

NOTCH1 gene

notch receptor 1

Normal Function

The *NOTCH1* gene provides instructions for making a protein called Notch1, a member of the Notch family of receptors. Receptor proteins have specific sites into which certain other proteins, called ligands, fit like keys into locks. Attachment of a ligand to the Notch1 receptor sends signals that are important for normal development of many tissues throughout the body, both before birth and after. Notch1 signaling helps determine the specialization of cells into certain cell types that perform particular functions in the body (cell fate determination). It also plays a role in cell growth and division (proliferation), maturation (differentiation), and self-destruction (apoptosis).

The protein produced from the *NOTCH1* gene has such diverse functions that the gene is considered both an oncogene and a tumor suppressor. Oncogenes typically promote cell proliferation or survival, and when mutated, they have the potential to cause normal cells to become cancerous. In contrast, tumor suppressors keep cells from growing and dividing too fast or in an uncontrolled way, preventing the development of cancer; mutations that impair tumor suppressors can lead to cancer development.

Health Conditions Related to Genetic Changes

Adams-Oliver syndrome

At least 15 mutations in the *NOTCH1* gene have been found to cause Adams-Oliver syndrome, a condition characterized by areas of missing skin (aplasia cutis congenita), usually on the scalp, and malformations of the hands and feet. These mutations are usually inherited and are present in every cell of the body. Some of the *NOTCH1* gene mutations involved in Adams-Oliver syndrome lead to production of an abnormally short protein that is likely broken down quickly, causing a shortage of Notch1. Other mutations change single protein building blocks (amino acids) in the Notch1 protein. These changes are thought to alter the structure of the protein, impairing its ability to function. Loss of Notch1 signaling may underlie blood vessel and heart abnormalities in people with Adams-Oliver syndrome. However, while these types of abnormalities are more common in affected individuals with *NOTCH1* gene mutations than in those with a different gene mutation, some people with Notch1-related Adams-Oliver syndrome do not have blood vessel or heart abnormalities. It is not clear how loss of Notch1 function leads to the scalp and limb abnormalities characteristic of the condition. Researchers

suggest these features may be due to abnormal blood vessel development before birth.

Head and neck squamous cell carcinoma

Mutations in the *NOTCH1* gene have been found in about 15 percent of head and neck squamous cell carcinomas (HNSCC). This type of cancerous tumor occurs in the moist lining of the mouth, nose, and throat. *NOTCH1* gene mutations associated with this condition are acquired during a person's lifetime and are found only in tumor cells; these changes are known as somatic mutations. Mutations in the *NOTCH1* gene may reduce or eliminate production of functional Notch1 protein or lead to production of a protein that is unable to participate in cell signaling. Without the tumor suppressor function of the Notch1 protein, cells can grow and divide without control, leading to tumor formation.

Critical congenital heart disease

NOTCH1 gene mutations are involved in critical congenital heart disease. Individuals with this condition have one or more specific heart abnormalities that affect the flow of blood into, out of, or through the heart. Some of the heart defects involve structures within the heart itself, such as the two lower chambers of the heart (the ventricles) or the valves that control blood flow through the heart. Others affect the structure of the large blood vessels leading into and out of the heart (including the aorta and pulmonary artery). Still others involve a combination of these structural abnormalities.

Other disorders

Mutations in the *NOTCH1* gene can impair normal heart development before birth, causing abnormalities of the heart and related structures. One such abnormality occurs in the valve that connects the aorta to the heart (the aortic valve). The aorta is the large blood vessel that distributes blood from the heart to the rest of the body. The aortic valve normally has three flaps, or cusps, that open to let blood leave the heart and come together to prevent blood from reentering the heart. However, in about 1 to 2 percent of people, the aortic valve has only two flaps, which is known as a bicuspid aortic valve. *NOTCH1* gene mutations appear to be involved in 4 to 10 percent of bicuspid aortic valve cases.

Individuals with a bicuspid aortic valve are at a higher than normal risk of developing other aortic abnormalities, such as a bulge in the wall of the aorta (thoracic aortic aneurysm) or a sudden tearing of the layers in the aorta wall (aortic dissection). In addition, accumulation of calcium on the aortic valve can occur in people with a bicuspid aortic valve. Researchers suspect that *NOTCH1* gene mutations also play a role in the development of thoracic aortic aneurysms and in calcification of the valve.

Other cancers

NOTCH1 gene mutations have been found in other types of cancer, particularly blood cell cancers called T-cell acute lymphoblastic leukemia and chronic lymphocytic

leukemia, and a type of lung cancer called non-small cell lung cancer. Unlike in HNSCC (described above), the *NOTCH1* gene mutations found in these cancers abnormally turn on (activate) Notch1 signaling. The increased activity can lead to uncontrolled cell growth and division, which can result in the development of cancer. Researchers are working to understand how both activating and inactivating *NOTCH1* gene mutations can lead to cancer development.

Other Names for This Gene

- AOS5
- AOVD1
- hN1
- neurogenic locus notch homolog protein 1
- neurogenic locus notch homolog protein 1 preproprotein
- Notch homolog 1, translocation-associated
- TAN1
- translocation-associated notch protein TAN-1

Additional Information & Resources

Tests Listed in the Genetic Testing Registry

- Tests of NOTCH1 ([https://www.ncbi.nlm.nih.gov/gtr/all/tests/?term=4851\[geneid\]](https://www.ncbi.nlm.nih.gov/gtr/all/tests/?term=4851[geneid]))

Scientific Articles on PubMed

- PubMed (<https://pubmed.ncbi.nlm.nih.gov/?term=%28%28NOTCH1%5BTI%5D%29+OR+%28notch+1%5BTI%5D%29%29+AND+%28%28Genes%5BMH%5D%29+OR+%28Genetic+Phenomena%5BMH%5D%29%29+AND+english%5Bla%5D+AND+human%5Bmh%5D+AND+%22last+360+days%22%5Bdp%5D%29%29%29>)

Catalog of Genes and Diseases from OMIM

- AORTIC VALVE DISEASE 1; AOVD1 (<https://omim.org/entry/109730>)
- LEUKEMIA, CHRONIC LYMPHOCYTIC; CLL (<https://omim.org/entry/151400>)
- NOTCH RECEPTOR 1; NOTCH1 (<https://omim.org/entry/190198>)
- LEUKEMIA, ACUTE LYMPHOBLASTIC; ALL (<https://omim.org/entry/613065>)

Gene and Variant Databases

- NCBI Gene (<https://www.ncbi.nlm.nih.gov/gene/4851>)

- ClinVar ([https://www.ncbi.nlm.nih.gov/clinvar?term=NOTCH1\[gene\]](https://www.ncbi.nlm.nih.gov/clinvar?term=NOTCH1[gene]))

References

- Agrawal N, Frederick MJ, Pickering CR, Bettegowda C, Chang K, Li RJ, Fakhry C, Xie TX, Zhang J, Wang J, Zhang N, El-Naggar AK, Jasser SA, Weinstein JN, Trevino L, Drummond JA, Muzny DM, Wu Y, Wood LD, Hruban RH, Westra WH, Koch WM, Califano JA, Gibbs RA, Sidransky D, Vogelstein B, Velculescu VE, Papadopoulos N, Wheeler DA, Kinzler KW, Myers JN. Exome sequencing of head and neck squamous cell carcinoma reveals inactivating mutations in NOTCH1. *Science*. 2011 Aug 26;333(6046):1154-7. doi: 10.1126/science.1206923. Epub 2011 Jul 28. Citation on PubMed (<https://pubmed.ncbi.nlm.nih.gov/21798897>) or Free article on PubMed Central (<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3162986/>)
- Arruga F, Gizdic B, Serra S, Vaisitti T, Ciardullo C, Coscia M, Laurenti L, Arena G, Jaksic O, Inghirami G, Rossi D, Gaidano G, Deaglio S. Functional impact of NOTCH1 mutations in chronic lymphocytic leukemia. *Leukemia*. 2014 May;28(5):1060-70. doi: 10.1038/leu.2013.319. Epub 2013 Oct 30. Citation on PubMed (<https://pubmed.ncbi.nlm.nih.gov/24170027>)
- Dotto GP. Notch tumor suppressor function. *Oncogene*. 2008 Sep 1;27(38):5115-23. doi: 10.1038/onc.2008.225. Citation on PubMed (<https://pubmed.ncbi.nlm.nih.gov/18758480>) or Free article on PubMed Central (<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2747622/>)
- Lobry C, Oh P, Aifantis I. Oncogenic and tumor suppressor functions of Notch in cancer: it's NOTCH what you think. *J Exp Med*. 2011 Sep 26;208(10):1931-5. doi:10.1084/jem.20111855. Citation on PubMed (<https://pubmed.ncbi.nlm.nih.gov/21948802>) or Free article on PubMed Central (<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3182047/>)
- Loyo M, Li RJ, Bettegowda C, Pickering CR, Frederick MJ, Myers JN, Agrawal N. Lessons learned from next-generation sequencing in head and neck cancer. *Head Neck*. 2013 Mar;35(3):454-63. doi: 10.1002/hed.23100. Epub 2012 Aug 21. Citation on PubMed (<https://pubmed.ncbi.nlm.nih.gov/22907887>) or Free article on PubMed Central (<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3715072/>)
- McKellar SH, Tester DJ, Yagubyan M, Majumdar R, Ackerman MJ, Sundt TM 3rd. Novel NOTCH1 mutations in patients with bicuspid aortic valve disease and thoracic aortic aneurysms. *J Thorac Cardiovasc Surg*. 2007 Aug;134(2):290-6. doi:10.1016/j.jtcvs.2007.02.041. Citation on PubMed (<https://pubmed.ncbi.nlm.nih.gov/17662764>)
- Southgate L, Sukalo M, Karountzos ASV, Taylor EJ, Collinson CS, Ruddy D, Snape KM, Dallapiccola B, Tolmie JL, Joss S, Brancati F, Digilio MC, Graul-Neumann LM, Salviati L, Coerdts W, Jacquemin E, Wuyts W, Zenker M, Machado RD, Trembath RC. Haploinsufficiency of the NOTCH1 Receptor as a Cause of Adams-Oliver Syndrome With Variable Cardiac Anomalies. *Circ Cardiovasc Genet*. 2015 Aug;8(4):572-581. doi: 10.1161/CIRCGENETICS.115.001086. Epub 2015 May 11. Citation on PubMed (<https://pubmed.ncbi.nlm.nih.gov/25963545>) or Free article on PubMed Central (<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4545518/>)

- Stittrich AB, Lehman A, Bodian DL, Ashworth J, Zong Z, Li H, Lam P, Khromykh A, Iyer RK, Vockley JG, Baveja R, Silva ES, Dixon J, Leon EL, Solomon BD, Glusman G, Niederhuber JE, Roach JC, Patel MS. Mutations in NOTCH1 cause Adams-Olivers syndrome. *Am J Hum Genet.* 2014 Sep 4;95(3):275-84. doi:10.1016/j.ajhg.2014.07.011. Epub 2014 Aug 14. Citation on PubMed (<https://pubmed.ncbi.nlm.nih.gov/25132448>) or Free article on PubMed Central (<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4157158/>)
- Weng AP, Ferrando AA, Lee W, Morris JP 4th, Silverman LB, Sanchez-Irizarry C, Blacklow SC, Look AT, Aster JC. Activating mutations of NOTCH1 in human T cell acute lymphoblastic leukemia. *Science.* 2004 Oct 8;306(5694):269-71. doi:10.1126/science.1102160. Citation on PubMed (<https://pubmed.ncbi.nlm.nih.gov/15472075>)

Genomic Location

The *NOTCH1* gene is found on chromosome 9 (<https://medlineplus.gov/genetics/chromosome/9/>).

Last updated November 1, 2015