

# Index

Note: Page numbers of article titles are in **boldface** type.

## A

- Accessory middle cerebral artery, 417
- Acidosis, in MELAS syndrome, 435–436
- Alk1 protein, in angiogenesis, 405
- Anemia, in cerebral venous sinus thrombosis, 515, 517
- Aneurysms, **491–501**
  - clinical presentation of, 491–494
  - diagnosis of, 494
  - dissecting, 537
  - false, 531
  - focal, 469–470
  - incidence of, 491
  - locations of, 494–495
  - mirror, 470–471
  - radiation-induced, 436
  - segmental, 470–471
  - shapes of, 495
  - sizes of, 494–495
  - surveillance of, 499
  - traumatic, 531
  - treatment of, 495–499
  - twin, 470–471
  - vein of Galen, 418–419
- Angiogenesis, 404–407
- Angiography
  - computed tomography
    - for aneurysms, 494
    - for AVMs, 446–447
    - for traumatic vascular injuries, 533–534
  - for AVMs, 446–447, 505
  - for moyamoya disease/syndrome, 543
  - for traumatic vascular injuries, 533
  - magnetic resonance. *See* Magnetic resonance angiography.
  - spina, 505
- Angiomas
  - cavernous, **483–490**
  - venous, 419–422
- Angioplasty, for carotid artery vasospasm, 538
- Angiopoietin/Tie2 signaling pathway, in angiogenesis, 405
- Anterior venous plexus, 411–413
- Antithrombotic therapy, for carotid artery injury, 535–536
- Antibiotics, for cerebral venous sinus thrombosis, 521
- Anticoagulants
  - for carotid artery injury, 535–536
  - for cerebral venous sinus thrombosis, 521–522
- Antiplatelet agents
  - for carotid artery injury, 536
  - for vertebral artery injury, 536–537
- Antithrombin deficiency, cerebral venous sinus thrombosis in, 518
- Antithrombotic therapy, for vertebral artery injury, 536–537
- Arterial dissection, radiation-induced, 436
- Arteriovenous fistulas
  - spinal cord, 503, 506–507
  - vertebral artery, 531–532
- Arteriovenous malformations, **443–456, 463–482**
  - capillary, 421–422, 471–479
  - classification of, 463
    - age-related, 464, 466
    - etiologic, 467–480
    - morphologic, 466–467
    - pathomechanical, 464–465
  - clinical features of, 443, 465–466, 504–505
  - diagnosis of, 445–447
  - dural, 466
  - feeders for, 474
  - focal, 469–477
  - high-flow, 464
  - imaging for, 505
  - incidence of, 444–445, 504
  - location of, 445
  - low-flow, 464
  - metameric, 469, 471, 478–479
  - morphology of, 466–467
  - mortality in, 445
  - natural history of, 444–445
  - nidus of, 474
  - occult, 446–447
  - pathology of, 445
  - pathophysiology of, 504–505
  - pediatric considerations in, 463
  - pial, 466, 475–476
  - segmental, 469–471, 477–478
  - treatment of, 447–452, 465, 469–480. *See also* Stereotactic radiosurgery.
    - spinal, 505–506
  - trigger of, 467–469
  - types of, 443

Artery of Heubner, variations of, 417  
 Aspirin, for carotid artery injury, 536  
 AVMs. *See* Arteriovenous malformations.  
 Axial nonfusion, in vertebrobasilar system, 418

## B

Basal ganglia, embryology of, 404, 409  
 Basal veins (of Rosenthal), 413  
 Basilar artery. *See also* Vertebrobasilar system.  
   embryology of, 402  
 Blue rubber bleb nevus syndrome, 435  
 Bone, hemihypertrophy of, in Klippel-Trenaunay syndrome, 433  
 Bowel dysfunction, in spinal AVMs, 504  
 Brain  
   aneurysms of, **491–501**  
   arteriovenous malformations of  
     classification of, **463–482**  
     diagnosis of, 443–456  
     treatment of, 443–461  
   cavernous malformations of, **483–490**  
   dysplasia of, in PHACE(S) syndrome, 432, 471  
   inherited neurovascular diseases of, **427–441**  
   moyamoya disease of, **543–551, 553–563, 565–573**  
   vascular injuries of, **529–542**  
   vascular system of, embryology and development of, **399–425**  
   venous sinus thrombosis in, **511–527**  
 Burr holes, multiple, for moyamoya disease/syndrome, 554–555

## C

Calcification, of cavernous malformations, 484–485  
 Capillaries, malformations of, 421–422, 471–479  
 Cardiac insufficiency, in AVMs, 465  
 Cardinal veins, 408, 411  
 Cardiovascular abnormalities, in PHACE(S) syndrome, 431–432, 471  
 Carotid artery  
   aneurysms of, 494, 537  
   embryology of, 401–402, 404, 411  
   for moyamoya disease bypass, 566–571  
   occlusion of, 537–538  
   persistent vertebrobasilar anastomoses with, 414–416  
   primitive, 401  
   stenosis of, in moyamoya disease/syndrome, 543  
   sympathectomy of, for moyamoya disease/syndrome, 554  
   traumatic injuries of, 529–531  
     diagnosis of, 533–534  
     extracranial, 529, 535–536  
     intracranial, 530–531, 537–538  
     treatment of, 534–538

  vasospasm of, 538  
 Carotid-cavernous fistulas, 531, 537  
 Cavernous malformations, **483–490**  
   clinical presentation of, 484  
   epidemiology of, 483  
   etiology of, 483–484  
   familial, 427–429  
   imaging for, 484–485  
   locations of, 485–486  
   natural history of, 485–486  
   pathology of, 483  
   spinal cord, 508–509  
   treatment of, 485–488  
 CCM proteins, in cavernous malformations, 483–484  
 Cephaloceles, parietal, 419  
 Cerebellum, angiogenesis in, 406  
 Cerebral angiography  
   for AVMs, 446–447  
   for traumatic vascular injuries, 533  
 Cerebral artery(ies)  
   anterior  
     aneurysms of, 494  
     embryology of, 402  
     variations of, 416–417  
   middle  
     aneurysms of, 494  
     embryology of, 403  
     for moyamoya disease bypass, 566–571  
     variations of, 417  
   traumatic injury of, 531  
 Cerebral veins  
   middle, 413  
   primitive internal, 408  
 Cerebral venous sinus thrombosis, **511–527**  
   anatomic considerations in, 511–515  
   clinical presentation of, 518–519  
   demographics of, 512–514  
   diagnosis of, 519–520  
   epidemiology of, 511  
   follow-up in, 522–523  
   laboratory findings in, 520–521  
   literature review on, 511–514  
   mortality and morbidity in, 522  
   pathophysiology of, 515  
   prediction of, 523  
   prevention of, 523  
   risk factors for, 512–515, 517–518  
   spectrum of brain injury in, 515–516  
   treatment of, 512–514, 520–522  
 Cervical carotid sympathectomy, for moyamoya disease/syndrome, 554  
 Cervical ganglionectomy, superior, for moyamoya disease/syndrome, 554  
 Choroid plexus, embryology of, 399, 401–403, 411–414  
 Choroid veins  
   dorsal, 408

- superior, 409
- Choroidal artery
  - anterior
    - embryology of, 402–404, 406
    - variations of, 417
  - posterior
    - embryology of, 402–403
    - variations of, 417
- Circle of Willis
  - embryology of, 403
  - variations of, 416
- Communicating arteries, embryology of, 401–402, 406
- Computed tomography
  - for aneurysms, 494
  - for AVMs, 446–447, 465
  - for cavernous malformations, 484–485
  - for cerebral venous sinus thrombosis, 520
  - for moyamoya disease/syndrome, 546–547
- Computed tomography angiography
  - for aneurysms, 494
  - for AVMs, 446–447
  - for traumatic vascular injuries, 533–534
- Computed tomography venography, for cerebral venous sinus thrombosis, 520
- Congestion, venous, in venous sinus thrombosis, 515
- Cooling, for moyamoya disease surgery, 567
- Cortical plate, angiogenesis in, 404–407
- Cortical-subcortical veins, 410
- Coumadin
  - for carotid artery injury, 536
  - for cerebral venous sinus thrombosis, 522

## D

- Dehydration, cerebral venous sinus thrombosis in, 517
- Dementia, in AVMs, 465
- Developmental venous anomalies, 419–422
  - cavernous malformations with, 485
  - morphology of, 466
- Diencephalic vein, ventral, 408
- Dll4/Notch signaling pathway, in angiogenesis, 405
- Diploic veins, anomalies of, in sinus pericranii, 433–434
- Direct bypass techniques, for moyamoya disease/syndrome, **565–573**
  - combined procedures for, 560–561
  - indications for, 565–566
  - indirect procedures with, 560–561
  - outcome of, 569–571
  - overview of, 567–569
  - patient selection for, 566–567
  - versus indirect techniques, 566–567
- Dissections, arterial, 469–470. *See also* Traumatic injuries.
- Doppler ultrasonography
  - for moyamoya disease/syndrome, 547–548
  - for traumatic injuries, 534
- Dural inversion, for moyamoya disease/syndrome, 558–559
- Dural venous sinuses, embryology of, 411

## E

- Electroencephalography, for moyamoya disease/syndrome, 548
- Embolization
  - for aneurysms, 498
  - for arteriovenous fistulas, 506–507
  - for AVMs, 449–451
  - for capillary malformations, 474–475
  - for vein of Galen malformation, 435
  - for vertebral artery injury, 538
- Embryology and development, of intracranial vascular system, **399–425**
  - angiogenesis, 404–407
  - arterial morphogenesis, 401–404
  - AVM pathology and, 445
  - malformations in, 414–422. *See also* Vascular malformations.
  - persistent structures in, 414–416
  - primitive perineural vascular meshwork, 400–401
  - steps in, 399–400
  - variants in, 416–418
  - venous anomalies in, 419–422
  - venous system morphogenesis, 408–414
- Encephaloarteriosynangiosis, for moyamoya disease/syndrome, 556
- Encephaloduroarteriosynangiosis, for moyamoya disease/syndrome, 557–559
- Encephalodurogaleosynangiosis, for moyamoya disease/syndrome, 560
- Encephaloduromyoarteriosynangiosis, for moyamoya disease/syndrome, 559–560
- Encephalodurosangiosis, for moyamoya disease/syndrome, 556–557
- Encephalomyoarteriosynangiosis, for moyamoya disease/syndrome, 557
- Encephalomyosynangiosis, for moyamoya disease/syndrome, 555–556
- Encephalopathy, in MELAS syndrome, 435–436
- Enderectomy, for carotid artery injury, 536
- Endoglin, in angiogenesis, 405
- Endothelial cells
  - connection of, in angiogenesis, 405–406
  - radiation damage of, 436
- Endovascular treatment
  - for aneurysms, 497–499, 537
  - for arteriovenous fistulas, 506–507
  - for carotid artery injury, 536–537
  - for carotid artery vasospasm, 538
  - for carotid dissecting aneurysm, 537
  - for carotid-cavernous fistulas, 537

Endovascular (*continued*)

## for malformations

arterial, 450–451, 469–471, 505–506

capillary, 471–479

venous, 479–480

for vertebral artery injury, 537–538

EphB4, in angiogenesis, 405

EphrinB2, in angiogenesis, 405

Epilepsy. *See* Seizures.

Ethnic factors, in moyamoya disease/syndrome, 544

Extracerebral venous system, morphogenesis of, 410–414

Extraatrial parenchymal vessels, in angiogenesis, 407

## Eye abnormalities

in PHACE(S) syndrome, 431–432, 471

in Wyburn-Mason syndrome, 432–433

**F**

Facial hemangiomas, in PHACE(S) syndrome, 431–432

False aneurysms, of carotid artery, 531

Familial cavernous malformations, 427–429

## Fetus

cerebral venous sinus thrombosis in, 518

vascular malformations in, 464

## Fistulas

## arteriovenous

spinal cord, 503, 506–507

vertebral artery, 531–532

carotid-cavernous, 531, 537

Forebrain, angiogenesis in, 404–407

Fusiform aneurysms, 495–496

**G**

Ganglionectomy, superior cervical, for moyamoya disease/syndrome, 554

## Genetic factors

in cavernous malformations, 483–484

in cerebral venous sinus thrombosis, 518

in moyamoya disease/syndrome, 544

in neurovascular diseases, **427–442**

Germinal matrices, angiogenesis in, 404–407

Gray matter, embryology of, 404

**H**

## Headache

in AVMs, 465

in cavernous malformations, 484

in moyamoya disease/syndrome, 545, 565

## Hemangiomas

cavernous, **483–490**

in Klippel-Trenaunay syndrome, 433

in PHACE(S) syndrome, 431–432, 471

Hemimegalencephaly, in Klippel-Trenaunay syndrome, 433

## Hemorrhage

after stereotactic radiosurgery, 459

in aneurysms, 491, 494

in AVMs, 443–447, 504–505

in cavernous malformations, 484, 486, 509

in cerebral venous sinus thrombosis, 515

in moyamoya disease/syndrome, 545

in vertebral artery injuries, 533

radiation-induced, 436

Hemorrhagic telangiectasia, hereditary, 429–431

Hemosiderin deposition, in cavernous malformations, 484–485

## Heparin

for carotid artery injury, 536

for cerebral venous sinus thrombosis, 521–522

Hereditary hemorrhagic telangiectasia, 429–431

Hereditary neurovascular diseases, **427–442**

Homocystinuria, cerebral venous sinus thrombosis in, 518

## Hypoglossal artery

embryology of, 401

persistent, 415–416

Hypothermia, for moyamoya disease surgery, 567

**I**Indirect revascularization, for moyamoya disease/syndrome, **553–563**

cervical carotid sympathectomy, 554

combined procedures for, 560–561

encephaloarteriosynangiosis, 556

encephaloduroarteriosynangiosis, 557–559

encephalodurogaleosynangiosis, 560

encephaloduromyoarteriosynangiosis, 559–560

encephalodurosangiosis, 556–557

encephalomyoarteriosynangiosis, 557

encephalomyosynangiosis, 555–556

multiple burr hole technique, 554–555

omental transplantation, 554

superior cervical ganglionectomy, 554

Infants, vascular malformations in, 464

Infarction, in cerebral venous sinus thrombosis, 515

Infections, cerebral venous sinus thrombosis in, 521

Infectious aneurysms, 495

Inherited neurovascular diseases, **427–442**Injuries, traumatic, **529–542**

Integrins, in angiogenesis, 405

Intercool method, for moyamoya disease surgery, 567

Intracerebral veins, embryology of, 409–410

Intraventricular hemorrhage, in cerebral venous sinus thrombosis, 515

Intrinsic vessels, in angiogenesis, 406

Ischemia, in moyamoya disease/syndrome, 543–545, 565

**K**

Klippel-Trenaunay syndrome, 433

**L**

Lactic acidosis, in MELAS syndrome, 435–436

Lasjaunias classification, of vein of Galen malformations, 434–435

Longitudinal nonfusion, in vertebrobasilar system, 418

**M**

Magnetic resonance angiography

for aneurysms, 494

for arteriovenous fistulas, 507

for moyamoya disease/syndrome, 547

for traumatic vascular injuries, 533

Magnetic resonance imaging

for aneurysms, 494

for AVMs, 446–447, 465, 505

for cavernous malformations, 484–485, 508

for cerebral venous sinus thrombosis, 520

for moyamoya disease/syndrome, 546–547

for spinal cavernous malformations, 508

prenatal, for vascular malformations, 464

Magnetic resonance venography, for cerebral venous sinus thrombosis, 520

Malformations. *See* Arteriovenous malformations; Vascular malformations.

Mastoiditis, cerebral venous sinus thrombosis in, 515

Maxillary vein, primitive, 411, 413

Mayo Clinic, stereotactic radiosurgery experience at, 457–461

Medullary veins

morphogenesis of, 409–410

transcerebral, 407

MELAS syndrome, 435–436

Meningeal artery, middle, for moyamoya disease bypass, 566–571

Menix primitiva, 399–401

Mesencephalic vesicle, 399

Metameric arteriovenous malformations, 469, 471, 478–479

Microsurgical resection, for AVMs, 449–450

Middle venous plexus, 411–413

Mitochondrial myopathy, in MELAS syndrome, 435–436

Moyamoya disease/syndrome, **543–551**

classification of, 547

clinical presentation of, 544–545

conditions associated with, 545

definition of, 543

diagnosis of, 546–548, 565

epidemiology of, 543–544, 565

ethnic factors in, 544

genetic factors in, 544

history of, 543

natural history of, 546

nomenclature of, 543

prognosis for, 546

radiation-induced, 436

screening for, 548

treatment of, 548

direct bypass for, 560–561, **565–573**

indirect revascularization for, **553–563**

Multiple burr hole technique, for moyamoya disease/syndrome, 554–555

Muscularis, in angiogenesis, 407

Myelopathy, in spinal AVMs, 504

**N**

Neonates

cerebral venous sinus thrombosis in, 518–519

vascular malformations in, 464

Neural crest cells, in angiogenesis, 407

Neural plate, embryology of, 407

Neural tube

angiogenesis and, 404

early growth of, 399–401

Neurologic disorders, in AVMs, 465

Neuron(s), migration of, 404

Neurophilin-1, in angiogenesis, 405

Nevi

in blue rubber bleb nevus syndrome, 435

in Klippel-Trenaunay syndrome, 433

in Wyburn-Mason syndrome, 433

Nidus, of AVMs, 474, 504

Nuclear veins, morphogenesis of, 409–410

**O**

Occipital artery, for moyamoya disease bypass, 566

Olfactory artery, persistent, 416–417

Omentum, transplantation of, for moyamoya disease/syndrome, 554

Ophthalmic artery, embryology of, 402

Ophthalmic vein, superior, 413

Otic artery

embryology of, 401

persistent, 415

Otitis media, cerebral venous sinus thrombosis in, 515

Otocyct, 413

**P**

Pain, in spinal AVMs, 504

Paraphysis, 408

Paraspinal arteriovenous malformations, 507–508

Pdgfb/Pdgfr $\beta$  pathway, in angiogenesis, 405

Perforators, transcerebral, 407

Pericytes, in angiogenesis, 407  
 Periventricular germinal zone, embryology of, 404  
 PHACE(S) syndrome, 431–432, 471  
 Pial diencephalic vein, 412  
 Pial synangiosis, for moyamoya disease/syndrome, 557–558  
 Popcorn appearance, of cavernous malformations, 484–485  
 Positron emission tomography, for moyamoya disease/syndrome, 547–548  
 Posterior fossa malformations, in PHACE(S) syndrome, 431–432, 471  
 Posterior venous plexus, 411–413  
 Primary head sinuses, 410  
 Proatlantal artery, embryology of, 401–402  
 Proatlantal intersegmental artery, persistent, 416  
 Prosencephalic vein, median, 408, 413  
 Prosencephalic vesicle, 399  
 Protein C or protein S deficiency, cerebral venous sinus thrombosis in, 518  
 Prothrombotic disorders, cerebral venous sinus thrombosis in, 518  
 Puff of smoke appearance, in moyamoya disease/syndrome, 543

## R

Radiation therapy. *See also* Stereotactic radiosurgery.  
     moyamoya disease/syndrome due to, 545  
     vasculopathy due to, 436  
 Radicular pain, in spinal AVMs, 504  
 Radiography, for moyamoya disease/syndrome, 546  
 Radiosurgery, stereotactic. *See* Stereotactic radiosurgery.  
 Resection, for AVMs  
     intracranial, 449–450  
     spinal, 505–506  
 Retina, AVMs of, in Wyburn-Mason syndrome, 432–433  
 Revascularization, for moyamoya disease/syndrome  
     direct bypass techniques, 560–561, **565–573**  
     indirect techniques, **553–563**  
 Rhombencephalic vesicle, 399

## S

Saccular aneurysms, 495–496  
 Seizures  
     in aneurysms, 491, 494  
     in AVMs, 444–445, 465  
     in blue rubber bleb nevus syndrome, 435  
     in cavernous malformations, 484  
     in cerebral venous sinus thrombosis, 518–519  
     in moyamoya disease/syndrome, 544–545, 565  
 Sick cell disease, moyamoya disease/syndrome due to, 545, 547–548

Single photon emission computed tomography, for moyamoya disease/syndrome, 547–548  
 Sinovenous thrombosis, cerebral. *See* Cerebral venous sinus thrombosis.  
 Sinus pericranii, 433–434  
 Sinusoid channels or capillaries, 407  
 Skull base injuries, vascular injuries in, 531  
 Slit2/Robo4 signaling pathway, in angiogenesis, 405  
 Smooth muscle cells, in angiogenesis, 407  
 Soft palate injury, arterial dissection in, 529  
 Spetzler classification, of spinal cord vascular malformations, 503  
 Sphenoparietal sinus of Breschet, 413  
 Spinal cord  
     vascular malformations near (paraspinal), 507–508  
     vascular malformations of, **503–510**  
         arteriovenous fistulas, 503, 506–507  
         arteriovenous malformations, 504–506  
         cavernous, **483–490**, 508–509  
         classification of, 503  
         types of, 503  
 Split dural technique, for moyamoya disease/syndrome, 559  
 Stereotactic radiosurgery  
     for AVMs, 451–452, **457–461**  
         indications for, 457–458  
         outcomes of, 458–460  
         technique for, 458  
     for capillary malformations, 475–476  
     for cavernous malformations, 486–487  
     hemorrhage risk in, 459  
     morbidity in, 459  
 Straight sinus, morphogenesis of, 412–413  
 Stroke  
     in MELAS syndrome, 435–436  
     in moyamoya disease/syndrome, 543–545, 565  
 Subependymal venous system, morphogenesis of, 409–410  
 Superior cervical ganglionectomy, for moyamoya disease/syndrome, 554  
 Suzuki classification, of moyamoya disease/syndrome, 547  
 Sympathectomy, cervical carotid, for moyamoya disease/syndrome, 554

## T

Tela choroidea, 408–409  
 Telangiectasia  
     hereditary hemorrhagic, 429–431  
     radiation-induced, 436  
 Telencephalic vein, 412  
 Telencephalon, embryology of, 406  
 Temporal artery, superficial, for moyamoya disease bypass, 566–571  
 Tentorial plexus, 413  
 Tentorial sinus, 412

Thrombectomy, for carotid artery injury, 536

Thrombosis

- radiation-induced, 436
- venous sinus. *See* Cerebral venous sinus thrombosis.

Transcerebral perforators, 407

Transcerebral veins, 410

Transient ischemia attacks, in moyamoya disease/syndrome, 544–545, 565

Transient vein of Markowski, 408–409, 412–413

Transplantation, of omentum, for moyamoya disease/syndrome, 554

Traumatic aneurysms, 495

Traumatic injuries, **529–542**

- of carotid artery, 529–531
  - diagnosis of, 533–534
  - extracranial, 529, 535–536
  - intracranial, 530–531, 537–538
  - treatment of, 534–538
- of vertebral artery
  - diagnosis of, 533–534
  - extracranial, 531–532, 536–537
  - intracranial, 532–533, 538
  - treatment of, 536–538

Trigeminal artery

- embryology of, 401
- persistent, 415

Triggers, for vascular malformations, 467–469

## U

Ultrasonography, 534

- for moyamoya disease/syndrome, 547–548
- prenatal, for vascular malformations, 464

## V

Varices, in Klippel-Trenaunay syndrome, 433

Vascular disorders

- aneurysms, **491–501**, 531, 537
- cerebral venous sinus thrombosis, **511–527**
- embryologic issues in, **399–425**
- inherited, **427–441**
- moyamoya disease, **543–551**, **553–563**, **565–573**
- traumatic, **529–542**
- vascular malformations. *See* Arteriovenous malformations; Vascular malformations.

Vascular endothelial growth factor, 401, 468

Vascular epithelial growth factor, in angiogenesis, 405

Vascular epithelial growth factor receptor, in angiogenesis, 405

Vascular malformations

- arteriovenous. *See* Arteriovenous malformations.
- cavernous, 427–429, **483–490**, 508–509
- developmental, 419–422
- inherited, **427–442**
- persistent vestigial carotid-vertebrobasilar anastomoses, 414–416
- spinal cord, **503–510**
- vein of Galen, 418–419

Vascular smooth muscle cells, recruitment of, 405

Vasculogenesis, 400–401

Vasculopathy, radiation-induced, 436

Vasospasm, of carotid artery, 538

Vein of Galen

- aneurysm of, 418–419
- embryology of, 418–419
- malformations of, 434–435
- morphogenesis of, 408–414

Vein of Markowski, 408–409, 412–413, 419

Vena mediana prosencephali, 408

Venography, for cerebral venous sinus thrombosis, 520

Venous congestion, in venous sinus thrombosis, 515

Venous malformations, 479–480, **483–490**

Venous plexuses, 411–413

Venous sinus thrombosis. *See* Cerebral venous sinus thrombosis.

Venous system, morphogenesis of, 408–414

Vertebral artery

- embryology of, 402
- traumatic injuries of
  - diagnosis of, 533–534
  - extracranial, 531–532, 536–537
  - intracranial, 532–533, 538
  - treatment of, 536–538

Vertebrobasilar system

- embryology of, 402, 417–418
- junction of, segmental agenesis/hypoplasia of, 416
- persistent carotid anastomoses with, 414–416
- variations of, 417–418

Vesicles, brain, embryology of, 410–411

Vestigial arteries, persistent, 414–416

## W

Wnt proteins, in angiogenesis, 405

Wyburn-Mason syndrome, 432–433

## Y

Yasargil classification, of vein of Galen malformations, 434