Hereditary paraganglioma-pheochromocytoma

Hereditary paraganglioma-pheochromocytoma is an inherited condition characterized by the growth of noncancerous (benign) tumors in structures called paraganglia. Paraganglia are groups of cells that are found near nerve cell bunches called ganglia. A tumor involving the paraganglia is known as a paraganglioma. A type of paraganglioma known as a pheochromocytoma develops in the adrenal glands, which are located on top of each kidney and produce hormones in response to stress. Other types of paraganglioma are usually found in the head, neck, or trunk. People with hereditary paraganglioma-pheochromocytoma develop one or more paragangliomas, which may include pheochromocytomas.

Pheochromocytomas and some other paragangliomas are associated with ganglia of the sympathetic nervous system. The sympathetic nervous system controls the "fight-or-flight" response, a series of changes in the body due to hormones released in response to stress. Sympathetic paragangliomas found outside the adrenal glands, usually in the abdomen, are called extra-adrenal paragangliomas. Most sympathetic paragangliomas, including pheochromocytomas, produce hormones called catecholamines, such as epinephrine (adrenaline) or norepinephrine. These excess catecholamines can cause signs and symptoms such as high blood pressure (hypertension), episodes of rapid heartbeat (palpitations), headaches, or sweating.

Most paragangliomas are associated with ganglia of the parasympathetic nervous system, which controls involuntary body functions such as digestion and saliva formation. Parasympathetic paragangliomas, typically found in the head and neck, usually do not produce hormones. However, large tumors may cause signs and symptoms such as coughing, hearing loss in one ear, or difficulty swallowing.

Although most paragangliomas and pheochromocytomas are noncancerous, some can become cancerous (malignant) and spread to other parts of the body (metastasize). Extra-adrenal paragangliomas become malignant more often than other types of paraganglioma or pheochromocytoma.

Researchers have identified several types of hereditary paraganglioma-pheochromocytoma. Each type is distinguished by its genetic cause. People with types 1, 2, and 3 typically develop paragangliomas in the head or neck region. People with type 4 usually develop extra-adrenal paragangliomas in the abdomen and are at higher risk for malignant tumors that metastasize. The other types are very rare. Hereditary paraganglioma-pheochromocytoma is typically diagnosed in a person's 30s.

Paragangliomas and pheochromocytomas can occur in individuals with other inherited disorders, such as von Hippel-Lindau syndrome, Carney-Stratakis syndrome, and certain types of multiple endocrine neoplasia. These other disorders feature
additional tumor types and have different genetic causes. Some paragangliomas and pheochromocytomas occur in people with no history of the tumors in their families and appear not to be inherited. These cases are designated as sporadic.

**Frequency**

Hereditary paraganglioma-pheochromocytoma occurs in approximately 1 in 1 million people.

**Causes**

Mutations in at least four genes increase the risk of developing the different types of hereditary paraganglioma-pheochromocytoma. Mutations in the \textit{SDHD} gene predispose an individual to hereditary paraganglioma-pheochromocytoma type 1; mutations in the \textit{SDHAF2} gene predispose to type 2; mutations in the \textit{SDHC} gene predispose to type 3; and mutations in the \textit{SDHB} gene predispose to type 4.

The \textit{SDHB}, \textit{SDHC}, and \textit{SDHD} genes provide instructions for making three of the four subunits of an enzyme called succinate dehydrogenase (SDH). In addition, the protein made by the \textit{SDHAF2} gene is required for the SDH enzyme to function. The SDH enzyme links two important cellular pathways called the citric acid cycle (or Krebs cycle) and oxidative phosphorylation. These pathways are critical in converting the energy from food into a form that cells can use.

As part of the citric acid cycle, the SDH enzyme converts a compound called succinate to another compound called fumarate. Succinate acts as an oxygen sensor in the cell and can help turn on specific pathways that stimulate cells to grow in a low-oxygen environment (hypoxia).

Mutations in the \textit{SDHB}, \textit{SDHC}, \textit{SDHD}, and \textit{SDHAF2} genes lead to the loss or reduction of SDH enzyme activity. Because the mutated SDH enzyme cannot convert succinate to fumarate, succinate accumulates in the cell. As a result, the hypoxia pathways are triggered in normal oxygen conditions, which lead to abnormal cell growth and tumor formation.

**Inheritance Pattern**

Hereditary paraganglioma-pheochromocytoma is inherited in an autosomal dominant pattern, which means one copy of the altered gene in each cell is sufficient to increase the risk of developing tumors. An additional mutation that deletes the normal copy of the gene is needed to cause the condition. This second mutation, called a somatic mutation, is acquired during a person's lifetime and is present only in tumor cells.

The risk of developing hereditary paraganglioma-pheochromocytoma types 1 and 2 is passed on only if the mutated copy of the gene is inherited from the father. The mechanism of this pattern of inheritance is unknown. The risk of developing types 3 and 4 can be inherited from the mother or the father.
Other Names for This Condition

- familial paraganglioma-pheochromocytoma syndromes
- familial paraganglioma syndrome
- FPGL
- FPGL/PHEO
- hereditary paraganglioma-pheochromocytoma syndromes
- hereditary pheochromocytoma-paraganglioma
- paragangliomas 1
- paragangliomas 2
- paragangliomas 3
- paragangliomas 4

Diagnosis & Management

Genetic Testing Information

- What is genetic testing? [primer/testing/genetictesting]

Research Studies from ClinicalTrials.gov

- ClinicalTrials.gov https://clinicaltrials.gov/ct2/results?cond=%22hereditary+paraganglioma-pheochromocytoma%22+OR+%22Paraganglioma%22
Other Diagnosis and Management Resources

- GeneReview: Hereditary Paraganglioma-Pheochromocytoma Syndromes
  https://www.ncbi.nlm.nih.gov/books/NBK1548
- MedlinePlus Encyclopedia: Pheochromocytoma
  https://medlineplus.gov/ency/article/000340.htm
- National Cancer Institute: Pheochromocytoma and Paraganglioma

Additional Information & Resources

Health Information from MedlinePlus

- Encyclopedia: Pheochromocytoma
  https://medlineplus.gov/ency/article/000340.htm
- Health Topic: Pheochromocytoma
  https://medlineplus.gov/pheochromocytoma.html

Genetic and Rare Diseases Information Center

- Hereditary paraganglioma-pheochromocytoma
  https://rarediseases.info.nih.gov/diseases/11984/hereditary-paraganglioma-pheochromocytoma
- Pheochromocytoma
  https://rarediseases.info.nih.gov/diseases/7385/pheochromocytoma

Additional NIH Resources

- Eunice Kennedy Shriver National Institute of Child Health and Human Development: Pheochromocytoma
  https://www.nichd.nih.gov/health/topics/pheochrom
- National Cancer Institute: Pheochromocytoma and Paraganglioma

Educational Resources

- MalaCards: hereditary paraganglioma-pheochromocytoma syndromes
  https://www.malacards.org/card/hereditary_paraganglioma_pheochromocytoma Syndromes
- Memorial Sloan-Kettering Cancer Center: Pheochromocytomas and Paragangliomas
  https://www.mskcc.org/cancer-care/types/adrenal-tumors/about/types/pheochromocytomas-paragangliomas
• Orphanet: Hereditary pheochromocytoma-paraganglioma
  https://www.orpha.net/consor/cgi-bin/OC_Exp.php?Lng=EN&Expert=29072

• The Children's Hospital of Philadelphia
  https://www.chop.edu/conditions-diseases/hereditary-paraganglioma-
  pheochromocytoma-syndrome

Patient Support and Advocacy Resources

• National Organization for Rare Disorders: Pheochromocytoma
  https://rarediseases.org/rare-diseases/pheochromocytoma/

• The Children's Hospital of Philadelphia: Paraganglioma-Pheochromocytoma
  Syndrome Resources
  https://www.chop.edu/conditions-diseases/hereditary-paraganglioma-
  pheochromocytoma-syndrome/health-resources

Clinical Information from GeneReviews

• Hereditary Paraganglioma-Pheochromocytoma Syndromes
  https://www.ncbi.nlm.nih.gov/books/NBK1548

Scientific Articles on PubMed

• PubMed
  %5BTIAB%5D%29+OR+%28paragangliomas+1%5BTIAB%5D%29+OR+%28fami
  milial+paraganglioma%5BTIAB%5D%29+OR+%28hereditary+pheochromocytoma-
  paraganglioma%5BTIAB%5D%29%29+AND+english%5Bla%5D+AND+human
  %5Bmh%5D+AND+%22last+1800+days%22%5Bdp%5D

Catalog of Genes and Diseases from OMIM

• PARAGANGLIOMAS 1
  http://omim.org/entry/168000

• PARAGANGLIOMAS 2
  http://omim.org/entry/601650

• PARAGANGLIOMAS 3
  http://omim.org/entry/605373

• PARAGANGLIOMAS 4
  http://omim.org/entry/115310

• PARAGANGLIOMAS 5
  http://omim.org/entry/614165
Sources for This Summary

  Citation on PubMed: https://www.ncbi.nlm.nih.gov/pubmed/11404820
  Free article on PubMed Central: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1226047/

  Citation on PubMed: https://www.ncbi.nlm.nih.gov/pubmed/20071235

  Citation on PubMed: https://www.ncbi.nlm.nih.gov/pubmed/19454582

  Citation on PubMed: https://www.ncbi.nlm.nih.gov/pubmed/20498024

  Citation on PubMed: https://www.ncbi.nlm.nih.gov/pubmed/28938417
  Free article on PubMed Central: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5716829/

  Citation on PubMed: https://www.ncbi.nlm.nih.gov/pubmed/14595761

  Citation on PubMed: https://www.ncbi.nlm.nih.gov/pubmed/11605159
  Free article on PubMed Central: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1235531/

  Citation on PubMed: https://www.ncbi.nlm.nih.gov/pubmed/14500403
Citation on PubMed: https://www.ncbi.nlm.nih.gov/pubmed/19628817 
Free article on PubMed Central: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3881419/

Citation on PubMed: https://www.ncbi.nlm.nih.gov/pubmed/20301715

Citation on PubMed: https://www.ncbi.nlm.nih.gov/pubmed/21547462

Citation on PubMed: https://www.ncbi.nlm.nih.gov/pubmed/15328326

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Citation on PubMed: https://www.ncbi.nlm.nih.gov/pubmed/19522823 
Free article on PubMed Central: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3163304/

Citation on PubMed: https://www.ncbi.nlm.nih.gov/pubmed/15987702

Citation on PubMed: https://www.ncbi.nlm.nih.gov/pubmed/16249420

Citation on PubMed: https://www.ncbi.nlm.nih.gov/pubmed/15652751