PCSK9 gene
proprotein convertase subtilisin/kexin type 9

Normal Function

The PCSK9 gene provides instructions for making a protein that helps regulate the amount of cholesterol in the bloodstream. Cholesterol is a waxy, fat-like substance that is produced in the body and obtained from foods that come from animals.

The PCSK9 protein controls the number of low-density lipoprotein receptors, which are proteins on the surface of cells. These receptors play a critical role in regulating blood cholesterol levels. The receptors bind to particles called low-density lipoproteins (LDLs), which are the primary carriers of cholesterol in the blood. Low-density lipoprotein receptors are particularly abundant in the liver, the organ responsible for removing most excess cholesterol from the body.

The number of low-density lipoprotein receptors on the surface of liver cells determines how quickly cholesterol is removed from the bloodstream. The PCSK9 protein breaks down low-density lipoprotein receptors before they reach the cell surface, so more cholesterol can remain in the bloodstream.

Health Conditions Related to Genetic Changes

Familial hypercholesterolemia

Researchers have identified more than 50 PCSK9 gene mutations that cause familial hypercholesterolemia. Most of these mutations change single protein building blocks (amino acids) in the PCSK9 protein. Researchers describe the mutations responsible for familial hypercholesterolemia as "gain-of-function" because they appear to enhance the activity of the PCSK9 protein.

The enhanced activity of the altered PCSK9 protein causes low-density lipoprotein receptors to be broken down more quickly than usual, reducing the number of receptors on the surface of liver cells. With fewer receptors to remove LDLs from the blood, people with gain-of-function mutations in the PCSK9 gene have very high blood cholesterol levels. As the excess cholesterol circulates through the bloodstream, it is deposited abnormally in tissues such as the skin, tendons, and arteries that supply blood to the heart (coronary arteries). A buildup of cholesterol in the walls of coronary arteries greatly increases a person's risk of having a heart attack.

Most people with familial hypercholesterolemia inherit one altered copy of the PCSK9 gene from an affected parent and one normal copy of the gene from the other parent. These cases are associated with an increased risk of early heart disease,
typically beginning in a person's forties or fifties. Rarely, a person with familial hypercholesterolemia is born with two mutated copies of the \textit{PCSK9} gene. This situation occurs when the person has two affected parents, each of whom passes on one altered copy of the gene. The presence of two \textit{PCSK9} gene mutations results in a more severe form of hypercholesterolemia that usually appears in childhood.

\textbf{Familial hypobetalipoproteinemia}

\textbf{Other disorders}

Other mutations in the \textit{PCSK9} gene result in reduced blood cholesterol levels (hypcholesterolemia). These genetic changes reduce the activity of the PCSK9 protein or decrease the amount of this protein that is produced in cells. Researchers describe this type of mutation as "loss-of-function." Loss-of-function mutations in the \textit{PCSK9} gene appear to be more common than gain-of-function mutations, which cause familial hypercholesterolemia (described above).

Loss-of-function mutations in the \textit{PCSK9} gene impair the break down of low-density lipoprotein receptors, which leads to an increase in the number of receptors on the surface of liver cells. The extra receptors can remove LDLs from the blood more quickly than usual, which decreases the amount of cholesterol circulating in the bloodstream. Studies suggest that people with reduced cholesterol levels caused by \textit{PCSK9} mutations have a significantly lower-than-average risk of developing heart disease.

Researchers suspect that normal changes (polymorphisms) in the \textit{PCSK9} gene are responsible for some of the variation in blood cholesterol levels among people without inherited cholesterol disorders. In particular, scientists are working to determine which polymorphisms are associated with relatively low levels of cholesterol in the blood and a reduced risk of heart disease.
Chromosomal Location

Cytogenetic Location: 1p32.3, which is the short (p) arm of chromosome 1 at position 32.3

Molecular Location: base pairs 55,039,548 to 55,064,853 on chromosome 1 (Homo sapiens Updated Annotation Release 109.20200228, GRCh38.p13) (NCBI)

Other Names for This Gene

- FH3
- HCHOLA3
- hypercholesterolemia, autosomal dominant 3
- NARC-1
- NARC1
- neural apoptosis regulated convertase 1
- PCSK9_HUMAN
- Proprotein convertase PC9
- Subtilisin/kexin-like protease PC9
Additional Information & Resources

Educational Resources

• Molecular Biology of the Cell (fourth Edition, 2002): The receptor-mediated endocytosis of LDL
  https://www.ncbi.nlm.nih.gov/books/NBK26870/?rendertype=figure&id=A2398

• Molecular Cell Biology (fourth edition, 2000): The LDL Receptor Binds and Internalizes Cholesterol-Containing Particles
  https://www.ncbi.nlm.nih.gov/books/NBK21639/#A4864

• News Release: PCSK9-inhibitor drug class that grew out of UTSW research becomes a game-changer for patient with extremely high cholesterol (UT Southwestern Medical Center, Feb. 25, 2016)
  https://www.utsouthwestern.edu/newsroom/articles/year-2016/pcsk9-patient-khera.html

Clinical Information from GeneReviews

• Familial Hypercholesterolemia
  https://www.ncbi.nlm.nih.gov/books/NBK174884

Scientific Articles on PubMed

• PubMed
  https://www.ncbi.nlm.nih.gov/pubmed?term=%28%28PCSK9%5BTIAB%5D%29+OR+%28proprotein+convertase+subtilisin/kexin+type+9%5BTIAB%5D%29%29+AND+%28%28Genes%5BMH%5D%29+OR+%28Genetic+Phenomena%5BMH%5D%29+AND+english%5Bla%5D+AND+human%5Bmh%5D+AND+%22last+1800+days%22%5Bdp%5D

Catalog of Genes and Diseases from OMIM

• PROPROTEIN CONVERTASE, SUBTILISIN/KEXIN-TYPE, 9
  http://omim.org/entry/607786

Research Resources

• Atlas of Genetics and Cytogenetics in Oncology and Haematology

• ClinVar
  https://www.ncbi.nlm.nih.gov/clinvar?term=PCSK9%5Bgene%5D

• HGNC Gene Symbol Report

• Monarch Initiative
  https://monarchinitiative.org/gene/NCBIGene:255738
• NCBI Gene

• UniProt
  https://www.uniprot.org/uniprot/Q8NBP7

Sources for This Summary

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  Citation on PubMed: https://www.ncbi.nlm.nih.gov/pubmed/16571601

  Citation on PubMed: https://www.ncbi.nlm.nih.gov/pubmed/15893176 
  Free article on PubMed Central: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2910256/

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  Citation on PubMed: https://www.ncbi.nlm.nih.gov/pubmed/15767856

  Citation on PubMed: https://www.ncbi.nlm.nih.gov/pubmed/15677715
  Free article on PubMed Central: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC546019/

  Citation on PubMed: https://www.ncbi.nlm.nih.gov/pubmed/16909389
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