Chapter 19

Pediatric Neuro-Ophthalmology

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Compared with the examination of adults, the neuro-ophthalmic evaluation of children differs in that there are significant developmental changes in visual and oculomotor function that limit their quantitative assessment. There are available, however, a number of qualitative and quantitative methods that, along with objective physical findings, allow for the more accurate identification and classification of neurological disorders of vision in children.

Normal Visual and General Development of Children

Neuro-ophthalmic disorders are frequently important elements or overt expressions of the CNS diseases that affect children, including neurodegenerative disorders, Hence, the age-related development of visual function must be carefully considered (■ Table 19.1). If the patient has older siblings, the parents can often provide useful comparisons between siblings in assessing their relative visual capabilities.

Practical Methods for the Neuro-Ophthalmic Evaluation of Children

In this chapter emphasis is placed on simple testing methods that can be relied on in any practice. ■ Table 19.2 provides a summary of the various ophthalmic and related consulting options for the evaluation of visual function in children. It is most important that the examiner be able to establish a relationship of trust with the patient. This begins with the pediatric waiting area. Quiet observation of the child and of the interactions between the parents and the child will yield important clues. All tests should be carefully explained in advance. The explanation should be frank and include the predictably unpleasant parts of the examination, such as the discomfort caused by mydriatic agents. It is often helpful to have the parents bring with them any occlusion device in use. Having the patch in place will allow for a peaceful period of observation, testing of acuity, and assessment of any compensatory head posture. (Monocular testing should be first with the occluding device in place, followed by removal of the occluder and binocular testing.) A number of objects of visual interest to the child, such as *Sesame Street* or cartoon characters/puppets, or other age-appropriate objects, will facilitate observation of pursuit and saccadic eye movements. Good fixation can be achieved by having the child try to "blow out" the hand light used for external examination. During the examination the more common devices used can be described as "magic glasses" or "sunglasses". Music or the mimicking of animal or automobile sounds usually encourages cooperation. Small television sets with a diagonal screen size of 5 in. (and placed 10 or more feet away) can be used to play cartoon videos, which will capture the child's attention. Prior to a more careful examination, the initial period of cooperation should be exploited to complete quickly a preliminary examination of all structures of both eyes.

Pearl

Once the examiner has developed a level of trust, essential instruments should be at hand, including a handheld slit lamp, an indirect ophthalmoscope (preferably head-mounted), a direct ophthalmoscope, and a retinoscope.

History and Neurological Assessment

For infants and small children, the history by its nature is indirect and depends on the ability of the parents or caregivers to describe accurately the visually dependent behavioral characteristics of the child. An experienced examiner can use the period of history taking to observe the child's behavior, often obtaining valid information that can guide the history-taking process. The most important elements are summarized in ■ Table 19.3. It is understood that the history taking must be done by the physician and cannot be delegated to others.

Table 19.1. Milestones of normal visual and general development

Age	Normal visual development	Motor function	Social development
After 30 weeks of gestational age	Pupillary light responses +		
At birth		Optokinetic nystagmus + with limited speed of the slow phase – nasotemporal asymmetry until 2–4 months of age	
1 month	Stable ocular positioning		
1–3 months		Good saccades	
6 weeks	Recognizes known faces	Head held steadily	Responsive smile
6–8 weeks		Good pursuit movements and steady fixation maintenance	
2–5 months	Threat induced blinking		
3 months	Visually inspects handheld objects	Holds objects	Babbles
3–7 months	Good stereopsis		
4 months	Adequate accommodation and foveal maturity		
6–8 months		Sits, turns	Expresses displeasure, holds bottle
7 months to 2 years	Myelination of optic nerves complete		
9–12 months		Crawls, stands with support, runs with hand held	Waves good-bye, speaks two to four words
12–15 months		Runs without help, throws objects, scribbles with crayons, builds stacks with wooden blocks	Points at desired objects, understands names of various objects, helps when getting dressed
18–24 months	Looks at picture books, names colors (by 2 years of age)	Stoops and picks up objects, runs, begins attending to cleanliness	Uses a spoon, speaks two- to three-word sentences, knows own body parts

Modified from Buckley EG (2003) Pediatric neuroophthalmology examination; and Stout AU, Wright KW (2003) Pediatric eye examination. In: Wright, K (ed) Pediatric ophthalmology and strabismus. Mosby, St. Louis

Table 19.2. Methods for examining children

Ophthalmic examination	Consultative examination
• History • Neurological examination • Spatial acuity • Binocular vision • Brückner test (red fundus reflex) • Pupillomotor responses • Perimetry • Color vision • Oculomotor examination • Refraction • Accommodation • Morphology: biomicroscopy and ophthalmoscopy • Electrophysiology	• Pediatric or neuropediatric • Neuroradiologic • Neurosurgical • Ear, nose, and throat • Child psychologist, psychiatrist • Human geneticist

Table 19.3. History and neurological assessment

- Course of pregnancy
- History of labor and delivery
- Family history
- Neurologic and psychomotor milestones of development
- Suspicion of brain damage? Spasticity? Seizures? Ataxia?
- Hearing problems?

Table 19.4. Assessment/measurement of vision and age-dependent testing of vision

Assessment/measurement of vision

Qualitative (Questioning of the parents is important!)
- Do you believe your child can see?
- Does your child react to lights, faces, or toys?
- Does he/she fix visual attention on your faces, on the bottle, or on own hands and feet?
- Does your child react to noises, but not to visual stimulation?
- Central fixation? Searching fixation? Corrective head posture
- Does your child pursue moving objects with his/her eyes?

Quantitative
- Binocular testing first, while child is relatively undisturbed (Build trust!)
  - With manifest or latent nystagmus the binocular visual acuity is often better
- Then monocular testing of acuity
  - Ideally with an occlusion patch – in the event of latent nystagmus fogging of distance vision or use of stereoptic isolation helps
- When possible, measure near acuity
  - It is often better than distant acuity (e.g., when nystagmus is present – important for questions about schooling)
- Optokinetic nystagmus (OKN)
  - When horizontal and vertical responses are elicitable, useful visual function can be expected
  - When not elicitable no useful conclusion can be made

Age-dependent testing of vision

Age	Expected acuity	Tests for when age-appropriate general development is present	Tests for when there is delayed psychomotor development
<2 months	0.1–0.3	Observe: blinking at bright lights, fixation and pursuit of objects (faces!), OKN	Observe: blinking at bright lights, fixation and pursuit of objects (faces!), OKN
2–6 months	0.4	Observe: blink response to visual threat, reaching for objects, PL (TAC), OKN, *VEP*	Observe: blink response to visual threat, reaching for objects, PL (TAC), OKN, *VEP*
6–18 months	≥0.5	PL (TAC, Cardiff-Cards), OKN, *VEP*	Observe: blinks at visual threats – fixes and follows objects (faces!) PL (TAC, Cardiff Cards), OKN, *VEP*
18–36 months	≥0.6	PL (Cardiff Cards), LEA-Test *VEP*	PL (TAC, Cardiff Cards), OKN, *VEP* Reaches for small, hard candy spheres (1 mm to 1 cm in size)
3–5 years	≥0.6	Tumbling Es, Landolt rings, Lea test *VEP (and mfERG) when functional visual loss is suspected*	PL (TAC, Cardiff Cards), *VEP* Reaches for small, hard candy spheres (1 mm to 1 cm in size)
≥6 years	≥0.8	Letters, Landolt rings *VEP and mfERG (when functional visual loss is suspected*	PL (TAC, Cardiff Cards), OKN, *VEP*, Lea test Reaches for small, hard candy spheres (1 mm to 1 cm in size)

Tests written in italics are those of lower or limited use
When using the Cardiff-Cards, one will commonly find an overestimation of acuity
TAC Teller Acuity Cards, *OKN* optokinetic nystagmus, *VEP* visually evoked potentials, *PL* preferential looking, *mfERG* multifocal ERG

Visual Testing

The important elements of pediatric vision testing are listed in ■ Table 19.4, and ■ Table 19.5 and provide a summary of the most appropriate methods, based on the child's age or level of development.

Preferential-looking methods are now established as conventional tests. Teller Acuity Cards (TAC) measure spatial acuity by grating resolution. In children with strabismic amblyopia, this method can produce an overestimate of function. In addition, the grating acuity cannot be reliably transposed into a Snellen acuity level. Grating test object methods measure a recognition function that is not strictly comparable with the results of conventional spatial acuity testing. For older children, the Cardiff Cards have proven to be effective (■ Fig. 19.1 a). Testing with sequential rows of alphabetical characters, e.g., the C chart according to Haase or the Lea character sequence cards (■ Fig. 19.1 b) allows for a distinction between acuity reductions because of a microstrabismus on the one hand, and a developmental central scotoma caused by diseases in the retrobulbar visual pathways on the other. This is because of the crowding phenomenon, which causes acuity levels for identification of single optotypes to be significantly better than those obtained by testing with rows of letters.

Reliable results, when testing children's visual function, require the use of trained personnel who are familiar with the specific techniques suited to the neuro-ophthalmic examination of children.

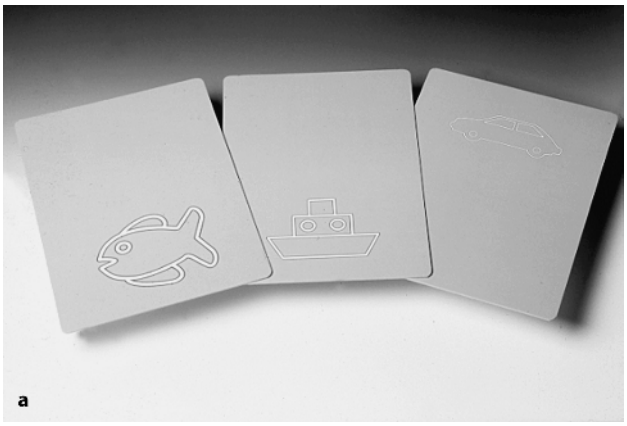
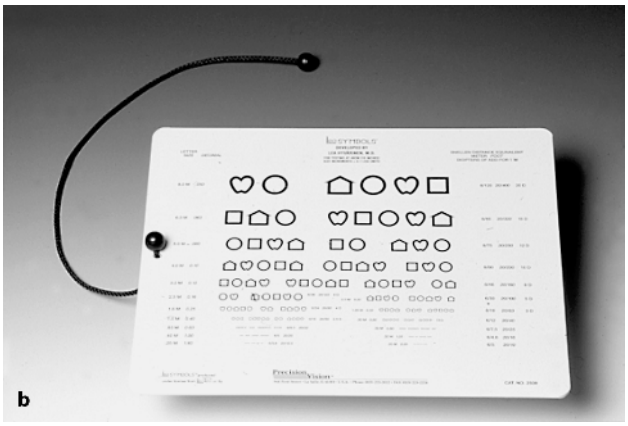


Fig. 19.1. a Acuity testing of small children. Cardiff Cards. The vertical orientation of the test characters has the advantage that the results will not be affected by horizontal but by vertical, motility disturbances. Visual function may be overestimated by this method, but it allows for a valid determination of interocular differences in preverbal children in whom the Teller Acuity Cards have already become uninteresting (i.e., from about 12 to 18 months of age).



b Vision tests for small children. Starting at about 24 months of age, comparison tests become useful. The Lea test has proven itself effective for both distant and near testing, including measures of the crowding phenomenon. Thus, it is useful for differentiating strabismic amblyopia on one hand from an acuity loss caused by an optic neuropathy on the other

Only specifically trained technical personnel should be permitted to record visual acuities. They must have specific knowledge of neuro-ophthalmic disorders and of the methods of testing suited to the examination of children.

Pupillomotor Testing

The testing of pupillary motility (see Chap. 5) is mandatory but is often neglected. The following discussion covers a few of the unique aspects of pupillary testing in children.

It is particularly easy to miss a strictly (or very strongly) unilateral loss of afferent function. The swinging flashlight test is difficult to use with children, particularly those with darkly pigmented irises. As an alternative to the swinging flashlight test, one can use monocular occlusion. The eye with an afferent deficit will show pupillary dilation ("escape") when the contralateral eye is occluded. The parents can help in such cases when specifically asked, by confirming that during patching of the dominant eye, the pupil of the strabismic eye is consistently and strikingly larger than when both eyes are open. (A typical example is the unrecognized optic disc hypoplasia of the strabismic eye).

A manifest anisocoria is not produced by a relative afferent pupillary defect, but rather reflects an efferent (autonomic) motor deficit.

! Note

Among newborns the distinction between essential anisocoria and Horner's syndrome is particularly important. Absence of sympathetic supply to the iris is frequently associated with mediastinal disease, such as in infants with neuroblastomas. Thus, Horner's syndrome requires an identification of the cause of the sympathetic deficit before it is dismissed as unimportant.

Nevertheless, even with thorough study, in only about 20% of cases of infantile Horner's syndrome will the exact cause be found. When a Horner's syndrome appears in the first few months of life, a typical heterochromia iridis will eventually appear. Initially, the irides will have identical color. But, since the development of iris stromal pigmentation requires the presence of an intact sympathetic supply, an easily apparent difference in iris color will appear by age 2 (■ Fig. 19.2).

Bilaterally absent or very poor pupillary light responses in an otherwise seemingly healthy infant most frequently indicate Leber's congenital amaurosis. This should be distinguished from delayed maturation of the pupillomotor pathways in which the pupillary light responses may be slow but are preserved.

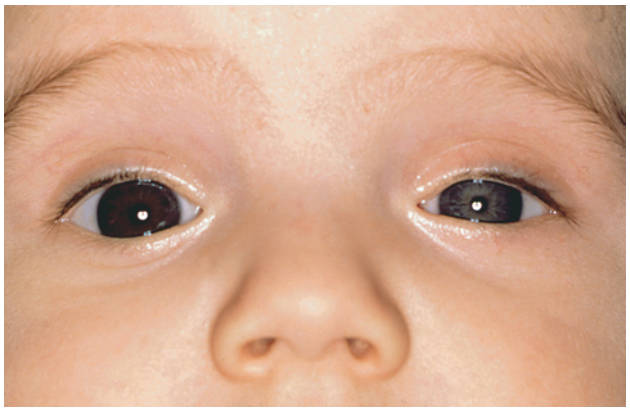


Fig. 19.2. Early childhood Horner's syndrome in the left eye with evident heterochromia iridis and miosis. Heterochromia is a reliable sign of an infantile onset

Visual Field Testing

A precise measure of visual field function in infants and toddlers is not possible. However, neuro-ophthalmically relevant defects are homonymous or bitemporal hemianopias, marked altitudinal deficits, or sector defects. Profound defects of this sort can usually be detected with a modified type of confrontational visual field testing. A summary is provided in ■ Table 19.5. ■ Figure 19.3 illustrates the preferred method for use with infants and also the procedure intended for use with somewhat older children.

Color Vision Testing

For testing color vision in preschool children, the Matsubara Color Vision Test (Handaya Co., Ltd., Tokyo) and the Color Vision Made Easy test by T.L. Waggoner (1994) have proved to be useful. In a modification analogous to the form comparison method (Lea test), black-and-white copies can be used for comparison.

Oculomotor Testing

When testing oculomotor function in small children, including pursuit and saccadic movements (see Chap. 11), the use of attractive toys, such as finger puppets, blinking colored lights, or small sound makers, has proved helpful.

Vestibuloocular Reflexes

When testing vestibuloocular reflexes (VOR) and their suppression in infants, it is best to hold the child in both hands with the arms extended, and then to turn to the right or left, while observing the child's eye movements (■ Fig. 19.4 a).

When testing the so-called doll's eye phenomenon, the child's head is moved while the body is held in a fixed position. This is easily done for horizontal movements, but is difficult for vertical movements. Vertical manipulation of the head often results in a loss of the child's cooperation (■ Fig. 19.4 b).

A detailed discussion of the testing of optokinetic nystagmus and the differential diagnosis of ocular motility disorders can be found in Chaps. 10 and 11.

Table 19.5. Visual field testing of children

	Test	Comments
6 months to 2 years	Central fixation on an attractive stimulus, while introducing objects in the periphery, moving from unseeing to seeing	An assistant introduces the object from the periphery, while the examiner carefully monitors the child's responses
>2 years	Finger play	One finger, five fingers, fist, fixation in abduction[a], monocular testing
>3 years	Finger counting	(One, two, five fingers, or fist) Monocular and binocular testing, altitudinal defects can also be discovered
Over 6–7 years	Goldmann (kinetic)	Look out for false constriction – test first with confrontation
From 8 to 10 years	Kinetic and static testing	Reproducible findings increase validity

[a] If fixation in abduction can be maintained, the eye will be restricted from further movement to the temporal side, increasing the accuracy when testing the temporal visual field. This trick is not of help with the nasal hemifield, since the nose often obstructs the nasal hemifield

Fig. 19.3. a, b Visual field testing of infants. A useful method is to have an associate introduce an interesting object starting in the far periphery and move toward the center of the visual field. Hemianopic defects can be demonstrated, including both horizontal and vertical hemianopias. **c** Visual field testing for preschool children. Kindergartners should be asked to hold up the same number of fingers as the examiner does. Somewhat older children can be asked to describe the number of visible fingers

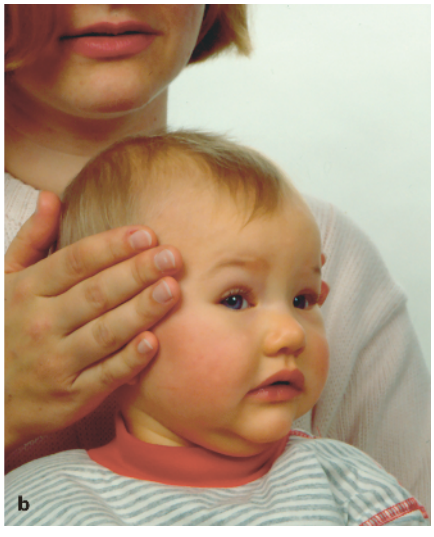


Fig. 19.4. a Testing of the vestibulo-ocular reflexes. Both simple and effective is the technique of holding the infant with both hands at arm's length, while turning about to one side or the other. The rate of turning must be sufficiently fast that it precludes fixation on objects in the surrounding area, otherwise the examiner will be generating an optokinetic nystagmus, rather than a vestibulo-ocular nystagmus. **b** Testing of the vestibulo-ocular reflexes. Testing with the doll's eye phenomenon is only poorly effective, as it usually generates defensive responses and unhappiness

Table 19.6. Ocular causes of a corrective head posture (CHP)

Maintaining binocularity
• With nonconcomitant forms of strabismus – Monocular strabismic hyperdeviation (head-tilt test – Bielschowsky positive) – A or V pattern – Duane's syndrome – Brown's syndrome – Paralytic strabismus • With monocular or binocular ptosis
Maximizing acuity
• Nystagmus with a null position outside of the primary position • Upper lid ptosis (so-called posture of obligatory arrogance) • Gaze paresis
Head posture of infantile strabismus

Corrective Head Posture

When an unusual and involuntary head posture is present, one should determine first whether it is an ocular form of corrective head posture (CHP). ■ Table 19.6 summarizes the most important causes of ocular CHP. Correct recognition of an ocular form of CHP is important, so that unnecessary physiotherapeutic or orthopedic treatments can be avoided. Spontaneous remission of CHP can sometimes be an indication of a worsening of vision, as in the loss of binocular vision. Proper classification of CHP requires both monocular and binocular testing. CHP is to be distinguished from a faulty head posture that has no apparent visual source, particularly when evaluating children with infantile strabismus.

Refraction

Even in this age of automated refractometry, determination of refractive errors in infants and children is usually best done by experienced examiners, using retinoscopy and cycloplegia. For children with nystagmus, retinoscopy is the only effective method for measuring refractive errors.

Measurement of Accommodation

An estimation of accommodative amplitude, when examining small and uncooperative children, is usually best done with the retinoscope. When possible, this should be done following spectacle correction of ametropia. A small fixation object that can attract the child's attention is affixed to the front of the retinoscope, just below the optical axis of the instrument. If brief illumination of the retinoscope attracts the child's visual attention, fixation will stimulate accommodation, so that the neutral fundus reflex (neutralization point) of emmetropia will be seen at all distances between the eye and the retinoscope. Estimation of accommodative amplitude is especially important in children with cerebral damage, particularly those with a history of prematurity and developmental delay, so that proper glasses can be fitted with bifocal segments, or so that monofocal glasses for near vision use can be given to infants. This is particularly important for visual imprinting of maternal facial features and bonding between mother and infant. Also, measures of accommodative amplitude can explain the child's rejection of corrective lenses, such as when a full correction of myopia has been prescribed.

Peculiarities of the Ocular Examination in Children

Features of the ophthalmic examination in small children can often indicate the source of an afferent visual disturbance. Optic atrophy, papilledema, and congenital optic disc anomalies must be ruled out.

Optic Atrophy

If optic atrophy is found, the differential diagnosis that one must consider is very extensive. When retinal or hereditary causes have been ruled out, a neuroradiologic examination is necessary. The flow diagram in ■ Fig. 19.5 summarizes the potential sources of optic nerve damage. A characteristic form of atrophy is found in lesions of the optic tract (■ Fig. 19.6; see also Chap. 8, ■ Fig. 8.23). Tract lesions in children appear not only from damage to the postchiasmal portions of the third-order neurons (retinal ganglion cell axons), but also are found associated with damage to the fourth-order neurons that form the postgeniculate optic radiations and their terminals in the primary visual cortex. This is true when the damage dates from the period of intrauterine development or during the first few months of life (at most 3 to 6 months of age). The mechanism is thought to be a retrograde trans-synaptic degeneration in which faulty development of geniculate ganglion cells provides no useful termination for the retinal ganglion cell axons, resulting in optic atrophy.

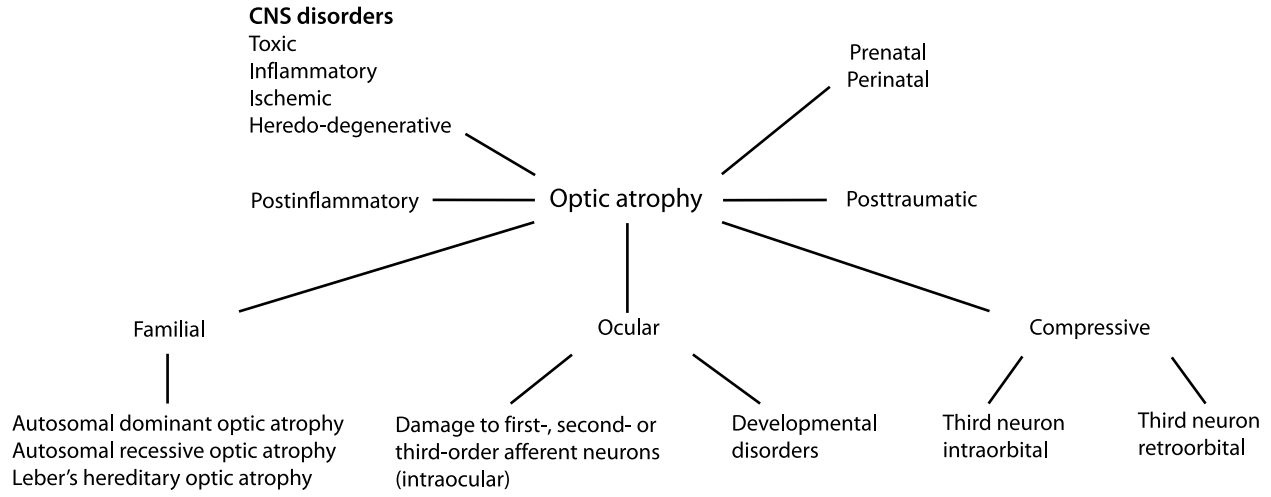
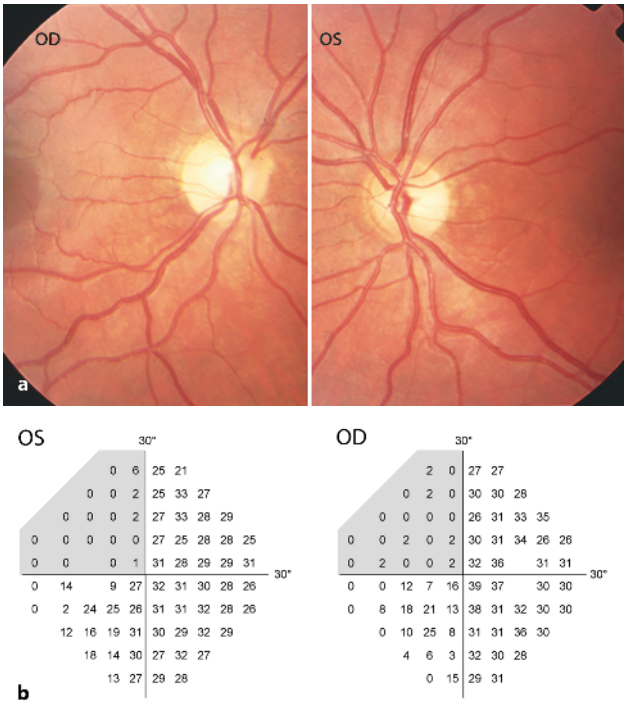


Fig. 19.5. The differential diagnosis of optic atrophy in children



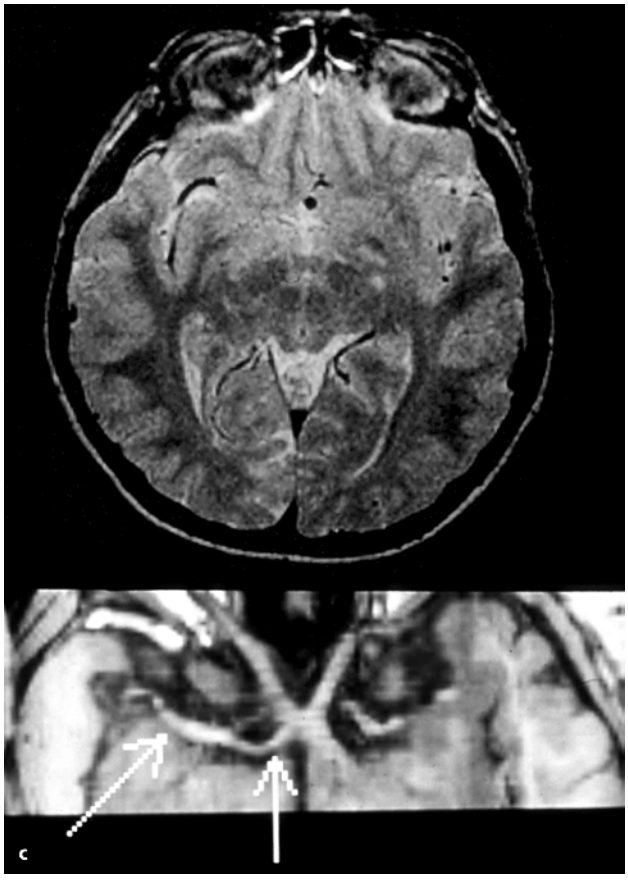
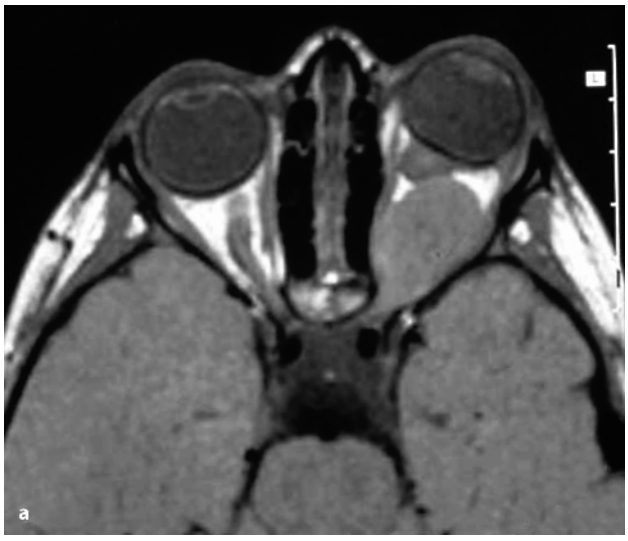


Fig. 19.6. **a** Lesion of the right optic tract with an incongruous, homonymous quadrantic hemianopia to the left. Optic discs: The disc of the right eye has temporal pallor with a shallow excavation, while the disc of the left eye has a bow-tie pattern of pallor, evident in both the nasal and temporal disc quadrants. This finding is easily missed, when a direct ophthalmoscope is not used. **b** Visual field testing (static perimetry with the Humphrey Field Analyzer), of the central visual field, i.e., within 30° of eccentricity. **c** MRI. Shown is the case of an 11-year-old patient with a circumscribed cortical lesion (zone of ischemia) and associated degeneration of the retrogeniculate optic radiations and optic tract on the right side. This finding reliably marks the damage as having been either intrauterine or neonatal in origin. Family members reported that the child could not catch a ball approaching from the left side. The *vertical arrow* indicates the tract hypoplasia; the *left arrow* indicates the middle cerebral artery



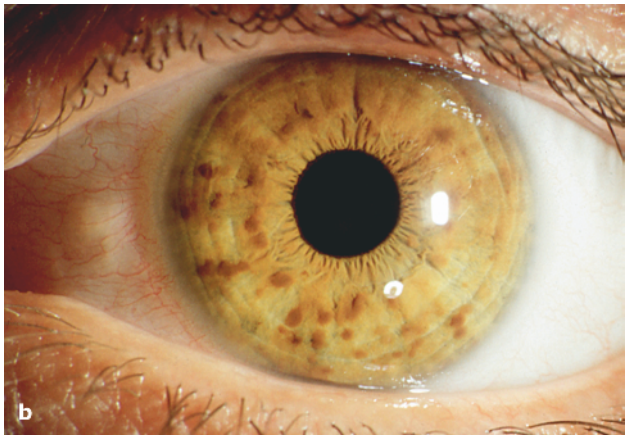


Fig. 19.7. a Optic nerve glioma (MRI). It is important to note that the nerve itself is enlarged, in contrast to the appearance of an optic sheath meningioma. Kinking or sharp angulation of the optic nerve is also very characteristic. Gliomas of the optic nerve frequently occur in the setting of neurofibromatosis type 1 (NF1). Depending on the location of the tumor, optic disc swelling may be seen at the time of discovery. In later stages, a partial or complete optic atrophy will be apparent. **b** Lisch nodules are typical in NF1, but may not be apparent during childhood

Optic Disc Elevation

The differential diagnosis of optic disc elevation in children includes several specific entities. A more detailed discussion of the various etiologic sources of disc elevation, independent of the patient's age, can be found in Chap. 8.

Optic Disc Drusen

During childhood, drusen are not usually calcified, making their identification difficult. Echographic detection of drusen is simple and noninvasive, when the drusen are calcified, and visible drusen are autofluorescent, providing a simple verification of the diagnosis. Superficially located drusen are easily identified by direct ophthalmoscopy, and they have an unmistakable appearance. It is often helpful to examine multiple members of the patient's family, since drusen develop as an autosomal dominant trait. They can also be found linked to a number of hereditary retinal degenerations.

Optic Nerve Gliomas

Optic nerve gliomas (■ Fig. 19.7 a) frequently occur in the setting of neurofibromatosis type 1 (NF1). Common signs and symptoms of NF1 include café-au-lait spots in the skin (at least six light brown, well-demarcated, macular skin marks) and Lisch nodules (pigmented iris hamartomas, consisting of epithelioid cells of neurectodermal origin; ■ Fig. 19.7 b), although they do not necessarily present during childhood. Lisch nodules are almost always absent in infants, are present in 50% of cases by age 5 years, and in 90% by age 20 years. NF1 is inherited as an autosomal dominant trait, and the spontaneous mutation rate is high.

Optic Nerve Sheath Meningioma

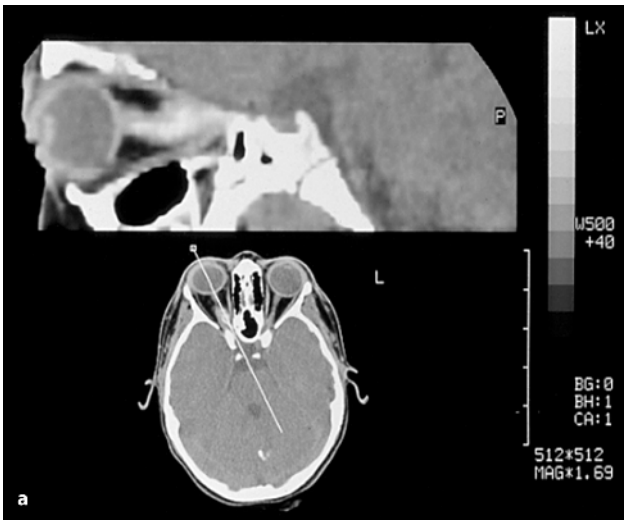
Disc elevation (infrequently) can be the presenting finding of an optic nerve sheath meningioma in children (■ Fig. 19.8 a). Neuroradiologic imaging almost always allows a clear and decisive differentiation between optic nerve gliomas and sheath meningiomas. Sheath meningiomas frequently occur in patients with neurofibromatosis type 2 (NF2), which is inherited as an autosomal dominant trait. NF2 commonly presents as an acoustic neuroma and is not infrequently bilateral. Initial findings can also include retinal pigment epithelial hamartomas (■ Fig. 19.8 c) and a variety of lens opacities (■ Fig. 19.8 b).

Craniosynostoses

Premature or disordered closure of cranial sutures can present as optic nerve compression, with or without optic disc edema. Visually evoked potential (VEP) testing and ophthalmoscopy are frequently helpful in determining a correct diagnosis.

! Note

Absence of optic disc edema does not rule out a compressive lesion of the optic nerve, as for instance in children presenting with open fontanels or already established optic atrophy.



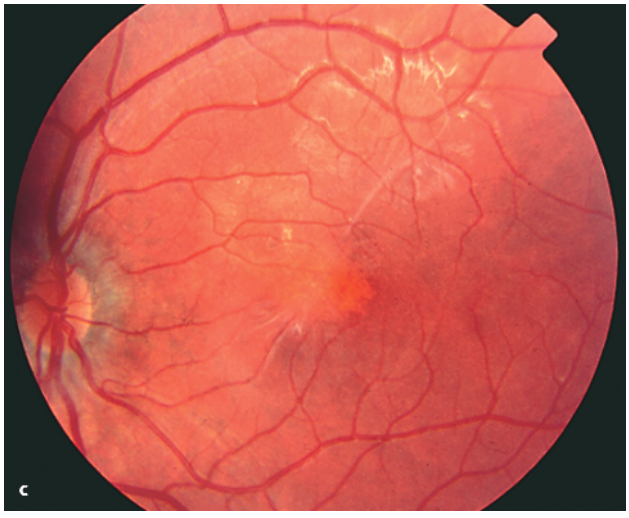


Fig. 19.8. **a** Optic nerve sheath meningioma (CT scan). The optic nerve itself has not changed, but it has been surrounded by tumor. Calcification of the tumor is a very characteristic sign, and best visualized with CT scan. Calcification may be absent in particular in larger tumors. Depending on the location of the tumor, optic disc swelling may be seen. Optic nerve sheath meningiomas also occur in the context of neurofibromatosis type 2 (NF2). **b** Additional ocular findings in NF2 include unilateral lens opacities, e.g., lens fiber haziness. **c** Retinal pigment epithelial hamartoma in a patient with NF2. These hamartomas may also occur as an isolated finding

Congenital Optic Disc Anomalies

■ Table 19.7 provides a summary of congenital optic disc anomalies (see Chap. 8). It is important to recognize that the appearance of the anomaly gives no absolute indication of the visual potential of the eye. The swinging flashlight test is of help in identifying anomalies associated with severe impairment of visual potential. But if there is any doubt about the visual potential of such an eye, a trial of occlusion therapy should always be attempted, so as to minimize the risk of amblyopia.

Table 19.7. Developmental anomalies of the optic disc

Optic nerve hypoplasia
Morning-glory optic disc anomaly
Optic disc coloboma
Peripapillary staphyloma
Megalopapilla
Optic nerve pit
Tilted disc

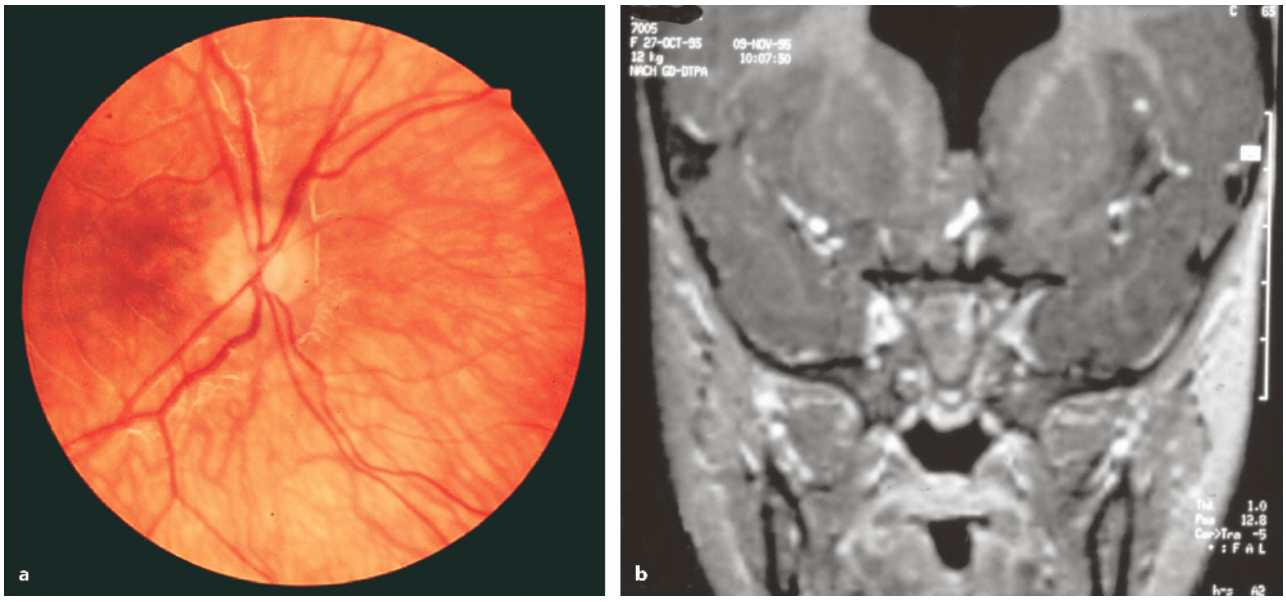


Fig. 19.9. a Optic disc hypoplasia. The peripapillary scleral ring (the so-called double-ring sign) can easily be missed and the outer ring mistaken for the true disc margin. This mistake is easily made when examining uncooperative children. **b** A missing septum pellucidum as the minimal necessary sign of an associated midline defect, as in De Morsier's syndrome, also called septo-optic dysplasia

Optic Disc Hypoplasia

Hypoplasia of the optic disc commonly goes undetected in unruly children seen by inexperienced examiners. At first glance, the typical peripapillary scleral ring may easily be mistaken for the margin of the disc (■ Fig. 19.9). Hypoplasia (and disc colobomas, see below) can be associated with midline developmental defects. In its most limited form, this will be expressed as only an absence of the septum pellucidum. Of more functional importance is an associated hypothalamic hypoplasia. Growth retardation is usually associated with a deficiency of somatotropin, hypothyroidism, or an adrenocorticotrophic hormone (ACTH) deficiency. A deficiency of ACTH release is particularly problematic during periods of stress, as in the face of a febrile disease, which can lead to convulsive seizures. The treatment of choice is not the use of anticonvulsive drugs, but rather of corticosteroids. When untreated, an ACTH deficiency is potentially fatal. Children with midline defects must consequently be monitored regularly to ensure that they do not suffer from an endocrinologic deficit.

Optic Nerve Colobomas

Optic disc colobomas may occur as isolated findings, or as part of a larger constellation of several colobomatous defects that result from a failure of optic cleft closure during embryonic development. They can also be found in the company of midline defects. Recently, a hereditary association has been found between optic disc colobomas and renal hypoplasia with mutations in the *PAX2* gene.

! Note

Children with newly discovered optic disc colobomas should be carefully studied to rule out an associated renal insufficiency.

Aicardi Syndrome

In Aicardi syndrome chorioretinal lacunas result in a characteristic appearance (■ Fig. 19.10). This disorder results in such severe malformations in males, that with few exceptions, none are born living. In affected girls, malformations of the CNS present, such as agenesis of the corpus callosum, schizencephaly (a variably pronounced cleft formation of the cerebrum), and heterotopia of gray matter – a combination that can result in severe CNS seizures.

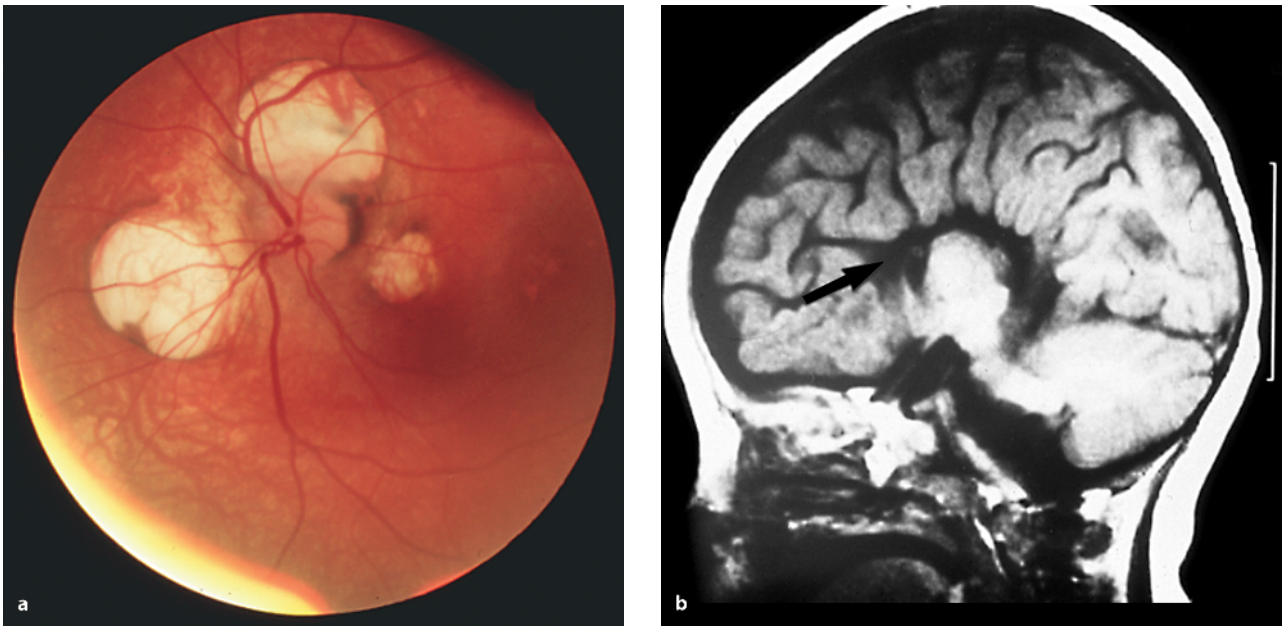


Fig. 19.10. **a** Aicardi syndrome. Circumpapillary chorioretinal lacunae in a young girl. The disease is lethal in males. **b** Aicardi syndrome. Hypoplasia of the corpus callosum (arrow) and cortical heterotopia

Nystagmus in Childhood

Congenital/Neonatal Nystagmus

Proper diagnostic classification of congenital or neonatal nystagmus is challenging. A practical schema is illustrated in the flow diagram of ■ Fig. 19.11 (see also Chap. 11).

Sensory defect nystagmus (SDN), or ocular nystagmus that arises from a congenital defect in retinal and/or optic nerve development, is in 80% of all cases considerably more common than congenital idiopathic nystagmus, which is a diagnosis of exclusion. A precise diagnostic classification allows for an accurate prognosis and assessment of the risk of recurrence in subsequent children by the same parents. Both forms can have characteristics that allow exclusion of more widespread neurological disease. Only if these characteristics are identifiable can either of the two be correctly diagnosed. When findings are uncharacteristic, complete neuropediatric and neuroradiologic examinations are required. This also holds true when complex combinations of nystagmus and other neurological disorders are mixed.

■ Table 19.9 summarizes the most frequently found disorders in children with SDN (ocular nystagmus). A form of albinism is found in more than one third of cases.

Table 19.9. The most common causes of SDN or ocular nystagmus, based on heredofamilial diseases of the retina or optic nerve

Disorders with macular hypoplasia • Albinism (all forms) • Aniridia (also minimal variants with limited iris changes) • Isolated macular hypoplasia
Cone dystrophies • Progressive cone (cone/rod) dystrophies – Leber's congenital amaurosis (LCA) (various forms) – Early onset retinitis pigmentosa • Stationary cone disease – Achromatopsia (autosomal recessive, various forms) – Blue-cone monochromacy (X-linked)
X-linked congenital stationary night blindness (CSNB) • Incomplete form (CSNB2) • Complete form (CSNB1)
Optic disc hypoplasia
Fundus colobomata
Familial isolated nystagmus (autosomal-dominant and X-linked forms)

Spasmus Nutans

See Chap. 11.

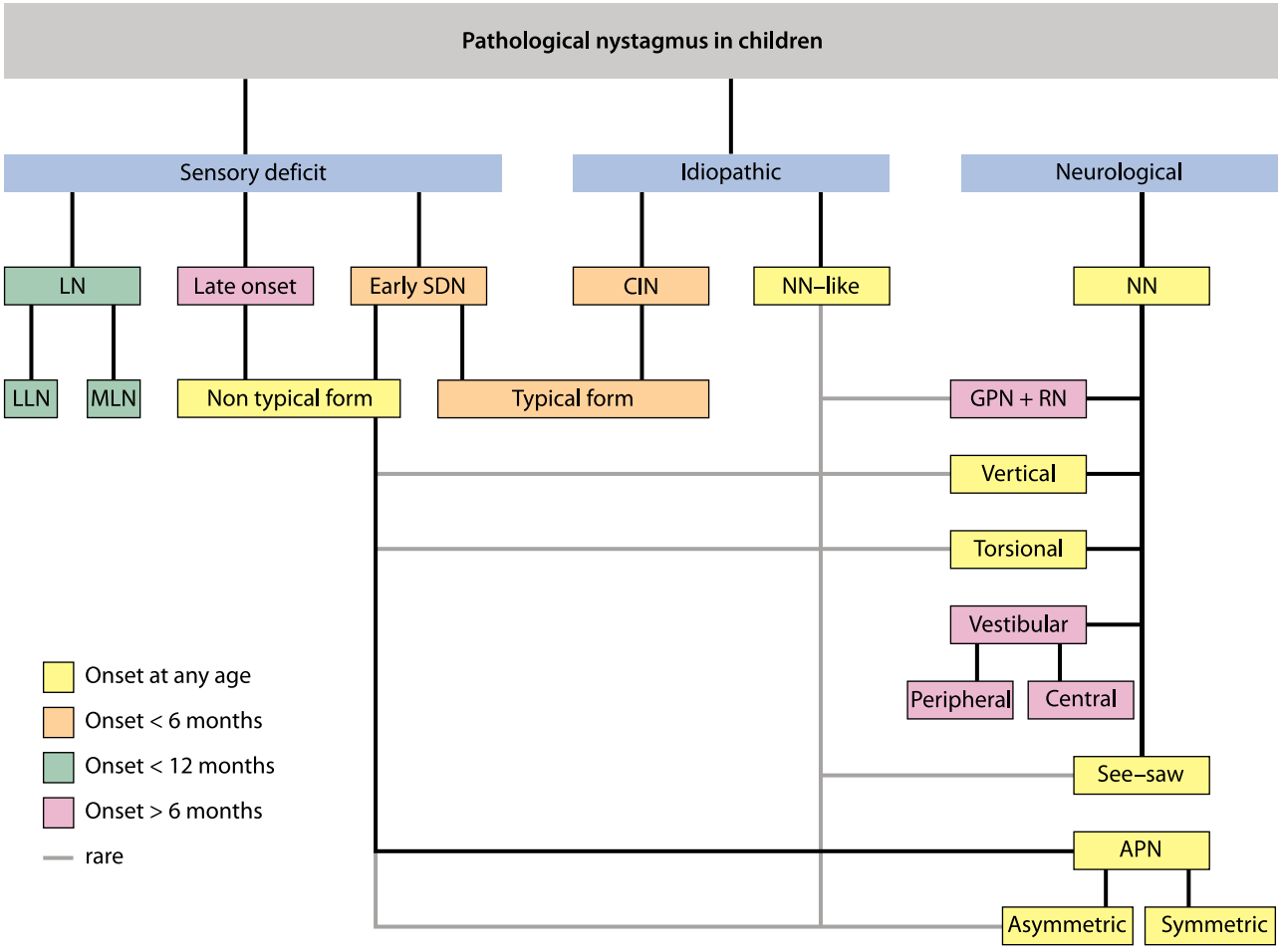


Fig. 19.11. Pathologic nystagmus in children. The flow diagram has been modified from that used by C. Harris. *APN* acquired pendular nystagmus, *CIN* congenital idiopathic nystagmus, *GPN* gaze paretic nystagmus, *LN* latent nystagmus (*MLN* manifest LN, *LLN* latent LN), *NN* neurological nystagmus, *RN* rebound nystagmus, *SDN* sensory deficit nystagmus. Published in D. Taylor's textbook *Paediatric Ophthalmology* (see "Further Reading")

Cerebral Disorders of Vision in Children

Definition

Cerebral disturbances of vision are impairments of vision caused by intracranial damage to the afferent visual pathways up to the level of the primary visual cortex. They can be found only by use of neuroradiological examination.

A cerebral disturbance of vision with an unremarkable fundus appearance is a certifying sign of intracranial disease affecting the afferent visual pathways up to the level of the visual cortex. This definition is important in some countries, since any specific claim for compensation based on visual loss requires confirmation of this sort of intracranial disease. ■ Table 19.10 provides a summary view of the etiologies of cerebral disorders of vision in children.

Table 19.10. Cerebral causes of visual damage in childhood (excluding tumors)

Common causes
• Infections of the central nervous system
• Intentional cranial trauma in child abuse, marked by fundus hemorrhages
• Hydrocephalus
• Hypoxic/ischemic encephalopathy
• Following brain hemorrhages (e.g., in prematurity)
Uncommon causes
• Secondary to a status epilepticus
• Subacute, sclerosing leukoencephalopathy
• Uremia
• Hypoglycemia
• Carbon monoxide poisoning

Table 19.11. Neuroradiologic signs associated with cerebral causes of visual damage (excluding tumors)

Periventricular leukomalacia
Infarcts in the parieto-occipital region
Infarcts in the occipital lobes

■ Table 19.11 lists the typical neuroradiologic findings in such cases. If the damage is present at birth, or appears in the first 3 to 6 months of life, fundus changes such as optic disc atrophy or pathological cupping will often be present, caused by descending transsynaptic degeneration.

Periventricular Leukomalacia

Definition

Periventricular leukomalacia is a softening of the white matter in the regions surrounding the ventricles of the brain.

Radiologically demonstrable periventricular leukomalacia is an important sign of cerebral damage in premature infants and those suffering from perinatal cerebral asphyxia. It can present with optic disc cupping that should be distinguished from the sort caused by congenital glaucoma. Associated disturbances of vision can escape detection when only spatial acuity is tested, since acuities can be largely normal in the face of significant visual loss. Other problems associated with damage to visually associated regions of cerebral cortex become apparent only later, when learning disabilities are exposed in primary school–aged children.

Congenital Brain Tumors and Other Lesions

Ocular manifestations of congenital CNS diseases can also be found, attributable to disturbances of cellular induction, migration, and proliferation. Other congenital anomalies of the brainstem and cerebellum often accompany these disorders, as summarized in ■ Table 19.12. In addition, a variety of brain tumors lead to ocular symptoms. A detailed discussion of congenital intracranial tumors is beyond the scope of this chapter, but it is dealt with more completely in Chap. 12. In all such cases the neuroradiologic findings are conclusive.

Table 19.12. Congenital brain lesions with ocular manifestations (excluding tumors)

Disorders of induction • Arnold-Chiari malformation • Holoprosencephaly • Septooptic dysplasia
Disorders of cell migration and proliferation • Fetal alcohol syndrome • Fetal hydantoin syndrome • Phacomatoses • Lissencephaly (agenesis of cerebral gyri) • Microcephaly
Other congenital anomalies of the brainstem and cerebellum • Moebius' syndrome • Joubert's syndrome • Dandy-Walker cysts
Hydrocephalus

Delayed Visual Maturation

Delayed visual maturation can occur as an isolated entity. Typically such children are noted at an age of 2 to 3 months to behave as blind, and yet seem to have normal pupillary light responses. (A differential diagnosis should include Leber's congenital amaurosis [LCA], which can be confirmed by absent or severely impaired pupillary light reactions and an undetectable or severely reduced electroretinogram [ERG].) Often, a response of the child to facial appearances may be present when light responses seem to be absent. By the age of 6 months this feature will typically become inapparent. Neither morphological nor electrophysiologic studies will show any detectable disease. Delayed visual maturation can also occur in company with retinal or intracranial diseases.

Differential Diagnosis of Unexplained Visual Loss – Psychogenic Disturbances of Vision (Functional Visual Loss)

Unexplained acquired visual loss in children can result from macular diseases that at first escape detection. This is particularly true in the early stages of Stargardt's disease. Typically, a psychogenic cause is suspected during the early stages of discovery. The diagnosis is often made by multifocal ERG (or by pattern ERG), and more recently by the detection of increased fundus autofluorescence at a wavelength of 488 nm. Correct diagnosis of an X-linked retinoschisis can be particularly difficult when only macular

changes are present. Only with precise optical examinations can schisis be found. This ordinarily requires the use of optical coherence tomography (OCT). Electrophysiology (see Chap. 7) can confirm the diagnosis.

Migraine equivalents produce the most highly varied forms of visual hallucinations, and can often be early signs of cerebral diseases that can be found only by appropriate neuroradiologic study. Psychogenic (functional) disorders of vision often pose serious problems with differential diagnosis (see Chap. 15). They constitute a diagnosis by exclusion. A high level of suspicion of a psychogenic disturbance should accompany findings, such as highly variable visual responses – as reflected, for instance, in the spiraling of isopters plotted during kinetic perimetry. If a profound unilateral loss of vision is claimed, conflicting data such as normal stereoacuity, absence of a relative afferent pupillary defect, or intact acuity demonstrated with polarizing filter isolation of test characters to one eye or the other during binocular reading usually permits a decisive determination of the psychogenic character of the visual loss.

Pearl

It is important to remember that such problems are almost never because of conscious simulation on the child's part, but are rather the byproduct of some unresolved difficulty.

Conclusion

Neuro-ophthalmic diseases during childhood include both a number of age-independent diseases and a variety of specific disorders that are variably expressed in an age-dependent fashion. Neuro-ophthalmic investigation of children with unexplained visual disorders requires the use of methods that are appropriate to the study of children, with consideration given to age-corrected measures of function. A decisive neuro-ophthalmic investigation often provides important insights into childhood diseases, facilitating their management by physicians in other branches of pediatric medicine.

Further Reading

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