

Title: Cerebrotendinous Xanthomatosis *GeneReview* Table 3

Authors: Federico A, Dotti MT, Gallus GN

Date: August 2013

Note: The following information is provided by the authors listed above and has not been reviewed by *GeneReviews* staff.

Table 3. Selected CYP27A1 Allelic Variants

Variant Classification	DNA Nucleotide Change	Predicted Protein Change	References or Reference Sequences
Pathogenic	c.5_6insC	p.Met1fsTer178	Segev et al 1995
	c.10_11 ins10bp	p.Ala7fsTer	Szlago et al 2008
	c.73delG		Tian & Zhang 2011
	c.206delC		Chen et al 2011
	c.355delC	p.Met118fsTer	Leitersdorf et al 1994
		(p.Arg104Gln) ¹	Nozue et al 2010
	c.369_375delGTACCCA		Tian & Zhang 2011
	c.379C>T	p.Arg127Trp	Verrips et al 1999
	c.380G>A	p.Arg127Gln	Watts et al 1996
		p.Trp133Ter	Lee et al 2001
	c.409C>T	p.Arg137Trp	Nakashima et al 1994
	c.433 G>A	p.Gly145Arg	Gallus et al 2010
	c.434G>A	p.Gly145Glu	Lamon-Fava et al 2002
	c.435G>T	p.Gly145Gly (alternative splicing)	Chen et al 1998b
	c.446+1G>A		Verrips et al 2000
	c.475C>T	p.Gln159Ter	Verrips et al 1996
	c.525-526delG	p.Thr175fsTer	Verrips et al 1996
	c.583G>T	p.Glu195Ter	Wakamatsu et al 1999
	c.599C>T	p.Gln191Ter	Huang et al 2011
	c.646G>C	p.Ala216Pro	Garuti et al 1996
	c.647-1 G>T		Gallus et al 2010
	c.691C>T	p.Arg231Ter	Garuti et al 1997
	c.745C>T	p.Gln249Ter	Verrips et al 2000
	c.752 C>A	p.Ser2518	Gallus et al 2010
	c.776A>G	p.Lys259Arg	Verrips et al 2000
	c.779G>A	p.Trp260Ter	Verrips et al 2000
	c.808C>T	p.Arg270Ter	Ahmed et al 1997
	c.819delT	p.Leu272fsTer	Leitersdorf et al 1993
	c.844+1G>A	p.del exon 4	Verrips et al 1997
	c.845-1G>A		Leitersdorf et al 1993
	c.850A>T	p.Lys284Ter	Meiner et al 1994
	c.863delA	p.Glu288fs	Gallus et al 2010

	c.944_948del TGGCC	p.Leu314fsTer	Lamon-Fava et al 2002
	c.1016C>T	p.Thr339Met	Reshef et al 1994
	c.1017 G>C		Wallon et al 2010
	c.1061A>G	p.Asp354Gly	Verrips et al 2000a
	c.1146_1151delins	p.H382QfsTer26	Suh et al 2012
	c.1151C>T	p.Pro384Leu	Verrips et al 2000
	c.1180-1181del CT	p.frame shift>ptc	Lee et al 2001
	c.1183C>T	p.Arg395Cys	Cali et al 1991
	c.1183C>A	p.Arg395Ser	Chen et al 1998b
	c.1184G>A	p.Arg395His	Chen et al 1996, Chen et al 1998a
	c.1184+1 G>A		Garuti et al 1997
	c.1185-1G>T		Mak et al 2004
	c.1263+81_1596+?del		Garuti et al 1996, Garuti et al 1997
	c.1202C>G	p.Pro401Arg	Okuyama et al 1996
	c.1209C>G	p.Asn403Lys	Castelnovo et al 2003
	c.1213C>T	p.Arg405Trp	Verrips et al 2000
	c.1214G>A	p.Arg405Gln	Chen et al 1997
	c.1222G>T	p.Glu408Ter	Von Bahr et al 2005
	c.1238T>A	p.Val413Asp	Koyama et al 2012
	c.1263G>A		Garuti et al 1996
	c.1263+5G>T		Garuti et al 1997
	c.1264-1G>A		Garuti et al 1997
	c.1323C>T	p.Pro441Ser	Lee et al 2001
	c.1330-1333delTTCC	p.Ser443fsTer449	Schneider et al 2010
	c.1402C>T	p.Gln461Ter	Lee et al 2001
	c.1415G>C	p.Gly472Ala	Verrips et al 2000
	c.1420C>T	p.Arg474Trp	Kuriyama et al 1991
	c.1421G>A	p.Arg474Gln	Kuriyama et al 1991
	c.1435C>T	p.Arg479Cys	Cali et al 1991
	c.1435C>G	p.Arg479Gly	Guyant-Maréchal et al 2005
Benign	c.366A>C	p.Gly122Gly	Nakashima et al 1994
	c.438G>A	p.Pro146Pro	Lamon-Fava et al 2002
	c.852G>A	p.Lys284Lys	Leitersdorf et al 1993
	c.243G>A	p.Leu81Leu	NM_000784.3:c.243G>A NP_000775.1
	c.882G>A	p.Glu294Glu	NM_000784.3:c.882G>A NP_000775.1
	c.888A>G	p.Gln296Gln	NM_000784.3:c.888A>G

			NP_000775.1
	c.1374C>A	p.Pro458Pro	NM_000784.3:c.1374C>A NP_000775.1

1. Variant designation that does not conform to current naming conventions

References

Ahmed MS, Afsar S, Hentati A, Ahmad A, Pasha J, Juneja T, Hung WY, Ahmad A, Choudhri A, Saya S, Siddique T. A novel mutation in the sterol 27-hydroxylase gene of a Pakistani family with autosomal recessive cerebrotendinous xanthomatosis. *Neurology*. 1997;48:258-60.

Cali JJ, Hsieh CL, Francke U, Russell DW. Mutations in the bile acid biosynthetic enzyme sterol 27-hydroxylase underlie cerebrotendinous xanthomatosis. *J Biol Chem*. 1991;266:7779-83.

Castelnovo G, Jomir L, Bouly S. Cerebrotendinous xanthomatosis. *J Neurol Neurosurg Psychiatry*. 2003;74:1335.

Chen W, Kubota S, Nishimura Y, Nozaki S, Yamashita S, Nakagawa T, Kameda-Takemura K, Menju M, Matsuzawa Y, Björkhem I, Eggertsen G, Seyama Y. Genetic analysis of a Japanese cerebrotendinous xanthomatosis family: identification of a novel mutation in the adrenodoxin binding region of the CYP 27 gene. *Biochim Biophys Acta*. 1996;1317:119-26.

Chen W, Kubota S, Teramoto T, Nishimura Y, Yonemoto K, Seyama Y. Silent nucleotide substitution in the sterol 27-hydroxylase gene (CYP 27) leads to alternative pre-mRNA splicing by activating a cryptic 5' splice site at the mutant codon in cerebrotendinous xanthomatosis patients. *Biochemistry*. 1998a;37:4420-8.

Chen W, Kubota S, Ujike H, Ishihara T, Seyama Y. A novel Arg362Ser mutation in the sterol 27-hydroxylase gene (CYP27): its effects on pre-mRNA splicing and enzyme activity. *Biochemistry*. 1998b;37:15050-6.

Chen WC, Wu KC, Hu CH, Chern TC, Jou IM. A compound heterozygous mutation of CYP27A1 gene in a Taiwanese patient with cerebrotendinous xanthomatosis. *J Orthop Sci*. 2011;16:825-7.

Gallus GN, Dotti MT, Mignarri A, Rufa A, Da Pozzo P, Cardaioli E, Federico A. Four novel CYP27A1 mutations in seven Italian patients with CTX. *Eur J Neurol*. 2010;17:1259-62.

Garuti R, Croce MA, Tiozzo R, Dotti MT, Federico A, Bertolini S, Calandra S. Four novel mutations of sterol 27-hydroxylase gene in Italian patients with cerebrotendinous xanthomatosis. *J Lipid Res*. 1997;38:2322-34.

Garuti R, Lelli N, Barozzini M, Tiozzo R, Dotti MT, Federico A, Ottomano AM, Croce A, Bertolini S, Calandra S. Cerebrotendinous xanthomatosis caused by two new mutations of the sterol-27-hydroxylase gene that disrupt mRNA splicing. *J Lipid Res*. 1996;37:1459-67.

Guyant-Maréchal L, Verrips A, Girard C, Wevers RA, Zijlstra F, Sistermans E, Vera P, Campion D, Hannequin D. Unusual cerebrotendinous xanthomatosis with fronto-temporal dementia phenotype. *Am J Med Genet A*. 2005;139A:114-7.

Huang L, Miao XD, Yang DS, Tao HM. Bilateral Achilles tendon enlargement. *Orthopedics*. 2011;34:e960-4.

Koyama S, Kawanami T, Tanji H, Arawaka S, Wada M, Saito N, Kato T. A case of cerebrotendinous xanthomatosis presenting with epilepsy as an initial symptom with a novel V413D mutation in the CYP27A1 gene. *Clin Neurol Neurosurg*. 2012;114:1021-3.

Kuriyama M, Fujiyama J, Yoshidome H, Takenaga S, Matsumuro K, Kasama T, Fukuda K, Kuramoto T, Hoshita T, Seyama Y, et al. Cerebrotendinous xanthomatosis: clinical and biochemical evaluation of eight patients and review of the literature. *J Neurol Sci*. 1991;102:225-32.

Lamon-Fava S, Schaefer EJ, Garuti R, Salen G, Calandra S. Two novel mutations in the sterol 27-hydroxylase gene causing cerebrotendinous xanthomatosis. *Clin Genet*. 2002;61:185-91.

Lee MH, Hazard S, Carpten JD, Yi S, Cohen J, Gerhardt GT, Salen G, Patel SB. Fine-mapping, mutation analyses, and structural mapping of cerebrotendinous xanthomatosis in U.S. pedigrees. *J Lipid Res*. 2001;42:159-69.

Leitersdorf E, Reshef A, Meiner V, Levitzki R, Schwartz SP, Dann EJ, Berkman N, Cali JJ, Klapholz L, Berginer VM. Frameshift and splice-junction mutations in the sterol 27-hydroxylase gene cause cerebrotendinous xanthomatosis in Jews of Moroccan origin. *J Clin Invest*. 1993;91:2488-96.

- Leitersdorf E, Safadi R, Meiner V, Reshef A, Björkhem I, Friedlander Y, Morkos S, Berginer VM. Cerebrotendinous xanthomatosis in the Israeli Druze: molecular genetics and phenotypic characteristics. *Am J Hum Genet.* 1994;55:907-15.
- Mak CM, Lam KS, Tan KC, Ma OC, Tam S. Cerebrotendinous xanthomatosis in a Hong Kong Chinese kinship with a novel splicing site mutation IVS6-1G>T in the sterol 27-hydroxylase gene. *Mol Genet Metab.* 2004;81:144-6.
- Nakashima N, Sakai Y, Sakai H, Yanase T, Haji M, Umeda F, Koga S, Hoshita T, Nawata H. A point mutation in the bile acid biosynthetic enzyme sterol 27-hydroxylase in a family with cerebrotendinous xanthomatosis. *J Lipid Res.* 1994;35:663-8.
- Nozue T, Higashikata T, Inazu A, Kawashiri MA, Nohara A, Kobayashi J, Koizumi J, Yamagishi M, Mabuchi H. Identification of a novel missense mutation in the sterol 27-hydroxylase gene in two Japanese patients with cerebrotendinous xanthomatosis. *Intern Med.* 2010;49:1127-31.
- Okuyama E, Tomita S, Takeuchi H, Ichikawa Y. A novel mutation in the cytochrome P450(27) (CYP27) gene caused cerebrotendinous xanthomatosis in a Japanese family. *J Lipid Res.* 1996;37:631-9.
- Schneider H, Lingesleben A, Vogel HP, Garuti R, Calandra S. A novel mutation in the sterol 27-hydroxylase gene of a woman with autosomal recessive cerebrotendinous xanthomatosis. *Orphanet J Rare Dis.* 2010;5:27.
- Segev H, Reshef A, Clavey V, Delbart C, Routier G, Leitersdorf E. Premature termination codon at the sterol 27-hydroxylase gene causes cerebrotendinous xanthomatosis in a French family. *Hum Genet.* 1995;95:238-40.
- Suh S, Kim HK, Park HD, Ki CS, Kim MY, Jin SM, Kim SW, Hur KY, Kim KW, Kim JH. Three siblings with Cerebrotendinous Xanthomatosis: a novel mutation in the CYP27A1 gene. *Eur J Med Genet.* 2012;55:71-4.
- Szlago M, Gallus GN, Schenone A, Patiño ME, Sfaelo Z, Rufa A, Da Pozzo P, Cardaioli E, Dotti MT, Federico A. The first cerebrotendinous xanthomatosis family from Argentina: a new mutation in CYP27A1 gene. *Neurology.* 2008;70:402-4.
- Tian D, Zhang ZQ. 2 Novel deletions of the sterol 27-hydroxylase gene in a Chinese Family with Cerebrotendinous Xanthomatosis. *BMC Neurol.* 2011;11:130.
- Verrips A, Hoefsloot LH, Steenbergen GC, Theelen JP, Wevers RA, Gabreëls FJ, van Engelen BG, van den Heuvel LP. Clinical and molecular genetic characteristics of patients with cerebrotendinous xanthomatosis. *Brain.* 2000;123:908-19.
- Verrips A, Nijeholt GJ, Barkhof F, Van Engelen BG, Wesseling P, Luyten JA, Wevers RA, Stam J, Wokke JH, van den Heuvel LP, Keyser A, Gabreëls FJ. Spinal xanthomatosis: a variant of cerebrotendinous xanthomatosis. *Brain.* 1999;122:1589-95.
- Verrips A, Steenbergen-Spanjers GC, Luyten JA, van den Heuvel LP, Keyser A, Gabreëls FJ, Wevers RA. Two new mutations in the sterol 27-hydroxylase gene in two families lead to cerebrotendinous xanthomatosis. *Hum Genet.* 1996;98:735-7.
- Verrips A, Steenbergen-Spanjers GC, Luyten JA, Wevers RA, Wokke JH, Gabreëls FJ, Wolthers BG, van den Heuvel LP. Exon skipping in the sterol 27-hydroxylase gene leads to cerebrotendinous xanthomatosis. *Hum Genet.* 1997;100:284-6.
- von Bahr S, Björkhem I, Van't Hooft F, Alvelius G, Nemeth A, Sjövall J, Fischler B. Mutation in the sterol 27-hydroxylase gene associated with fatal cholestasis in infancy. *J Pediatr Gastroenterol Nutr.* 2005;40:481-6.
- Wakamatsu N, Hayashi M, Kawai H, Kondo H, Gotoda Y, Nishida Y, Kondo R, Tsuji S, Matsumoto T. Mutations producing premature termination of translation and an amino acid substitution in the sterol 27-hydroxylase gene cause cerebrotendinous xanthomatosis associated with parkinsonism. *J Neurol Neurosurg Psychiatry.* 1999;67:195-8.
- Wallon D, Guyant-Maréchal L, Laquerrière A, Wevers RA, Martinaud O, Kluijtmans LA, Yntema HG, Saugier-Verber P, Hannequin D. Clinical imaging and neuropathological correlations in an unusual case of cerebrotendinous xanthomatosis. *Clin Neuropathol.* 2010;29:361-4.
- Watts GF, Mitchell WD, Bending JJ, Reshef A, Leitersdorf E. Cerebrotendinous xanthomatosis: a family study of sterol 27-hydroxylase mutations and pharmacotherapy. *QJM.* 1996;89:55-63.