SKIN

IN-DEPTH REVIEW

Vascular Effects of Pseudoxanthoma Elasticum

Erika L. Hubbard, BA[1], Mark G. Lebwohl, MD[1]

[1]The Kimberly and Eric J. Waldman Department of Dermatology, Icahn School of Medicine at Mount Sinai Hospital, New York, NY

ABSTRACT

Background: Pseudoxanthoma elasticum (PXE) is a rare hereditary disease caused by mutations in the ABCC6 gene, characterized by ectopic calcification of connective tissue throughout the body. Vascular conditions associated with PXE have been well-documented in the literature, but to our knowledge, analysis of the myriad of PXE case reports with associated vascular diseases in addition to larger cohort studies, has not been undertaken.

Methods: A search of the PubMed database using the key words “pseudoxanthoma elasticum” and “vascular” was performed.

Results: A total of 345 cases of PVD, 97 cases of CVD, and 123 case of CeVD were reported. Additionally, 88 cases of hypertension and 5 cases of CRM were reported.

Conclusions: PXE patients are at risk of developing serious vascular conditions, particularly peripheral vascular disease. This condition also appears to have some connection to carotid rete mirabile, which is extremely rare in humans. Further research should be conducted to analyze the connection between PXE and CRM in order to better understand and treat both conditions.

INTRODUCTION

Pseudoxanthoma elasticum (PXE) is a rare autosomal recessive disease caused by biallelic mutation of the ABCC6 gene. The condition is characterized by the degradation and calcification of elastic fibers in connective tissue, including the skin, eyes, and arterial media, resulting in cutaneous yellowish papules, angioid streaks in Bruch’s membrane, and vascular calcification. Prevalence of the condition is estimated from 1:25,000 to 1:56,000, with a 2:1 female to male ratio. [1,2]

The vascular effects of PXE are extensive. The ABCC6 gene maintains inorganic phosphate levels that inhibit calcification, so it follows that loss of ABCC6 function results in systemic calcification.[3] Arterial calcification caused by elastin degradation is associated with increased carotid intima-media thickness, which puts PXE patients at higher risk of developing cardiovascular and cerebrovascular disease.[4] Some studies suggest that older PXE patients also have increased arterial compressibility and distensibility, though debate on this issue remains.[5-7] In this paper, we reviewed the

literature published on vascular conditions associated with PXE, broadly categorized as peripheral vascular disease, cardiovascular disease, cerebrovascular disease, hypertension, and carotid rete mirabile, in order to capture a general idea of the prevalence and range of this association.

METHODS

We performed a PubMed search using the terms "pseudoxanthoma elasticum" and "vascular," and limited our analysis to English-language, French-language studies, and studies with abstracts in English with extractable data. Animal studies, treatment studies, and PXE studies focusing on cutaneous or ophthalmologic symptoms were excluded. Articles without full-text availability were also excluded from our review. Of the 90 relevant articles, upon review of the case descriptions, 73 had extractable vascular conditions data to analyze, comprised of 59 case studies/series and 14 cohort/cross-sectional studies.

RESULTS

From the 73 relevant articles, 1049 PXE patients were reported. Of these patients, 345 had some form of peripheral vascular disease (PVD), 97 had cardiovascular disease, and 123 had cerebrovascular disease. The most common PVD diagnoses included intermittent claudication (24 patients), lower limb atherosclerosis (67 patients), and peripheral arterial stenosis or occlusion (23 patients). Cardiovascular disease conditions primarily consisted of myocardial infarction (15 patients), angina pectoris (12 patients), and coronary artery disease (7 patients). Transient ischemic attacks (17 patients), ischemic strokes (67 patients), and carotid artery disease or stenosis (31 patients) accounted for the bulk of cerebrovascular disease cases. It is also worth noting that 88 PXE patients had hypertension. Additionally, 5 case study patients presented with carotid rete mirabile, a rare disorder characterized by an arterial

Table 1. Characteristics of included cohort and cross-sectional studies

Reference	Patients	PVD	CVD	CeVD	HT	CRM
Campens et al.[8]	32	13	0	10	8	0
Gutierrez-Cardo et al.[9]	18	5	2	1	6	0
Hammami et al.[10]	22	0	0	0	0	0
Iwanaga et al.[11]	76	24	18	0	0	0
Kauw et al.[12]	178	0	0	29	0	0
Leftheriotis et al.[13]	71	40	7	8	18	0
Legrand et al.[14]	194	84	37	17	0	0
Nollet et al.[15]	56	18	6	17	17	0
Omarjee et al.[16]	151	0	0	13	0	0
Omarjee et al.[17]	23	9	1	1	0	0
Passon et al.[18]	44	44	0	0	0	0
Pingel et al.[19]	46	45	0	0	0	0
Utani et al.[20]	14	0	4	0	0	0
Vanakker et al.[21]	38	22	7	6	17	0
TOTALS	**963**	**304**	**82**	**102**	**66**	**0**

PVD: peripheral vascular disease; CVD: cardiovascular disease; CeVD: cerebrovascular disease; HT: hypertension; CRM: carotid rete mirabile

network communicating between the internal and external carotid networks.

DISCUSSION

From our PubMed search, it appears that peripheral vascular, cardiovascular, and cerebrovascular disease are all well-documented among PXE patients in the literature. These comorbidities are expected considering the arterial calcification of elastic tissue that occurs as a result of ABCC6 mutations. Arterial calcification alters the elastic properties of the arterial wall, causing it to stiffen, which consequently increases systemic arterial pressure.[2] Peripheral vascular disease (PVD), detected by low ankle-brachial index (ABI), absence of ankle pulse, and lower limb claudication, is particularly well-documented in patients with PXE (45% of French PXE cohort, 53% of Belgian PXE cohort).[21,81] Cardiovascular abnormalities, including angina pectoris and myocardial infarction, are relatively rare (15% with angina pectoris and 5% myocardial infarction in large cohort study).[21] Cerebrovascular events are also relatively rare, but occur at significantly higher rates in PXE patients relative to the general population (around 8% prevalence of cerebrovascular accidents in PXE patients, compared to 3% prevalence in general population).[82]

Hypertension is quite common among PXE patients (25% in Leftheriotis et al. 2014; 41% in Vanakker et al.).[13,21] Though hypertension has historically been viewed as a risk factor in developing arterial calcification, more recent research has found that arterial calcification also causes hypertension in the elderly, suggesting that arterial calcification and hypertension are part of a vicious cycle of vascular aging.[83] This relationship has particular relevance to PXE patients, whose vascular condition can be characterized as early-onset vascular aging.[51]

Reports of five PXE patients with carotid rete mirabile (CRM) is particularly intriguing. A rete mirabile is a vascular network of arteries and arterioles that replaces the normal adult carotid arteries. CRM supplies the brain in lower mammals, but is absent in normal human development.[84] Individuals with CRM most commonly present clinically with hemorrhagic or ischemic strokes. This and other cerebrovascular malformations have generally been treated as only coincidentally associated with PXE. However, of the 32 human cases of CRM reported in the literature before 2011, five (16%) were PXE patients.[75] Given that both CRM and PXE are quite rare conditions, it seems unlikely that they would accidentally co-occur at this frequency. Some researchers have suggested that abnormal signaling caused by ABCC6 mutation during embryological development could create abnormalities in arterial wall construction, including CRM, implying a systematic association between PXE and CRM.[75]

CONCLUSION

In conclusion, PXE patients often suffer from a wide range of vascular conditions, most common of which is peripheral vascular disease. Hypertension is also quite prevalent among PXE patients, which is of particular concern, as hypertension is not only an effect of PXE, but also a cause of further arterial calcification. A finding of particular interest from this review is the potential systematic association between PXE and CRM. Further research should be conducted to discern the nature of the relationship, if any, between PXE and CRM, as an understanding of a vascular

developmental disorder such as CRM would further our understanding of PXE and its mechanisms of arterial onset.

Table 2. Characteristics of included case studies/series

Reference	Patients	PVD	CVD	CeVD	HT	CRM
Aissaoui et al.[22]	5	0	0	0	1	0
Ammi et al.[23]	4	4	0	0	0	0
Araki et al.[24]	1	1	1	1	1	0
Araki et al.[25]	1	0	0	1	0	1
Bardsley et al.[26]	2	2	0	0	1	0
Barrie et al.[27]	2	1	0	1	1	0
Bete et al.[28]	1	0	1	0	0	0
Bock et al.[29]	1	0	0	1	0	0
Bruno et al.[30]	4	0	1	2	4	0
Cailleux et al.[31]	1	1	0	0	0	0
Carter et al.[32]	1	1	0	0	0	0
Chalk et al.[33]	1	0	0	1	0	0
Dalloz et al.[34]	1	0	0	1	0	0
Del Zotto et al.[35]	1	0	0	1	0	1
Devriese et al.[36]	1	1	0	0	0	0
Dibi et al.[37]	4	0	1	0	4	0
Dymock et al.[38]	1	1	1	0	1	0
Ekim et al.[39]	1	0	0	0	1	0
Elhatimi et al.[40]	1	0	0	0	1	0
Fasshauer et al.[41]	1	0	0	1	0	0
Galle et al.[42]	1	0	0	1	0	0
García Acuña et al.[43]	1	0	1	0	0	0
Gillgren et al.[44]	1	1	0	0	0	0
Heno et al.[45]	1	0	1	0	0	0
Jackson et al.[46]	1	1	0	0	0	0
Kévorkian et al.[47]	1	0	1	0	0	0
Khan et al.[48]	1	1	0	0	0	0
Lamb et al.[49]	1	1	0	0	0	0
Li et al.[50]	1	0	0	0	0	0
Mendelsohn et al.[51]	3	3	0	0	1	0
Miki et al.[52]	1	0	0	0	0	0
Miwa et al.[53]	1	0	0	0	1	0

Montani et al.[54]	1	1	1	0	0	0
Neumann et al.[55]	1	1	0	0	0	0
Nishida et al.[56]	1	0	1	0	0	0
Nolte et al.[57]	1	0	1	0	0	0
Pavlovic et al.[58]	3	0	0	3	2	0
Perdu et al.[59]	7	7	0	0	0	0
Pieczuro et al.[60]	1	0	0	1	0	0
Rios-Montenegro et al.[61]	1	0	0	0	0	1
Rodríguez-Camarero et al.[62]	1	1	0	0	0	0
Rühlmann et al.[63]	1	1	0	0	0	0
Sabán-Ruiz et al.[64]	1	0	0	0	1	0
Sasai et al.[65]	1	1	0	0	0	0
Schröder et al.[66]	1	1	0	1	0	0
Sharma et al.[67]	1	0	0	1	1	0
Siskos et al.[68]	1	1	0	0	0	0
Slade et al.[69]	1	1	0	0	0	0
Song et al.[70]	1	1	2	0	0	0
Sunmonu et al.[71]	1	0	0	1	0	0
Takeshita et al.[72]	1	0	0	1	0	0
Tromp et al.[73]	2	1	0	0	0	0
ul Bari et al.[74]	1	1	0	0	1	0
Vasseur et al.[75]	1	0	1	0	0	1
Wahlqvist et al.[76]	2	2	0	0	0	0
Wolff et al.[77]	1	1	0	0	0	0
Yasuhara et al.[78]	1	0	1	1	0	1
Zimmo et al.[79]	1	0	0	0	0	0
Zuily et al.[80]	1	1	0	1	0	0
TOTALS	**86**	**41**	**15**	**21**	**22**	**5**

PVD: peripheral vascular disease; CVD: cardiovascular disease; CeVD: cerebrovascular disease; HT: hypertension; CRM: carotid rete mirabile

Conflict of Interest Disclosures: None

Funding: None

Corresponding Author:
Erika Hubbard
95 W 95th Street, 16th floor,
New York, NY 10025
Phone: (435)890-5272
Email: elh2174@columbia.edu

References:

1. Kranenburg G, Baas AF, de Jong PA, et al. The prevalence of pseudoxanthoma elasticum: Revised estimations based on genotyping in a high vascular risk cohort. *Eur J Med Genet.* Feb 2019;62(2):90-92.
2. Leftheriotis G, Omarjee L, Le Saux O, et al. The vascular phenotype in Pseudoxanthoma elasticum and related disorders: contribution of a

genetic disease to the understanding of vascular calcification. *Front Genet.* 2013;4:4.
3. Bartstra JW, Spiering W, van den Ouweland JMW, Mali W, Janssen R, de Jong PA. Increased Elastin Degradation in Pseudoxanthoma Elasticum Is Associated with Peripheral Arterial Disease Independent of Calcification. *J Clin Med.* Aug 26 2020;9(9).
4. Kranenburg G, Visseren FLJ, de Borst GJ, de Jong PA, Spiering W, studygroup S. Arterial stiffening and thickening in patients with pseudoxanthoma elasticum. *Atherosclerosis.* Mar 2018;270:160-165.
5. Kornet L, Bergen AA, Hoeks AP, et al. In patients with pseudoxanthoma elasticum a thicker and more elastic carotid artery is associated with elastin fragmentation and proteoglycans accumulation. *Ultrasound Med Biol.* Aug 2004;30(8):1041-1048.
6. Boutouyrie P, Germain DP, Tropeano A, et al. Compressibility of the carotid artery in patients with pseudoxanthoma elasticum. *Hypertension.* 2001;38(5):1181-1184.
7. Germain DP, Boutouyrie P, Laloux B, Laurent S. Arterial remodeling and stiffness in patients with pseudoxanthoma elasticum. *Arterioscler Thromb Vasc Biol.* May 1 2003;23(5):836-841.
8. Campens L, Vanakker OM, Trachet B, et al. Characterization of cardiovascular involvement in pseudoxanthoma elasticum families. *Arterioscler Thromb Vasc Biol.* Nov 2013;33(11):2646-2652.
9. Gutierrez-Cardo A, Lillo E, Murcia-Casas B, et al. Skin and Arterial Wall Deposits of 18F-NaF and Severity of Disease in Patients with Pseudoxanthoma Elasticum. *J Clin Med.* May 8 2020;9(5).
10. Hammami H, Badri T, Benmously R, et al. Pseudoxanthoma elasticum: a study of 22 cases. *Rev Med Liege.* 2009;64(12):629.
Iwanaga A, Okubo Y, Yozaki M, et al. Analysis of clinical symptoms and ABCC6 mutations in 76 Japanese patients with pseudoxanthoma elasticum. *J Dermatol.* Jun 2017;44(6):644-650.
11. Kauw F, Kranenburg G, Kappelle LJ, et al. Cerebral disease in a nationwide Dutch pseudoxanthoma elasticum cohort with a systematic review of the literature. *J Neurol Sci.* Feb 15 2017;373:167-172.
12. Leftheriotis G, Kauffenstein G, Hamel JF, et al. The contribution of arterial calcification to peripheral arterial disease in pseudoxanthoma elasticum. *PLoS One.* 2014;9(5):e96003.
13. Legrand A, Cornez L, Samkari W, et al. Mutation spectrum in the ABCC6 gene and genotype-phenotype correlations in a French cohort with pseudoxanthoma elasticum. *Genet Med.* Aug 2017;19(8):909-917.
14. Nollet L, Campens L, De Zaeytijd J, et al. Clinical and subclinical findings in heterozygous ABCC6 carriers: results from a Belgian cohort and clinical practice guidelines. *J Med Genet.* Apr 5 2021.
15. Omarjee L, Fortrat JO, Larralde A, et al. Internal Carotid Artery Hypoplasia: A New Clinical Feature in Pseudoxanthoma Elasticum. *J Stroke.* Jan 2019;21(1):108-111.
16. Omarjee L, Mention PJ, Janin A, et al. Assessment of Inflammation and Calcification in Pseudoxanthoma Elasticum Arteries and Skin with 18F-FluroDeoxyGlucose and 18F-Sodium Fluoride Positron Emission Tomography/Computed Tomography Imaging: The GOCAPXE Trial. *J Clin Med.* Oct 27 2020;9(11).
17. Passon SG, Kullmar V, Blatzheim AK, et al. Carotid strain measurement in patients with pseudoxanthoma elasticum - Hint for a different pathomechanism? *Intractable Rare Dis Res.* Feb 2018;7(1):25-31.
18. Pingel S, Pausewang KS, Passon SG, et al. Increased vascular occlusion in patients with pseudoxanthoma elasticum. *Vasa-European Journal of Vascular Medicine.* 2017;46(1):47-52.
19. Utani A, Tanioka M, Yamamoto Y, et al. Relationship between the distribution of pseudoxanthoma elasticum skin and mucous membrane lesions and cardiovascular involvement. *J Dermatol.* Feb 2010;37(2):130-136.
20. Vanakker OM, Leroy BP, Coucke P, et al. Novel clinico-molecular insights in pseudoxanthoma elasticum provide an efficient molecular screening method and a comprehensive diagnostic flowchart. *Hum Mutat.* Jan 2008;29(1):205.
21. Aissaoui R, Derbel F, Jallouli A, et al. [Pseudoxanthoma elasticum, 5 case reports]. *Presse Med.* Oct 18 2003;32(34):1595-1598.
22. Ammi M, Kranenburg G, Omarjee L, Martin L, Spiering W, Lefthériotis G. Abnormally high failure rate for femoral angioplasty in patients with pseudoxanthoma elasticum. *J Vasc Surg Cases.* Dec 2015;1(4):276-278.
23. Araki Y, Yokoyama T, Sagawa N, et al. Pseudoxanthoma elasticum diagnosed 25 years after the onset of cardiovascular disease. *Intern Med.* Nov 2001;40(11):1117-1120.
24. Araki Y, Imai S, Saitoh A, Ito T, Shimizu K, Yamada H. [A case of carotid rete mirabile associated with pseudoxanthoma elasticum: a case report]. *No To Shinkei.* May 1986;38(5):495-500.

25. Bardsley JL, Koehler PR. Pseudoxanthoma elasticum: angiographic manifestations in abdominal vessels. *Radiology.* Sep 1969;93(3):559-562.
26. Barrie L, Mazereeuw-Hautier J, Garat H, Bonafe JL. [Early pseudoxanthoma elasticum with severe cardiovascular involvement]. *Ann Dermatol Venereol.* Mar 2004;131(3):275-278.
27. Bete JM, Banas JS, Jr., Moran J, Pinn V, Levine HJ. Coronary artery disease in an 18 year old with pseudoxanthoma elasticum: successful surgical therapy. *Am J Cardiol.* Oct 6 1975;36(4):515-520.
28. Bock A, Schwegler G. Intracerebral haemorrhage as first manifestation of pseudoxanthoma elasticum. *Clin Neurol Neurosurg.* Mar 2008;110(3):262-264.
29. Bruno G, Ritelli M, Di Pietro A, et al. Clinical and Genetic Heterogeneity in a Large Family with Pseudoxanthoma Elasticum: MTHFR and SERPINE1 Variants as Possible Disease Modifiers in Developing Ischemic Stroke. *J Stroke Cerebrovasc Dis.* Apr 1 2021;30(6):105744.
30. Cailleux N, Hachulla E, Perez-Cousin M, Labalette P, Lecomte-Houcke M. [Pseudoxanthoma elasticum: a rare cause of leg artery diseases in young adults]. *J Mal Vasc.* Mar 1997;22(1):51-55.
31. Carter DJ, Woodward DA, Vince FP. Arterial surgery in pseudoxanthoma elasticum. *Postgrad Med J.* May 1976;52(607):291-292.
32. Chalk JB, Patterson MC, Pender MP. An intracranial arteriovenous malformation and palatal myoclonus related to pseudoxanthoma elasticum. *Aust N Z J Med.* Apr 1989;19(2):141-143.
33. Dalloz MA, Debs R, Bensa C, Alamowitch S. [White matter lesions leading to the diagnosis of pseudoxanthoma elasticum]. *Rev Neurol (Paris).* Oct 2010;166(10):844-848.
34. Del Zotto E, Ritelli M, Pezzini A, et al. Clinical, neuroradiological and molecular features of a patient affected by pseudoxhantoma elasticum associated to carotid rete mirabile: case report. *Clin Neurol Neurosurg.* Jul 2012;114(6):758-761.
35. Devriese M, Legrand A, Courtois M, Jeunemaitre X, Albuisson J. Pseudoxanthoma elasticum with prominent arterial calcifications evoking CD73 deficiency. *Vasc. Med.* 2019;24(5):461-464.
36. Dibi A, Mouane N, El Fahime E, Dafiri R, Bentahila A. Calcifications vasculaires dans le pseudoxanthome élastique chez l'enfant. *JMV.* 2017;42(6):333-337.
37. Dymock RB. Pseudoxanthoma elasticum: report of a case with reno-vascular hypertension. *Aust. J. Derm.* 1979;20(82).
38. Ekim M, Tümer N, Atmaca L, et al. Pseudoxanthoma elasticum: a rare cause of hypertension in children. *Pediatr Nephrol.* Apr 1998;12(3):183-185.
39. Elhatimi A, Elbakkal A, Iguermia S, Meziane M, Mikou O, Mernissi FZ. Yellow papules: the iceberg of systemic elastorrhexis. *Pan Afr Med J.* 2013;14:106.
40. Fasshauer K, Reimers CD, Gnau HJ, Strempel I, Rossberg C. Neurological complications of Grönblad-Strandberg syndrome. *J Neurol.* 1984;231(5):250-252.
41. Galle G, Galle K, Huk W, Taghavy A. [Stenoses of the cerebral arteries in pseudoxanthoma elasticum (author's transl)]. *Arch Psychiatr Nervenkr (1970).* 1981;231(1):61-70.
42. García Acuña JM, Vázquez Caamaño M, González Cid A, González-Juanatey JR, López Lago AM, Gil De La Peña M. [Coronary ischemia caused by pseudoxanthoma elasticum and myocardial revascularization with double arterial graft]. *Rev Esp Cardiol.* Jul 2001;54(7):908-911.
43. Gillgren P, Malmstedt J. Pseudoxanthoma Elasticum and Isolated Iliac Artery Occlusion. *Eur J Vasc Endovasc Surg.* Sep 2020;60(3):409.
44. Heno P, Fourcade L, Duc HN, et al. [Aorto-coronary dysplasia and pseudoxanthoma elastica]. *Arch Mal Coeur Vaiss.* Apr 1998;91(4):415-418.
45. Jackson A, Loh CL. Pulmonary calcification and elastic tissue damage in pseudoxanthoma elasticum. *Histopathology.* Nov 1980;4(6):607-611.
46. **47.** Kévorkian JP, Masquet C, Kural-Ménasché S, Le Dref O, Beaufils P. New report of severe coronary artery disease in an eighteen-year-old girl with pseudoxanthoma elasticum. Case report and review of the literature. *Angiology.* Aug 1997;48(8):735-741.
47. Khan MA, Beard J. Peripheral vascular disease in an individual with pseudoxanthoma elasticum. *Eur J Vasc Endovasc Surg.* Nov 2007;34(5):590-591.
48. Lamb CM, Johns RA, Gallagher PJ, Odurny A, Shearman CP. A case of pseudo-xanthoma elasticum presenting with ischaemic claudication. *Eur J Vasc Endovasc Surg.* Apr 2012;43(4):478-479.
49. Li Q, Baker J, Kowalczyk J, Jiang Q, Uitto J, Schachner L. Paediatric pseudoxanthoma elasticum with cardiovascular involvement. *Br J Dermatol.* Nov 2013;169(5):1148-1151.

50. Mendelsohn G, Bulkley BH, Hutchins GM. Cardiovascular manifestations of Pseudoxanthoma elasticum. *Arch Pathol Lab Med.* Jun 1978;102(6):298-302.
51. Miki K, Yuri T, Takeda N, Takehana K, Iwasaka T, Tsubura A. An autopsy case of pseudoxanthoma elasticum: histochemical characteristics. *Med Mol Morphol.* Sep 2007;40(3):172-177.
52. Miwa K, Higashikata T, Mabuchi H. Intravascular ultrasound findings of coronary wall morphology in a patient with pseudoxanthoma elasticum. *Heart.* Oct 2004;90(10):e61.
53. Montani D, Jais X, Humbert M, Sitbon O. Pulmonary Hypertension Complicating Pulmonary Artery Involvement in Pseudoxanthoma Elasticum. *Am J Respir Crit Care Med.* Sep 1 2020;202(5):e90-e91.
54. Neumann E, Mühlberg H. [Blood circulation disturbances of the upper extremities as a principle symptom of pseudoxanthoma elasticum]. *Z Gesamte Inn Med.* Nov 15 1976;31(22):948-952.
55. Nishida H, Endo M, Koyanagi H, Ichihara T, Takao A, Maruyama M. Coronary artery bypass in a 15-year-old girl with pseudoxanthoma elasticum. *Ann Thorac Surg.* Mar 1990;49(3):483-485.
56. Nolte KB. Sudden cardiac death owing to pseudoxanthoma elasticum: a case report. *Hum Pathol.* Aug 2000;31(8):1002-1004.
57. Pavlovic AM, Zidverc-Trajkovic J, Milovic MM, et al. Cerebral small vessel disease in pseudoxanthoma elasticum: three cases. *Can J Neurol Sci.* Feb 2005;32(1):115-118.
58. Perdu J, Champion K, Emmerich J, Fiessinger JN. [Microvascular involvement in pseudoxanthoma elasticum. Capillaroscopic findings]. *Presse Med.* Apr 24 2004;33(8):518-521.
59. Pieczuro A, Lozza M. [Cerebrovascular disease and pseudoxanthoma elasticum: apropos of a case]. *Riv Neurol.* Sep-Oct 1981;51(5):261-273.
60. Rios-Montenegro EN, Behrens MM, Hoyt WF. Pseudoxanthoma elasticum. Association with bilateral carotid rete mirabile and unilateral carotid-cavernous sinus fistula. *Arch Neurol.* Feb 1972;26(2):151-155.
61. Rodríguez-Camarero SJ, Manchado P, González JA, Castro MA, Rodero JI, Mateo AM. [Acute arterial thrombosis of the extremity in pseudoxanthoma elasticum]. *Angiologia.* Mar-Apr 1992;44(2):58-61.
62. Rühlmann C, Wittig I, Lochner A, et al. [Grönblad-Strandberg syndrome from the angiological viewpoint]. *Dtsch Med Wochenschr.* Mar 13 1998;123(11):312-317.
63. Sabán-Ruiz J, Fabregate Fuente R, Sánchez-Largo Uceda E, Fabregate Fuente M. Pseudoxanthoma elasticum: case report with arterial stiffness evaluated by a research cardiovascular profiling system. *Eur J Dermatol.* Nov-Dec 2010;20(6):785-787.
64. Sasai H, Sakakura K, Wada H, Sugawara Y, Ako J, Momomura S. Stiff coronary stenosis in a young female with pseudoxanthoma elasticum. *JACC Cardiovasc Interv.* Jan 2012;5(1):112-113.
65. Schröder F, Hausser I, Szliska C, Lawall H, Diehm C. Images in vascular medicine. Pseudoxanthoma elasticum: under-recognized cause of early onset peripheral arterial disease? *Vasc Med.* Nov 2006;11(4):266-267.
66. Sharma NG, Ghosh SK, Beohar PC, Gupta PS. Subarachnoid haemorrhage in pseudoxanthoma elasticum. *Postgrad Med J.* Dec 1974;50(590):774-776.
67. Siskos D, Giannakakis S, Makris S, Pirgakis K, Psyllas A, Maltezos C. Case report of a patient with iliac occlusive disease due to pseudoxantoma elasticum and review of the bibliography. *Ann Vasc Surg.* Feb 2012;26(2):278.e211-274.
68. Slade AKB, John RM, Swantong RH. Pseudoxanthoma elasticum presenting with myocardial infarction. *Br Heart J.* 1990;63:372-373.
69. Song HK, Sharoni E, Williams B, Jr., Guyton RA, Puskas JD. Long-term left internal mammary artery graft patency for coronary artery disease associated with pseudoxanthoma elasticum. *Ann Thorac Surg.* Aug 2004;78(2):691-693.
70. Sunmonu NA. Multiple Cerebrovascular Insults in Pseudoxanthoma Elasticum. *J Stroke Cerebrovasc Dis.* Mar 2021;30(3):105524.
71. **72.** Takeshita T, Ozaki M. Central retinal artery occlusion in a patient with pseudoxanthoma elasticum. *Hiroshima J Med Sci.* Jun 2003;52(2):33-34.
72. Tromp TR, Kranenburg G, Ossewaarde-van Norel J, Spiering W. [Pseudoxanthoma elasticum: A disorder with different manifestations]. *Ned Tijdschr Geneeskd.* 2016;160:D203.
73. ul Bari A, Mehmood T. Pseudoxanthoma elasticum. *J Coll Physicians Surg Pak.* Oct 2005;15(10):650-652.
74. Vasseur M, Carsin-Nicol B, Ebran JM, et al. Carotid rete mirabile and pseudoxanthoma elasticum: an accidental association? *Eur J Vasc Endovasc Surg.* Sep 2011;42(3):292-294.

75. Wahlqvist ML, Fox RM, Beech AM, Favilla I. Peripheral vascular disease as a mode of presentation of pseudoxanthoma elasticum. *Aust N Z J Med.* Oct 1977;7(5):523-525.
76. Wolff HH, Stokes JF, Schlesinger BE. Vascular abnormalities associated with pseudoxanthoma elasticum. *Arch Dis Child.* Feb 1952;27(131):82-88.
77. Yasuhara T, Sugiu K, Kakishita M, Date I. Pseudoxanthoma elasticum with carotid rete mirabile. *Clin Neurol Neurosurg.* Mar 2004;106(2):114-117.
78. Zimmo L, Rudarakanchana N, Thompson M, Hamady MS, Cheshire NJ, Bicknell CD. Renal artery aneurysm formation secondary to pseudoxanthoma elasticum. *J Vasc Surg.* Mar 2013;57(3):842-844.
79. Zuily S, Angioi K, Fauret AL, et al. Severe and diffuse arterial lesions in a patient with pseudoxanthoma elasticum. *J Am Coll Cardiol.* May 29 2012;59(22):1991.
80. Leftheriotis G, Abraham P, Le Corre Y, et al. Relationship between ankle brachial index and arterial remodeling in pseudoxanthoma elasticum. *J Vasc Surg.* Nov 2011;54(5):1390-1394.
81. Domzalski C, Wei N, Lebwohl M. Systematic review of neurovascular complications in patients with pseudoxanthoma elasticum. *J of Skin.* 2020;4(6):491-496.
82. Kalra SS, Shanahan CM. Vascular calcification and hypertension: cause and effect. *Ann Med.* Jun 2012;44 Suppl 1:S85-92.
83. Mondel PK, Saraf R, Limaye US. Rete mirabile associated with pial arteriovenous fistula: imaging features with literature review. *BMJ Case Rep.* Feb 16 2017;2017.