

Chapter 172

Vascular Malformations

Laurence M. Boon & Miikka Viikkula

REFERENCES

1. Brouillard P, Viikkula M: Vascular malformations: Localized defects in vascular morphogenesis. *Clin Genet* **63**(5):340-351, 2003
2. Pocock B, Boon LM, Viikkula M: Molecular basis of vascular birthmarks. *Sem Plast Surg* **20**:149-156, 2006
3. Boon LM, Ballieux F, Viikkula M: Pathogenesis of vascular anomalies. *Clin Plast Surg* **38**(1):7-19, 2011
4. Mulliken JB, Glowacki J: Hemangiomas and vascular malformations in infants and children: A classification based on endothelial characteristics. *Plast Reconstr Surg* **69**(3):412-422, 1982
5. Mulliken JB, Young AE: *Vascular Birthmarks: Hemangiomas and Malformations*. Philadelphia, WB Saunders, 1988
6. Enjolras O, Mulliken JB: Vascular cutaneous anomalies in children: Malformations and hemangiomas. *Pediatr Surg Int* **11**:290-295, 1996
7. Enjolras O, Wassef M, Merland JJ: [Maffucci syndrome: A false venous malformation? A case with hemangioendothelioma with fusiform cells]. *Ann Dermatol Venereol* **125**(8):512-515, 1998
8. Sapp JC et al: Newly delineated syndrome of congenital lipomatous overgrowth, vascular malformations, and epidermal nevi (CLOVE syndrome) in seven patients. *Am J Med Genet A* **143A**(24):2944-2958, 2007
9. Alomari AI: CLOVE(S) syndrome: Expanding the acronym. *Am J Med Genet A* **149A**(2):294; author reply 295, 2009
10. Enjolras O, Chapot R, Merland JJ: Vascular anomalies and the growth of limbs: A review. *J Pediatr Orthop B* **13**(6):349-357, 2004
11. Burrows PE et al: Diagnostic imaging in the evaluation of vascular birthmarks. *Dermatol Clin* **16**(3):455-488, 1998
12. Jacobs AH, Walton RG: The incidence of birthmarks in the neonate. *Pediatrics* **58**(2):218-222, 1976
13. Leung AK, Telmesani AM: Salmon patches in Caucasian children. *Pediatr Dermatol* **6**(3):185-187, 1989
14. Pratt AG: Birthmarks in infants. *AMA Arch Derm Syphilol* **67**(3):302-305, 1953
15. Eerola I et al: Locus for susceptibility for familial capillary malformation ('port-wine stain') maps to 5q. *Eur J Hum Genet* **10**(6):375-380, 2002
16. Eerola I et al: Capillary malformation-arteriovenous malformation, a new clinical and genetic disorder caused by RASA1 mutations. *Am J Hum Genet* **73**(6):1240-1249, 2003
17. Boon LM, Mulliken JB, Viikkula M: RASA1: Variable phenotype with capillary and arteriovenous malformations. *Curr Opin Genet Dev* **15**(3):265-269, 2005
18. Revencu N et al: Parkes Weber syndrome, vein of Galen aneurysmal malformation, and other fast-flow vascular anomalies are caused by RASA1 mutations. *Hum Mutat* **29**(7):959-965, 2008
19. Revencu N et al: RASA1 and capillary malformation-arteriovenous malformation. In: *Inborn errors of Development*, 2nd edition, edited by C Epstein, RP Erickson, A Wynshaw-Boris. New York, Oxford University Press, Inc, 2008, pp. 647-650
20. Etchevers HC et al: The cephalic neural crest provides pericytes and smooth muscle cells to all blood vessels of the face and forebrain. *Development* **128**(7):1059-1068, 2001
21. Finley JL et al: Immunofluorescent staining with antibodies to factor VIII, fibronectin, and collagenous basement membrane protein in normal human skin and port wine stains. *Arch Dermatol* **118**(12):971-975, 1982
22. Breugem CC et al: Are capillary malformations neurovenular or purely neural? *Plast Reconstr Surg* **115**(2):578-587, 2005
23. Enjolras O, Boukobza M, Jdid R: Cervical occult spinal dysraphism: MRI findings and the value of a vascular birthmark. *Pediatr Dermatol* **12**(3):256-259, 1995
24. Boukobza M et al: [Sturge-Weber syndrome. The current neuroradiologic data]. *J Radiol* **81**(7):765-771, 2000

25. Ruiz-Maldonado R et al: Phacomatosis pigmentovascularis: a new syndrome? Report of four cases. *Pediatr Dermatol* 4(3):189-196, 1987
26. Happle R: Phacomatosis pigmentovascularis revisited and reclassified. *Arch Dermatol* 141(3):385-388, 2005
27. Capraro PA et al: Klippel-Trenaunay syndrome. *Plast Reconstr Surg* 109(6):2052-2060; quiz 2061-2052, 2002
28. Enjolras O, Riche MC, Merland JJ: Facial port-wine stains and Sturge-Weber syndrome. *Pediatrics* 76(1):48-51, 1985
29. Enjolras O: [Cutis marmorata telangiectatica congenita]. *Ann Dermatol Venereol* 128(2):161-166, 2001
30. Matsubara S et al: Angiographic and clinical characteristics of patients with cerebral arteriovenous malformations associated with hereditary hemorrhagic telangiectasia. *AJNR Am J Neuroradiol* 21(6):1016-1020, 2000
31. Jones EW, Orkin M: Tufted angioma (angioblastoma). A benign progressive angioma, not to be confused with Kaposi's sarcoma or low-grade angiosarcoma. *J Am Acad Dermatol* 20(2 Pt 1):214-225, 1989
32. Clayton-Smith J et al: Macrocephaly with cutis marmorata, haemangioma and syndactyly—a distinctive overgrowth syndrome. *Clin Dysmorphol* 6(4):291-302, 1997
33. Bork K, Pfeifle J: Multifocal aplasia cutis congenita, distal limb hemimelia, and cutis marmorata telangiectatica in a patient with Adams-Oliver syndrome. *Br J Dermatol* 127(2):160-163, 1992
34. Paller AS et al: Cutaneous granulomatous lesions in patients with ataxia-telangiectasia. *J Pediatr* 119(6):917-922, 1991
35. Klapman MH, Yao JF: Thickening and nodules in port-wine stains. *J Am Acad Dermatol* 44(2):300-302, 2001
36. Valeyrue L et al: Pyogenic granuloma within port-wine stains: An alarming clinical presentation. *Eur J Dermatol* 12(4):373-375, 2002
37. van der Horst CM et al: Effect of the timing of treatment of port-wine stains with the flash-lamp-pumped pulsed-dye laser. *N Engl J Med* 338(15):1028-1033, 1998
38. Dover JS et al: Dye laser treatment of port-wine stains: Comparison of the continuous-wave dye laser with a robotized scanning device and the pulsed dye laser. *J Am Acad Dermatol* 32(2 Pt 1):237-240, 1995
39. Ville D et al: Prophylactic antiepileptic treatment in Sturge-Weber disease. *Seizure* 11(3):145-150, 2002
40. Arzimanoglou AA et al: Sturge-Weber syndrome: Indications and results of surgery in 20 patients. *Neurology* 55(10):1472-1479, 2000
41. Boon LM et al: Assignment of a locus for dominantly inherited venous malformations to chromosome 9p. *Hum Mol Genet* 3(9):1583-1587, 1994
42. Boon LM et al: Glomuvenous malformation (glomangioma) and venous malformation: Distinct clinicopathologic and genetic entities. *Arch Dermatol* 140(8):971-976, 2004
43. Brouillard P et al: Mutations in a novel factor, glomulin, are responsible for glomuvenous malformations ("glomangiomas"). *Am J Hum Genet* 70(4):866-874, 2002
44. Dompfartin A, Viikkula M, Boon LM: *Phlebology* 25(5): 224-235, 2010
45. Wassef M, Enjolras O: [Superficial vascular malformations: Classification and histopathology]. *Ann Pathol* 19(3):253-264, 1999
46. Kato N, Kumakiri M, Ohkawara A: Localized form of multiple glomus tumors: Report of the first case showing partial involution. *J Dermatol* 17(7):423-428, 1990
47. Goodman TF, Abele DC: Multiple glomus tumors. A clinical and electron microscopic study. *Arch Dermatol* 103(1):11-23, 1971
48. Brouillard P et al: Glomulin and glomuvenous malformation. In: *Inborn Errors of Development*, 2nd edition, edited by CJ Epstein, RP Erickson, A Wynshaw-Boris. New York, Oxford University Press, 2008, pp. 1561-1565
49. Limaye N et al: Somatic mutations in angiopoietin receptor gene TEK cause solitary and multiple sporadic venous malformations. *Nat Genet* 41(1):118-124, 2009
50. Wouters V et al: Hereditary cutaneomucosal venous malformations are caused by TIE2 mutations with widely variable hyper-phosphorylating effects. *Eur J Hum Genet* 18(4):414-420, 2010
51. Wouters V et al: TIE2 and cutaneomucosal venous malformation. In: *Inborn Errors of Development*. 2nd edition, edited by C Epstein, RP Erickson, A Wynshaw-Boris. New York, Oxford University Press, Inc, 2008, pp. 491-494
52. Brouillard P et al: Four common glomulin mutations cause two thirds of glomuvenous malformations ("familial glomangiomas"): Evidence for a founder effect. *J Med Genet* 42(2):e13, 2005

53. Hein KD et al: Venous malformations of skeletal muscle. *Plast Reconstr Surg* **110**(7):1625-1635, 2002
54. Viikkula M et al: Vascular dysmorphogenesis caused by an activating mutation in the receptor tyrosine kinase TIE2. *Cell* **87**(7):1181-1190, 1996
55. Mallory SB et al: Congenital plaque-type glomus venous malformations presenting in childhood. *Arch Dermatol* **142**(7):892-896, 2006
56. Blume-Peytavi U et al: Multiple familial cutaneous glomangioma: A pedigree of 4 generations and critical analysis of histologic and genetic differences of glomus tumors. *J Am Acad Dermatol* **42**(4):633-639, 2000
57. Ertem D et al: Blue rubber bleb nevus syndrome. *Pediatrics* **107**(2):418-420, 2001
58. Brunereau L et al: Familial form of intracranial cavernous angioma: MR imaging findings in 51 families. French Society of Neurosurgery. *Radiology* **214**(1):209-216, 2000
59. Labauge P et al: Prospective follow-up of 33 asymptomatic patients with familial cerebral cavernous malformations. *Neurology* **57**(10):1825-1828, 2001
60. Eerola I et al: KRIT1 is mutated in hyperkeratotic cutaneous capillary-venous malformation associated with cerebral capillary malformation. *Hum Mol Genet* **9**(9):1351-1355, 2000
61. Labauge P et al: An association between autosomal dominant cerebral cavernomas and a distinctive hyperkeratotic cutaneous vascular malformation in 4 families. *Ann Neurol* **45**(2):250-254, 1999
62. Toll A et al: Cutaneous venous malformations in familial cerebral cavernomatosis caused by KRIT1 gene mutations. *Dermatology* **218**(4):307-313, 2009
63. Sirvente J et al: Frequency and phenotypes of cutaneous vascular malformations in a consecutive series of 417 patients with familial cerebral cavernous malformations. *J Eur Acad Dermatol Venereol* **23**(9):1066-1072, 2009
64. Dubovsky J et al: A gene responsible for cavernous malformations of the brain maps to chromosome 7q. *Hum Mol Genet* **4**(3):453-458, 1995
65. Craig HD et al: Multilocus linkage identifies two new loci for a mendelian form of stroke, cerebral cavernous malformation, at 7p15-13 and 3q25.2-27. *Hum Mol Genet* **7**(12):1851-1858, 1998
66. Bergametti F et al: Mutations within the programmed cell death 10 gene cause cerebral cavernous malformations. *Am J Hum Genet* **76**(1):42-51, 2005
67. Revencu N, Viikkula M: Cerebral cavernous malformation: New molecular and clinical insights. *J Med Genet* **43**(9):716-721, 2006
68. Kaplan RP et al: Maffucci's syndrome: Two case reports with a literature review. *J Am Acad Dermatol* **29**(5 Pt 2):894-899, 1993
69. Hopyan S et al: A mutant PTH/PTHrP type I receptor in enchondromatosis. *Nat Genet* **30**(3):306-310, 2002
70. Couvineau A et al: PTHR1 mutations associated with Ollier disease result in receptor loss of function. *Hum Mol Genet* **17**(18):2766-2775, 2008
71. Enjolras O et al: [Cervicofacial superficial venous malformations and developmental abnormalities of the cerebral venous system]. *Ann Dermatol Venereol* **123**(4):235-239, 1996
72. Dompmartin A et al: Association of localized intravascular coagulopathy with venous malformations. *Arch Dermatol* **144**(7):873-877, 2008
73. Dompmartin A et al: Elevated D-dimer level is diagnostic for venous malformations. *Arch Dermatol* **145**:1239-1244, 2009
74. Mazoyer E et al: Coagulation abnormalities associated with extensive venous malformations of the limbs: Differentiation from Kasabach-Merritt syndrome. *Clin Lab Haematol* **24**(4):243-251, 2002
75. Hermans C et al: [Venous malformations and coagulopathy]. *Ann Chir Plast Esthet* **51**(4-5):388-393, 2006
76. Sarkar M et al: Thrombocytopenic coagulopathy (Kasabach-Merritt phenomenon) is associated with Kaposiform hemangioendothelioma and not with common infantile hemangioma. *Plast Reconstr Surg* **100**(6):1377-1386, 1997
77. Enjolras O et al: Infants with Kasabach-Merritt syndrome do not have "true" hemangiomas. *J Pediatr* **130**(4):631-640, 1997
78. Paltiel HJ et al: Soft-tissue vascular anomalies: Utility of US for diagnosis. *Radiology* **214**(3):747-754, 2000
79. Konez O, Burrows PE: Magnetic resonance of vascular anomalies. *Magn Reson Imaging Clin N Am* **10**(2):363-388, vii, 2002
80. Hammer FD et al: Ethanol sclerotherapy of venous malformations: Evaluation of systemic ethanol contamination. *J Vasc Interv Radiol* **12**(5):595-600, 2001
81. Glaessl A et al: Laser surgical planning with magnetic resonance imaging-based 3-dimensional reconstructions for intralesional Nd:YAG laser therapy of a venous malformation of the neck. *Arch Dermatol* **137**(10):1331-1335, 2001

82. Fishman SJ, Fox VL: Visceral vascular anomalies. *Gastrointest Endosc Clin N Am* 11(4):813-834, viii, 2001
83. Marler JJ et al: Prenatal diagnosis of vascular anomalies. *J Pediatr Surg* 37(3):318-326, 2002
84. Irrthum A et al: Mutations in the transcription factor gene SOX18 underlie recessive and dominant forms of hypotrichosis-lymphedema-telangiectasia. *Am J Hum Genet* 72(6):1470-1478, 2003
85. Sybert VP, McCauley E: Turner's syndrome. *N Engl J Med* 351(12):1227-1238, 2004
86. Irrthum A et al: Congenital hereditary lymphedema caused by a mutation that inactivates VEGFR3 tyrosine kinase. *Am J Hum Genet* 67(2):295-301, 2000
87. Evans AL et al: Identification of eight novel VEGFR-3 mutations in families with primary congenital lymphoedema. *J Med Genet* 40(9):697-703, 2003
88. Hennekam RC et al: Autosomal recessive intestinal lymphangiectasia and lymphedema, with facial anomalies and mental retardation. *Am J Med Genet* 34(4):593-600, 1989
89. Alders M et al: Mutations in CCBE1 cause generalized lymph vessel dysplasia in humans. *Nat Genet* 41(12):1272-1274, 2009
90. Connell F et al: Linkage and sequence analysis indicate that CCBE1 is mutated in recessively inherited generalised lymphatic dysplasia. *Hum Genet* 127(2):231-241, 2010
91. Galambos C, Nodit L: Identification of lymphatic endothelium in pediatric vascular tumors and malformations. *Pediatr Dev Pathol* 8(2):181-189, 2005
92. Edwards PD et al: Lymphatic malformation of the lingual base and oral floor. *Plast Reconstr Surg* 115(7):1906-1915, 2005
93. Moller G et al: The Gorham-Stout syndrome (Gorham's massive osteolysis). A report of six cases with histopathological findings. *J Bone Joint Surg Br* 81(3):501-506, 1999
94. Brice G et al: Milroy disease and the VEGFR-3 mutation phenotype. *J Med Genet* 42(2):98-102, 2005
95. Ghalamkarpoor A et al: Hereditary lymphedema type I associated with VEGFR3 mutation: The first de novo case and atypical presentations. *Clin Genet* 70(4):330-335, 2006
96. Daniel-Spiegel E et al: Hydrops fetalis: An unusual prenatal presentation of hereditary congenital lymphedema. *Prenat Diagn* 25(11):1015-1018, 2005
97. Ghalamkarpoor A et al: Recessive primary congenital lymphoedema caused by a VEGFR3 mutation. *J Med Genet* 46(6):399-404, 2009
98. Stevenson DA et al: Familial congenital non-immune hydrops, chylothorax, and pulmonary lymphangiectasia. *Am J Med Genet A* 140(4):368-372, 2006
99. Ghalamkarpoor A, Devriendt K, Viikula M: SOX18 and the Hypotrichosis-Lymphedema-Telangiectasia Syndrome. In: *Inborn Errors of Development*. 2nd edition, edited by C Epstein, RP Erickson, A Wynshaw-Boris. New York, Oxford University Press, Inc, 2008, pp. 913-915
100. Hayward PG et al: Congenital fibrosarcoma masquerading as lymphatic malformation: Report of two cases. *J Pediatr Surg* 30(1):84-88, 1995
101. Bhutta MF, Ching HY, Hartley BE: Cervico-thoracic teratoma masquerading as lymphatic malformation. *J Laryngol Otol* 120(11):955-958, 2006
102. Mathur NN et al: Bleomycin sclerotherapy in congenital lymphatic and vascular malformations of head and neck. *Int J Pediatr Otorhinolaryngol* 69(1):75-80, 2005
103. Claesson G, Kuylestierna R: OK-432 therapy for lymphatic malformation in 32 patients (28 children). *Int J Pediatr Otorhinolaryngol* 65(1):1-6, 2002
104. Harsha WJ et al: Pediatric admissions and procedures for lymphatic malformations in the United States: 1997 and 2000. *Lymphat Res Biol* 3(2):58-65, 2005
105. Greene AK et al: Periorbital lymphatic malformation: Clinical course and management in 42 patients. *Plast Reconstr Surg* 115(1):22-30, 2005
106. Bossler AD et al: Novel mutations in ENG and ACVRL1 identified in a series of 200 individuals undergoing clinical genetic testing for hereditary hemorrhagic telangiectasia (HHT): Correlation of genotype with phenotype. *Hum Mutat* 27(7):667-675, 2006
107. Richards-Yutz J et al: Update on molecular diagnosis of hereditary hemorrhagic telangiectasia. *Hum Genet* 128(1):61-77, 2010
108. Zhou XP et al: Germline and germline mosaic PTEN mutations associated with a Proteus-like syndrome of hemihypertrophy, lower limb asymmetry, arteriovenous malformations and lipomatosis. *Hum Mol Genet* 9(5):765-768, 2000
109. Cohen MM Jr: Vasculogenesis, angiogenesis, hemangiomas, and vascular malformations. *Am J Med Genet* 108(4):265-274, 2002

110. Tan WH et al: The spectrum of vascular anomalies in patients with PTEN mutations: Implications for diagnosis and management. *J Med Genet* 44(9):594-602, 2007
111. Thiex R et al: A novel association between RASA1 mutations and spinal arteriovenous anomalies. *Am J Neuroradiol* 31(4):775-779, 2010
112. Lester J, Ruano-Calderon LA, Gonzalez-Olhovich I: Wyburn-Mason syndrome. *J Neuroimaging* 15(3):284-285, 2005
113. Rodesch G et al: Classification of spinal cord arteriovenous shunts: Proposal for a reappraisal—the Bicetre experience with 155 consecutive patients treated between 1981 and 1999. *Neurosurgery* 51(2):374-379; discussion 379-380, 2002
114. Liu AS et al: Extracranial arteriovenous malformations: Natural progression and recurrence after treatment. *Plast Reconstr Surg* 125(4):1185-1194, 2010
115. Burrows PE, Fellows KE: Techniques for management of pediatric vascular anomalies. In: *Current Techniques in Interventional Radiology*, vol 2. Philadelphia, Current Medicine, 1995, pp. 12-27
116. Yakes WF, Rossi P, Odink H: How I do it. Arteriovenous malformation management. *Cardiovasc Intervent Radiol* 19(2):65-71, 1996
117. Wu JK et al: Auricular arteriovenous malformation: Evaluation, management, and outcome. *Plast Reconstr Surg* 115(4):985-995, 2005
118. Dompmartin A et al: Use of a regulating flap in the treatment of a large arteriovenous malformation of the scalp. *Br J Plast Surg* 51(7):561-563, 1998
119. Lebrin F et al: Thalidomide stimulates vessel maturation and reduces epistaxis in individuals with hereditary hemorrhagic telangiectasia. *Nat Med* 16(4):420-428, 2010

