Retinal vascular disorders in children, unlike those in adults, rarely represent the sequelae of chronic systemic insults such as hyperglycemia or hypertension. Children are more likely to suffer from developmental, infectious, neoplastic, or traumatic retinal vascular disorders. As with any other cause of visual loss in childhood, prompt treatment of retinal vascular disorders can be essential to the avoidance of amblyopia. Table 7-1 lists the usual age of presentation for the entities discussed in this chapter.

**SICKLE CELL DISEASE**

Eight percent of the African-American population in the United States is heterozygous for the sickle trait (AS) [Table 7-2]. With the exception of some Mediterranean and Indian populations, the sickle trait is very rare in Americans of Asian or European descent. Sickle hemoglobin (S Hb) varies from normal hemoglobin (A Hb) at position six of the beta-hemoglobin chain. The substitution of valine for glutamic acid at this position produces a hemoglobin that offers some protection against malaria because the *Plasmodium* organism is unable to break down Hb S. Heterozygous patients are generally asymptomatic systemically and ophthalmically. Unfortunately, Hb S polymerizes under hypoxic conditions, leading to rigid, sickle-shaped erythrocytes. Homozygous (SS) patients can develop systemic complications such as splenic autoinfarction, hemolysis, severe and chronic anemia, and blast crisis. However, only 8.8% of these patients develop proliferative sickle retinopathy and only 3% develop vitreous hemorrhage. In contrast, proliferative sickle
### TABLE 7-1. Usual Age of Presentation of Various Retinal Vascular Disorders.

<table>
<thead>
<tr>
<th>Disease</th>
<th>Age of presentation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Background sickle retinopathy</td>
<td>Late childhood</td>
</tr>
<tr>
<td>Proliferative sickle retinopathy</td>
<td>Adolescents and young adults</td>
</tr>
<tr>
<td>Coats’ disease</td>
<td>Prepubertal; first or second decade of life</td>
</tr>
<tr>
<td>Von Hippel syndrome</td>
<td>Young adults; may present in late childhood or adolescence</td>
</tr>
<tr>
<td>Retinal cavernous hemangioma</td>
<td>First or second decade of life; congenital?</td>
</tr>
<tr>
<td>Sturge–Weber syndrome</td>
<td>Congenital</td>
</tr>
<tr>
<td>Wyburn–Mason syndrome</td>
<td>Congenital</td>
</tr>
<tr>
<td>Background diabetic retinopathy</td>
<td>50% of patients after 7 years of disease</td>
</tr>
<tr>
<td>Proliferative diabetic retinopathy</td>
<td>Rare before puberty; 50% of postpubertal patients after 15 years type 1 disease</td>
</tr>
<tr>
<td>Hypertensive retinopathy</td>
<td>Rare before puberty; acute changes may occur in pregnant adolescents (greater risk of eclampsia in this age group)</td>
</tr>
<tr>
<td>Terson’s syndrome</td>
<td>May occur following an intracranial hemorrhage; may occur at any age</td>
</tr>
<tr>
<td>Shaken baby syndrome</td>
<td>Infants and toddlers</td>
</tr>
<tr>
<td>Purtscher’s retinopathy</td>
<td>May occur at any age</td>
</tr>
<tr>
<td>Eales disease</td>
<td>Young adults</td>
</tr>
<tr>
<td>Hypomelanosis of Ito</td>
<td>Congenital</td>
</tr>
<tr>
<td>Incontinentia pigmenti</td>
<td>Infancy</td>
</tr>
<tr>
<td>Goodpasture syndrome</td>
<td>Any age</td>
</tr>
<tr>
<td>Allergic granulomatosis</td>
<td>Any age after infancy</td>
</tr>
<tr>
<td>Takayasu’s arteritis</td>
<td>Adolescence</td>
</tr>
<tr>
<td>Norrie’s disease</td>
<td>Congenital</td>
</tr>
<tr>
<td>Fascioscapulohumeral dystrophy</td>
<td>Young adults</td>
</tr>
<tr>
<td>Anemic retinopathy</td>
<td>May occur at any age</td>
</tr>
<tr>
<td>Leukemic retinopathy</td>
<td>May occur at any age</td>
</tr>
<tr>
<td>Hyperviscosity syndromes</td>
<td>May occur at any age</td>
</tr>
<tr>
<td>Kawasaki’s disease</td>
<td>First or second decade of life</td>
</tr>
<tr>
<td>Carotid cavernous fistula</td>
<td>May occur following trauma at any age</td>
</tr>
<tr>
<td>Vein occlusions</td>
<td>Rare in children</td>
</tr>
<tr>
<td>Congenital vascular loops</td>
<td>Congenital</td>
</tr>
</tbody>
</table>

### TABLE 7-2. Incidence of Various Hemoglobinopathies in the U.S. Black Population.

<table>
<thead>
<tr>
<th>Hemoglobinopathy</th>
<th>Incidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>AS, 8%</td>
<td></td>
</tr>
<tr>
<td>AC, 2%–3%</td>
<td></td>
</tr>
<tr>
<td>SS, 0.2%</td>
<td></td>
</tr>
<tr>
<td>SC, 0.1%</td>
<td></td>
</tr>
<tr>
<td>SThal, 0.003%</td>
<td></td>
</tr>
</tbody>
</table>

AS, sickle cell heterozygous; AC, heterozygous for hemoglobin A and C; SS, sickle cell homozygous; SC, heterozygous for sickle hemoglobin and hemoglobin C; SThal, sickle hemoglobin and thalassemia heterozygous.

retinopathy develops in up to 72% of those patients heterozygous for sickle hemoglobin and hemoglobin C (Hb SC) and in 33% of patients heterozygous for sickle hemoglobin and thalassemia (SThal).

The underlying etiology of sickle retinopathy is sickling of erythrocytes in response to hypoxia in the peripheral retinal circulation. The low incidence of proliferative retinopathy in homozygous hemoglobin S patients has been postulated to be the result of a protective effect of lowered blood viscosity that results from the relatively low hematocrit. The relative frequency of various hemoglobinopathies in the African-American population is listed in Table 7-2.16

Fundus findings in background sickle cell retinopathy include salmon patch hemorrhages (Fig. 7-1), which are full-thickness intraretinal hemorrhages (often with some subinternal limiting membrane blood) that occur distal to arteriolar occlusions. As these hemorrhages reabsorb over time, these areas may develop into iridescent spots or into black sunbursts (Fig. 7-2). The former are thought to be schisis cavities containing hemosiderin whereas the latter result from hypertrophy, hyperplasia, and migration of the retinal pigment epithelium.

**FIGURE 7-1.** This “salmon patch” represents an intraretinal hemorrhage that extends from the internal limiting membrane and may involve the entire thickness of the retina. These hemorrhages typically have a bright red appearance.
Cotton wool spots may occur in the posterior pole, and the thinning of the retina that follows their resolution may be seen as a “macular depression.” The sickle disc sign refers to comma-shaped capillaries on the disc that are caused by chronic sludging of blood. A similar finding can occasionally be seen in conjunctival capillaries. Iris atrophy may also be observed in patients with sickle cell retinopathy [Fig. 7-3]. Additional fundus changes include angioid streaks and tortuosity and dilation of the retinal venules. Retinal arteriolar occlusions have been reported in both a 5.5-year-old and a 9-year-old with SS hemoglobinopathy. A 31-year-old with hemoglobin SC with a spontaneous central retinal artery occlusion was recently reported. These cases of posterior disease stand in contrast to the more common picture of peripheral vascular occlusion.

Proliferative sickle retinopathy typically occurs in young and middle-aged adults but may occur in the second decade of life, usually following puberty. Patients with proliferative sickle retinopathy develop peripheral vascular occlusions followed by arteriovenous anastomoses and, eventually, peripheral neovascularization. The peripheral neovascular tufts typically have a shape similar to the aquatic plant Gorgonia flabellum and were consequently termed sea fans by Welch and Goldberg [Fig. 7-4]. Patients with these findings are at risk for vitreous
FIGURE 7-3. Iris atrophy in a patient with sickle cell disease.

FIGURE 7-4. Peripheral neovascular tufts in the shape of a sea fan are found at the anterior edge of perfused retina in proliferative sickle retinopathy.
hemorrhage as well as tractional and rhegmatogenous retinal detachment.

Penman et al., reporting on the Jamaican sickle cohort, found that proliferative sickle retinopathy was more likely to occur in those with vascular morphological abnormalities [abrupt terminations, vascular buds] at the border of nonperfused retina compared to patients with more normal-appearing peripheral vascular beds.32

Scatter laser photocoagulation is recommended for patients with more than 60° of proliferative sickle retinopathy. If scatter treatment alone is insufficient to induce nonfusion in the proliferative tufts, then supplemental feeder vessel treatment may be required. Feeder vessel treatment should not be considered as primary treatment because of an increased risk of rhegmatogenous retinal detachment following argon photocoagulation.10 Patients with less than 60° of peripheral neovascularization are at a lower risk for both vitreous hemorrhage and retinal detachment, and there is insufficient evidence to make any treatment recommendation for these patients.10

In patients with cloudy media from vitreous hemorrhage, or small pupils, transscleral cryotherapy or transscleral diode laser photocoagulation may be employed.38

**COATS’ DISEASE**

*Coats’ disease* is an idiopathic, typically nonhereditary condition in which telangiectatic and aneurysmal retinal vessels are associated with massive subretinal exudate. The classic, adolescent form of the disease may occur at as early as 4 months of age with two-thirds of cases occurring before 10 years of age; 80% of cases are unilateral, and there is a 3:1 male predilection.17

Clinical diagnosis of Coats’ disease is often made following the incidental findings of strabismus or of a white pupillary reflex. On fundus examination, yellowish to greenish subretinal exudate or intraretinal or intravitreal hemorrhage may be seen. Exudates and hemorrhage may be minimal but also may be massive, resulting in large areas of retinal detachment and obscuration of fundus details (Fig. 7-5). Although exudates and hemorrhages are usually located posteriorly, the underlying defect is a localized area of telangiectasias and aneurysms of the retinal vessels. These vascular changes may occur adjacent to exudates or may be more peripherally located. In some cases,
fluorescein angiography is necessary to identify the location and extent of vascular changes. Angiography demonstrates early and persistent leakage from the areas of vascular abnormality as well as surrounding areas of capillary nonperfusion.

Coats’ disease is a progressive disorder and when untreated may lead to permanent loss of central vision. Treatment consists of transcleral cryoablation of anterior areas of telangiectasis and laser photocoagulation of posterior areas. Multiple treatments may be necessary for ablation of areas of telangiectasia. Eyes with extensive retinal detachment may be treated with modern vitreoretinal techniques, including vitrectomy, drainage of subretinal fluid, placement of expandable gas, cryotherapy, and photocoagulation. Shields et al. developed a staging classification of Coats’ disease that may be useful in determining prognosis and in guiding treatment decisions (Table 7-3). Of 124 affected eyes treated as necessary and followed for at least 6 months, 20% achieved a visual acuity of 20/100 or better; 24% had acuities from count fingers to 20/200; 40% had hand motions vision or no light perception; and 16% required enucleation. Poor visual outcomes were caused by complications such as subfoveal fluid and fibrosis, foveal exudation, and macular edema. Enucleation was usually reserved for those with

**FIGURE 7-5.** Although the retinal vascular telangiectasias of Coats’ disease are located peripherally, the subretinal exudate typically occurs in the posterior pole, reducing vision dramatically in some cases.
total retinal detachment and glaucoma (stage 4). Pauleikhoff and Wessing reported complete resolution of subretinal exudates in 67.3% of cases with no retinal detachment and in 33% of cases with retinal detachment. Final visual acuity in their series was between 20/30 and 20/200 in 39.4% of cases and better than 20/30 in 15.3%.

**PHAKOMATOSES (NEUROCUTANEOUS DISEASES)**

The phakomatoses are a group of disorders that affect multiple organs, typically the eyes, the skin, and the central nervous system. The phakomatoses that are associated with retinal or choroidal vascular lesions are *Von Hippel syndrome*, *Sturge–Weber syndrome*, and *Wyburn–Mason syndrome*.

*Von Hippel syndrome* is an autosomal dominantly inherited disorder in which retinal capillary hemangiomas occur. The gene that is mutated in this disease has been mapped to chromosome 3p25–3p26. Penetrance in this syndrome is approximately 80%. In approximately one-half of cases, multiple hemangiomas may occur. These hemangiomas may remain asymptomatic or may cause reduced visual acuity due to subretinal exudate. Approximately one-half of patients have an associated infratentorial hemangioblastoma of the cerebellum, brainstem, or spinal cord, in which case the disorder is called *Von Hippel–Lindau syndrome*. Patients with *Von Hippel–Lindau syndrome* are at increased risk of renal cell carcinoma, pheochro-

<table>
<thead>
<tr>
<th>TABLE 7-3. Staging Classification of Coats’ Disease.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 1. Retinal telangiectasia only</td>
</tr>
<tr>
<td>Stage 2. Telangiectasia and exudation</td>
</tr>
<tr>
<td>A. Extrafoveal exudation</td>
</tr>
<tr>
<td>B. Foveal exudation</td>
</tr>
<tr>
<td>Stage 3. Exudative retinal detachment</td>
</tr>
<tr>
<td>A. Subtotal detachment</td>
</tr>
<tr>
<td>1. Extrafoveal</td>
</tr>
<tr>
<td>2. Foveal</td>
</tr>
<tr>
<td>B. Total retinal detachment</td>
</tr>
<tr>
<td>Stage 4. Total retinal detachment and glaucoma</td>
</tr>
<tr>
<td>Stage 5. Advanced end-stage disease</td>
</tr>
</tbody>
</table>


208 HANDBOOK OF PEDIATRIC RETINAL DISEASE
mocytoma, and cysts of the pancreas, epididymis, kidney, liver, lung, adrenal gland, bone, omentum, or mesocolon. Symptomatic hemangiomas can be treated with laser photocoagulation using long-duration burns or with cryotherapy. Multiple treatment sessions may be required.

Retinal cavernous hemangioma is characterized by dark, grapelike clusters of intraretinal aneurysms. Their clinical appearance is distinct from retinal capillary hemangioma. On fluorescein angiography, separation of the serum and cellular components of blood may be seen. These vascular hamartomas are symptomatic in approximately 10% of cases and may cause subretinal, intraretinal, and vitreous hemorrhage. Treatment is indicated only in symptomatic cases, and the value of treatment in these cases is still unproven. Choroidal hemangiomas may occur in a localized or a diffuse form. Sturge–Weber syndrome is a noninherited clinical condition characterized by a facial nevus flammeus (hemangioma of skin with capillary and cavernous channels) with ipsilateral intracranial hemangioma. In 40% of patients with Sturge–Weber syndrome, an associated diffuse, ipsilateral choroidal hemangioma may be found. Secondary hyperopia may occur with diffuse choroidal hemangioma as well as overlying retinal detachment in one-half of cases. Treatment of retinal detachment in these cases is by placement of light photocoagulation scars over the entire tumor in an attempt to strengthen the adhesion between the retina and the underlying pigment epithelium. In patients with diffuse choroidal hemangioma associated with Sturge–Weber syndrome, the median age at onset of ocular symptoms is 9 years. Patients with isolated, localized choroidal hemangiomas have a median age of onset of 39 years.

Wyburn–Mason syndrome is characterized by the association of abnormal retinal arteriovenous anastomoses with similar lesions in the ipsilateral midbrain. This condition is nonhereditary and is only rarely associated with subretinal exudation. The degree of arteriovenous anastomosis in the involved retina is variable and may be minor or involve the entire retinal circulation. Vision is dependent on the relative sparing of the macular circulation. Neurological sequelae are similarly variable. Only rarely is photocoagulation indicated for subretinal exudate or iris neovascularization.40
DIABETIC RETINOPATHY

The major retinal complications of diabetes are retinal neovascularization (proliferative diabetic retinopathy), diabetic macular edema, and capillary nonperfusion. These conditions are all related to the duration of chronic hyperglycemia and are quite rare before puberty. Following puberty, the incidence of diabetic retinopathy in type I diabetes begins to rise sharply such that 50% of patients have proliferative disease after 15 years. A similar acceleration of activity of diabetic retinopathy occurs with pregnancy. Pregnant women without advanced proliferative diabetic retinopathy are unlikely to develop exuberant proliferation and severe visual loss, but pregnant women with active proliferative disease are at significant risk. Women with background disease are at risk for both proliferative disease and diabetic macular edema. Follow-up examination of diabetics should be at least twice yearly during puberty and every 1 to 2 months during pregnancy.4

HYPERTENSIVE RETINOPATHY

Fundus findings of hypertensive retinopathy consist of widening of the arteriolar reflex associated with diffuse arteriolar narrowing, nicking (focal narrowing) of the veins distal to arteriovenous crossings, intraretinal hemorrhages, and disc edema. These changes result from arteriolosclerosis following chronic hypertension and are not usually seen in children. The acute fundus changes of hypertension are more common in the adolescent age group, specifically in the clinical setting of preeclampsia. Preeclampsia is a hypertensive disorder of pregnancy that occurs in the absence of other etiologies. It usually begins following the 12th week of gestation and is more common in the primigravida and in the adolescent. In preeclampsia, as in other acute hypertensive episodes, the primary fundus findings are focal constriction of retinal arteri- oles, cotton wool spots, choroidal infarctions with secondary serous retinal detachments (usually in the macula), and optic disc edema not associated with elevated intracranial pressure [Fig. 7-6]. Prompt obstetrical evaluation and treatment are essential for pregnant patients with these fundus findings.36,43
Intraocular hemorrhage is a known complication of subarachnoid hemorrhage and occurs in approximately 20% of these patients (Fig. 7-7). Terson's syndrome refers to cases in which vit-
reous hemorrhage accompanies subarachnoid hemorrhage. It is probably more appropriate to consider intraocular hemorrhage in this setting as a spectrum ranging from mild intraretinal hemorrhage to massive vitreous hemorrhage. This finding is highly significant because mortality from subarachnoid hemorrhage increases from 19.7% to 53.6% when associated with intraocular hemorrhage. Terson believed that a sudden increase in venous pressure following an abrupt elevation of intracranial pressure caused the intraocular hemorrhage. It is interesting that similar findings may occur following traumatic subdural hemorrhage.39

**SHAKEN BABY SYNDROME**

Blunt trauma of the head is the leading cause of death in child abuse. Blunt trauma in this setting may lead to ocular findings ranging from the anterior segment to the retina and optic nerve. When violent shaking of a small child occurs (shaken baby syndrome (SBS), the typical fundus finding is a diffuse, often massive, intraretinal and vitreous hemorrhage. The intraretinal hemorrhages are typically located in the nerve fiber layer and may be unilateral or bilateral. This fundus appearance may closely resemble Terson’s syndrome. However, the mechanism of injury in shaken baby syndrome differs from that in Terson’s syndrome, and the latter designation should not be used to describe the intraocular hemorrhages in SBS.28 A typical perimacular fold of the retina may also be seen in SBS and in few other entities.

Dense vitreous hemorrhages are associated with poor visual outcome because of both ocular disease and concomitant damage to the visual pathways.25 The presence of a midline shift of brain structures on neuroimaging, and of nonreactive pupils, were both strongly predictive of mortality in one study.26

Historical details provided by caregivers are often inconsistent with the functional level of the child. Any time a diagnosis of child abuse is suspected, a report should be made to the proper authorities so that investigation can be undertaken.49

**PURTSCHER’S RETINOPATHY**

Sudden elevation of the venous pressure following chest compression can cause diffuse cotton wool spots and nerve fiber layer hemorrhages throughout the fundus. Suggested etiologies
for these findings include aberrant coagulation and physical injury due to direct transmission of the elevated venous pressure. Fluorescein angiography shows leakage corresponding to areas of cotton wool spots and staining of small arterioles. *Purtscher’s retinopathy* may be seen following motor vehicle accidents or cardiopulmonary resuscitation and in child abuse cases, especially those involving sexual abuse.

**EALES DISEASE**

_Eales disease_ is an idiopathic peripheral retinal vasculitis with the peak onset of symptoms between the ages of 20 and 30 years. Eales disease is rare in the United States but is a significant cause of uveitis in the Middle East and India. Historically, Eales disease has been described as a peripheral periphlebitis, but more recent studies have suggested an equal amount of arteriolar sheathing. Nonperfusion of the peripheral retina is a hallmark of the disease and most often involves the temporal retina. Retinal neovascularization occurs in up to 80% of patients and often leads to vitreous hemorrhage. Although serious complications such as rubeosis iridis with neovascular glaucoma or macular nonperfusion may occur, the visual prognosis of Eales disease is usually quite good, with two-thirds of patients maintaining vision of 20/40 or better. \(^{15}\)

**INCONTINENTIA PIGMENTI**

_Incontinentia pigmenti_ is characterized by abnormalities in ectodermal structures such as the eyes, skin, teeth, and central nervous system. Affected patients usually present in infancy with a vesicular eruption of the skin that evolves into a whirling pattern of abnormal pigmentation (Fig. 7-8A). These whorls become less visible with increasing age and may be nearly invisible by the third decade of life. Patches of alopecia may be seen as well.

Ophthalmic findings include strabismus, nystagmus, blue sclera, cataract, and microphthalmia. Fundus findings may include optic nerve atrophy or papillitis, retinal hemorrhages or neovascularization, retinal edema, and chorioretinitis (Fig. 7-8B). \(^{47}\) Holmstrom and Thoren found serious and vision-threatening ocular disease in 45% of their 30 patients. \(^{19}\) Retinal
FIGURE 7-8A,B. (A) Blister-like lesions that develop in infancy, then evolve into whorls of brown pigment, are characteristic of incontinentia pigmenti. (Courtesy of Mary S. Stone, M.D.) (B) Peripheral retinal neovascularization may be seen in incontinentia pigmenti and may be associated with vitreous hemorrhages in some cases.
disease is the greatest threat to vision. The natural history of ocular disease in IP is poorly defined. However, a screening schedule for retinal examinations has been proposed and includes examinations shortly after birth and then monthly for 3 to 4 months. This schedule is followed by examinations at 3-month intervals for an additional year, then by semiannual examinations until age 3.\textsuperscript{19,29}

The condition is most commonly inherited as an X-linked dominant that is lethal in males (Bloch–Sulzberger syndrome). One gene has been localized to the long arm of the X chromosome (Xq28).\textsuperscript{19} Thus, almost all affected patients are female. Some pedigrees have been reported in which affected males have transmitted the disease to daughters, but no male-to-male transmission has been documented.\textsuperscript{23}

**HYPOMELANOSIS OF ITO**

*Hypomelanosis of Ito* is a rare syndrome characterized by bizarre, patterned, hypopigmented streaks along the lines of Blashko. Hypomelanosis of Ito is also distinguishable from incontinentia pigментi in that the skin lesions are not preceded by the inflammatory vesicles that are seen in the latter disease. Ophthalmic findings can include nystagmus, strabismus, heterochromia irides, iris coloboma, microphthalmia, myopia, corneal pannus, choroidal atrophy, retinal hypopigmentation, and retinal detachment.\textsuperscript{35} Half these patients have systemic findings that may include central nervous system dysfunction (delayed development or seizure) and musculoskeletal anomalies.\textsuperscript{37}

**GOODPASTURE SYNDROME**

*Goodpasture syndrome* is a chronic, relapsing autoimmune disease characterized by episodic bouts of hemoptysis, dyspnea, and glomerular nephritis caused by immunoglobulin G deposition in the basement membrane of lung alveoli and renal glomeruli. An episcleritis may develop in some patients resembling that seen with rheumatoid arthritis. Patients may also develop choroidal infarctions with secondary serous retinal detachment or macular edema.\textsuperscript{21} A 40-year-old patient with Goodpasture’s syndrome developed bilateral peripapillary sub-
ALLERGIC GRANULOMATOSIS
(CHURG–STRAUSS DISEASE)

Churg–Straus disease is a systemic allergic disease that is characterized by a granulomatous and eosinophil-rich inflammation involving the respiratory tract, with necrotizing vasculitis. The primary complications of Churg–Strauss disease of interest to the ophthalmologist are orbital inflammatory pseudotumor and ischemic vasculitis. Branch and central retinal artery occlusion, and ischemic optic neuropathy, have been reported. Diagnosis is aided by the presence of blood eosinophilia and perinuclear antineutrophil cytoplasmic antibodies.

TAKAYASU’S ARTERITIS

The inflammatory condition called Takayasu’s arteritis primarily affects the aorta and its branches in children and young women. It is rare in the United States and Europe but common in Japan and other parts of the Orient. Synonyms for this disease include “pulseless disease” and “aortitis syndrome.” Histologically, the disease is characterized by a granulomatous panarteritis. Systemic findings may include fatigue, weight loss, low-grade fever, diminished pulses, orthostatic syncope, intermittent claudication, and seizures. The reported mortality rates vary from 10% to 75%, depending in part on the length of follow-up. Death usually results from a cerebrovascular accident or complications of congestive heart failure. Ophthalmic findings result from ischemia. Mild ischemia is associated with retinal vasodilation and formation of microaneurysms. Severe ischemia leads to arteriovenous shunting, capillary dropout, cotton wool spots, anterior segment ischemia, neovascular glaucoma, vitreous hemorrhage, retinal detachment, and optic atrophy. Treatment with prednisone or other glucocorticoids may alleviate symptoms and induce a remission in many patients but has yet to be proven to increase life expectancy. Neovascularization may be treated with photocoagulation. In cases with carotid artery narrowing, endarterectomy should be considered to improve blood pressure to the eye.
Norrie’s disease, a rare, X-linked disorder, is also known as Andersen–Warburg syndrome. Clinical findings include mental retardation in two-thirds of cases and deafness that typically occurs between childhood and middle age. Ophthalmic findings include retinal detachments, usually with microphthalmos and blindness from birth (Fig. 7-9). In the fundus, there is formation of pseudotumors by dysplastic retinal tissue. Clinical findings can range from a clear anterior segment with retinal pseudotumors resembling retinopathy of prematurity to complete disorganization of all intraocular contents.18,46 Dozens of mutations in the Norrie disease gene, resulting in abnormalities of the protein, norrin, have been identified as causative. This protein is normally expressed in the brain, retina, and choroid.31

FASCIOSCAPULOHUMERAL DYSTROPHY

The autosomal dominant form of muscular dystrophy called fascioscapulohumeral dystrophy predominantly affects the muscles of the shoulders and may be associated with sensorineural hearing loss and peripheral retinal telangiectasis.
similar to those of Coats’ disease. Similar retinal telangiectasis has also been described in a patient with scapuloperoneal muscular dystrophy, a rare myopathy of the muscles of the proximal shoulder and anterior thigh. Sporadic, autosomal dominant and X-linked cases of scapuloperoneal dystrophy have been described.9,42

ANEMIA

Patients with anemia may have a variety of fundus findings including retinal hemorrhages, cotton wool spots, hard exudates, venous dilation and tortuosity, and disc edema (Fig. 7-10). The retinal hemorrhages associated with anemia may vary from flame shaped, to white centered, to subinternal limiting membrane. Fundus findings in anemia are most often seen with moderate to severe anemia of acute onset; children have these findings less commonly than adults. Associated thrombocytopenia may play an etiological role in anemic retinopathy. Vision may be normal but can also be profoundly affected when macular hemorrhage or optic nerve ischemia occur.20

FIGURE 7-10. Retinal hemorrhages may be seen in anemia, reflecting a combination of poor endothelial oxygenation and deficient platelet function.
LEUKEMIA

The retinal findings of leukemia resemble those of patients with severe anemia and include retinal hemorrhages, venous dilation and tortuosity, and hard exudates (Fig. 7-11). Additional findings may include microaneurysmal changes in peripheral retinal vessels, capillary nonperfusion, neovascularization of the retina or optic nerve, and direct leukemic infiltration of the choroid, optic nerve, retina, or vitreous. Fundus findings in leukemia are most often associated with acute leukemic episodes or with relapses and may be related to coexisting anemia or hyperviscosity. If a leukemic patient develops optic disc swelling, increased intracranial pressure should be ruled out and prompt treatment begun with some combination of irradiation, steroids, and chemotherapy to prevent permanent, profound visual loss.20,33

HYPERVIScosity SYNDROMES

Several disorders may result in hyperviscosity of the blood, including Waldenstrom’s macroglobulinemia, polycythemia, and multiple myeloma. Waldenstrom’s macroglobulinemia
is characterized by production of monoclonal IgM protein with hyperviscosity. Systemic findings may include fatigue, headaches, and epistaxis. Fundus findings are similar to those of anemia or leukemia and involve retinal hemorrhages, venous tortuosity and dilation, and optic disc edema (Fig. 7-12). Multiple myeloma is a plasma cell neoplasm and results in osteoporosis, a tendency to fractures, and amyloid deposits throughout the body. Fundus findings may be suggestive of hyperviscosity. Polycythemia is an overproduction of erythrocytes and may be a primary bone marrow disorder or a response to a hypoxic environment such as high altitude. Fundus findings typical of hyperviscosity may be observed in many of these patients.\textsuperscript{11,24}

**KAWASAKI’S DISEASE**

*Kawasaki’s disease*, also known as mucocutaneous lymph node syndrome, is an idiopathic, acute, febrile illness of children. The disease is characterized by fever of 5 or more days duration, petechial rash of the palms and soles, nonpurulent cervical lymph node swelling, bilateral conjunctival injection, and tran-
sient anterior uveitis during the acute phase of the disease. Retinal arterial obstruction may occur secondary to arteritis in these patients. Careful medical follow-up of these patients is necessary because approximately 3% of patients with this disorder die of coronary arteritis. Mortality can be reduced by appropriate and early intervention.14

CAROTID CAVERNOUS FISTULA

Carotid-cavernous fistulas in children are almost always the result of trauma. Rupture of the internal carotid artery inside the cavernous sinus produces a high-pressure arteriovenous shunt. Reversal of flow in vessels that ordinarily drain into the cavernous sinus results in “arterialization” with engorgement of the veins of the orbit, conjunctiva, and lids on the affected side (Fig. 7-13). Exophthalmos, glaucoma, and an orbital bruit may also become evident. Cranial nerves III through VI may become affected in their intracavernous course. Fundus changes can include disc edema, retinal hemorrhages, and central retinal vein occlusion.

FIGURE 7-13. Arterialization of the conjunctival circulation in patients with carotid cavernous fistulas may lead to a mistaken diagnosis of “pink eye.”
VEIN OCclusions

Branch retinal vein occlusion in adults is typically associated with chronic systemic hypertension and occurs at arteriovenous crossings. This type of branch retinal vein occlusion is exceedingly rare in children. Branch retinal vein occlusions may occur in children in association with hyperviscosity syndromes, sickle hemoglobinopathies, and retinal venous loops. Central retinal vein occlusion in children is even less common than branch retinal vein occlusion and probably has a similar etiology.\textsuperscript{30}

CONGENITAL VASCULAR LOOPS

Dilated vascular loops may be located on or near the optic disc. These loops are arterial in approximately 80\% of cases and involve the inferior retinal circulation in approximately two-thirds of cases (Fig. 7-14). Cilioretinal arteries are an associated finding in the majority of eyes. Complications are infrequent but include occlusion of an arterial loop with resultant branch retinal arterial occlusion, occlusion of a venous loop with result-

FIGURE 7-14. Although retinal vascular loops at the optic disc are typically arterial, venous loops may be seen in 20\% of these cases.
ant branch retinal venous occlusion, vitreous hemorrhage from traction on a loop, amaurosis fugax, and hyphema.\textsuperscript{5}

**Acknowledgments.** The preparation of this chapter was supported in part by an unrestricted grant from Research to Prevent Blindness, Inc.

**References**