, inflammation, and vascular health, but translation is limited by delivery and stability challenges. Advances such as antisense oligonucleotides, miRNA mimics, and engineered delivery systems (e.g., lipid nanoparticles, GalNAc conjugates, EVs, aptamers) are helping overcome these hurdles, supporting their potential in precision medicine.

Author Contributions: Conceptualization, Z.Z., A.M., A.T. and S.H.B.; writing—original draft preparation, Z.Z., A.M. and S.H.B.; writing—review and editing, Z.Z., A.M., A.T., S.S.M. and S.H.B.; visualization, A.T. and S.S.M.; supervision, A.M., A.T. and S.H.B. All authors have read and agreed to the published version of the manuscript.

Funding: S.H.B. is funded through a research contract with the University of Zaragoza, within the framework of the Sudoe-NEWPOWER Project (S1/1.1/E01116).

Data Availability Statement: No new data were created or analyzed in this study.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Gyamfi, D.; Awuah, E.O.; Owusu, S. Lipid Metabolism: An Overview. *Mol. Nutr. Fats* **2019**, 17–32. [CrossRef]
2. Bruce, K.D.; Tang, M.; Reigan, P.; Eckel, R.H. Genetic Variants of Lipoprotein Lipase and Regulatory Factors Associated with Alzheimer's Disease Risk. *Int. J. Mol. Sci.* **2020**, *21*, 8338. [CrossRef] [PubMed]
3. Fujimoto, T.; Parton, R.G. Not Just Fat: The Structure and Function of the Lipid Droplet. *Cold Spring Harb. Perspect. Biol.* **2011**, *3*, a004838. [CrossRef] [PubMed]
4. Wymann, M.P.; Schneiter, R. Lipid Signalling in Disease. *Nat. Rev. Mol. Cell Biol.* **2008**, *9*, 162–176. [CrossRef] [PubMed]
5. Bidooki, S.H.; Spitzer, L.; Petitpas, A.; Sánchez-Marco, J.; Martínez-Beamonte, R.; Lasheras, R.; Pellerin, V.; Rodríguez-Yoldi, M.J.; Navarro, M.A.; Osada, J. Chitosan Nanoparticles, a Novel Drug Delivery System to Transfer Squalene for Hepatocyte Stress Protection. *ACS Omega* **2024**, *9*, 51379–51393. [CrossRef]
6. Song, R.; Hu, M.; Qin, X.; Qiu, L.; Wang, P.; Zhang, X.; Liu, R.; Wang, X. The Roles of Lipid Metabolism in the Pathogenesis of Chronic Diseases in the Elderly. *Nutrients* **2023**, *15*, 3433. [CrossRef]

7. Siddique, M.M.; Li, Y.; Chaurasia, B.; Kaddai, V.A.; Summers, S.A. Dihydroceramides: From Bit Players to Lead Actors. *J. Biol. Chem.* **2015**, *290*, 15371–15379. [CrossRef]
8. Horton, J.D.; Goldstein, J.L.; Brown, M.S. SREBPs: Transcriptional Mediators of Lipid Homeostasis. In Proceedings of the Cold Spring Harbor Symposia on Quantitative Biology; Cold Spring Harbor Laboratory Press: Woodbury, NY, USA, 2002; Volume 67, pp. 491–498.
9. Priest, C.; Tontonoz, P. Inter-Organ Cross-Talk in Metabolic Syndrome. *Nat. Metab.* **2019**, *1*, 1177–1188. [CrossRef]
10. Van Herpen, N.A.; Schrauwen-Hinderling, V. Lipid Accumulation in Non-Adipose Tissue and Lipotoxicity. *Physiol. Behav.* **2008**, *94*, 231–241. [CrossRef]
11. Jiang, H.; Zhou, Y.; Nabavi, S.M.; Sahebkar, A.; Little, P.J.; Xu, S.; Weng, J.; Ge, J. Mechanisms of Oxidized LDL-Mediated Endothelial Dysfunction and Its Consequences for the Development of Atherosclerosis. *Front. Cardiovasc. Med.* **2022**, *9*, 925923. [CrossRef]
12. Choudhary, R.C.; Kuschner, C.E.; Kazmi, J.; Mcdevitt, L.; Espin, B.B.; Essaihi, M.; Nishikimi, M.; Becker, L.B.; Kim, J. The Role of Phospholipid Alterations in Mitochondrial and Brain Dysfunction after Cardiac Arrest. *Int. J. Mol. Sci.* **2024**, *25*, 4645. [CrossRef]
13. Bidooki, S.H.; Barranquero, C.; Sánchez-Marco, J.; Martínez-Beamonte, R.; Rodríguez-Yoldi, M.J.; Navarro, M.A.; Fernandes, S.C.M.; Osada, J. TXNDC5 Plays a Crucial Role in Regulating Endoplasmic Reticulum Activity through Different ER Stress Signaling Pathways in Hepatic Cells. *Int. J. Mol. Sci.* **2024**, *25*, 7128. [CrossRef] [PubMed]
14. Wang, D.; Wei, Y.; Pagliassotti, M.J. Saturated Fatty Acids Promote Endoplasmic Reticulum Stress and Liver Injury in Rats with Hepatic Steatosis. *Endocrinology* **2006**, *147*, 943–951. [CrossRef] [PubMed]
15. Zayani, Z.; Matinahmadi, A.; Tavakolpournegari, A.; Bidooki, S.H. Exploring Stressors: Impact on Cellular Organelles and Implications for Cellular Functions. *Stresses* **2025**, *5*, 26. [CrossRef]
16. Glass, C.K.; Olefsky, J.M. Inflammation and Lipid Signaling in the Etiology of Insulin Resistance. *Cell Metab.* **2012**, *15*, 635–645. [CrossRef]
17. Esteller, M. Non-Coding RNAs in Human Disease. *Nat. Rev. Genet.* **2011**, *12*, 861–874. [CrossRef]
18. Gholamzad, A.; Khakpour, N.; Khosroshahi, E.M.; Asadi, S.; Koohpar, Z.K.; Matinahmadi, A.; Jebali, A.; Rashidi, M.; Hashemi, M.; Sadi, F.H. Cancer Stem Cells: The Important Role of CD Markers, Signaling Pathways, and MicroRNAs. *Pathol.-Res. Pract.* **2024**, *256*, 155227. [CrossRef]
19. Hashemi, M.; Daneii, P.; Asadalizadeh, M.; Tabari, K.; Matinahmadi, A.; Bidoki, S.S.; Motlagh, Y.S.M.; Jafari, A.M.; Ghorbani, A.; Dehghanpour, A. Epigenetic Regulation of Hepatocellular Carcinoma Progression: MicroRNAs as Therapeutic, Diagnostic and Prognostic Factors. *Int. J. Biochem. Cell Biol.* **2024**, *170*, 106566. [CrossRef]
20. Salzman, J. Circular RNA Expression: Its Potential Regulation and Function. *Trends Genet.* **2016**, *32*, 309–316. [CrossRef]
21. Wilczynska, A.; Bushell, M. The Complexity of MiRNA-Mediated Repression. *Cell Death Differ.* **2015**, *22*, 22–33. [CrossRef]
22. Moore, K.J.; Rayner, K.J.; Suárez, Y.; Fernández-Hernando, C. The Role of MicroRNAs in Cholesterol Efflux and Hepatic Lipid Metabolism. *Annu. Rev. Nutr.* **2011**, *31*, 49–63. [CrossRef]
23. Kopp, F.; Mendell, J.T. Functional Classification and Experimental Dissection of Long Noncoding RNAs. *Cell* **2018**, *172*, 393–407. [CrossRef] [PubMed]
24. Park, J.G.; Kim, G.; Jang, S.Y.; Lee, Y.R.; Lee, E.; Lee, H.W.; Han, M.-H.; Chun, J.M.; Han, Y.S.; Yoon, J.S. Plasma Long Noncoding RNA LeXis Is a Potential Diagnostic Marker for Non-Alcoholic Steatohepatitis. *Life* **2020**, *10*, 230. [CrossRef] [PubMed]
25. Zayani, Z.; Hooshmandi, E.; Borhani-Haghighi, A.; Rahimi, M.; Ostovan, V.R.; Fadakar, N.; Tabrizi, R.; Bayat, M.; Hojati, S.S.; Gharbi, N. Diagnostic Potential of LncRNAs-ANRIL and MIAT in the Blood of Patients with Cerebral Venous Thrombosis. *Curr. J. Neurol.* **2024**, *23*, 117. [CrossRef] [PubMed]
26. Kristensen, L.S.; Andersen, M.S.; Stagsted, L.V.W.; Ebbesen, K.K.; Hansen, T.B.; Kjems, J. The Biogenesis, Biology and Characterization of Circular RNAs. *Nat. Rev. Genet.* **2019**, *20*, 675–691. [CrossRef]
27. Le Lay, S.; Scherer, P.E. Exploring Adipose Tissue-Derived Extracellular Vesicles in Inter-Organ Crosstalk: Implications for Metabolic Regulation and Adipose Tissue Function. *Cell Rep.* **2025**, *44*, 115732. [CrossRef]
28. Grillone, K.; Caridà, G.; Luciano, F.; Cordua, A.; Di Martino, M.T.; Tagliaferri, P.; Tassone, P. A Systematic Review of Non-Coding RNA Therapeutics in Early Clinical Trials: A New Perspective against Cancer. *J. Transl. Med.* **2024**, *22*, 731. [CrossRef]
29. Rupaimoole, R.; Slack, F.J. MicroRNA Therapeutics: Towards a New Era for the Management of Cancer and Other Diseases. *Nat. Rev. Drug Discov.* **2017**, *16*, 203–222. [CrossRef]
30. Chen, L.; Zhang, Q.; Meng, Y.; Zhao, T.; Mu, C.; Fu, C.; Deng, C.; Feng, J.; Du, S.; Liu, W. Saturated Fatty Acids Increase LPI to Reduce FUNDC1 Dimerization and Stability and Mitochondrial Function. *EMBO Rep.* **2023**, *24*, e54731. [CrossRef]
31. Jimenez, A.G.; Winward, J.D.; Walsh, K.E.; Champagne, A.M. Effects of Membrane Fatty Acid Composition on Cellular Metabolism and Oxidative Stress in Dermal Fibroblasts from Small and Large Breed Dogs. *J. Exp. Biol.* **2020**, *223*, jeb221804. [CrossRef]
32. Niki, E. Lipid Peroxidation: Physiological Levels and Dual Biological Effects. *Free Radic. Biol. Med.* **2009**, *47*, 469–484. [CrossRef] [PubMed]

33. Marnett, L.J. Oxy Radicals, Lipid Peroxidation and DNA Damage. *Toxicology* **2002**, *181*, 219–222. [CrossRef] [PubMed]
34. Ma, Y.; Zhang, L.; Rong, S.; Qu, H.; Zhang, Y.; Chang, D.; Pan, H.; Wang, W. Relation between Gastric Cancer and Protein Oxidation, DNA Damage, and Lipid Peroxidation. *Oxid. Med. Cell Longev.* **2013**, *2013*, 543760. [CrossRef] [PubMed]
35. Yoon, H.; Shaw, J.L.; Haigis, M.C.; Greka, A. Lipid Metabolism in Sickness and in Health: Emerging Regulators of Lipotoxicity. *Mol. Cell* **2021**, *81*, 3708–3730. [CrossRef]
36. Gofman, J.W.; Lindgren, F.; Elliott, H.; Mantz, W.; Hewitt, J.; Strisower, B.; Herring, V.; Lyon, T.P. The Role of Lipids and Lipoproteins in Atherosclerosis. *Science* **1950**, *111*, 166–186. [CrossRef]
37. Kang, N.; Ji, Z.; Li, Y.; Gao, J.; Wu, X.; Zhang, X.; Duan, Q.; Zhu, C.; Xu, Y.; Wen, L. Metabolite-derived Damage-associated Molecular Patterns in Immunological Diseases. *FEBS J.* **2024**, *291*, 2051–2067. [CrossRef]
38. Sun, T.; Chen, M.; Shen, H.; PingYin; Fan, L.; Chen, X.; Wu, J.; Xu, Z.; Zhang, J. Predictive Value of LDL/HDL Ratio in Coronary Atherosclerotic Heart Disease. *BMC Cardiovasc. Disord.* **2022**, *22*, 273. [CrossRef]
39. Khatana, C.; Saini, N.K.; Chakrabarti, S.; Saini, V.; Sharma, A.; Saini, R.V.; Saini, A.K. Mechanistic Insights into the Oxidized Low-density Lipoprotein-induced Atherosclerosis. *Oxid. Med. Cell Longev.* **2020**, *2020*, 5245308. [CrossRef]
40. Berberich, A.J.; Hegele, R.A. A Modern Approach to Dyslipidemia. *Endocr. Rev.* **2022**, *43*, 611–653. [CrossRef]
41. Paquette, M.; Carrié, A.; Bernard, S.; Cariou, B.; Hegele, R.A.; Genest, J.; Trinder, M.; Brunham, L.R.; Béliard, S.; Baass, A. Effect of the LDL Receptor Mutation Type on Incident Major Adverse Cardiovascular Events in Familial Hypercholesterolaemia. *Eur. J. Prev. Cardiol.* **2022**, *29*, 2125–2131. [CrossRef]
42. Besler, K.J.; Blanchard, V.; Francis, G.A. Lysosomal Acid Lipase Deficiency: A Rare Inherited Dyslipidemia but Potential Ubiquitous Factor in the Development of Atherosclerosis and Fatty Liver Disease. *Front. Genet.* **2022**, *13*, 1013266. [CrossRef]
43. Rehman, W.U.; Yarkoni, M.; Ilyas, M.A.; Athar, F.; Javaid, M.; Ehsan, M.; Khalid, M.T.; Pasha, A.; Selma, A.B.; Yarkoni, A. Cholesteryl Ester Transfer Protein Inhibitors and Cardiovascular Outcomes: A Systematic Review and Meta-Analysis. *J. Cardiovasc. Dev. Dis.* **2024**, *11*, 152. [CrossRef] [PubMed]
44. Abuobeid, R.; Herrera-Marcos, L.V.; Arnal, C.; Bidooki, S.H.; Sánchez-Marco, J.; Lasheras, R.; Surra, J.C.; Rodríguez-Yoldi, M.J.; Martínez-Beamonte, R.; Osada, J. Differentially Expressed Genes in Response to a Squalene-Supplemented Diet Are Accurate Discriminants of Porcine Non-Alcoholic Steatohepatitis. *Int. J. Mol. Sci.* **2023**, *24*, 12552. [CrossRef] [PubMed]
45. Stoekenbroek, R.M.; Hartgers, M.L.; Rutte, R.; de Wijer, D.D.; Stroes, E.S.G.; Hovingh, G.K. PCSK9 Inhibitors in Clinical Practice: Delivering on the Promise? *Atherosclerosis* **2018**, *270*, 205–210. [CrossRef] [PubMed]
46. Kiani, P.; Khodadadi, E.S.; Nikdasti, A.; Yarahmadi, S.; Gheibi, M.; Yousefi, Z.; Ehtiati, S.; Yahyazadeh, S.; Shafiee, S.M.; Taghizadeh, M. Autophagy and the Peroxisome Proliferator-Activated Receptor Signaling Pathway: A Molecular Ballet in Lipid Metabolism and Homeostasis. *Mol. Cell Biochem.* **2025**, *480*, 3477–3499. [CrossRef]
47. Coutinho-Wolino, K.S.; Almeida, P.P.; Mafra, D.; Stockler-Pinto, M.B. Bioactive Compounds Modulating Toll-like 4 Receptor (TLR4)-Mediated Inflammation: Pathways Involved and Future Perspectives. *Nutr. Res.* **2022**, *107*, 96–116. [CrossRef]
48. Tong, Y.; Xu, S.; Huang, L.; Chen, C. Obesity and Insulin Resistance: Pathophysiology and Treatment. *Drug Discov. Today* **2022**, *27*, 822–830. [CrossRef]
49. Ahmed, B.; Sultana, R.; Greene, M.W. Adipose Tissue and Insulin Resistance in Obese. *Biomed. Pharmacother.* **2021**, *137*, 111315. [CrossRef]
50. Chait, A.; Den Hartigh, L.J. Adipose Tissue Distribution, Inflammation and Its Metabolic Consequences, Including Diabetes and Cardiovascular Disease. *Front. Cardiovasc. Med.* **2020**, *7*, 522637. [CrossRef]
51. Bou Matar, D.; Zhra, M.; Nassar, W.K.; Altemyatt, H.; Naureen, A.; Abotouk, N.; Elahi, M.A.; Aljada, A. Adipose Tissue Dysfunction Disrupts Metabolic Homeostasis: Mechanisms Linking Fat Dysregulation to Disease. *Front. Endocrinol.* **2025**, *16*, 1592683. [CrossRef]
52. Vandanmagsar, B.; Youm, Y.-H.; Ravussin, A.; Galgani, J.E.; Stadler, K.; Mynatt, R.L.; Ravussin, E.; Stephens, J.M.; Dixit, V.D. The NLRP3 Inflammasome Instigates Obesity-Induced Inflammation and Insulin Resistance. *Nat. Med.* **2011**, *17*, 179–188. [CrossRef]
53. Chen, B.; Li, T.; Wu, Y.; Song, L.; Wang, Y.; Bian, Y.; Qiu, Y.; Yang, Z. Lipotoxicity: A New Perspective in Type 2 Diabetes Mellitus. *Diabetes Metab. Syndr. Obes.* **2025**, *18*, 1223–1237. [CrossRef] [PubMed]
54. Bidooki, S.H.; Navarro, M.A.; Fernandes, S.C.M.; Osada, J. Thioredoxin Domain Containing 5 (TXNDC5): Friend or Foe? *Curr. Issues Mol. Biol.* **2024**, *46*, 3134–3163. [CrossRef] [PubMed]
55. Aon, M.A.; Bhatt, N.; Cortassa, S.C. Mitochondrial and Cellular Mechanisms for Managing Lipid Excess. *Front. Physiol.* **2014**, *5*, 282. [CrossRef] [PubMed]
56. Bidooki, S.H.; Quero, J.; Sánchez-Marco, J.; Herrero-Continente, T.; Marmol, I.; Lasheras, R.; Sebastian, V.; Arruebo, M.; Osada, J.; Rodriguez-Yoldi, M.J. Squalene in Nanoparticles Improves Antiproliferative Effect on Human Colon Carcinoma Cells Through Apoptosis by Disturbances in Redox Balance. *Int. J. Mol. Sci.* **2024**, *25*, 13048. [CrossRef]
57. Vasselli, J.R.; Scarpace, P.J.; Harris, R.B.S.; Banks, W.A. Dietary Components in the Development of Leptin Resistance. *Adv. Nutr.* **2013**, *4*, 164–175. [CrossRef]
58. Luo, L.; Liu, M. Adiponectin: Friend or Foe in Obesity and Inflammation. *Med. Rev.* **2022**, *2*, 349–362. [CrossRef]

59. Guo, X.; Yin, X.; Liu, Z.; Wang, J. Non-Alcoholic Fatty Liver Disease (NAFLD) Pathogenesis and Natural Products for Prevention and Treatment. *Int. J. Mol. Sci.* **2022**, *23*, 15489. [CrossRef]
60. Cheng, X.; Jiang, S.; Pan, B.; Xie, W.; Meng, J. Ectopic and Visceral Fat Deposition in Aging, Obesity, and Idiopathic Pulmonary Fibrosis: An Interconnected Role. *Lipids Health Dis.* **2023**, *22*, 201. [CrossRef]
61. Bidooki, S.H.; Alejo, T.; Sánchez-Marco, J.; Martínez-Beamonte, R.; Abuobeid, R.; Burillo, J.C.; Lasheras, R.; Sebastian, V.; Rodríguez-Yoldi, M.J.; Arruebo, M. Squalene Loaded Nanoparticles Effectively Protect Hepatic AML12 Cell Lines against Oxidative and Endoplasmic Reticulum Stress in a TXNDC5-Dependent Way. *Antioxidants* **2022**, *11*, 581. [CrossRef]
62. Luukkonen, P.K.; Porthan, K.; Ahlholm, N.; Rosqvist, F.; Dufour, S.; Zhang, X.-M.; Lehtimäki, T.E.; Seppänen, W.; Orho-Melander, M.; Hodson, L. The PNPLA3 I148M Variant Increases Ketogenesis and Decreases Hepatic de Novo Lipogenesis and Mitochondrial Function in Humans. *Cell Metab.* **2023**, *35*, 1887–1896. [CrossRef] [PubMed]
63. Caon, E.; Martins, M.; Hodgetts, H.; Blanken, L.; Vilia, M.G.; Levi, A.; Thanapirom, K.; Al-Akkad, W.; Abu-Hanna, J.; Baselli, G. Exploring the Impact of the PNPLA3 I148M Variant on Primary Human Hepatic Stellate Cells Using 3D Extracellular Matrix Models. *J. Hepatol.* **2024**, *80*, 941–956. [CrossRef] [PubMed]
64. Bidooki, S.H.; Sánchez-Marco, J.; Martínez-Beamonte, R.; Herrero-Continente, T.; Navarro, M.A.; Rodríguez-Yoldi, M.J.; Osada, J. Endoplasmic Reticulum Protein TXNDC5 Interacts with PRDX6 and HSPA9 to Regulate Glutathione Metabolism and Lipid Peroxidation in the Hepatic AML12 Cell Line. *Int. J. Mol. Sci.* **2023**, *24*, 17131. [CrossRef] [PubMed]
65. Tirosh, O. Hypoxic Signaling and Cholesterol Lipotoxicity in Fatty Liver Disease Progression. *Oxid. Med. Cell Longev.* **2018**, *2018*, 2548154. [CrossRef]
66. Xu, G.-X.; Wei, S.; Yu, C.; Zhao, S.-Q.; Yang, W.-J.; Feng, Y.-H.; Pan, C.; Yang, K.-X.; Ma, Y. Activation of Kupffer Cells in NAFLD and NASH: Mechanisms and Therapeutic Interventions. *Front. Cell Dev. Biol.* **2023**, *11*, 1199519. [CrossRef]
67. Lei, Y.-M.; Yan, R.; Gao, Y.-D.; Yang, H.-J.; Bi, H.-Y.; Duan, Y.-Q. Cholesterol Crystals Activate NLRP3 Inflammasomes and Promote Gallstone Formation by Increasing Mucin Secretion. *Biotech. Histochem.* **2022**, *97*, 546–553. [CrossRef]
68. Dixon, L.J.; Barnes, M.; Tang, H.; Pritchard, M.T.; Nagy, L.E. Kupffer cells in the liver. *Compr. Physiol.* **2013**, *3*, 785–797. [CrossRef]
69. Mesa-Herrera, F.; Taoro-González, L.; Valdés-Baizabal, C.; Diaz, M.; Marín, R. Lipid and Lipid Raft Alteration in Aging and Neurodegenerative Diseases: A Window for the Development of New Biomarkers. *Int. J. Mol. Sci.* **2019**, *20*, 3810. [CrossRef]
70. Kanekiyo, T.; Xu, H.; Bu, G. ApoE and Aβ in Alzheimer's Disease: Accidental Encounters or Partners? *Neuron* **2014**, *81*, 740–754. [CrossRef]
71. Jazvinšćak Jembrek, M.; Hof, P.R.; Šimić, G. Ceramides in Alzheimer's Disease: Key Mediators of Neuronal Apoptosis Induced by Oxidative Stress and Aβ Accumulation. *Oxid. Med. Cell Longev.* **2015**, *2015*, 346783. [CrossRef]
72. Rushworth, J.V.; Hooper, N.M. Lipid Rafts: Linking Alzheimer′ s Amyloid-β Production, Aggregation, and Toxicity at Neuronal Membranes. *Int. J. Alzheimers Dis.* **2011**, *2011*, 603052. [CrossRef] [PubMed]
73. Niedzielska, E.; Smaga, I.; Gawlik, M.; Moniczewski, A.; Stankowicz, P.; Pera, J.; Filip, M. Oxidative Stress in Neurodegenerative Diseases. *Mol. Neurobiol.* **2016**, *53*, 4094–4125. [CrossRef] [PubMed]
74. Miao, J.; Ma, H.; Yang, Y.; Liao, Y.; Lin, C.; Zheng, J.; Yu, M.; Lan, J. Microglia in Alzheimer's Disease: Pathogenesis, Mechanisms, and Therapeutic Potentials. *Front. Aging Neurosci.* **2023**, *15*, 1201982. [CrossRef] [PubMed]
75. Dias, V.; Junn, E.; Mouradian, M.M. The Role of Oxidative Stress in Parkinson's Disease. *J. Parkinsons Dis.* **2013**, *3*, 461–491. [CrossRef]
76. Alkhalifa, A.E.; Alkhalifa, O.; Durdanovic, I.; Ibrahim, D.R.; Maragkou, S. Oxidative Stress and Mitochondrial Dysfunction in Alzheimer's Disease: Insights into Pathophysiology and Treatment. *J. Dement. Alzheimer's Dis.* **2025**, *2*, 17. [CrossRef]
77. Fu, Y.; Zou, T.; Shen, X.; Nelson, P.J.; Li, J.; Wu, C.; Yang, J.; Zheng, Y.; Bruns, C.; Zhao, Y. Lipid Metabolism in Cancer Progression and Therapeutic Strategies. *MedComm* **2021**, *2*, 27–59. [CrossRef]
78. Latasa, M.-J.; Moon, Y.S.; Kim, K.-H.; Sul, H.S. Nutritional Regulation of the Fatty Acid Synthase Promoter in Vivo: Sterol Regulatory Element Binding Protein Functions through an Upstream Region Containing a Sterol Regulatory Element. *Proc. Natl. Acad. Sci. USA* **2000**, *97*, 10619–10624.
79. Tracz-Gaszewska, Z.; Sowka, A.; Dobrzyn, P. Stearoyl-CoA Desaturase 1 Inhibition Impairs Triacylglycerol Accumulation and Lipid Droplet Formation in Colorectal Cancer Cells. *J. Cell Physiol.* **2023**, *238*, 2888–2903. [CrossRef]
80. Bensaad, K.; Favaro, E.; Lewis, C.A.; Peck, B.; Lord, S.; Collins, J.M.; Pinnick, K.E.; Wigfield, S.; Buffa, F.M.; Li, J.-L. Fatty Acid Uptake and Lipid Storage Induced by HIF-1α Contribute to Cell Growth and Survival after Hypoxia-Reoxygenation. *Cell Rep.* **2014**, *9*, 349–365. [CrossRef]
81. Jarc, E.; Petan, T. Lipid Droplets and the Management of Cellular Stress. *Yale J. Biol. Med.* **2019**, *92*, 435.
82. Sánchez-Marco, J.; Bidooki, S.H.; Abuobeid, R.; Barranquero, C.; Herrero-Continente, T.; Arnal, C.; Martínez-Beamonte, R.; Lasheras, R.; Surra, J.C.; Navarro, M.A. Thioredoxin Domain Containing 5 Is Involved in the Hepatic Storage of Squalene into Lipid Droplets in a Sex-Specific Way. *J. Nutr. Biochem.* **2024**, *124*, 109503. [CrossRef] [PubMed]
83. Wang, Q.; Morris, R.J.; Bode, A.M.; Zhang, T. Prostaglandin Pathways: Opportunities for Cancer Prevention and Therapy. *Cancer Res.* **2022**, *82*, 949–965. [CrossRef] [PubMed]

84. Rolin, J.; Maghazachi, A.A. Effects of Lysophospholipids on Tumor Microenvironment. *Cancer Microenviron.* **2011**, *4*, 393–403. [CrossRef]
85. Zhao, W.; Zhang, Z.; Xie, M.; Ding, F.; Zheng, X.; Sun, S.; Du, J. Exploring Tumor-Associated Macrophages in Glioblastoma: From Diversity to Therapy. *NPJ Precis. Oncol.* **2025**, *9*, 126. [CrossRef]
86. Balaban, S.; Shearer, R.F.; Lee, L.S.; van Geldermalsen, M.; Schreuder, M.; Shtein, H.C.; Cairns, R.; Thomas, K.C.; Fazakerley, D.J.; Grewal, T. Adipocyte Lipolysis Links Obesity to Breast Cancer Growth: Adipocyte-Derived Fatty Acids Drive Breast Cancer Cell Proliferation and Migration. *Cancer Metab.* **2017**, *5*, 1. [CrossRef]
87. Wang, X.; Zhou, Y.; Ding, K. Roles of Exosomes in Cancer Chemotherapy Resistance, Progression, Metastasis and Immunity, and Their Clinical Applications. *Int. J. Oncol.* **2021**, *59*, 44. [CrossRef]
88. Jin, H.-R.; Wang, J.; Wang, Z.-J.; Xi, M.-J.; Xia, B.-H.; Deng, K.; Yang, J.-L. Lipid Metabolic Reprogramming in Tumor Microenvironment: From Mechanisms to Therapeutics. *J. Hematol. Oncol.* **2023**, *16*, 103. [CrossRef]
89. Peschansky, V.J.; Wahlestedt, C. Non-Coding RNAs as Direct and Indirect Modulators of Epigenetic Regulation. *Epigenetics* **2014**, *9*, 3–12. [CrossRef]
90. Mirzaei, S.; Paskeh, M.D.A.; Entezari, M.; Bidooki, S.H.; Ghaleh, V.J.; Rezaei, S.; Hejazi, E.S.; Kakavand, A.; Behroozaghdam, M.; Movafagh, A. SiRNA and Targeted Delivery Systems in Breast Cancer Therapy. *Clin. Transl. Oncol.* **2023**, *25*, 1167–1188. [CrossRef]
91. Kaikkonen, M.U.; Lam, M.T.Y.; Glass, C.K. Non-Coding RNAs as Regulators of Gene Expression and Epigenetics. *Cardiovasc. Res.* **2011**, *90*, 430–440. [CrossRef]
92. Liu, C.-X.; Chen, L.-L. Circular RNAs: Characterization, Cellular Roles, and Applications. *Cell* **2022**, *185*, 2016–2034. [CrossRef]
93. Statello, L.; Guo, C.-J.; Chen, L.-L.; Huarte, M. Gene Regulation by Long Non-Coding RNAs and Its Biological Functions. *Nat. Rev. Mol. Cell Biol.* **2021**, *22*, 96–118. [CrossRef]
94. Weitz, S.H.; Gong, M.; Barr, I.; Weiss, S.; Guo, F. Processing of MicroRNA Primary Transcripts Requires Heme in Mammalian Cells. *Proc. Natl. Acad. Sci. USA* **2014**, *111*, 1861–1866. [CrossRef]
95. Tavakolpournegari, A.; Hashemi, M.; Karizi, S.Z.; Ahmadi, A.M.; Bidooki, S.H.; Banaei, G. Expression Patterns of MiR181a and MiR30d in Patients with Breast Cancer. *Iran. J. Public. Health* **2022**, *51*, 1594. [CrossRef]
96. Santhekadur, P.K.; Kumar, D.P. RISC Assembly and Post-Transcriptional Gene Regulation in Hepatocellular Carcinoma. *Genes. Dis.* **2020**, *7*, 199–204. [CrossRef]
97. Wu, Y.; Song, Y.; Xiong, Y.; Wang, X.; Xu, K.; Han, B.; Bai, Y.; Li, L.; Zhang, Y.; Zhou, L. MicroRNA-21 (Mir-21) Promotes Cell Growth and Invasion by Repressing Tumor Suppressor PTEN in Colorectal Cancer. *Cell. Physiol. Biochem.* **2017**, *43*, 945–958. [CrossRef] [PubMed]
98. Yang, Y.; Guo, J.-X.; Shao, Z.-Q. MiR-21 Targets and Inhibits Tumor Suppressor Gene PTEN to Promote Prostate Cancer Cell Proliferation and Invasion: An Experimental Study. *Asian Pac. J. Trop. Med.* **2017**, *10*, 87–91. [CrossRef] [PubMed]
99. Zhang, J.; Wang, J.; Zhao, F.; Liu, Q.; Jiang, K.E.; Yang, G. MicroRNA-21 (MiR-21) Represses Tumor Suppressor PTEN and Promotes Growth and Invasion in Non-Small Cell Lung Cancer (NSCLC). *Clin. Chim. Acta* **2010**, *411*, 846–852. [CrossRef] [PubMed]
100. Wang, D.; Zhang, Z.; O'Loughlin, E.; Wang, L.; Fan, X.; Lai, E.C.; Yi, R. MicroRNA-205 Controls Neonatal Expansion of Skin Stem Cells by Modulating the PI (3) K Pathway. *Nat. Cell Biol.* **2013**, *15*, 1153–1163. [CrossRef]
101. Huang, C.; Azizi, P.; Vazirzadeh, M.; Aghaei-Zarch, S.M.; Aghaei-Zarch, F.; Ghanavi, J.; Farnia, P. Non-Coding RNAs/DNMT3B Axis in Human Cancers: From Pathogenesis to Clinical Significance. *J. Transl. Med.* **2023**, *21*, 621. [CrossRef]
102. Saviana, M.; Le, P.; Micalo, L.; Del Valle-Morales, D.; Romano, G.; Acunzo, M.; Li, H.; Nana-Sinkam, P. Crosstalk between MiRNAs and DNA Methylation in Cancer. *Genes* **2023**, *14*, 1075. [CrossRef]
103. Aryal, B.; Singh, A.K.; Rotllan, N.; Price, N.; Fernández-Hernando, C. MicroRNAs and Lipid Metabolism. *Curr. Opin. Lipidol.* **2017**, *28*, 273–280. [CrossRef]
104. You, Z.; Wu, F.; Zheng, Y.; Yang, H.; Ye, J.; Cai, H.; Luo, C.; Liu, Y.; Ke, Y.; Xu, X. MiR-139-5p Activates Ferroptosis by Inhibiting the Expression of HMG-CoA Reductase to Inhibit the Progression of Glioma. *Cell Death Discov.* **2025**, *11*, 245. [CrossRef] [PubMed]
105. Wang, D.; Yeung, A.W.K.; Atanasov, A.G. A Review: Molecular Mechanism of Regulation of ABCA1 Expression. *Curr. Protein Pept. Sci.* **2022**, *23*, 170–191. [CrossRef] [PubMed]
106. Niculae, A.M.; Dobre, M.; Herlea, V.; Vasilescu, F.; Ceafalan, L.C.; Trandafir, B.; Milanesi, E.; Hinescu, M.E. Lipid Handling Protein Gene Expression in Colorectal Cancer: CD36 and Targeting MiRNAs. *Life* **2022**, *12*, 2127. [CrossRef] [PubMed]
107. Sundrani, D.P.; Karkhanis, A.R.; Joshi, S.R. Peroxisome Proliferator-Activated Receptors (PPAR), Fatty Acids and MicroRNAs: Implications in Women Delivering Low Birth Weight Babies. *Syst. Biol. Reprod. Med.* **2021**, *67*, 24–41. [CrossRef]
108. Salman, M.; Kamel, M.A.; El-Nabi, S.E.H.; Ismail, A.H.A.; Ullah, S.; Al-Ghamdi, A.; Hathout, H.M.R.; El-Garawani, I.M. The Regulation of HBP1, SIRT1, and SREBP-1c Genes and the Related MicroRNAs in Non-Alcoholic Fatty Liver Rats: The Association with the Folic Acid Anti-Steatosis. *PLoS ONE* **2022**, *17*, e0265455. [CrossRef]

109. Ru, L.; Wang, X.; Niu, J. The MiR-23–27–24 Cluster: An Emerging Target in NAFLD Pathogenesis. *Acta Pharmacol. Sin.* **2022**, *43*, 1167–1179. [CrossRef]
110. Holvoet, P. Non-Coding RNAs Related to Lipid Metabolism and Non-Alcoholic Fatty Liver Disease. In *Non-Coding RNAs at the Cross-Road of Cardiometabolic Diseases and Cancer*; Springer: Berlin/Heidelberg, Germany, 2021; pp. 73–88.
111. Yu, Y.; Du, H.; Wei, S.; Feng, L.; Li, J.; Yao, F.; Zhang, M.; Hatch, G.M.; Chen, L. Adipocyte-Derived Exosomal MiR-27a Induces Insulin Resistance in Skeletal Muscle through Repression of PPARγ. *Theranostics* **2018**, *8*, 2171. [CrossRef]
112. Ando, Y.; Yamazaki, M.; Yamada, H.; Munetsuna, E.; Fujii, R.; Mizuno, G.; Ichino, N.; Osakabe, K.; Sugimoto, K.; Ishikawa, H. Association of Circulating MiR-20a, MiR-27a, and MiR-126 with Non-Alcoholic Fatty Liver Disease in General Population. *Sci. Rep.* **2019**, *9*, 18856. [CrossRef]
113. Ignačáková, H. Therapeutic Targeting of MicroRNA-21 and Bile Acid-Activated Receptors in Non-Alcoholic Fatty Liver Disease. Master's Thesis, Universidade de Lisboa, Lisboa, Portugal, 2021.
114. Liu, M.; Lu, T.; Bai, Y.; Han, X.; Zhang, W.; Zhang, L.; Chen, S.; Lin, C.; Liu, C.; Yuan, C. The Critical Role of MicroRNA-21 in Non-Alcoholic Fatty Liver Disease Pathogenesis. *Curr. Pharm. Des.* **2023**, *29*, 904–913. [CrossRef]
115. Holland, A.; Enrick, M.; Diaz, A.; Yin, L. Is MiR-21 A Therapeutic Target in Cardiovascular Disease? *Int. J. Drug Discov. Pharmacol.* **2023**, *2*, 26. [CrossRef] [PubMed]
116. Feng, J.; Li, A.; Deng, J.; Yang, Y.; Dang, L.; Ye, Y.; Li, Y.; Zhang, W. MiR-21 Attenuates Lipopolysaccharide-Induced Lipid Accumulation and Inflammatory Response: Potential Role in Cerebrovascular Disease. *Lipids Health Dis.* **2014**, *13*, 27. [CrossRef] [PubMed]
117. Lu, Y.; Thavarajah, T.; Gu, W.; Cai, J.; Xu, Q. Impact of MiRNA in Atherosclerosis. *Arterioscler. Thromb. Vasc. Biol.* **2018**, *38*, e159–e170. [CrossRef] [PubMed]
118. Zhang, X.; Deng, F.; Zhang, Y.; Zhang, X.; Chen, J.; Jiang, Y. PPARγ Attenuates Hepatic Inflammation and Oxidative Stress of Non-Alcoholic Steatohepatitis via Modulating the MiR-21-5p/SFRP5 Pathway. *Mol. Med. Rep.* **2021**, *24*, 823. [CrossRef]
119. Bertran, L.; Portillo-Carrasquer, M.; Barrientos-Riosalido, A.; Aguilar, C.; Riesco, D.; Martínez, S.; Culebradas, A.; Vives, M.; Sabench, F.; Castillo, D. Del Increased Secreted Frizzled-Related Protein 5 MRNA Expression in the Adipose Tissue of Women with Nonalcoholic Fatty Liver Disease Associated with Obesity. *Int. J. Mol. Sci.* **2022**, *23*, 9871. [CrossRef]
120. Rodrigues, P.M.; Afonso, M.B.; Simão, A.L.; Islam, T.; Gaspar, M.M.; O'Rourke, C.J.; Lewinska, M.; Andersen, J.B.; Arretxe, E.; Alonso, C. MiR-21-5p Promotes NASH-related Hepatocarcinogenesis. *Liver Int.* **2023**, *43*, 2256–2274. [CrossRef]
121. Yang, K.; Liu, C.; Shao, J.; Guo, L.; Wang, Q.; Meng, Z.; Jin, X.; Chen, X. Would Combination Be Better: Swimming Exercise and Intermittent Fasting Improve High-Fat Diet-Induced Nonalcoholic Fatty Liver Disease in Obese Rats via the MiR-122-5p/SREBP-1c/CPT1A Pathway. *Diabetes Metab. Syndr. Obes.* **2024**, *17*, 1675–1686. [CrossRef]
122. Qiang, J.; Tao, Y.F.; Bao, J.W.; Chen, D.J.; Li, H.X.; He, J.; Xu, P. High Fat Diet-Induced MiR-122 Regulates Lipid Metabolism and Fat Deposition in Genetically Improved Farmed Tilapia (GIFT, Oreochromis Niloticus) Liver. *Front. Physiol.* **2018**, *9*, 1422. [CrossRef]
123. Abdou, S.M.; Abd El-Maksoud, A.M.; Ahmed, G.F.; Abd El-Aziz, H.G. MiRNA-122 as a Biomarker for Insulin Resistance and Risk of Cardiovascular Diseases in Obese Children. *Gene Rep.* **2024**, *36*, 101947. [CrossRef]
124. Kim, J.; Yoon, H.; Horie, T.; Burchett, J.M.; Restivo, J.L.; Rotllan, N.; Ramírez, C.M.; Verghese, P.B.; Ihara, M.; Hoe, H.-S. MicroRNA-33 Regulates ApoE Lipidation and Amyloid-β Metabolism in the Brain. *J. Neurosci.* **2015**, *35*, 14717–14726. [CrossRef] [PubMed]
125. Jaouen, F.; Gascon, E. Understanding the Role of MiR-33 in Brain Lipid Metabolism: Implications for Alzheimer's Disease. *J. Neurosci.* **2016**, *36*, 2558–2560. [CrossRef] [PubMed]
126. Chen, W.-J.; Zhang, M.; Zhao, G.-J.; Fu, Y.; Zhang, D.-W.; Zhu, H.-B.; Tang, C.-K. MicroRNA-33 in Atherosclerosis Etiology and Pathophysiology. *Atherosclerosis* **2013**, *227*, 201–208. [CrossRef] [PubMed]
127. Ortega, R.; Liu, B.; Persaud, S.J. Effects of MiR-33 Deficiency on Metabolic and Cardiovascular Diseases: Implications for Therapeutic Intervention. *Int. J. Mol. Sci.* **2023**, *24*, 10777. [CrossRef]
128. Nguyen, M.-A.; Hoang, H.-D.; Rasheed, A.; Duchez, A.-C.; Wyatt, H.; Cottee, M.L.; Graber, T.E.; Susser, L.; Robichaud, S.; Berber, İ. MiR-223 Exerts Translational Control of Proatherogenic Genes in Macrophages. *Circ. Res.* **2022**, *131*, 42–58. [CrossRef]
129. Zhang, M.-W.; Shen, Y.-J.; Shi, J.; Yu, J.-G. MiR-223-3p in Cardiovascular Diseases: A Biomarker and Potential Therapeutic Target. *Front. Cardiovasc. Med.* **2021**, *7*, 610561. [CrossRef]
130. Gu, J.; Xu, H.; Chen, Y.; Li, N.; Hou, X. MiR-223 as a Regulator and Therapeutic Target in Liver Diseases. *Front. Immunol.* **2022**, *13*, 860661. [CrossRef]
131. Tabet, F.; Vickers, K.C.; Cuesta Torres, L.F.; Wiese, C.B.; Shoucri, B.M.; Lambert, G.; Catherinet, C.; Prado-Lourenco, L.; Levin, M.G.; Thacker, S. HDL-Transferred MicroRNA-223 Regulates ICAM-1 Expression in Endothelial Cells. *Nat. Commun.* **2014**, *5*, 3292. [CrossRef]
132. Wang, X.; Ma, Y.; Yang, L.-Y.; Zhao, D. MicroRNA-20a-5p Ameliorates Non-Alcoholic Fatty Liver Disease via Inhibiting the Expression of CD36. *Front. Cell Dev. Biol.* **2020**, *8*, 596329. [CrossRef]

133. Gao, G.; Chen, W.; Liu, M.; Yan, X.; Yang, P. Circulating MicroRNAs as Novel Potential Biomarkers for Left Ventricular Remodeling in Postinfarction Heart Failure. *Dis. Markers* **2019**, *2019*, 5093803. [CrossRef]
134. Ye, D.; Zhang, T.; Lou, G.; Xu, W.; Dong, F.; Chen, G.; Liu, Y. Plasma MiR-17, MiR-20a, MiR-20b and MiR-122 as Potential Biomarkers for Diagnosis of NAFLD in Type 2 Diabetes Mellitus Patients. *Life Sci.* **2018**, *208*, 201–207. [CrossRef]
135. Wu, C.; Qin, N.; Ren, H.; Yang, M.; Liu, S.; Wang, Q. Metformin Regulating MiR-34a Pathway to Inhibit Egr1 in Rat Mesangial Cells Cultured with High Glucose. *Int. J. Endocrinol.* **2018**, *2018*, 6462793. [CrossRef] [PubMed]
136. Ding, J.; Li, M.; Wan, X.; Jin, X.; Chen, S.; Yu, C.; Li, Y. Effect of MiR-34a in Regulating Steatosis by Targeting PPARα Expression in Nonalcoholic Fatty Liver Disease. *Sci. Rep.* **2015**, *5*, 13729. [CrossRef] [PubMed]
137. Xu, Y.; Zhu, Y.; Hu, S.; Pan, X.; Bawa, F.C.; Wang, H.H.; Wang, D.Q.-H.; Yin, L.; Zhang, Y. Hepatocyte MiR-34a Is a Key Regulator in the Development and Progression of Non-Alcoholic Fatty Liver Disease. *Mol. Metab.* **2021**, *51*, 101244. [CrossRef] [PubMed]
138. Sarkar, S.; Engler-Chiurazzi, E.B.; Cavendish, J.Z.; Povroznik, J.M.; Russell, A.E.; Quintana, D.D.; Mathers, P.H.; Simpkins, J.W. Over-Expression of MiR-34a Induces Rapid Cognitive Impairment and Alzheimer's Disease-like Pathology. *Brain Res.* **2019**, *1721*, 146327. [CrossRef]
139. Zheng, L.; Lv, G.; Sheng, J.; Yang, Y. Effect of MiRNA-10b in Regulating Cellular Steatosis Level by Targeting PPAR-α Expression, a Novel Mechanism for the Pathogenesis of NAFLD. *J. Gastroenterol. Hepatol.* **2010**, *25*, 156–163. [CrossRef]
140. Kiran, S.; Mandal, M.; Rakib, A.; Bajwa, A.; Singh, U.P. MiR-10a-3p Modulates Adiposity and Suppresses Adipose Inflammation through TGF-B1/Smad3 Signaling Pathway. *Front. Immunol.* **2023**, *14*, 1213415. [CrossRef]
141. Wang, H.; Ma, M.; Li, Y.; Liu, J.; Sun, C.; Liu, S.; Ma, Y.; Yan, Y.; Tang, Z.; Shen, S. MiR-183 and MiR-96 Orchestrate Both Glucose and Fat Utilization in Skeletal Muscle. *EMBO Rep.* **2021**, *22*, e52247. [CrossRef]
142. Nemeth, K.; Bayraktar, R.; Ferracin, M.; Calin, G.A. Non-coding RNAs in disease: From mechanisms to therapeutics. *Nat. Rev. Genet.* **2024**, *25*, 211–232. [CrossRef]
143. Wang, L.; Jia, X.-J.; Jiang, H.-J.; Du, Y.; Yang, F.; Si, S.-Y.; Hong, B. MicroRNAs 185, 96, and 223 Repress Selective High-Density Lipoprotein Cholesterol Uptake through Posttranscriptional Inhibition. *Mol. Cell Biol.* **2013**, *33*, 1956–1964. [CrossRef]
144. Ramírez, C.M.; Rotllan, N.; Vlassov, A.V.; Dávalos, A.; Li, M.; Goedeke, L.; Aranda, J.F.; Cirera-Salinas, D.; Araldi, E.; Salerno, A. Control of Cholesterol Metabolism and Plasma High-Density Lipoprotein Levels by MicroRNA-144. *Circ. Res.* **2013**, *112*, 1592–1601. [CrossRef]
145. Cheng, J.; Cheng, A.; Clifford, B.L.; Wu, X.; Hedin, U.; Maegdefessel, L.; Pamir, N.; Sallam, T.; Tarling, E.J.; de Aguiar Vallim, T.Q. MicroRNA-144 Silencing Protects against Atherosclerosis in Male, but Not Female Mice. *Arterioscler. Thromb. Vasc. Biol.* **2020**, *40*, 412–425. [CrossRef] [PubMed]
146. Du, F.; Yu, F.; Wang, Y.; Hui, Y.; Carnevale, K.; Fu, M.; Lu, H.; Fan, D. MicroRNA-155 Deficiency Results in Decreased Macrophage Inflammation and Attenuated Atherogenesis in Apolipoprotein E–Deficient Mice. *Arterioscler. Thromb. Vasc. Biol.* **2014**, *34*, 759–767. [CrossRef] [PubMed]
147. Wang, G.; Chen, J.-J.; Deng, W.-Y.; Ren, K.; Yin, S.-H.; Yu, X.-H. CTRP12 Ameliorates Atherosclerosis by Promoting Cholesterol Efflux and Inhibiting Inflammatory Response via the MiR-155-5p/LXRα Pathway. *Cell Death Dis.* **2021**, *12*, 254. [CrossRef]
148. González-López, P.; Ares-Carral, C.; López-Pastor, A.R.; Infante-Menéndez, J.; González Illaness, T.; Vega de Ceniga, M.; Esparza, L.; Beneit, N.; Martín-Ventura, J.L.; Escribano, Ó. Implication of MiR-155-5p and MiR-143-3p in the Vascular Insulin Resistance and Instability of Human and Experimental Atherosclerotic Plaque. *Int. J. Mol. Sci.* **2022**, *23*, 10253. [CrossRef]
149. Klöting, N.; Berthold, S.; Kovacs, P.; Schön, M.R.; Fasshauer, M.; Ruschke, K.; Stumvoll, M.; Blüher, M. MicroRNA Expression in Human Omental and Subcutaneous Adipose Tissue. *PLoS ONE* **2009**, *4*, e4699. [CrossRef]
150. Liu, J.; Long, Y.; Xu, P.; Guo, H.; Cui, G. Pathogenesis of MiR-155 on Nonmodifiable and Modifiable Risk Factors in Alzheimer's Disease. *Alzheimers Res. Ther.* **2023**, *15*, 122. [CrossRef]
151. Massart, J.; Sjögren, R.J.O.; Lundell, L.S.; Mudry, J.M.; Franck, N.; O'Gorman, D.J.; Egan, B.; Zierath, J.R.; Krook, A. Altered MiR-29 Expression in Type 2 Diabetes Influences Glucose and Lipid Metabolism in Skeletal Muscle. *Diabetes* **2017**, *66*, 1807–1818. [CrossRef]
152. Wu, P.; Wang, Q.; Jiang, C.; Chen, C.; Liu, Y.; Chen, Y.; Zeng, Y. MicroRNA-29a Is Involved Lipid Metabolism Dysfunction and Insulin Resistance in C2C12 Myotubes by Targeting PPARδ. *Mol. Med. Rep.* **2018**, *17*, 8493–8501. [CrossRef]
153. Mahdy, M.M.; El-Ekiaby, N.M.; Hashish, R.M.; Salah, R.A.; Hanafi, R.S.; Azzazy, H.M.E.-S.; Abdelaziz, A.I. MiR-29a Promotes Lipid Droplet and Triglyceride Formation in HCV Infection by Inducing Expression of SREBP-1c and CaV1. *J. Clin. Transl. Hepatol.* **2016**, *4*, 293–299.
154. Liu, M.; Gao, M.; Li, C.; Yu, C.; Yan, H.; Peng, C.; Li, Y.; Li, C.; Ma, Z.; Zhao, Y. Dicer1/MiR-29/HMGCR Axis Contributes to Hepatic Free Cholesterol Accumulation in Mouse Non-Alcoholic Steatohepatitis. *Acta Pharmacol. Sin.* **2017**, *38*, 660–671. [CrossRef] [PubMed]
155. Yang, Y.-L.; Wang, P.-W.; Wang, F.-S.; Lin, H.-Y.; Huang, Y.-H. MiR-29a Modulates GSK3β/SIRT1-Linked Mitochondrial Proteostatic Stress to Ameliorate Mouse Non-Alcoholic Steatohepatitis. *Int. J. Mol. Sci.* **2020**, *21*, 6884. [CrossRef] [PubMed]

156. Chen, L.; Hou, J.; Ye, L.; Chen, Y.; Cui, J.; Tian, W.; Li, C.; Liu, L. MicroRNA-143 Regulates Adipogenesis by Modulating the MAP2K5–ERK5 Signaling. *Sci. Rep.* **2014**, *4*, 3819. [CrossRef] [PubMed]
157. Li, B.; Dong, Y.; Hu, S.; Liu, T. MiR-143-3p/FNDC5 Axis: A Novel Regulator of Insulin Sensitivity. *Endocrine* **2024**, *83*, 368–377. [CrossRef]
158. Blumensatt, M.; Wronkowitz, N.; Wiza, C.; Cramer, A.; Mueller, H.; Rabelink, M.J.; Hoeben, R.C.; Eckel, J.; Sell, H.; Ouwens, D.M. Adipocyte-Derived Factors Impair Insulin Signaling in Differentiated Human Vascular Smooth Muscle Cells via the Upregulation of MiR-143. *Biochim. Biophys. Acta (BBA) Mol. Basis Dis.* **2014**, *1842*, 275–283. [CrossRef]
159. Zhang, Y.-H.; Xie, H.-L.; Yang, Y.-W.; Wen, J.; Liu, R.-R.; Zhao, G.-P.; Tan, X.-D.; Liu, Z.; Zheng, Y.; Zhang, J.-B. MiR-375 Upregulates Lipid Metabolism and Inhibits Cell Proliferation Involved in Chicken Fatty Liver Formation and Inheritance via Targeting Recombination Signal Binding Protein for Immunoglobulin Kappa J Region (RBPJ). *Poult. Sci.* **2023**, *102*, 102218. [CrossRef]
160. García-Jacobo, R.E.; Uresti-Rivera, E.E.; Portales-Pérez, D.P.; González-Amaro, R.; Lara-Ramírez, E.E.; Enciso-Moreno, J.A.; García-Hernández, M.H. Circulating MiR-146a, MiR-34a and MiR-375 in Type 2 Diabetes Patients, Pre-diabetic and Normal-glycaemic Individuals in Relation to B-cell Function, Insulin Resistance and Metabolic Parameters. *Clin. Exp. Pharmacol. Physiol.* **2019**, *46*, 1092–1100. [CrossRef]
161. Lei, L.; Zhou, C.; Yang, X.; Li, L. Down-regulation of Micro RNA-375 Regulates Adipokines and Inhibits Inflammatory Cytokines by Targeting AdipoR2 in Non-alcoholic Fatty Liver Disease. *Clin. Exp. Pharmacol. Physiol.* **2018**, *45*, 819–831. [CrossRef]
162. Zhan, J.; Lv, H.; Dai, B.; Yuan, S.; Fan, J.; Zhao, Y.; Yin, Z.; Wang, D.W.; Chen, C.; Li, H. The Nuclear and Cytoplasmic Roles of MiR-320 in Non-Alcoholic Fatty Liver Disease. *Aging* **2020**, *12*, 22019. [CrossRef]
163. Du, H.; Zhao, Y.; Yin, Z.; Wang, D.W.; Chen, C. The Role of MiR-320 in Glucose and Lipid Metabolism Disorder-Associated Diseases. *Int. J. Biol. Sci.* **2021**, *17*, 402–416. [CrossRef]
164. Lin, Y.; Ding, D.; Huang, Q.; Liu, Q.; Lu, H.; Lu, Y.; Chi, Y.; Sun, X.; Ye, G.; Zhu, H. Downregulation of MiR-192 Causes Hepatic Steatosis and Lipid Accumulation by Inducing SREBF1: Novel Mechanism for Bisphenol A-Triggered Non-Alcoholic Fatty Liver Disease. *Biochim. Biophys. Acta (BBA) Mol. Cell Biol. Lipids* **2017**, *1862*, 869–882. [CrossRef]
165. Chen, Z.; Yan, D.; Guo, S.; Song, Y.; Zhang, X.; Gu, W.; Dong, H.; Huang, L. METTL3/MiR-192-5p/SCD1 Axis Regulates Lipid Metabolism to Affect T Cell Differentiation in Asthma. *Mediat. Inflamm.* **2025**, *2025*, 4955849. [CrossRef] [PubMed]
166. Pokharel, D.R.; Maskey, A.; Kafle, R.; Batajoo, A.; Dahal, P.; Raut, R.; Adhikari, S.; Manandhar, B.; Manandhar, K. Das Evaluation of Circulating Plasma MiR-9, MiR-29a, MiR-192, and MiR-375 as Potential Biomarkers for Predicting Prediabetes and Type 2 Diabetes in Nepali Adult Population. *Noncoding RNA Res.* **2024**, *9*, 1324–1332. [CrossRef] [PubMed]
167. Soronen, J.; Yki-Järvinen, H.; Zhou, Y.; Sädevirta, S.; Sarin, A.; Leivonen, M.; Sevastianova, K.; Perttilä, J.; Laurila, P.; Sigruener, A. Novel Hepatic MicroRNAs Upregulated in Human Nonalcoholic Fatty Liver Disease. *Physiol. Rep.* **2016**, *4*, e12661. [CrossRef] [PubMed]
168. Zhang, Y.; Wang, L.; Xu, J.; Kong, X.; Zou, L. Up-Regulated MiR-106b Inhibits Ox-LDL-Induced Endothelial Cell Apoptosis in Atherosclerosis. *Braz. J. Med. Biol. Res.* **2020**, *53*, e8960. [CrossRef]
169. Kim, J.; Yoon, H.; Ramírez, C.M.; Lee, S.-M.; Hoe, H.-S.; Fernández-Hernando, C.; Kim, J. MiR-106b Impairs Cholesterol Efflux and Increases Aβ Levels by Repressing ABCA1 Expression. *Exp. Neurol.* **2012**, *235*, 476–483. [CrossRef]
170. Zhang, J.; Lin, X.; Huang, Q.; Fu, Z.; Huang, Y.; Chen, Z.; Li, N.; Lin, X. The Overexpression of MiR-146a in Hippocampal Microglia via IRAK1/TRAF6/NF-KB Pathway Improves Cognitive Function in Diabetic Mice. *Exp. Neurol.* **2025**, *391*, 115291. [CrossRef]
171. Li, K.; Ching, D.; Luk, F.S.; Raffai, R.L. MicroRNA-146a Suppression of NF-KB-Driven Monocyte/Macrophage Activation and Atherosclerosis Is Regulated by Cellular ApoE Expression. *Arterioscler. Thromb. Vasc. Biol.* **2015**, *35*, A155. [CrossRef]
172. Xiong, J.; Yan, Z.; Shi, M.; Zhou, G.; Zhang, J.; Xu, J.; Liao, Y.; Tang, H. MiR-146a Regulates Neuroinflammation and Immune Cell Function in Neurodegenerative Diseases. *Curr. Med. Sci.* **2025**, *45*, 725–744. [CrossRef]
173. Li, K.; Zhao, B.; Wei, D.; Wang, W.; Cui, Y.; Qian, L.; Liu, G. MiR-146a Improves Hepatic Lipid and Glucose Metabolism by Targeting MED1. *Int. J. Mol. Med.* **2020**, *45*, 543–555. [CrossRef]
174. Zhang, Z.-C.; Liu, Y.; Xiao, L.-L.; Li, S.-F.; Jiang, J.-H.; Zhao, Y.; Qian, S.-W.; Tang, Q.-Q.; Li, X. Upregulation of MiR-125b by Estrogen Protects against Non-Alcoholic Fatty Liver in Female Mice. *J. Hepatol.* **2015**, *63*, 1466–1475. [CrossRef] [PubMed]
175. Zhang, Q.; Yu, K.; Cao, Y.; Luo, Y.; Liu, Y.; Zhao, C. MiR-125b Promotes the NF-KB-Mediated Inflammatory Response in NAFLD via Directly Targeting TNFAIP3. *Life Sci.* **2021**, *270*, 119071. [CrossRef] [PubMed]
176. Liu, R.; Wang, M.; Li, E.; Yang, Y.; Li, J.; Chen, S.; Shen, W.-J.; Azhar, S.; Guo, Z.; Hu, Z. Dysregulation of MicroRNA-125a Contributes to Obesity-Associated Insulin Resistance and Dysregulates Lipid Metabolism in Mice. *Biochim. Biophys. Acta (BBA) Mol. Cell Biol. Lipids* **2020**, *1865*, 158640. [CrossRef]
177. Wasim, M.; Guo, J.; Wang, Z.; Parveen, R.; Chen, R.; Wang, Y.; Ma, G. MiR-137: A Therapeutic Candidate or a Key Molecular Regulator in Alzheimer's Disease? *J. Alzheimers Dis. Rep.* **2025**, *9*, 25424823251352170. [CrossRef]

178. Yu, Y.; He, C.; Tan, S.; Huang, M.; Guo, Y.; Li, M.; Zhang, Q. MicroRNA-137-3p Improves Nonalcoholic Fatty Liver Disease through Activating AMPKα. *Anal. Cell. Pathol.* **2021**, *2021*, 4853355. [CrossRef]
179. Patra, D.; Roy, S.; Arora, L.; Kabeer, S.W.; Singh, S.; Dey, U.; Banerjee, D.; Sinha, A.; Dasgupta, S.; Tikoo, K. MiR-210-3p Promotes Obesity-Induced Adipose Tissue Inflammation and Insulin Resistance by Targeting SOCS1-Mediated NF-KB Pathway. *Diabetes* **2023**, *72*, 375–388. [CrossRef]
180. Qiao, X.-R.; Wang, L.; Liu, M.; Tian, Y.; Chen, T. MiR-210-3p Attenuates Lipid Accumulation and Inflammation in Atherosclerosis by Repressing IGF2. *Biosci. Biotechnol. Biochem.* **2020**, *84*, 321–329. [CrossRef]
181. Szabo, G.; Csak, T. Role of MicroRNAs in NAFLD/NASH. *Dig. Dis. Sci.* **2016**, *61*, 1314–1324. [CrossRef]
182. Wang, G.; Zou, H.; Lai, C.; Huang, X.; Yao, Y.; Xiang, G. Repression of MicroRNA-124-3p Alleviates High-Fat Diet–Induced Hepatosteatosis by Targeting Pref-1. *Front. Endocrinol.* **2020**, *11*, 589994. [CrossRef]
183. Shaw, T.A.; Singaravelu, R.; Powdrill, M.H.; Nhan, J.; Ahmed, N.; Özcelik, D.; Pezacki, J.P. MicroRNA-124 Regulates Fatty Acid and Triglyceride Homeostasis. *iScience* **2018**, *10*, 149–157. [CrossRef]
184. Cheng, Y.; Jung, J.; Guo, L.; Shuboni-Mulligan, D.D.; Chen, J.-F.; Hu, W.; Guo, M.-L. HIV-TAT Dysregulates Microglial Lipid Metabolism through SREBP2/MiR-124 Axis: Implication of Lipid Droplet Accumulation Microglia in NeuroHIV. *Brain Behav. Immun.* **2025**, *123*, 108–122. [CrossRef] [PubMed]
185. Han, Z.; Wang, L.; Xu, S.; Zhang, H.; Cheng, J.; Pan, S. Microvesicle-Shuttled MicroRNA-130b Activates the Hepatic Inflammation by Inhibiting Glucocorticoid-Receptor-Mediated Immunosuppression in High-Fat Diet-Induced Obese Mice. *Vet. Sci.* **2024**, *11*, 565. [CrossRef] [PubMed]
186. Zhang, M.; Zhou, Z.; Wang, J.; Li, S. MiR-130b Promotes Obesity Associated Adipose Tissue Inflammation and Insulin Resistance in Diabetes Mice through Alleviating M2 Macrophage Polarization via Repression of PPAR-γ. *Immunol. Lett.* **2016**, *180*, 1–8. [CrossRef] [PubMed]
187. Ben-Aicha, S.; Escate, R.; Casaní, L.; Padró, T.; Peña, E.; Arderiu, G.; Mendieta, G.; Badimón, L.; Vilahur, G. High-Density Lipoprotein Remodelled in Hypercholesterolaemic Blood Induce Epigenetically Driven down-Regulation of Endothelial HIF-1α Expression in a Preclinical Animal Model. *Cardiovasc. Res.* **2020**, *116*, 1288–1299. [CrossRef]
188. Goedeke, L.; Rotllan, N.; Canfrán-Duque, A.; Aranda, J.F.; Ramírez, C.M.; Araldi, E.; Lin, C.-S.; Anderson, N.N.; Wagschal, A.; De Cabo, R. MicroRNA-148a Regulates LDL Receptor and ABCA1 Expression to Control Circulating Lipoprotein Levels. *Nat. Med.* **2015**, *21*, 1280–1289. [CrossRef]
189. Goedeke, L.; Rotllan, N.; Canfrán-Duque, A.; Aranda, J.F.; Ramírez, C.M.; Araldi, E.; Lin, C.-S.; Anderson, N.N.; Wagschal, A.; de Cabo, R. Identification of MiR-148a as a Novel Regulator of Cholesterol Metabolism. *Nat. Med.* **2015**, *21*, 1280–1289. [CrossRef]
190. Trajkovski, M.; Hausser, J.; Soutschek, J.; Bhat, B.; Akin, A.; Zavolan, M.; Heim, M.H.; Stoffel, M. MicroRNAs 103 and 107 Regulate Insulin Sensitivity. *Nature* **2011**, *474*, 649–653. [CrossRef]
191. Luo, M.; Xu, C.; Luo, Y.; Wang, G.; Wu, J.; Wan, Q. Circulating MiR-103 Family as Potential Biomarkers for Type 2 Diabetes through Targeting CAV-1 and SFRP4. *Acta Diabetol.* **2020**, *57*, 309–322. [CrossRef]
192. Lorente-Cebrian, S.; Mejhert, N.; Kulyte, A.; Laurencikiene, J.; Åström, G.; Heden, P.; Ryden, M.; Arner, P. MicroRNAs Regulate Human Adipocyte Lipolysis: Effects of MiR-145 Are Linked to TNF-α. *PLoS ONE* **2014**, *9*, e86800. [CrossRef]
193. Fernández-de Frutos, M.; Pardo-Marqués, V.; Torrecilla-Parra, M.; Rada, P.; Pérez-García, A.; Martín-Martín, Y.; de la Peña, G.; Gómez, A.; Toledano-Zaragoza, A.; Gómez-Coronado, D. MiR-7 Controls Cholesterol Biosynthesis through Posttranscriptional Regulation of DHCR24 Expression. *Biochim. Biophys. Acta (BBA) Gene Regul. Mech.* **2023**, *1866*, 194938.
194. Cuevas-Diaz Duran, R.; Wei, H.; Kim, D.H.; Wu, J.Q. Invited Review: Long Non-coding RNA s: Important Regulators in the Development, Function and Disorders of the Central Nervous System. *Neuropathol. Appl. Neurobiol.* **2019**, *45*, 538–556. [CrossRef] [PubMed]
195. Maclary, E.; Hinten, M.; Harris, C.; Sethuraman, S.; Gayen, S.; Kalantry, S. PRC2 Represses Transcribed Genes on the Imprinted Inactive X Chromosome in Mice. *Genome Biol.* **2017**, *18*, 82. [CrossRef] [PubMed]
196. Mongelli, A.; Mohammed, S.A.; Gorica, E.; Mengozzi, A.; Matter, C.M.; Ruschitzka, F.; Paneni, F.; Costantino, S. Long Non-Coding RNA PANDA Drives Diabetic Vascular Dysfunction by Promoting Endothelial Senescence and Oxidative Damage. *Eur. Heart J.* **2023**, *44*, ehad655-3236. [CrossRef]
197. Farberov, S.; Ziv, O.; Lau, J.Y.; Ben-Tov Perry, R.; Lubelsky, Y.; Miska, E.; Kudla, G.; Ulitsky, I. Structural Features within the NORAD Long Noncoding RNA Underlie Efficient Repression of Pumilio Activity. *Nat. Struct. Mol. Biol.* **2025**, *32*, 287–299. [CrossRef]
198. Farooq, U.; Notani, D. Transcriptional Regulation of INK4/ARF Locus by Cis and Trans Mechanisms. *Front. Cell Dev. Biol.* **2022**, *10*, 948351. [CrossRef]
199. Li, A.; Mallik, S.; Luo, H.; Jia, P.; Lee, D.-F.; Zhao, Z. H19, a Long Non-Coding RNA, Mediates Transcription Factors and Target Genes through Interference of MicroRNAs in Pan-Cancer. *Mol. Ther. Nucleic Acids* **2020**, *21*, 180–191. [CrossRef]
200. Arun, G.; Diermeier, S.D.; Spector, D.L. Therapeutic Targeting of Long Non-Coding RNAs in Cancer. *Trends Mol. Med.* **2018**, *24*, 257–277. [CrossRef]

201. Singh, A.K.; Aryal, B.; Zhang, X.; Fan, Y.; Price, N.L.; Suárez, Y.; Fernández-Hernando, C. Posttranscriptional Regulation of Lipid Metabolism by Non-Coding RNAs and RNA Binding Proteins. In Proceedings of the Seminars in Cell & Developmental Biology; Elsevier: Amsterdam, The Netherlands, 2018; Volume 81, pp. 129–140.
202. Alluri, A.; Saxena, P.; Mishra, A.; Gutti, R.K. Association of Long Non-Coding RNA in Lipid Metabolism: Implications in Leukemia. *Int. J. Biochem. Cell Biol.* **2025**, *184*, 106785. [CrossRef]
203. Johnson, A.A.; Stolzing, A. The role of lipid metabolism in aging, lifespan regulation, and age-related disease. *Aging Cell* **2019**, *18*, e13048. [CrossRef]
204. Zhao, Y.; Wu, J.; Liangpunsakul, S.; Wang, L. Long non-coding RNA in liver metabolism and disease: Current status. *Liver Res.* **2017**, *1*, 163–167. [CrossRef]
205. Sallam, T.; Jones, M.C.; Gilliland, T.; Zhang, L.; Wu, X.; Eskin, A.; Sandhu, J.; Casero, D.; de Aguiar Vallim, T.Q.; Hong, C. Feedback Modulation of Cholesterol Metabolism by the Lipid-Responsive Non-Coding RNA LeXis. *Nature* **2016**, *534*, 124–128. [CrossRef]
206. Li, P.; Ruan, X.; Yang, L.; Kiesewetter, K.; Zhao, Y.; Luo, H.; Chen, Y.; Gucek, M.; Zhu, J.; Cao, H. A Liver-Enriched Long Non-Coding RNA, LncLSTR, Regulates Systemic Lipid Metabolism in Mice. *Cell Metab.* **2015**, *21*, 455–467. [CrossRef]
207. Le, N.-A.; Walter, M.F. The Role of Hypertriglyceridemia in Atherosclerosis. *Curr. Atheroscler. Rep.* **2007**, *9*, 110–115. [CrossRef]
208. Xiang, J.; Deng, Y.-Y.; Liu, H.-X.; Pu, Y. LncRNA MALAT1 Promotes PPARα/CD36-Mediated Hepatic Lipogenesis in Nonalcoholic Fatty Liver Disease by Modulating MiR-206/ARNT Axis. *Front. Bioeng. Biotechnol.* **2022**, *10*, 858558. [CrossRef] [PubMed]
209. Liu, S.-X.; Zheng, F.; Xie, K.-L.; Xie, M.-R.; Jiang, L.-J.; Cai, Y. Exercise Reduces Insulin Resistance in Type 2 Diabetes Mellitus via Mediating the LncRNA MALAT1/MicroRNA-382-3p/Resistin Axis. *Mol. Ther. Nucleic Acids* **2019**, *18*, 34–44. [CrossRef]
210. Wang, H.; Zhang, Y.; Guan, X.; Li, X.; Zhao, Z.; Gao, Y.; Zhang, X.; Chen, R. An Integrated Transcriptomics and Proteomics Analysis Implicates LncRNA MALAT1 in the Regulation of Lipid Metabolism. *Mol. Cell. Proteom.* **2021**, *20*, 100141. [CrossRef]
211. Liu, L.; Tan, L.; Yao, J.; Yang, L. Long Non-Coding RNA MALAT1 Regulates Cholesterol Accumulation in Ox-LDL-Induced Macrophages via the MicroRNA-17-5p/ABCA1 Axis. *Mol. Med. Rep.* **2020**, *21*, 1761–1770. [CrossRef]
212. Zheng, J.; Ludin, A.F.M.; Rajab, N.F.; Shaolong, L.; Jufri, N.F. The Roles of LncMALAT1 in Coronary Artery Disease Regulation and Therapeutic Perspective: A Systematic Review. *iScience* **2025**, *28*, 112945. [CrossRef]
213. Wang, H.; Cao, Y.; Shu, L.; Zhu, Y.; Peng, Q.; Ran, L.; Wu, J.; Luo, Y.; Zuo, G.; Luo, J. Long Non-coding RNA (LncRNA) H19 Induces Hepatic Steatosis through Activating MLXIPL and MTORC1 Networks in Hepatocytes. *J. Cell Mol. Med.* **2020**, *24*, 1399–1412. [CrossRef]
214. Lin, F.; Yi, M.; Zhou, S.; Wang, Q. LncRNA H19 Promotes Adipogenic Differentiation Disorder by Sponging MiR-130b-3p to Upregulate PPARγ in Steroid-Induced Osteonecrosis of the Femoral Head. *Front. Genet.* **2025**, *16*, 1529797. [CrossRef]
215. Shi, X.; Wei, Y.-T.; Li, H.; Jiang, T.; Zheng, X.-L.; Yin, K.; Zhao, G.-J. Long Non-Coding RNA H19 in Atherosclerosis: What Role? *Mol. Med.* **2020**, *26*, 72. [CrossRef]
216. Daghistani, H.; Hegazy, G.A.; Alkhalofah, M.; Alsobeihy, A.; Nasser, S.; Gad, H.; Shamrani, T.; Mufrrih, M.; Alyousfi, D. Long Noncoding RNAs in Familial Hypercholesterolemia: Biomarkers, Therapeutics, and AI in Precision Medicine. *Lipids Health Dis.* **2025**, *24*, 182. [CrossRef] [PubMed]
217. Chen, L.; Qu, H.; Guo, M.; Zhang, Y.; Cui, Y.; Yang, Q.; Bai, R.; Shi, D. ANRIL and Atherosclerosis. *J. Clin. Pharm. Ther.* **2020**, *45*, 240–248. [CrossRef]
218. Chi, J.; Li, J.; Jia, J.; Zhang, T.; Liu, X.; Yi, L. Long Non-Coding RNA ANRIL in Gene Regulation and Its Duality in Atherosclerosis. *Curr. Med. Sci.* **2017**, *37*, 816–822. [CrossRef]
219. Gareev, I.; Kudriashov, V.; Sufianov, A.; Begliarzade, S.; Ilyasova, T.; Liang, Y.; Beylerli, O. The Role of Long Non-Coding RNA ANRIL in the Development of Atherosclerosis. *Noncoding RNA Res.* **2022**, *7*, 212–216. [CrossRef]
220. Zhao, X.-Y.; Xiong, X.; Liu, T.; Mi, L.; Peng, X.; Rui, C.; Guo, L.; Li, S.; Li, X.; Lin, J.D. Long Noncoding RNA Licensing of Obesity-Linked Hepatic Lipogenesis and NAFLD Pathogenesis. *Nat. Commun.* **2018**, *9*, 2986. [CrossRef]
221. Mi, L.; Zhao, X.-Y.; Li, S.; Yang, G.; Lin, J.D. Conserved Function of the Long Noncoding RNA Blnc1 in Brown Adipocyte Differentiation. *Mol. Metab.* **2017**, *6*, 101–110. [CrossRef]
222. Tang, S.; Zhu, W.; Zheng, F.; Gui, W.; Zhang, W.; Lin, X.; Li, H. The Long Noncoding RNA Blnc1 Protects against Diet-Induced Obesity by Promoting Mitochondrial Function in White Fat. *Diabetes Metab. Syndr. Obes.* **2020**, *13*, 1189–1201. [CrossRef]
223. Meng, X.; Long, M.; Yue, N.; Li, Q.; Chen, J.; Zhao, H.; Deng, W. LncRNA MEG3 Restrains Hepatic Lipogenesis via the FOXO1 Signaling Pathway in HepG2 Cells. *Cell Biochem. Biophys.* **2024**, *82*, 1253–1259. [CrossRef]
224. Ghaedi, H.; Zare, A.; Omrani, M.D.; Doustimotlagh, A.H.; Meshkani, R.; Alipoor, S.; Alipoor, B. Genetic Variants in Long Noncoding RNA H19 and MEG3 Confer Risk of Type 2 Diabetes in an Iranian Population. *Gene* **2018**, *675*, 265–271. [CrossRef]
225. Zou, D.; Liu, L.; Zeng, Y.; Wang, H.; Dai, D.; Xu, M. LncRNA MEG3 Up-Regulates SIRT6 by Ubiquitinating EZH2 and Alleviates Nonalcoholic Fatty Liver Disease. *Cell Death Discov.* **2022**, *8*, 103. [CrossRef] [PubMed]
226. Huang, P.; Huang, F.; Liu, H.; Zhang, T.; Yang, M.; Sun, C. LncRNA MEG3 Functions as a CeRNA in Regulating Hepatic Lipogenesis by Competitively Binding to MiR-21 with LRP6. *Metabolism* **2019**, *94*, 1–8. [CrossRef]

227. Tran, K.-V.; Nandrup-Bus, C.; DeSouza, T.; Soares, R.; Jespersen, N.Z.; Min, S.Y.; Rojas-Rodriguez, R.; Willenbrock, H.; Juhlin, T.; Severinsen, M.C.K. A Long-Non-Coding RNA, LINC00473, Confers the Human Adipose Tissue Thermogenic Phenotype through Enhanced CAMP Responsiveness. *bioRxiv* **2018**, 339192. [CrossRef]
228. Aggarwal, D.D.; Mishra, P.; Yadav, G.; Mitra, S.; Patel, Y.; Singh, M.; Sahu, R.K.; Sharma, V. Decoding the Connection between LncRNA and Obesity: Perspective from Humans and Drosophila. *Heliyon* **2024**, *10*, e35327. [CrossRef]
229. Zhang, T.-N.; Wang, W.; Yang, N.; Huang, X.-M.; Liu, C.-F. Regulation of Glucose and Lipid Metabolism by Long Non-Coding RNAs: Facts and Research Progress. *Front. Endocrinol.* **2020**, *11*, 457. [CrossRef]
230. Xiao, T.; Liu, L.; Li, H.; Sun, Y.; Luo, H.; Li, T.; Wang, S.; Dalton, S.; Zhao, R.C.; Chen, R. Long Noncoding RNA ADINR Regulates Adipogenesis by Transcriptionally Activating C/EBPα. *Stem Cell Rep.* **2015**, *5*, 856–865. [CrossRef]
231. Petkovic, A.; Erceg, S.; Munjas, J.; Ninic, A.; Vladimirov, S.; Davidovic, A.; Vukmirovic, L.; Milanov, M.; Cvijanovic, D.; Mitic, T. LncRNAs as Regulators of Atherosclerotic Plaque Stability. *Cells* **2023**, *12*, 1832. [CrossRef]
232. Chen, X.; Tan, X.-R.; Li, S.-J.; Zhang, X.-X. LncRNA NEAT1 Promotes Hepatic Lipid Accumulation via Regulating MiR-146a-5p/ROCK1 in Nonalcoholic Fatty Liver Disease. *Life Sci.* **2019**, *235*, 116829. [CrossRef]
233. Liu, X.; Liang, Y.; Song, R.; Yang, G.; Han, J.; Lan, Y.; Pan, S.; Zhu, M.; Liu, Y.; Wang, Y. Long Non-Coding RNA NEAT1-Modulated Abnormal Lipolysis via ATGL Drives Hepatocellular Carcinoma Proliferation. *Mol. Cancer* **2018**, *17*, 90. [CrossRef]
234. Sun, Y.; Song, Y.; Liu, C.; Geng, J. LncRNA NEAT1-MicroRNA-140 Axis Exacerbates Nonalcoholic Fatty Liver through Interrupting AMPK/SREBP-1 Signaling. *Biochem. Biophys. Res. Commun.* **2019**, *516*, 584–590. [CrossRef]
235. Gernapudi, R.; Wolfson, B.; Zhang, Y.; Yao, Y.; Yang, P.; Asahara, H.; Zhou, Q. MicroRNA 140 Promotes Expression of Long Noncoding RNA NEAT1 in Adipogenesis. *Mol. Cell Biol.* **2016**, *36*, 30–38. [CrossRef] [PubMed]
236. Pan, Y.; Xin, W.; Wei, W.; Tatenhorst, L.; Graf, I.; Popa-Wagner, A.; Gerner, S.T.; Huber, S.E.; Kilic, E.; Hermann, D.M. Knockdown of NEAT1 Prevents Post-Stroke Lipid Droplet Agglomeration in Microglia by Regulating Autophagy. *Cell. Mol. Life Sci.* **2024**, *81*, 30. [CrossRef] [PubMed]
237. Hennessy, E.J.; van Solingen, C.; Scacalossi, K.R.; Ouimet, M.; Afonso, M.S.; Prins, J.; Koelwyn, G.J.; Sharma, M.; Ramkhelawon, B.; Carpenter, S. The Long Noncoding RNA CHROME Regulates Cholesterol Homeostasis in Primates. *Nat. Metab.* **2019**, *1*, 98–110. [CrossRef] [PubMed]
238. Gluba-Sagr, A.; Franczyk, B.; Rysz-Górzyńska, A.; Olszewski, R.; Rysz, J. The Role of Selected LncRNAs in Lipid Metabolism and Cardiovascular Disease Risk. *Int. J. Mol. Sci.* **2024**, *25*, 9244. [CrossRef]
239. Zhang, Y.; Gu, M.; Ma, Y.; Peng, Y. LncRNA TUG1 Reduces Inflammation and Enhances Insulin Sensitivity in White Adipose Tissue by Regulating MiR-204/SIRT1 Axis in Obesity Mice. *Mol. Cell Biochem.* **2020**, *475*, 171–183. [CrossRef]
240. Xue, M.; Xia, F.; Wang, Y.; Zhu, L.; Li, Y.; Jia, D.; Gao, Y.; Shi, Y.; Zhang, C.; He, Y. The Role of LncRNA TUG1 in Obesity-Related Diseases. *Mini Rev. Med. Chem.* **2022**, *22*, 1305–1313. [CrossRef]
241. Zhang, Y.; Ma, Y.; Gu, M.; Peng, Y. LncRNA TUG1 Promotes the Brown Remodeling of White Adipose Tissue by Regulating MiR-204-targeted SIRT1 in Diabetic Mice. *Int. J. Mol. Med.* **2020**, *46*, 2225–2234. [CrossRef]
242. Das, S.; Reddy, M.A.; Senapati, P.; Stapleton, K.; Lanting, L.; Wang, M.; Amaram, V.; Ganguly, R.; Zhang, L.; Devaraj, S. Diabetes Mellitus–Induced Long Noncoding RNA Dnm3os Regulates Macrophage Functions and Inflammation via Nuclear Mechanisms. *Arterioscler. Thromb. Vasc. Biol.* **2018**, *38*, 1806–1820. [CrossRef]
243. Morán, I.; Akerman, I.; Van De Bunt, M.; Xie, R.; Benazra, M.; Nammo, T.; Arnes, L.; Nakić, N.; García-Hurtado, J.; Rodríguez-Seguí, S. Human β Cell Transcriptome Analysis Uncovers LncRNAs That Are Tissue-Specific, Dynamically Regulated, and Abnormally Expressed in Type 2 Diabetes. *Cell Metab.* **2012**, *16*, 435–448. [CrossRef]
244. Ismail, N.; Abdullah, N.; Abdul Murad, N.A.; Jamal, R.; Sulaiman, S.A. Long Non-Coding RNAs (LncRNAs) in Cardiovascular Disease Complication of Type 2 Diabetes. *Diagnostics* **2021**, *11*, 145. [CrossRef]
245. Yu, X.; Song, M.; Rong, P.; Chen, X.; Shi, L.; Wang, C.; Pang, Q. LncRNA SNHG1 Modulates Adipogenic Differentiation of BMSCs by Promoting DNMT1 Mediated Opg Hypermethylation via Interacting with PTBP1. *J. Cell Mol. Med.* **2022**, *26*, 60–74. [CrossRef]
246. Cao, B.; Wang, T.; Qu, Q.; Kang, T.; Yang, Q. Long Noncoding RNA SNHG1 Promotes Neuroinflammation in Parkinson's Disease via Regulating MiR-7/NLRP3 Pathway. *Neuroscience* **2018**, *388*, 118–127. [CrossRef] [PubMed]
247. Chen, E.; Yi, J.; Jiang, J.; Zou, Z.; Mo, Y.; Ren, Q.; Lin, Z.; Lu, Y.; Zhang, J.; Liu, J. Identification and Validation of a Fatty Acid Metabolism-Related LncRNA Signature as a Predictor for Prognosis and Immunotherapy in Patients with Liver Cancer. *BMC Cancer* **2022**, *22*, 1037. [CrossRef] [PubMed]
248. Du, M.; Wang, C.; Yang, L.; Liu, B.; Zheng, Z.; Yang, L.; Zhang, F.; Peng, J.; Huang, D.; Huang, K. The Role of Long Noncoding RNA Nron in Atherosclerosis Development and Plaque Stability. *iScience* **2022**, *25*, 103978. [CrossRef]
249. Gharbi, N.; Mahmoudinasab, H.; Hooshmandi, E.; Rahimi, M.; Bayat, M.; Karimi, N.; Hojati, S.S.; Zayani, Z.; Tabrizi, R.; Borhani-Haghighi, A. Altered Expression of Long Non-Coding RNAs NRON and SNHG11 in Patients with Ischemic Stroke. *Egypt. J. Med. Hum. Genet.* **2024**, *25*, 11. [CrossRef]

250. Tanase, D.M.; Gosav, E.M.; Costea, C.F.; Ciocoiu, M.; Lacatusu, C.M.; Maranduca, M.A.; Ouatu, A.; Floria, M. The Intricate Relationship between Type 2 Diabetes Mellitus (T2DM), Insulin Resistance (IR), and Nonalcoholic Fatty Liver Disease (NAFLD). *J. Diabetes Res.* **2020**, *2020*, 3920196. [CrossRef]
251. Liu, B.; Zhong, Y.; Huang, D.; Yang, L.; Wang, P.; Yang, L.; Zhang, F.; Li, X.; Liang, M.; Huang, K. LncRNA Nron Deficiency Protects Mice from Diet-Induced Adiposity and Hepatic Steatosis. *Metabolism* **2023**, *148*, 155609. [CrossRef]
252. Cai, L.; Tu, L.I.; Li, T.; Yang, X.; Ren, Y.; Gu, R.; Zhang, Q.; Yao, H.; Qu, X.; Wang, Q. Downregulation of LncRNA UCA1 Ameliorates the Damage of Dopaminergic Neurons, Reduces Oxidative Stress and Inflammation in Parkinson's Disease through the Inhibition of the PI3K/Akt Signaling Pathway. *Int. Immunopharmacol.* **2019**, *75*, 105734. [CrossRef]
253. Xiang, H.; Tu, B.; Luo, M.; Hou, P.; Wang, J.; Zhang, R.; Wu, L. Knockdown of UCA1 Attenuated the Progression of Alcoholic Fatty Disease by Sponging MiR-214. *Mamm. Genome* **2022**, *33*, 534–542. [CrossRef]
254. Huang, S.; Wu, K.; Li, B.; Liu, Y. LncRNA UCA1 Inhibits Mitochondrial Dysfunction of Skeletal Muscle in Type 2 Diabetes Mellitus by Sequestering MiR-143-3p to Release FGF21. *Cell Tissue Res.* **2023**, *391*, 561–575. [CrossRef]
255. Sun, S.; Li, H.; Liu, S.; Xie, X.; Zhai, W.; Pan, J. Long Noncoding RNA UCA1 Inhibits Epirubicin-Induced Apoptosis by Activating PPARα-Mediated Lipid Metabolism. *Exp. Cell Res.* **2024**, *442*, 114271. [CrossRef] [PubMed]
256. Li, B.; Du, Y.-J.; Xu, F.; Li, H.-B.; Yang, X. Potential Diagnostic Markers of Diabetic Retinopathy: Serum LncRNA MIAT, HOTTIP, SNHG16. *Diabetes Metab. Syndr. Obes.* **2024**, *2024*, 4247–4256. [CrossRef] [PubMed]
257. Yan, C.; Li, J.; Feng, S.; Li, Y.; Tan, L. Long Noncoding RNA Gomafu Upregulates Foxo1 Expression to Promote Hepatic Insulin Resistance by Sponging MiR-139-5p. *Cell Death Dis.* **2018**, *9*, 289. [CrossRef] [PubMed]
258. Tan, J.; Liu, S.; Jiang, Q.; Yu, T.; Huang, K. LncRNA-MIAT Increased in Patients with Coronary Atherosclerotic Heart Disease. *Cardiol. Res. Pract.* **2019**, *2019*, 6280194. [CrossRef]
259. Mazidi, M.; Penson, P.; Gluba-Brzozka, A.; Rysz, J.; Banach, M. Relationship between long noncoding RNAs and physiological risk factors of cardiovascular disease. *J. Cli. Lip.* **2017**, *11*, 617–623. [CrossRef]
260. Ma, M.; Duan, R.; Shen, L.; Liu, M.; Ji, Y.; Zhou, H.; Li, C.; Liang, T.; Li, X.; Guo, L. The LncRNA Gm15622 Stimulates SREBP-1c Expression and Hepatic Lipid Accumulation by Sponging the MiR-742-3p in Mice [S]. *J. Lipid Res.* **2020**, *61*, 1052–1064. [CrossRef]
261. Zhao, Y.; Han, S.; Zeng, Z.; Zheng, H.; Li, Y.; Wang, F.; Huang, Y.; Zhao, Y.; Zhuo, W.; Lv, G. Decreased LncRNA HNF4A-AS1 Facilitates Resistance to Sorafenib-Induced Ferroptosis of Hepatocellular Carcinoma by Reprogramming Lipid Metabolism. *Theranostics* **2024**, *14*, 7088. [CrossRef]
262. Xiao, F.; He, Z.; Wang, S.; Li, J.; Fan, X.; Yan, T.; Yang, M.; Yang, D. Regulatory Mechanism of Circular RNAs in Neurodegenerative Diseases. *CNS Neurosci. Ther.* **2024**, *30*, e14499. [CrossRef]
263. Zhao, M.; Lin, M.; Zhang, Z.; Ye, L. Research Progress of Circular RNA FOXO3 in Diseases. *Glob. Med. Genet.* **2025**, *12*, 100003. [CrossRef]
264. Huang, A.; Zheng, H.; Wu, Z.; Chen, M.; Huang, Y. Circular RNA-Protein Interactions: Functions, Mechanisms, and Identification. *Theranostics* **2020**, *10*, 3503–3517. [CrossRef]
265. Meng, E.; Deng, J.; Jiang, R.; Wu, H. CircRNA-Encoded Peptides or Proteins as New Players in Digestive System Neoplasms. *Front. Oncol.* **2022**, *12*, 944159. [CrossRef]
266. Zeng, Y.; Zheng, Z.; Liu, F.; Yi, G. Circular RNAs in Metabolism and Metabolic Disorders. *Obes. Rev.* **2021**, *22*, e13220. [CrossRef]
267. Zhou, W.-Y.; Cai, Z.-R.; Liu, J.; Wang, D.-S.; Ju, H.-Q.; Xu, R.-H. Circular RNA: Metabolism, Functions and Interactions with Proteins. *Mol. Cancer* **2020**, *19*, 172. [CrossRef]
268. Yang, B.; Wang, Y.-W.; Zhang, K. Interactions between CircRNA and Protein in Breast Cancer. *Gene* **2024**, *895*, 148019. [CrossRef] [PubMed]
269. Rossbach, O. Artificial Circular RNA Sponges Targeting MicroRNAs as a Novel Tool in Molecular Biology. *Mol. Ther. Nucleic Acids* **2019**, *17*, 452–454. [CrossRef] [PubMed]
270. Chen, C.; Zhang, X.; Deng, Y.; Cui, Q.; Zhu, J.; Ren, H.; Liu, Y.; Hu, X.; Zuo, J.; Peng, Y. Regulatory Roles of CircRNAs in Adipogenesis and Lipid Metabolism: Emerging Insights into Lipid-related Diseases. *FEBS J.* **2021**, *288*, 3663–3682. [CrossRef] [PubMed]
271. Banerjee, J.; Khanna, S.; Bhattacharya, A. MicroRNA Regulation of Oxidative Stress. *Oxid. Med. Cell Longev.* **2017**, *2017*, 2872156. [CrossRef]
272. Abdelgwad, M.; Zakaria, R.; Marzouk, S.; Sabry, D.; Ahmed, R.; Badary, H.A.; Samir, M. The Emerging Role of Circular RNA Homeodomain Interacting Protein Kinase 3 and Circular RNA 0046367 through Wnt/Beta-Catenin Pathway on the Pathogenesis of Nonalcoholic Steatohepatitis in Egyptian Patients. *Rep. Biochem. Mol. Biol.* **2023**, *11*, 614–625. [CrossRef]
273. Guo, X.-Y.; Chen, J.-N.; Sun, F.; Wang, Y.-Q.; Pan, Q.; Fan, J.-G. CircRNA_0046367 Prevents Hepatoxicity of Lipid Peroxidation: An Inhibitory Role against Hepatic Steatosis. *Oxid. Med. Cell Longev.* **2017**, *2017*, 3960197. [CrossRef]
274. Wang, G.; Tong, J.; Li, Y.; Qiu, X.; Chen, A.; Chang, C.; Yu, G. Overview of CircRNAs Roles and Mechanisms in Liver Fibrosis. *Biomolecules* **2023**, *13*, 940. [CrossRef]

275. Guha, S.; Sesili, S.; Mir, I.H.; Thirunavukkarasu, C. Epigenetics and Mitochondrial Dysfunction Insights into the Impact of the Progression of Non-alcoholic Fatty Liver Disease. *Cell Biochem. Funct.* **2023**, *41*, 4–19. [CrossRef]
276. Arcinas, C.; Tan, W.; Fang, W.; Desai, T.P.; Teh, D.C.; Degirmenci, U.; Xu, D.; Foo, R.; Sun, L. Adipose circular RNAs exhibit dynamic regulation in obesity and functional role in adipogenesis. *Nat. Metab.* **2019**, *1*, 688–703. [CrossRef] [PubMed]
277. Li, P.; Shan, K.; Liu, Y.; Zhang, Y.; Xu, L.; Xu, L. CircScd1 Promotes Fatty Liver Disease via the Janus Kinase 2/Signal Transducer and Activator of Transcription 5 Pathway. *Dig. Dis. Sci.* **2019**, *64*, 113–122. [CrossRef] [PubMed]
278. Chen, W.; Xu, J.; Wu, Y.; Liang, B.; Yan, M.; Sun, C.; Wang, D.; Hu, X.; Liu, L.; Hu, W. The Potential Role and Mechanism of CircRNA/MiRNA Axis in Cholesterol Synthesis. *Int. J. Biol. Sci.* **2023**, *19*, 2879. [CrossRef] [PubMed]
279. Li, H.; Liu, X.; Sun, N.; Wang, T.; Zhu, J.; Yang, S.; Song, X.; Wang, R.; Wang, X.; Zhao, Y. Differentially Expressed Circular Non-Coding RNAs in Atherosclerotic Aortic Vessels and Their Potential Functions in Endothelial Injury. *Front. Cardiovasc. Med.* **2021**, *8*, 657544. [CrossRef]
280. Ning, H.; Jiang, Y.; Li, B.; Ren, J.; Wang, C.; Wei, L.; Li, L.; Ran, A.; Li, Z.; Li, J. CircABCA1 Promotes CcRCC by Reprogramming Cholesterol Metabolism and Facilitating M2 Macrophage Polarization through IGF2BP3-Mediated Stabilization of SCARB1 MRNA. *Mol. Cancer* **2025**, *24*, 199. [CrossRef]
281. Holdt, L.M.; Stahringer, A.; Sass, K.; Pichler, G.; Kulak, N.A.; Wilfert, W.; Kohlmaier, A.; Herbst, A.; Northoff, B.H.; Nicolaou, A. Circular Non-Coding RNA ANRIL Modulates Ribosomal RNA Maturation and Atherosclerosis in Humans. *Nat. Commun.* **2016**, *7*, 12429. [CrossRef]
282. Wouters, K.; van Gorp, P.J.; Bieghs, V.; Gijbels, M.J.; Duimel, H.; Lütjohann, D.; Kerksiek, A.; van Kruchten, R.; Maeda, N.; Staels, B.; et al. Dietary cholesterol, rather than liver steatosis, leads to hepatic inflammation in hyperlipidemic mouse models of nonalcoholic steatohepatitis. *Hepatology* **2008**, *48*, 474–486. [CrossRef]
283. Burd, C.E.; Jeck, W.R.; Liu, Y.; Sanoff, H.K.; Wang, Z.; Sharpless, N.E. Expression of Linear and Novel Circular Forms of an INK4/ARF-Associated Non-Coding RNA Correlates with Atherosclerosis Risk. *PLoS Genet.* **2010**, *6*, e1001233. [CrossRef]
284. Cai, H.; Jiang, Z.; Yang, X.; Lin, J.; Cai, Q.; Li, X. Circular RNA HIPK3 Contributes to Hyperglycemia and Insulin Homeostasis by Sponging MiR-192-5p and Upregulating Transcription Factor Forkhead Box O1. *Endocr. J.* **2020**, *67*, 397–408. [CrossRef]
285. Zhang, W.-B.; Qi, Y.-F.; Xiao, Z.-X.; Chen, H.; Liu, S.-H.; Li, Z.-Z.; Zeng, Z.-F.; Wu, H.-F. CircHIPK3 Regulates Vascular Smooth Muscle Cell Calcification via the MiR-106a-5p/MFN2 Axis. *J. Cardiovasc. Transl. Res.* **2022**, *15*, 1315–1326. [CrossRef] [PubMed]
286. Feng, Y.; Yang, Z.; Lv, B.; Xu, X. The Diagnostic and Therapeutic Role of Circular RNA HIPK3 in Human Diseases. *Diagnostics* **2022**, *12*, 2469. [CrossRef] [PubMed]
287. Zaiou, M. The Emerging Role and Promise of Circular RNAs in Obesity and Related Metabolic Disorders. *Cells* **2020**, *9*, 1473. [CrossRef]
288. Guo, X.-Y.; He, C.-X.; Wang, Y.-Q.; Sun, C.; Li, G.-M.; Su, Q.; Pan, Q.; Fan, J.-G. Circular RNA Profiling and Bioinformatic Modeling Identify Its Regulatory Role in Hepatic Steatosis. *Biomed. Res. Int.* **2017**, *2017*, 5936171. [CrossRef]
289. Sun, C.; Fan, J.-G.; Qiao, L. Potential Epigenetic Mechanism in Non-Alcoholic Fatty Liver Disease. *Int. J. Mol. Sci.* **2015**, *16*, 5161–5179. [CrossRef]
290. Yu, G.; Yang, Z.; Peng, T.; Lv, Y. Circular RNAs: Rising Stars in Lipid Metabolism and Lipid Disorders. *J. Cell Physiol.* **2021**, *236*, 4797–4806. [CrossRef]
291. Liu, Y.; Liu, H.; Li, Y.; Mao, R.; Yang, H.; Zhang, Y.; Zhang, Y.; Guo, P.; Zhan, D.; Zhang, T. Circular RNA SAMD4A Controls Adipogenesis in Obesity through the MiR-138-5p/EZH2 Axis. *Theranostics* **2020**, *10*, 4705–4719. [CrossRef]
292. Lu, P.; Fan, J.; Li, B.; Wang, X.; Song, M. A Novel Protein Encoded by CircLARP1B Promotes the Proliferation and Migration of Vascular Smooth Muscle Cells by Suppressing CAMP Signaling. *Atherosclerosis* **2024**, *395*, 117575. [CrossRef]
293. Li, J.; Wang, X.; Shi, L.; Liu, B.; Sheng, Z.; Chang, S.; Cai, X.; Shan, G. A Mammalian Conserved Circular RNA CircLARP1B Regulates Hepatocellular Carcinoma Metastasis and Lipid Metabolism. *Adv. Sci.* **2024**, *11*, 2305902. [CrossRef]
294. Li, Q.; Wang, Y.; Wu, S.; Zhou, Z.; Ding, X.; Shi, R.; Thorne, R.F.; Zhang, X.D.; Hu, W.; Wu, M. CircACC1 Regulates Assembly and Activation of AMPK Complex under Metabolic Stress. *Cell Metab.* **2019**, *30*, 157–173. [CrossRef]
295. Haque, S.; Harries, L.W. Circular RNAs (circRNAs) in Health and Disease. *Genes* **2017**, *8*, 353. [CrossRef]
296. Jiang, R.; Li, H.; Yang, J.; Shen, X.; Song, C.; Yang, Z.; Wang, X.; Huang, Y.; Lan, X.; Lei, C. CircRNA Profiling Reveals an Abundant CircFUT10 That Promotes Adipocyte Proliferation and Inhibits Adipocyte Differentiation via Sponging Let-7. *Mol. Ther. Nucleic Acids* **2020**, *20*, 491–501. [CrossRef] [PubMed]
297. Chen, Q.; Liu, M.; Luo, Y.; Yu, H.; Zhang, J.; Li, D.; He, Q. Maternal Obesity Alters CircRNA Expression and the Potential Role of Mmu_circRNA_0000660 via Sponging MiR_693 in Offspring Liver at Weaning Age. *Gene* **2020**, *731*, 144354. [CrossRef] [PubMed]
298. Wang, L.; Zheng, Z.; Feng, X.; Zang, X.; Ding, W.; Wu, F.; Zhao, Q. CircRNA/LncRNA-MiRNA-MRNA Network in Oxidized, Low-Density, Lipoprotein-Induced Foam Cells. *DNA Cell Biol.* **2019**, *38*, 1499–1511. [CrossRef]
299. Zhang, Z.; Zhang, T.; Feng, R.; Huang, H.; Xia, T.; Sun, C. CircARF3 Alleviates Mitophagy-Mediated Inflammation by Targeting MiR-103/TRAF3 in Mouse Adipose Tissue. *Mol. Ther. Nucleic Acids* **2019**, *14*, 192–203. [CrossRef]

300. Shen, L.-P.; Zhang, W.-C.; Deng, J.-R.; Qi, Z.-H.; Lin, Z.-W.; Wang, Z.-D. Advances in the Mechanism of Small Nucleolar RNA and Its Role in DNA Damage Response. *Mil. Med. Res.* **2024**, *11*, 53. [CrossRef]
301. Weng, W.; Li, H.; Goel, A. Piwi-Interacting RNAs (PiRNAs) and Cancer: Emerging Biological Concepts and Potential Clinical Implications. *Biochim. Biophys. Acta (BBA) Rev. Cancer* **2019**, *1871*, 160–169. [CrossRef]
302. Russell, S.J.; LaMarre, J. Transposons and the PIWI Pathway: Genome Defense in Gametes and Embryos. *Reproduction* **2018**, *156*, R111–R124. [CrossRef]
303. Majewska, K.; Wróblewska-Ankiewicz, P.; Rudzka, M.; Hyjek-Składanowska, M.; Gołębiewski, M.; Smoliński, D.J.; Kołowerzo-Lubnau, A. Different Patterns of MRNA Nuclear Retention during Meiotic Prophase in Larch Microsporocytes. *Int. J. Mol. Sci.* **2021**, *22*, 8501. [CrossRef]
304. Harrison, L.J.; Bose, D. Enhancer RNAs Step Forward: New Insights into Enhancer Function. *Development* **2022**, *149*, dev200398. [CrossRef]
305. Chen, Z. Progress and Prospects of Long Noncoding RNAs in Lipid Homeostasis. *Mol. Metab.* **2016**, *5*, 164–170. [CrossRef] [PubMed]
306. Ginckels, P.; Holvoet, P. Oxidative Stress and Inflammation in Cardiovascular Diseases and Cancer: Role of Non-Coding RNAs. *Yale J. Biol. Med.* **2022**, *95*, 129–152. [PubMed]
307. Zhang, X.; Price, N.L.; Fernández-Hernando, C. Non-Coding RNAs in Lipid Metabolism. *Vasc. Pharmacol.* **2019**, *114*, 93–102. [CrossRef] [PubMed]
308. Xu, D.; Di, K.; Fan, B.; Wu, J.; Gu, X.; Sun, Y.; Khan, A.; Li, P.; Li, Z. MicroRNAs in Extracellular Vesicles: Sorting Mechanisms, Diagnostic Value, Isolation, and Detection Technology. *Front. Bioeng. Biotechnol.* **2022**, *10*, 948959. [CrossRef]
309. Boon, R.A.; Vickers, K.C. Intercellular Transport of MicroRNAs. *Arterioscler. Thromb. Vasc. Biol.* **2013**, *33*, 186–192. [CrossRef]
310. Babuta, M.; Szabo, G. Extracellular Vesicles in Inflammation: Focus on the MicroRNA Cargo of EVs in Modulation of Liver Diseases. *J. Leukoc. Biol.* **2022**, *111*, 75–92. [CrossRef]
311. Jopling, C. Liver-Specific MicroRNA-122: Biogenesis and Function. *RNA Biol.* **2012**, *9*, 137–142. [CrossRef]
312. Yang, L.; Jiang, S. Adipose Tissue-Derived Extracellular Vesicle MicroRNAs: Diagnostic Biomarkers for the Pathophysiology Associated with Obesity. *Precis. Chem.* **2025**, *3*, 480–491. [CrossRef]
313. Dabravolski, S.A.; Bezsonov, E.E.; Baig, M.S.; Popkova, T.V.; Orekhov, A.N. Mitochondrial Lipid Homeostasis at the Crossroads of Liver and Heart Diseases. *Int. J. Mol. Sci.* **2021**, *22*, 6949. [CrossRef]
314. Hashemi, M.; Raesi, R.; Eslami Vaghar, M.; Hamzeh Jouneghani, S.; Hasany, S.; Bidooki, S.H.; Mirzaei, M.; Shahpasand, K.; Nabavi, N.; Farahani, N. Nanoparticles in the Stimulation of Ferroptosis in Cancer Therapy. In *Autophagy, Apoptosis and Ferroptosis in Oncology: Cell Death and Cancer*; World Scientific: Singapore, 2025; pp. 923–960.
315. Ru, W.; Zhang, S.; Liu, J.; Liu, W.; Huang, B.; Chen, H. Non-Coding RNAs and Adipogenesis. *Int. J. Mol. Sci.* **2023**, *24*, 9978. [CrossRef]
316. Vitali, C.; Wellington, C.L.; Calabresi, L. HDL and Cholesterol Handling in the Brain. *Cardiovasc. Res.* **2014**, *103*, 405–413. [CrossRef]
317. Qi, L.; Xing, J.; Yuan, Y.; Lei, M. Noncoding RNAs in Atherosclerosis: Regulation and Therapeutic Potential. *Mol. Cell Biochem.* **2024**, *479*, 1279–1295. [CrossRef]
318. Chen, H.; Gao, J.; Xu, Q.; Wan, D.; Zhai, W.; Deng, L.; Qie, R. MiR-145-5p Modulates Lipid Metabolism and M2 Macrophage Polarization by Targeting PAK7 and Regulating β-Catenin Signaling in Hyperlipidemia. *Can. J. Physiol. Pharmacol.* **2021**, *99*, 857–863. [CrossRef] [PubMed]
319. Kölling, M.; Kaucsar, T.; Schauerte, C.; Hübner, A.; Dettling, A.; Park, J.-K.; Busch, M.; Wulff, X.; Meier, M.; Scherf, K. Therapeutic MiR-21 Silencing Ameliorates Diabetic Kidney Disease in Mice. *Mol. Ther.* **2017**, *25*, 165–180. [CrossRef] [PubMed]
320. Wang, J.; Duan, L.; Tian, L.; Liu, J.; Wang, S.; Gao, Y.; Yang, J. Serum MiR-21 May Be a Potential Diagnostic Biomarker for Diabetic Nephropathy. *Exp. Clin. Endocrinol. Diabetes* **2016**, *124*, 417–423. [CrossRef] [PubMed]
321. Liu, J.; Xiong, Y.; Mo, H.; Niu, H.; Miao, J.; Shen, W.; Zhou, S.; Wang, X.; Li, X.; Zhang, Y. MicroRNA-29b Plays a Vital Role in Podocyte Injury and Glomerular Diseases through Inducing Mitochondrial Dysfunction. *Int. J. Biol. Sci.* **2024**, *20*, 4654–4673. [CrossRef]
322. Zhou, L.; Yang, D.; Ou, L.-N.; Guo, X.-R.; Wu, B. Circulating Expression Level of LncRNA Malat1 in Diabetic Kidney Disease Patients and Its Clinical Significance. *J. Diabetes Res.* **2020**, *2020*, 4729019. [CrossRef]
323. Song, P.; Chen, Y.; Liu, Z.; Liu, H.; Xiao, L.; Sun, L.; Wei, J.; He, L. LncRNA MALAT1 Aggravates Renal Tubular Injury via Activating LIN28A and the Nox4/AMPK/MTOR Signaling Axis in Diabetic Nephropathy. *Front. Endocrinol.* **2022**, *13*, 895360. [CrossRef]
324. Li, B.; Leung, J.C.K.; Chan, L.Y.Y.; Li, H.-Y.; Yiu, W.-H.; Lok, S.W.Y.; Xue, R.; Zou, Y.-X.; Chen, W.; Lai, K.-N. Tubule-Specific Deletion of LincRNA-P21 Ameliorates Lipotoxic Kidney Injury. *Mol. Ther. Nucleic Acids* **2021**, *26*, 1280–1290.

325. Jiang, Y.; Ma, F.; Wang, J.; Chen, X.; Xue, L.; Chen, X.; Hu, J. Up-Regulation of Long Non-Coding RNA H19 Ameliorates Renal Tubulointerstitial Fibrosis by Reducing Lipid Deposition and Inflammatory Response through Regulation of the MicroRNA-130a-3p/Long-Chain Acyl-CoA Synthetase 1 Axis. *Noncoding RNA Res.* **2024**, *9*, 1120–1132. [CrossRef]
326. Zong, Y.; Wang, X.; Cui, B.; Xiong, X.; Wu, A.; Lin, C.; Zhang, Y. Decoding the Regulatory Roles of Non-Coding RNAs in Cellular Metabolism and Disease. *Mol. Ther.* **2023**, *31*, 1562–1576. [CrossRef]
327. Velu, C.S.; Grimes, H.L. Utilizing AntagomiR (Antisense MicroRNA) to Knock down MicroRNA in Murine Bone Marrow Cells. In *Rational Drug Design: Methods and Protocols*; Springer: Berlin/Heidelberg, Germany, 2012; pp. 185–195.
328. Krützfeldt, J.; Rajewsky, N.; Braich, R.; Rajeev, K.G.; Tuschl, T.; Manoharan, M.; Stoffel, M. Silencing of MicroRNAs in Vivo with 'Antagomirs'. *Nature* **2005**, *438*, 685–689. [CrossRef]
329. Mattes, J.; Yang, M.; Foster, P.S. Regulation of MicroRNA by Antagomirs: A New Class of Pharmacological Antagonists for the Specific Regulation of Gene Function? *Am. J. Respir. Cell Mol. Biol.* **2007**, *36*, 8–12. [CrossRef] [PubMed]
330. Tao, Y.; Xu, S.; Wang, J.; Xu, L.; Zhang, C.; Chen, K.; Lian, Z.; Zhou, J.; Xie, H.; Zheng, S. Delivery of MicroRNA-33 Antagomirs by Mesoporous Silica Nanoparticles to Ameliorate Lipid Metabolic Disorders. *Front. Pharmacol.* **2020**, *11*, 921. [CrossRef] [PubMed]
331. Lee, H.Y.; Lee, H.Y.; Choi, J.Y.; Hur, J.; Kim, I.K.; Kim, Y.K.; Kang, J.Y.; Lee, S.Y. Inhibition of MicroRNA-21 by an Antagomir Ameliorates Allergic Inflammation in a Mouse Model of Asthma. *Exp. Lung Res.* **2017**, *43*, 109–119. [CrossRef] [PubMed]
332. van Solingen, C.; Seghers, L.; Bijkerk, R.; Duijs, J.M.G.J.; Roeten, M.K.; van Oeveren-Rietdijk, A.M.; Baelde, H.J.; Monge, M.; Vos, J.B.; de Boer, H.C. Antagomir-mediated Silencing of Endothelial Cell Specific MicroRNA-126 Impairs Ischemia-induced Angiogenesis. *J. Cell Mol. Med.* **2009**, *13*, 1577–1585. [CrossRef]
333. Ray, K.K.; Wright, R.S.; Kallend, D.; Koenig, W.; Leiter, L.A.; Raal, F.J.; Bisch, J.A.; Richardson, T.; Jaros, M.; Wijngaard, P.L.J. Two Phase 3 Trials of Inclisiran in Patients with Elevated LDL Cholesterol. *N. Engl. J. Med.* **2020**, *382*, 1507–1519. [CrossRef]
334. Ray, K.K.; Troquay, R.P.T.; Visseren, F.L.J.; Leiter, L.A.; Wright, R.S.; Vikarunnessa, S.; Talloczy, Z.; Zang, X.; Maheux, P.; Lesogor, A. Long-Term Efficacy and Safety of Inclisiran in Patients with High Cardiovascular Risk and Elevated LDL Cholesterol (ORION-3): Results from the 4-Year Open-Label Extension of the ORION-1 Trial. *Lancet Diabetes Endocrinol.* **2023**, *11*, 109–119. [CrossRef]
335. Ahmad, M.; Hegele, R.A. Molecular Therapeutics in Development to Treat Hyperlipoproteinemia. *Mol. Diagn. Ther.* **2025**, *29*, 291–305. [CrossRef]
336. Zhao, H.; Wang, Y.; Li, Y.; Cheng, R.; Chen, W. Research Advances in Current Drugs Targeting Hyperlipidemia. *Mol. Med. Rep.* **2025**, *32*, 1–17. [CrossRef]
337. Bergmark, B.A.; Marston, N.A.; Bramson, C.R.; Curto, M.; Ramos, V.; Jevne, A.; Kuder, J.F.; Park, J.-G.; Murphy, S.A.; Verma, S. Effect of Vupanorsen on Non–High-Density Lipoprotein Cholesterol Levels in Statin-Treated Patients with Elevated Cholesterol: TRANSLATE-TIMI 70. *Circulation* **2022**, *145*, 1377–1386. [CrossRef]
338. Rosenson, R.S.; Gaudet, D.; Hegele, R.A.; Ballantyne, C.M.; Nicholls, S.J.; Lucas, K.J.; San Martin, J.; Zhou, R.; Muhsin, M.; Chang, T. Zodasiran, an RNAi Therapeutic Targeting ANGPTL3, for Mixed Hyperlipidemia. *N. Engl. J. Med.* **2024**, *391*, 913–925. [CrossRef]
339. Rosenson, R.; Gaudet, D.; Hegele, R.; Ballantyne, C.; Nicholls, S.; Lucas, K.; Hellawell, J.; Chang, T.; Fu, R.; Muhsin, M. Zodasiran Silences Hepatic ANGPTL3 Leading to Deep and Durable Reductions in Atherogenic Lipids and Lipoproteins in Mixed Dyslipidemia Patients: Final Results from Arches-2, Double-Blind Period. *Atherosclerosis* **2024**, *395*, 118515. [CrossRef]
340. Tang, X.L.; Hooper, A.J.; Burnett, J.R. Assessing the Clinical Potential of Plozasiran, an APOC3 SiRNA Therapy for Severe Hypertriglyceridemia. *Expert Opin. Investig. Drugs* **2024**, *33*, 1099–1102. [CrossRef] [PubMed]
341. Ballantyne, C.M.; Gaudet, D.; Rosenson, R.S.; Hegele, R.A.; Zhou, R.; Melquist, S.; Hellawell, J.; Leeper, N.J. Effect of Targeting Apoc-III with Plozasiran on Lipoprotein Particle Size and Number in Hypertriglyceridemia. *J. Am. Coll. Cardiol.* **2025**, *85*, 1839–1854. [CrossRef] [PubMed]
342. Ballantyne, C.M.; Vasas, S.; Azizad, M.; Clifton, P.; Rosenson, R.S.; Chang, T.; Melquist, S.; Zhou, R.; Mushin, M.; Leeper, N.J. Plozasiran, an RNA Interference Agent Targeting APOC3, for Mixed Hyperlipidemia. *N. Engl. J. Med.* **2024**, *391*, 899–912. [CrossRef]
343. Gaudet, D.; Pall, D.; Watts, G.F.; Nicholls, S.J.; Rosenson, R.S.; Modesto, K.; San Martin, J.; Hellawell, J.; Ballantyne, C.M. Plozasiran (ARO-APOC3) for Severe Hypertriglyceridemia: The SHASTA-2 Randomized Clinical Trial. *JAMA Cardiol.* **2024**, *9*, 620–630. [CrossRef]
344. O'Donoghue, M.L.; Rosenson, R.S.; Gencer, B.; López, J.A.G.; Lepor, N.E.; Baum, S.J.; Stout, E.; Gaudet, D.; Knusel, B.; Kuder, J.F. Small Interfering RNA to Reduce Lipoprotein (a) in Cardiovascular Disease. *N. Engl. J. Med.* **2022**, *387*, 1855–1864. [CrossRef]
345. O'Donoghue, M.L.; López, J.A.G.; Knusel, B.; Gencer, B.; Wang, H.; Wu, Y.; Kassahun, H.; Sabatine, M.S. Study Design and Rationale for the Olpasiran Trials of Cardiovascular Events And LipoproteiN (a) Reduction-DOSE Finding Study (OCEAN (a)-DOSE). *Am. Heart J.* **2022**, *251*, 61–69. [CrossRef]
346. Warden, B.A.; Duell, P.B. Antisense Oligonucleotide Targeting Apolipoprotein (a) Treatment of Lipoprotein Disorders Treatment of Cardiovascular Diseases. *Drugs Future* **2022**, *47*, 11–25. [CrossRef]

347. Ogieuhi, I.J.; Callender, K.; Odukudu, G.O.; Obi, E.S.; Muzofa, K.; Babalola, A.E.; Ugiomoh, O.M.-A.; Umenzeakor, K.H.; Akingbola, A.; Ayoson, C.O. Antisense Oligonucleotides in Dyslipidemia Management: A Review of Clinical Trials. *High. Blood Press. Cardiovasc. Prev.* **2025**, *32*, 33–47. [PubMed]
348. Wang, Z. The Guideline of the Design and Validation of MiRNA Mimics. In *MicroRNA and Cancer: Methods and Protocols*; Springer: Berlin/Heidelberg, Germany, 2010; pp. 211–223.
349. Hassan, M.; Elzallat, M.; Aboushousha, T.; Elhusseny, Y.; El-Ahwany, E. MicroRNA-122 Mimic/MicroRNA-221 Inhibitor Combination as a Novel Therapeutic Tool against Hepatocellular Carcinoma. *Noncoding RNA Res.* **2023**, *8*, 126–134. [CrossRef] [PubMed]
350. Li, S.; Chen, H.; Ren, J.; Geng, Q.; Song, J.; Lee, C.; Cao, C.; Zhang, J.; Xu, N. MicroRNA-223 Inhibits Tissue Factor Expression in Vascular Endothelial Cells. *Atherosclerosis* **2014**, *237*, 514–520. [CrossRef] [PubMed]
351. Sallam, T.; Jones, M.; Gilliland, T.; Li, Z.; Wu, X.; Eskin, A.; Sandhu, J.; Casero, D.; Vallim, T.; Cynthia, H. Feedback Regulation of Cholesterol Metabolism by Lexis, a Lipid-Responsive Non-Coding RNA. *Circulation* **2015**, *132*, A13674. [CrossRef]
352. Rayner, K.J.; Suárez, Y.; Dávalos, A.; Parathath, S.; Fitzgerald, M.L.; Tamehiro, N.; Fisher, E.A.; Moore, K.J.; Fernández-Hernando, C. MiR-33 Contributes to the Regulation of Cholesterol Homeostasis. *Science* **2010**, *328*, 1570–1573. [CrossRef]
353. Huang, L.; Luo, J.; Gao, W.; Song, N.; Tian, H.; Zhu, L.; Jiang, Q.; Loor, J.J. Crispr/Cas9-Induced Knockout of MiR-24 Reduces Cholesterol and Monounsaturated Fatty Acid Content in Primary Goat Mammary Epithelial Cells. *Foods* **2022**, *11*, 2012. [CrossRef]
354. Ijee, S.; Chambayil, K.; Chaudhury, A.D.; Bagchi, A.; Modak, K.; Das, S.; Benjamin, E.S.B.; Rani, S.; Paul, D.Z.; Nath, A. Efficient Deletion of MicroRNAs Using CRISPR/Cas9 with Dual Guide RNAs. *Front. Mol. Biosci.* **2024**, *10*, 1295507. [CrossRef]
355. Laterza, O.F.; Scott, M.G.; Garrett-Engele, P.W.; Korenblat, K.M.; Lockwood, C.M. Circulating MiR-122 as a Potential Biomarker of Liver Disease. *Biomark. Med.* **2013**, *7*, 205–210. [CrossRef]
356. Zhang, Y.; Jia, Y.; Zheng, R.; Guo, Y.; Wang, Y.; Guo, H.; Fei, M.; Sun, S. Plasma MicroRNA-122 as a Biomarker for Viral-, Alcohol-, and Chemical-Related Hepatic Diseases. *Clin. Chem.* **2010**, *56*, 1830–1838. [CrossRef]
357. Tobaruela-Resola, A.L.; Milagro, F.I.; Elorz, M.; Benito-Boillos, A.; Herrero, J.I.; Mogna-Peláez, P.; Tur, J.A.; Martínez, J.A.; Abete, I.; Zulet, M.Á. Circulating MiR-122-5p, MiR-151a-3p, MiR-126-5p and MiR-21-5p as Potential Predictive Biomarkers for Metabolic Dysfunction-Associated Steatotic Liver Disease Assessment. *J. Physiol. Biochem.* **2024**, 1–14. [CrossRef]
358. Tobaruela-Resola, A.L.; Milagro, F.I.; Mogna-Pelaez, P.; Moreno-Aliaga, M.J.; Abete, I.; Zulet, M.Á. The Use of Circulating MiRNAs for the Diagnosis, Prognosis, and Personalized Treatment of MASLD. *J. Physiol. Biochem.* **2025**, *81*, 589–609. [CrossRef]
359. Cermelli, S.; Ruggieri, A.; Marrero, J.A.; Ioannou, G.N.; Beretta, L. Circulating MicroRNAs in Patients with Chronic Hepatitis C and Non-Alcoholic Fatty Liver Disease. *PLoS ONE* **2011**, *6*, e23937. [CrossRef] [PubMed]
360. Liu, X.-L.; Pan, Q.; Zhang, R.-N.; Shen, F.; Yan, S.-Y.; Sun, C.; Xu, Z.-J.; Chen, Y.-W.; Fan, J.-G. Disease-Specific MiR-34a as Diagnostic Marker of Non-Alcoholic Steatohepatitis in a Chinese Population. *World J. Gastroenterol.* **2016**, *22*, 9844. [CrossRef] [PubMed]
361. Li, P.; Yan, X.; Xu, G.; Pang, Z.; Weng, J.; Yin, J.; Li, M.; Yu, L.; Chen, Q.; Sun, K. A Novel Plasma LncRNA ENST00000416361 Is Upregulated in Coronary Artery Disease and Is Related to Inflammation and Lipid Metabolism. *Mol. Med. Rep.* **2020**, *21*, 2375–2384. [CrossRef] [PubMed]
362. Yang, Y.; Cai, Y.; Wu, G.; Chen, X.; Liu, Y.; Wang, X.; Yu, J.; Li, C.; Chen, X.; Jose, P.A. Plasma Long Non-Coding RNA, CoroMarker, a Novel Biomarker for Diagnosis of Coronary Artery Disease. *Clin. Sci.* **2015**, *129*, 675–685. [CrossRef]
363. Cai, Y.; Yang, Y.; Chen, X.; Wu, G.; Zhang, X.; Liu, Y.; Yu, J.; Wang, X.; Fu, J.; Li, C. Circulating 'LncRNA OTTHUMT00000387022'from Monocytes as a Novel Biomarker for Coronary Artery Disease. *Cardiovasc. Res.* **2016**, *112*, 714–724. [CrossRef]
364. Hsu, S.; Yu, B.; Wang, X.; Lu, Y.; Schmidt, C.R.; Lee, R.J.; Lee, L.J.; Jacob, S.T.; Ghoshal, K. Cationic Lipid Nanoparticles for Therapeutic Delivery of SiRNA and MiRNA to Murine Liver Tumor. *Nanomedicine* **2013**, *9*, 1169–1180. [CrossRef]
365. Schachner-Nedherer, A.-L.; Fuchs, J.; Vidakovic, I.; Höller, O.; Schratter, G.; Almer, G.; Fröhlich, E.; Zimmer, A.; Wabitsch, M.; Kornmueller, K. Lipid Nanoparticles as a Shuttle for Anti-Adipogenic MiRNAs to Human Adipocytes. *Pharmaceutics* **2023**, *15*, 1983. [CrossRef]
366. Hashemi, M.; Ghadyani, F.; Hasani, S.; Olyaee, Y.; Raei, B.; Khodadadi, M.; Ziyarani, M.F.; Basti, F.A.; Tavakolpournegari, A.; Matinahmadi, A. Nanoliposomes for Doxorubicin Delivery: Reversing Drug Resistance, Stimuli-Responsive Carriers and Clinical Translation. *J. Drug Deliv. Sci. Technol.* **2023**, *80*, 104112. [CrossRef]
367. Albakr, L.; Alqahtani, F.Y.; Aleanizy, F.S.; Alomrani, A.; Badran, M.; Alhindas, H.; Al-Mohanna, F. Improved Delivery of MiR-1296 Loaded Cationic Nanoliposomes for Effective Suppression of Triple Negative Breast Cancer. *Saudi Pharm. J.* **2021**, *29*, 446–455. [CrossRef]
368. Qin, Z.-X.; Zuo, L.; Zeng, Z.; Ma, R.; Xie, W.; Zhu, X.; Zhou, X. GalNac-SiRNA Conjugate Delivery Technology Promotes the Treatment of Typical Chronic Liver Diseases. *Expert. Opin. Drug Deliv.* **2025**, *22*, 455–469. [CrossRef] [PubMed]

369. Zhang, H.; Qin, G.; Shi, L.; Li, R.; Shen, L.; Cao, W.; Tao, Y. Comparative Metabolism of an N-Acetylgalactosamine–Conjugated Small Interfering RNA, Inclisiran, among Various in Vitro Systems and Correlations with in Vivo Metabolism in Rats. *Drug Metab. Dispos.* **2025**, *53*, 100089. [CrossRef] [PubMed]
370. Wang, J.; Zheng, W.; Zheng, S.; Yuan, Y.; Wen, W.; Cui, W.; Xue, L.; Sun, X.; Shang, H.; Zhang, H. Targeting ANGPTL3 by GalNAc-Conjugated SiRNA ANGsiR10 Lowers Blood Lipids with Long-Lasting and Potent Efficacy in Mice and Monkeys. *Mol. Ther. Nucleic Acids* **2023**, *31*, 68–77. [CrossRef] [PubMed]
371. Sutaria, D.S.; Jiang, J.; Elgamal, O.A.; Pomeroy, S.M.; Badawi, M.; Zhu, X.; Pavlovicz, R.; Azevedo-Pouly, A.C.P.; Chalmers, J.; Li, C. Low Active Loading of Cargo into Engineered Extracellular Vesicles Results in Inefficient MiRNA Mimic Delivery. *J. Extracell. Vesicles* **2017**, *6*, 1333882. [CrossRef]
372. Momen-Heravi, F.; Bala, S.; Bukong, T.; Szabo, G. Exosome-Mediated Delivery of Functionally Active MiRNA-155 Inhibitor to Macrophages. *Nanomedicine* **2014**, *10*, 1517–1527. [CrossRef]
373. Jin, Y.; Lee, J.S.; Min, S.; Park, H.; Kang, T.J.; Cho, S. Bioengineered Extracellular Membranous Nanovesicles for Efficient Small-Interfering RNA Delivery: Versatile Platforms for Stem Cell Engineering and In Vivo Delivery. *Adv. Funct. Mater.* **2016**, *26*, 5804–5817. [CrossRef]
374. Tai, Z.; Ma, J.; Ding, J.; Pan, H.; Chai, R.; Zhu, C.; Cui, Z.; Chen, Z.; Zhu, Q. Aptamer-Functionalized Dendrimer Delivery of Plasmid-Encoding LncRNA MEG3 Enhances Gene Therapy in Castration-Resistant Prostate Cancer. *Int. J. Nanomed.* **2020**, *15*, 10305–10320. [CrossRef]
375. Ning, H.; Jiang, Y.; Li, B.; Ren, J.; Ran, A.; Li, W.; Xiao, B. Targeted Delivery of CircPDHK1 SiRNA via Aptamer Functionalized Lipid Nanoparticles Inhibits CcRCC Growth and Migration. *Int. J. Pharm.* **2025**, *677*, 125666. [CrossRef]

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.