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## WEB CHAPTER 80

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# Anisocoria and Abnormalities of the Pupillary Light Reflex: The Neuro-ophthalmic Examination

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The neuro-ophthalmic examination is a tool that localizes a defect to the nervous system or the eye. The ultimate goal is to provide the information necessary to proceed with diagnosis, prognosis, and treatment of the pet. This chapter summarizes key aspects of this examination and interpretation of the findings.

Anisocoria (unequal size of the pupils) is abnormal and is a common neuro-ophthalmic problem. This abnormality also may be associated with abnormalities of the pupillary light reflex (PLR). The clinician's role is to determine which pupil is abnormal and whether the underlying cause is ophthalmic or neurologic. This chapter provides a logical guide to address frequent owner concerns: What is wrong? What caused it? How is it treated? Will it get better? These goals are best achieved by first examining the eye with the normal pupil, assessing the PLRs, and then evaluating the eye with the abnormal pupil. Identification of lesions enables a short list of potential causes to be assessed. Once the cause is known, a prognosis can be given.

There are two types of anisocoria: static and dynamic. Static anisocoria is unequal pupils when both eyes are receiving equal illumination. In a patient with dynamic anisocoria, the difference in pupil size depends on the stimulation of one pupil. Some degree of dynamic anisocoria is normal because of incomplete decussation of afferent fibers at two locations: the optic chiasm and the pretectal nucleus. At the optic chiasm, nerve fibers cross

to the contralateral side, whereas at the pretectal nucleus, nerve fibers cross back to the original (ipsilateral) stimulated side. Although pupils of both eyes react to light when it is directed at only one eye, the iris sphincter muscle of the directly stimulated eye receives more efferent impulses than the nonstimulated eye. Therefore it is normal for the pupil receiving direct stimulation to be smaller than the fellow (nonstimulated) pupil. This is termed *physiologic dynamic anisocoria* and does not indicate a pathologic condition.

For all patients in which a neuro-ophthalmic defect, anisocoria, or abnormal PLR is diagnosed, a thorough medical history that includes past medical conditions, current medications, current medical conditions, behavioral changes, and physical signs should be elicited. The owner should be asked about any trauma or absence of the pet from its environment, as well as prior treatment by either the owner or a previous veterinarian. For example, if atropine is used as a mydriatic instead of a more appropriate short-acting agent such as tropicamide, the resulting mydriasis could last up to 2 weeks. Alternatively, owners may try home remedies, which can include medications used for a previous condition, that may alter the pupil size. Behavioral changes often accompany visual deficits because the pathways for both are intimately associated in the brain, particularly the forebrain.

A complete ophthalmic examination (see Chapter 242), including measurement of intraocular pressure,

	OD	OS
Vision	-	+
Pupillary light reflexes		
Direct	-	+
Consensual	+	-

**Web Figure 80-1** Grid to record visual status and pupillary light reflexes (PLRs). Possible entries include +, normal; -, absent; *I*, incomplete; and *M*, minimal. The latter two entries are used to designate degrees of constriction in the PLRs (e.g., the “incomplete” designation may be used in cases of iris atrophy). The example in the chart depicts the responses for a lesion of the right retina or prechiasmatic optic nerve. OD, Right eye; OS, left eye.

examination of the cranial nerves, and a full physical examination, always should be done. Recording all examination findings is essential (Web Figure 80-1) to compile the information that must be reviewed before making a decision regarding the cause of the neuro-ophthalmic defect or anisocoria.

### Role of the Cranial Nerves in the Neuro-ophthalmic Examination

Most of the cranial nerves are involved in vision, PLRs, eye position, and movement. Cranial nerve II (CN II), or the optic nerve, is the afferent arm of the PLR and vision and transmits sensory information to the brain. Parasympathetic fibers of CN III, the oculomotor nerve, comprise the efferent arm of the PLR. CN III also innervates the levator palpebrae superioris muscle (to elevate the upper eyelid) and most of the extraocular muscles. CN IV, the trochlear nerve, innervates the dorsal oblique muscle that passes over a trochlea to rotate the globe medially. CN V, the trigeminal nerve, provides sensory input via the ophthalmic (medial) and maxillary (lateral) branches to the surfaces of the eye (cornea, conjunctiva, periocular skin) and provides afferent input to the lacrimal gland. CN VI, the abducens nerve, serves the lateral rectus muscle (to abduct the globe) and the retractor bulbi muscles. A helpful acronym for remembering the innervation of the extraocular muscles is *LR<sub>6</sub>, SO<sub>4</sub>*, similar to a chemical equation. This denotes that the lateral rectus and the retractor bulbi are innervated by cranial nerve 6 and the superior oblique by cranial nerve 4 (whereas all other extraocular muscles are controlled by CN III). CN VII, the facial nerve, innervates the facial muscles controlling eyelid closure, important in the menace and palpebral reflex. CN VIII, the vestibular nerve, is responsible for coordination of globe position and gaze.

### Functional Anatomy of the Pupillary Light Reflex

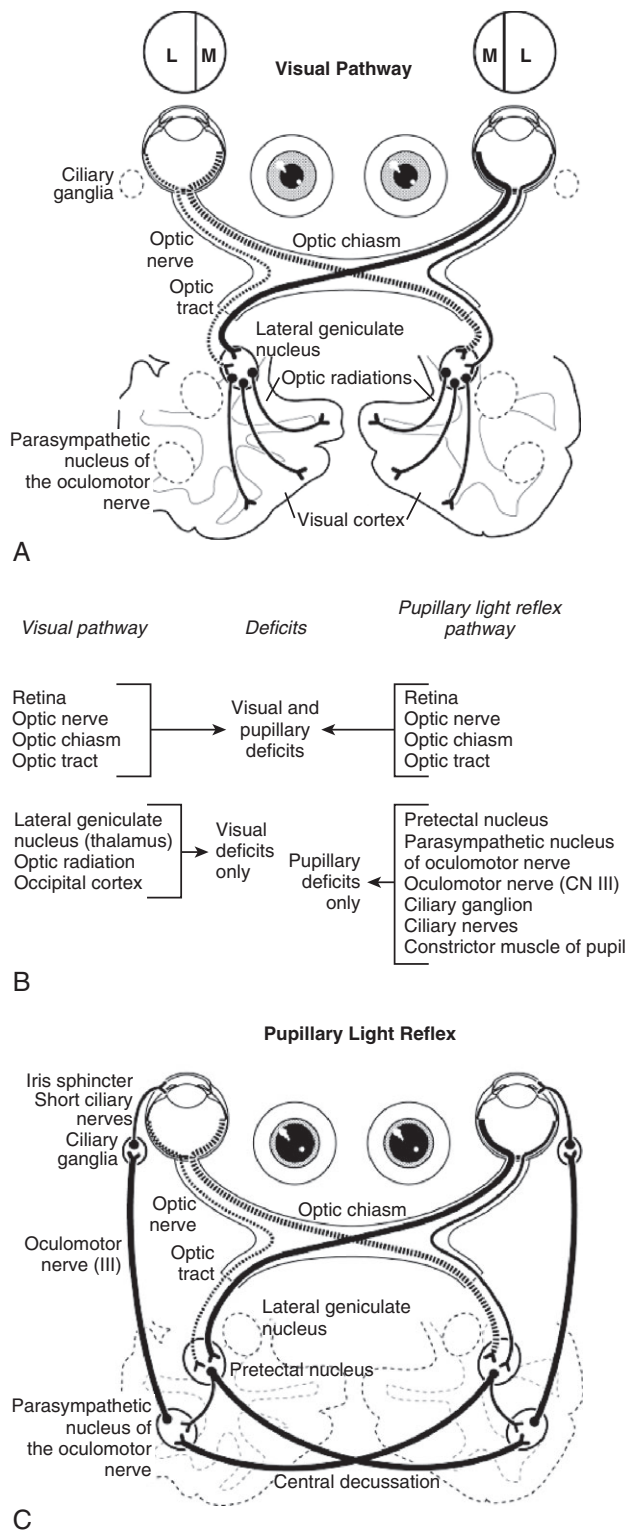
Pupil size (and shape in the cat) is determined by the balance between parasympathetic and sympathetic innervation of the iris. Although emotional and other non-neuro-ophthalmic factors can affect this aperture, pupil size depends in large part on the amount of light illuminating the retina and the afferent and efferent pathways

of the PLR. An understanding of the anatomy of the PLR is essential (Web Figure 80-2, *B* and *C*), along with recognition that the PLR reflex is subcortical (without cerebral cortical involvement) and that the reflex is not an indicator of vision. The response of only a few photoreceptors is required for the PLR to occur.

The afferent arm of the PLR for each eye consists of the retina, optic nerve, optic chiasm, and optic tract. Nerve fibers originating in the medial retina decussate to the opposite optic tract, whereas fibers from the lateral retina remain in the ipsilateral tract. In the dog approximately 75% of the optic nerve fibers decussate to the contralateral optic tract. In the cat approximately 65% of the optic nerve fibers decussate. The optic tracts carry impulses beyond the decussation and include both sensory visual fibers and pupillomotor fibers that differ according to their destinations. This fact is useful for localizing lesions by noting the presence or absence of vision and PLR in each eye. The pupillomotor fibers progress to the pretectal nucleus, and from there the majority of these fibers decussate to the parasympathetic nucleus of the oculomotor nerve (previously known as the Edinger-Westphal nucleus) on the contralateral side. This second decussation marks a return to the side of the originating (light) impulse. In contrast, the visual fibers proceed from the optic tract sequentially to the ipsilateral lateral geniculate nucleus, the optic radiation, and the occipital (visual) cortex. Therefore *lesions that cause anisocoria and affect both PLRs and vision* can be localized to the retina, optic nerve, optic chiasm, or optic tract (see Web Figure 80-2). By contrast, *lesions affecting vision, but not PLRs*, are located in the lateral geniculate nucleus, optic radiation, or occipital cortex.

The efferent arm of the PLR consists of parasympathetic fibers in the oculomotor nerve (CN III) that travel to the ciliary ganglion, postganglionic ciliary nerves, and finally the iris sphincter muscle. In the dog there are five to eight short ciliary nerves that contain both sympathetic and parasympathetic efferent fibers and are considered “mixed.” Therefore a lesion of the ciliary nerve in the dog results in a circular, midrange pupil. By contrast, the cat has only two short ciliary nerves, the nasal (medial) and malar (lateral) nerves; these are solely parasympathetic. Thus lesions involving the feline nerves cause more dramatic pupil dilation than in the dog because sympathetic function is still present and is now unopposed. If only the medial or lateral branch is damaged, dyscoria (altered pupil shape) results in a D-shaped or reverse D-shaped pupil in addition to anisocoria.

The sympathetic fibers innervate the iris dilator muscle. The three-neuron pathway that the sympathetic axons traverse is more complex. The central fibers originate in the hypothalamus and exit the brain with the tectotegmentospinal tract. The preganglionic cell bodies lie in spinal cord segments T1 to T3 and issue fibers that travel with the ventral spinal nerve roots. These pass cranially via the thoracic and cervical sympathetic trunk to terminate in the cranial cervical ganglion, caudal and medial to the tympanic bulla. Postganglionic fibers then exit the ganglion and pass through the cavernous sinus into the periorbita, nasociliary nerve, long ciliary nerve, ciliary body, and finally the iris dilator muscle.



**Web Figure 80-2** Deficits caused by lesions of the visual and pupillary light reflex pathways. (B, From Oliver JE, Lorenz MD, Kornegay JN: Blindness, anisocoria, and abnormal eye movements. In *Handbook of veterinary neurology*, ed 3, Philadelphia, 1997, Saunders, p 274, with permission.)

## The Neuro-ophthalmic Examination

The neuro-ophthalmic examination has a number of components including general observations, neurologic evaluation, assessment of the pupils and PLR, and general ophthalmic examination.

### Observation of Behavior, Gait, and Facial Symmetry and Assessment of Cranial Nerves

The examination begins as the patient is walking toward the examination room. Does the pet have a normal gait or are there abnormalities such as ataxia, hugging the wall, leading with the nose, or tentativeness in movement? Is there a head tilt or circling? When the pet is off leash in the examination room, does it explore (an indication of a sighted or confident long-blind dog) or does it stay close to its owner? If it explores, does it bump into things? Does the pet tend to “lead with one eye” while bumping into objects on the other side?

A crucial part of the neuro-ophthalmic examination is observation of the carriage of the head and assessment of facial and ocular symmetry. It is quite easy to miss neurologic lesions by focusing on only the apparently affected eye in the assessment, especially in cases of anisocoria. For example, Horner’s syndrome and facial nerve paralysis are recognized most often during the initial observation of facial symmetry.

CN II to VIII should be assessed during the neuro-ophthalmic examination. Elicitation of the menace response tests CN II and VII. Pupil size and PLR are observed in order to assess CN II and parasympathetic fibers of CN III along with the sympathetic innervation. The size of the eyelid opening is affected by CN III and VII and sympathetic nerves. The palpebral reflex is determined by CN V and VII. The position of the eyes is controlled by CN III, IV, and VI, the vestibular system, and the brainstem. The oculocephalic reflex induces nystagmus and tests CN VIII along with CN III, IV, VI, and a relatively long segment of brainstem connections from the pontomedullary junction to the midbrain.

### Assessment of Visual Status

It is important to determine the visual status of each eye *before* checking the PLRs. Each eye should be assessed individually because the patient can easily compensate for unilateral blindness. The menace response usually is more notable during the initial part of the examination, before the pet has been subjected to bright lights shone in its eyes but after it is relatively calm on the table.

A properly performed menace test, done without creating air currents or noise, is a helpful test of vision. The menace test involves a learned *response* rather than a *reflex* and is not developed in small animals until 8 to 12 weeks of age. The appropriate response to this gesture is to close the eyes rapidly. Frightened dogs and recalcitrant cats may not blink, even though visual. Often, a cat’s menace response is the slightest flicker of its eyelids. The pathway being tested is optic nerve→optic chiasm→optic tract→lateral geniculate nucleus→optic radiation→visual cortex→motor cortex→internal capsule

and crus cerebri→the facial nuclei in the medulla→facial nerve→eyelid muscles. One hand should cover one eye as the other eye is being tested. The menacing gesture should appear suddenly in the pet's visual field. An easy way to do this is to begin the gesture below the level of the pet's eyes and rapidly bring the menacing hand straight up. Flicking the fingers toward the pet creates noise and air currents and therefore is unreliable. If the pet fails to respond, the reason could be that the facial nerve is not functioning, that the response has not been learned, that there is a cerebellar deficit, or that the examiner is not menacing enough! Facial nerve function should be checked by testing the palpebral reflex. If the eyelids close in response to being tapped, that response is intact. If only the globe retracts and the nictitans protrudes during the menace response, the facial nerve is not functioning, but the pet is visual. Note that the trigeminal nerve (CN V) provides the afferent arm of the palpebral reflex via ocular and periocular sensation and also must be assessed; however, facial nerve problems are more common than trigeminal disorders. If the facial nerve is intact and the pet fails to respond, the examiner should gently tap the head to indicate that he or she will follow through with the menacing gesture, then repeat the menacing gesture without touching the head.

Observing an animal tracking cotton balls dropped in front of it while shielding one eye perhaps is a more reliable test of visual function. Tracking a laser pointer or the light from a penlight are good tests of vision in small animals, especially in cats, because they are notoriously reluctant to participate in the menace response.

Maze tests can be set up easily in the examination room using available objects such as chairs and wastebaskets. The pet should be taken to the opposite side of the room from the owner, should be turned to face away from the owner, and then should be called by the owner. This test can be done under photopic (normal room lighting) and scotopic (darkened room) conditions to test for subtle visual deficits, such as early progressive retinal atrophy.

Visual placing is an additional vision test performed by holding the pet under one's arm as it is moved toward a table. The desired response is for the pet to lift the front limb and place it on the table before touching the table.

The dazzle reflex is a subcortical reflex performed by stimulating one eye with a bright light, with the expected result being closure of the eyelids. The pathway is CN II→rostral colliculus→CN VII. Unlike the menace response, the dazzle reflex still occurs in animals blind from cerebrocortical disease because the cerebrum is not involved in this pathway. This reflex also is present in animals that are blind due to a complete cataract, for example, but have an intact CN II. The response is absent in patients blind due to a subcortical lesion, such as glaucoma causing destruction of the optic nerve.

### Assessment of Pupillary Light Reflexes

A direct PLR is elicited by directing a *bright* light source into the pupil. Ideally, a focused 3.5-volt halogen light source such as a Finnoff transilluminator is used. The transilluminator head can be attached to the battery handle used for a direct ophthalmoscope or otoscope. An

excellent alternative to this is a halogen penlight. The illumination from an ordinary penlight is too diffuse and often too dim to produce a reliable PLR. Use of a weak light source decreases the amplitude and duration of pupil constriction and may induce a delay before pupil constriction begins. The light source should produce light of consistent brightness so that the examiner becomes familiar with the expected response in the examination room. Pupillary constriction on direct light stimulation is known as the *direct PLR*. Pupil constriction in the fellow eye is known as the *consensual response* and, due to incomplete decussation of nerve fibers, usually is less than the direct response (so-called physiologic dynamic anisocoria). If the PLR is incomplete, the light should be redirected to another part of the fundus since areas of the retina may have different light sensitivities, especially with focal or regional abnormalities of the afferent pathway, particularly the retina. Normal findings when eliciting PLRs include equal pupil sizes and shapes in diffuse light, pupils that dilate almost maximally and equally in the dark, and brisk direct and consensual PLRs in both eyes with expected physiologic dynamic anisocoria. Direct and consensual PLRs should be assessed in ambient light first, with findings recorded as "normal," "absent," "incomplete," or "minimal" (see Web Figure 80-1).

### Swinging Flashlight Test

The swinging flashlight test is used to assess and compare the function of the retina and the prechiasmal optic nerve in one eye with the other. The flashlight is not actually swung, but a bright light first is directed into one eye for a few seconds and then is redirected into the fellow eye. The normal response is for the first pupil to constrict fully. Sometimes slight dilation occurs after full pupil constriction in a normal eye as a result of adaptation of the retina to the light stimulus. This is known as *pupillary escape*. As the light is swung to illuminate the second eye, the pupil should constrict a little further (or already be fully constricted) as a result of the consensual PLR. An abnormal finding on the swinging flashlight test occurs when the pupil of the second eye dilates as the light is directed into it. This is known as a *positive swinging flashlight test result* (or the Marcus Gunn sign) and is a hallmark of a lesion in the retina or prechiasmal optic nerve of the eye that dilates when illuminated.

### Dark Adaptation Test and Retroillumination

Once these initial tests are completed, the lights should be turned off to allow the patient's and examiner's eyes to adapt to the darkness for approximately 2 minutes. The examiner should then stand back at arm's length from the patient with the light source set to emit bright illumination and centered between the *examiner's* eyes. This permits the examiner to assess the tapetal reflex obtained simultaneously from both of the patient's eyes. In particular, the degree and symmetry of pupil dilation should be assessed since some causes of anisocoria are associated with more marked pupil asymmetry in dim than in bright ambient light. The examiner should repeat assessment of

PLRs and the swinging flashlight test in the dark because differences are more marked after dark adaptation.

## Completion of the Ophthalmic Examination

After vision testing, PLR testing, retroillumination, and the swinging flashlight test are performed, a thorough ocular examination, including tonometry and assessment of aqueous flare, should be completed to identify or eliminate ophthalmic causes of anisocoria (see Chapter 242). This approach allows the clinician to identify and confirm the presence of anisocoria, recognize the abnormal pupil, and begin consideration of causes under the broad mechanistic headings of “nonneurologic” (further divided into ophthalmic and pharmacologic causes) and “neurologic” (further divided into afferent and efferent lesions).

## Nonneurologic Causes of Anisocoria

### Ophthalmic Causes of Anisocoria

Ophthalmic causes of anisocoria can be divided into conditions that cause miosis (a constricted pupil) and those that cause mydriasis (a dilated pupil).

*Miotic pupils* are associated with a number of ocular diseases. Anterior uveitis may cause miosis. PLRs may be sluggish or difficult to see because of extreme miosis or posterior synechiae (adhesions between the iris and the anterior lens capsule). Corneal irritation, especially ulcers and lacerations, causes a reflex miosis mediated by the trigeminal nerve known as the *axonal reflex*. These conditions are recognized easily by focal corneal edema, possible corneal stromal defect, and retention of fluorescein dye. It is wise to apply fluorescein stain to all eyes with miosis as a presenting sign.

Similarly, mydriasis can be associated with primary ocular lesions. Iris atrophy is a normal aging change resulting in an irregular or scallop-edged pupil, as well as defects in the iris caused by atrophy of the iris musculature. These defects are best seen during retroillumination (directing a light toward the fundus and observing light reflected from the tapetum through the pupil). Because the atrophy involves the iris muscles, PLRs may be diminished or absent. Iris atrophy is usually bilateral but is not always symmetric, and such unevenness can produce anisocoria. Iris hypoplasia, a congenital defect in iris stromal thickness, can cause decreased pupillary constriction similar to that seen in patients with iris atrophy. Iris tumors such as melanomas may cause mydriasis if they infiltrate the iridal musculature and impede its function. They also may produce mydriasis if they cause secondary glaucoma. The pupil of glaucomatous eyes may be mydriatic. Other signs of glaucoma include episcleral congestion, generalized corneal edema, and above-normal intraocular pressure. PLRs often are slow or absent. Visual deficits also are present if the intraocular pressure is markedly or persistently elevated. Severe blunt ocular trauma can damage iridal sphincter fibers, with resultant iridoplegia.

Unilateral retinal or optic nerve disease can cause mydriasis, although the anisocoria tends to be relatively subtle (especially in dim ambient light) because decussation of afferent fibers causes stimulation of the

pupillomotor fibers of the affected eye via the contralateral retina. However, direct and consensual PLRs typically are slow or absent, and the swinging flashlight test should yield positive results. In addition, visual deficits usually are present but may or may not be noted by owners since pets typically compensate well for unilateral vision loss. Fundic examination can reveal the cause of unilateral retinal abnormalities leading to mydriasis. Perhaps the most common cause of unilateral retinal disease is retinal detachment, which has the ophthalmoscopic appearance of an undulating veil containing blood vessels coming toward the observer (see Web Chapter 76). Severe chorioretinitis that affects a large area in one eye can cause unilateral mydriasis. Unilateral optic neuritis and optic nerve neoplasia also can produce mydriasis and vision loss. Optic nerve causes of mydriasis usually produce ophthalmoscopically visible changes, but only the retrobulbar portion of the nerve may be affected. Orbital neoplasia, cellulitis, or retrobulbar abscess also should be considered in patients with unilateral loss of vision, altered PLRs, and a positive finding on the swinging flashlight test in conjunction with exophthalmos or decreased retropulsion.

### Pharmacologic Causes of Anisocoria

Pharmacologic causes of anisocoria can be divided into drugs that produce miosis and those that produce mydriasis. Miosis most often is caused by administration of agents used for management of glaucoma. These include pilocarpine, demecarium bromide, and any of the new synthetic prostaglandins such as latanoprost. Mydriasis can be caused by administration of tropicamide or atropine, ocular contact with jimsonweed (*Datura stramonium*) or other toxic plants, or topical administration of collyria or ocular decongestants containing phenylephrine. The likelihood of exposure to pharmacologic agents that alter pupil size should be specifically elicited when the patient history is obtained.

### Neurologic Causes of Anisocoria

Neurologic causes of anisocoria should be localized as afferent or efferent lesions within the nervous system. A complete ophthalmic examination and elicitation of any history of exposure to pharmacologic agents are essential first steps in neuroanatomic localization. Monitoring the change in anisocoria during dark adaptation assists further with the localization.

### Characteristics of Afferent and Efferent Lesions

Anisocoria caused by an *afferent lesion* is abolished (or sometimes reduced) as both pupils dilate in the dark. This is because the stimulus producing the anisocoria (light causing constriction of the normal pupil but inadequate constriction of the abnormal pupil) is eliminated. Thus anisocoria caused by afferent lesions is less prominent in dim ambient light and more prominent in bright light. In addition, afferent lesions cause abnormal PLRs in *both* the abnormal and the normal pupil (Web Table 80-1 and Web Figure 80-3). If the pupils remain unequal or do not

**WEB TABLE 80-1**

**Signs of Lesions in the Visual Pathways**

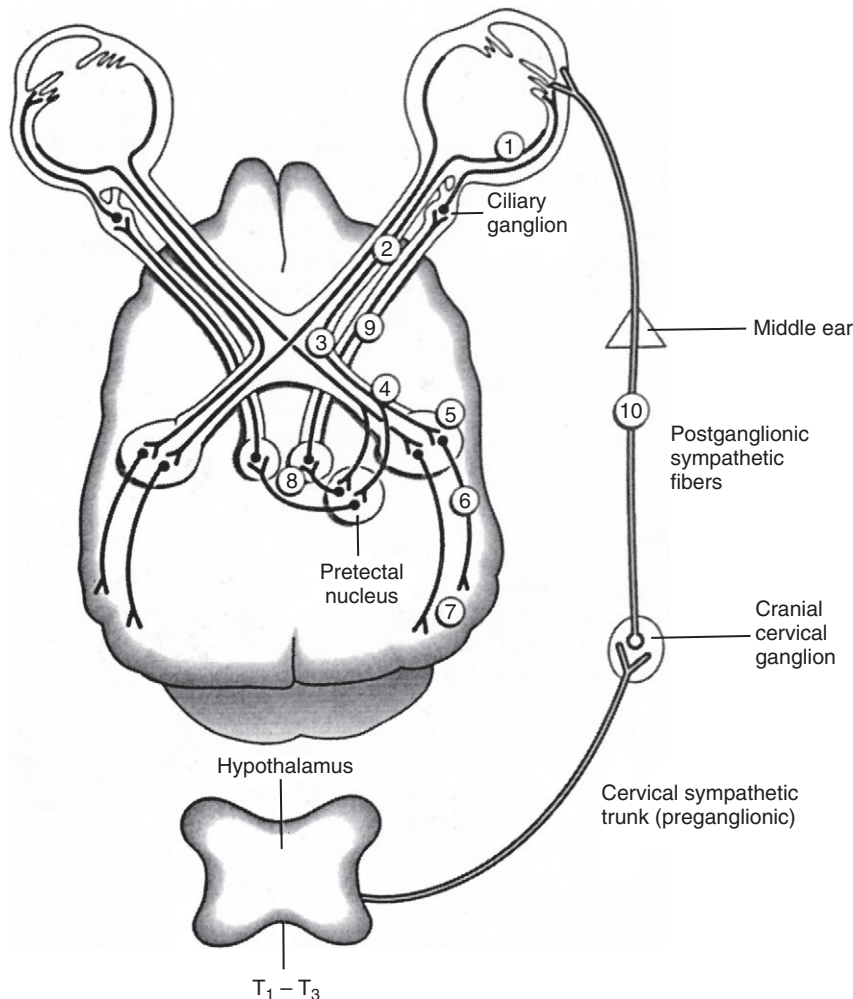
This table is designed for use with Web Figure 80-3. Numbers correspond to those in the figure indicating structures that are possible lesion sites.

Complete Lesion on <i>Right Side</i>	VISION		RESTING PUPIL		PUPILLARY LIGHT REFLEX	
	Right Eye	Left Eye	Right Eye	Left Eye	Light in Right Eye	Light in Left Eye
1. Retina or optic nerve	Absent	Normal	Slightly dilated	Normal	No response	Both constrict
2. Orbit (CN II, III)	Absent	Normal	Dilated	Normal	No response	Left constricts
3. Optic chiasm (bilateral)*	Absent	Absent	Dilated	Dilated	No response	No response
4. Optic tract	Normal	Absent†	Normal or slightly miotic	Normal or slightly dilated	Both constrict	Both constrict
5. Lateral geniculate nucleus	Normal	Absent†	Normal	Normal	Both constrict	Both constrict
6. Optic radiation	Normal	Absent†	Normal	Normal	Both constrict	Both constrict
7. Occipital cortex	Normal	Absent†	Normal	Normal	Both constrict	Both constrict
8. Parasympathetic nucleus of CN III (bilateral)*	Normal	Normal	Dilated	Dilated	No response	No response
9. Oculomotor nerve	Normal	Normal	Dilated	Normal	Left constricts	Left constricts
10. Sympathetic nerve	Normal	Normal	Constricted	Normal	Both constrict	Both constrict

\*Unilateral lesions of these structures are rare.

†Possibly loss of sight in left visual field with partial sparing of right visual field.

CN, Cranial nerve.



**Web Figure 80-3** Pathway for vision, pathway for the pupillary light reflex, and the sympathetic pathway affecting the eye. Numbers correspond to structures that are lesion sites as identified in Web Table 80-1. *T<sub>1</sub>-T<sub>3</sub>*, Spinal cord segments. (Modified and redrawn from Oliver JE, Lorenz MD, Kornegay JN: Blindness, anisocoria, and abnormal eye movements. In *Handbook of veterinary neurology*, ed 3, Philadelphia, 1997, Saunders, p 275, with permission.)

dilate completely in the dark, the cause must be (1) a lesion in the sympathetic efferent arm, (2) an ophthalmic lesion, or (3) pharmacologic.

Signs of *efferent lesions* involving the PLR produce dramatically different signs depending on how intense the ambient light is and whether (1) the lesion involves the parasympathetic or sympathetic neurons of the efferent arm, (2) the lesion affects the central neurons (for the sympathetic supply) or preganglionic or postganglionic neurons (for both parasympathetic and sympathetic supplies), and (3) the patient is feline or canine. These differences are discussed more fully in the following paragraphs. However, efferent lesions of any type or site do not cause visual deficits in either species (see Web Table 80-1 and Web Figure 80-3).

## Afferent Lesions

### *Unilateral Retinal or Prechiasmal Optic Nerve Lesions*

Patients with unilateral retinal or prechiasmal lesions have mydriasis (usually subtle) and a slow or absent direct PLR on the affected side but a normal consensual PLR from the unaffected to the affected eye. They also have visual deficits on the affected side and a positive finding on the swinging flashlight test. The last feature is pathognomonic for lesions at these sites. The fundus should be examined for retinal or optic nerve head abnormalities. If the fundic examination shows normal findings, an electroretinogram can be performed to localize the lesion further. If the electroretinogram results are normal (i.e., the retina is functioning) and the optic nerve head appears ophthalmoscopically normal, the retrobulbar (but prechiasmal) optic nerve is affected.

### *Unilateral Optic Tract Lesions*

Patients with unilateral optic tract lesions have mydriasis (usually subtle) in the eye contralateral to the affected optic tract, regardless of which eye is receiving the light stimulus. Additionally, visual field deficits and a negative result on the swinging flashlight test are observed. Unlike with prechiasmal lesions, with postchiasmal lesions the pupil contralateral to the lesion is affected because of the influence of CN II fiber decussation (75% in dogs, 65% in cats). The input to the pretectal nucleus on the affected side and to the central (second) decussation becomes markedly decreased, which results in fewer impulses to the contralateral parasympathetic nucleus of CN III. Consequently normal stimulation of the oculomotor nerve on the contralateral side does not occur. The eye contralateral to the optic tract lesion also will have a partial visual deficit in the temporal field because the majority of the optic tract is composed of fibers from the medial retina of the contralateral eye. A small nasal visual field deficit on the ipsilateral side also will be seen due the presence of nondecussated fibers in the affected optic tract; however, this small visual field deficit is not usually apparent to the owner.

### *Optic Chiasm Lesions*

Chiasm lesions rarely cause anisocoria; rather, they usually cause bilateral mydriatic pupils, absent PLRs, and vision loss. This is due to the fact that chiasm lesions

typically are caused by space-occupying masses such as pituitary tumors that affect both sides of the chiasm.

## Efferent Lesions

### *Parasympathetic Efferent Lesions*

The preganglionic efferent nerves in dogs are purely parasympathetic, but the postganglionic nerves are mixed. In cats both nerves are purely parasympathetic. Therefore lesion site and species affected cause notable differences in the pupillary signs observed.

Lesions of the nucleus of CN III, the preganglionic fibers, or the ganglion itself produce similar signs in dogs and cats. Direct and consensual PLRs are diminished or absent on the affected side and normal on the unaffected side. Vision is normal, and the pupils dilate equally and maximally in the dark.

In cats, lesions of the ganglion or postganglionic nerves cause signs identical to those of preganglionic lesions because only parasympathetic fibers are affected. However, pupil shape also differs if only one of the two postganglionic short ciliary nerves is affected (as discussed earlier). In contrast, ganglionic or postganglionic lesions in the dog cause anisocoria after dark adaptation, with the smaller pupil ipsilateral to the lesion because the concurrent parasympathetic and sympathetic denervation affects the ability of the pupil to constrict and dilate.

Mydriasis induced by dysfunction of the parasympathetic component of CN III that innervates the iris sphincter muscle is termed *internal ophthalmoplegia*. This is differentiated from external ophthalmoplegia, which occurs following damage to the oculomotor fibers that also run in CN III and which is manifested as ptosis (drooping of the upper lid) and lateral strabismus. Dogs and cats can experience internal ophthalmoplegia without external ophthalmoplegia because the parasympathetic fibers are superficial and medial to the oculomotor fibers of CN III and therefore are more susceptible to injury than the oculomotor fibers. Internal ophthalmoplegia may be the result of trauma from proptosis; retrobulbar disease such as abscess, cellulitis, hemorrhage, or orbital or optic nerve neoplasm; or midbrain lesions.

**Pharmacologic Localization of Parasympathetic Lesions.** Pharmacologic testing may be used to confirm the presence of a lesion in the efferent arm of the PLR, rule out pharmacologic blockade and iridal disease, and localize the lesion as preganglionic or postganglionic. A lesion in the ganglion or postganglionic fibers causes denervation hypersensitivity to what normally would be an ineffective concentration of a topically administered parasympathomimetic drug. The first agent used in localizing a lesion in the parasympathetic efferent pathway is an indirect-acting parasympathomimetic such as 0.5% physostigmine. The desired response is miosis. The pupil of an eye with a central or preganglionic lesion constricts sooner than one with normal parasympathetic innervation. The pupil of an eye with a lesion in the ciliary ganglion or postganglionic fibers does not constrict. Application of dilute pilocarpine (<0.2%) is perhaps the most useful test for the general practitioner. Denervation hypersensitivity causes the affected pupil to constrict sooner and more completely and to maintain the

constriction longer in response to this low concentration of a direct-acting parasympathomimetic compared with the pupil in the normal eye. Application of a more concentrated direct-acting parasympathomimetic agent such as 2% pilocarpine can be used simply to confirm the presence of an efferent arm lesion (and to rule out mechanical obstruction such as synechia, iris atrophy, or pharmacologic mydriasis). However, this will not define the lesion location.

### **Sympathetic Efferent Lesions**

The loss of sympathetic tone to the eye commonly is known as *Horner's syndrome* (HS). Signs of HS always are ipsilateral to the lesion and include miosis, ptosis, protrusion of the third eyelid, and enophthalmos. Miosis may persist after the other signs have disappeared. About 50% of canine cases and 42% of feline cases of HS are idiopathic (Kern et al, 1989). However, the patient should be evaluated for commonly identified causes of HS in small animals such as trauma to the head, neck, or chest; brachial plexus root avulsion; intracranial, mediastinal, or intrathoracic neoplasia; cervical or thoracic spinal cord disease; otitis media or interna; and injury to the ear during cleaning. Hypothyroidism may be a factor in HS. Dogs that are tied and repeatedly lunge at the end of their tether are at risk of neck trauma and HS. Golden retrievers and collies are suggested to be predisposed to HS. Preganglionic lesions have a poorer prognosis than postganglionic ones because of the structures involved. Most idiopathic cases of HS resolve in 4 to 16 weeks.

**Pharmacologic Localization of Sympathetic Efferent Lesions.** As with parasympathetic lesions, pharmacologic testing may be used to confirm the presence of a sympathetic lesion in the efferent arm of the PLR, rule out pharmacologic blockade and iridal disease, and further localize the lesion. The same principles of denervation hypersensitivity apply (i.e., lesions of the ganglion or postganglionic neuron cause hypersensitivity); however, in this case mydriasis is the desired response. Ideally the first step is to instill an indirect-acting sympathomimetic such as 1% hydroxyamphetamine into both eyes; however, this drug is difficult to obtain commercially. When it is applied topically, the affected pupil dilates if the lesion is central or preganglionic, whereas no or little dilation occurs if the lesion is postganglionic. An easier way to confirm the diagnosis of HS is to instill a dilute direct-acting sympathomimetic such as 1% phenylephrine into each eye. Both eyes should be reassessed every 10 minutes until pupil dilation has occurred in the

affected eye or until 40 minutes have passed. The denervated (hypersensitive) pupil reacts by dilating before or in the absence of pupillary dilation in the unaffected eye. The other signs of HS also may diminish during this pharmacologic challenge. Some authors suggest that if mydriasis occurs before 20 minutes the lesion is postganglionic, and if it occurs between 20 and 45 minutes it likely is preganglionic. This phenomenon is explained by a greater hypersensitivity and quicker response with postganglionic lesions. The phenylephrine test alone does not allow discrimination between a preganglionic and a central lesion.

### **Spastic Pupil Syndrome**

Spastic pupil syndrome occurs only in cats and is characterized by static anisocoria (at the time of examination), failure of the pupil to dilate after dark adaptation, normal vision, and no ocular abnormalities. The curious feature of this syndrome is that the degree of anisocoria and the relative size of the pupils can change from day to day (i.e., the anisocoria can be caused by a relative miosis or mydriasis, and this can change). There even may be intervals when the pupils are normal. Most cats with this syndrome test positive for feline leukemia virus.

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