Horner syndrome: clinical perspectives

Sivashakthi Kanagalingam1–3
Neil R Miller1–3
1Department of Ophthalmology,
2Department of Neurology,
3Department of Neurosurgery,
The Johns Hopkins Hospital,
Baltimore, MD, USA

Abstract: Horner syndrome consists of unilateral ptosis, an ipsilateral miotic but normally reactive pupil, and in some cases, ipsilateral facial anhidrosis, all resulting from damage to the ipsilateral oculosympathetic pathway. Herein, we review the clinical signs and symptoms that can aid in the diagnosis and localization of a Horner syndrome as well as the causes of the condition. We emphasize that pharmacologic testing can confirm its presence and direct further testing and management.

Keywords: Horner syndrome, oculosympathoparesis, anisocoria, ptosis, anhidrosis

Horner syndrome

The disruption of sympathetic innervation to the eye gives rise to a constellation of symptoms consisting of miosis, ptosis, and anhidrosis. This syndrome was initially described in animals by the French physiologist Claude Bernard in 1854 and subsequently in a soldier who sustained a gunshot injury to his neck. However, Swiss ophthalmologist Johann Friedrich Horner is largely credited to be the first to completely describe this syndrome in 1869 and to correctly attribute it to oculosympathetic paresis. (Figure 1)

Localization

Central (first-order neuron) Horner syndrome

First-order neurons are located in the posterolateral hypothalamus, and from there, sympathetic fibers pass through the lateral brain stem and extend to the ciliospinal center of Budge and Waller in the intermediolateral gray column of the spinal cord at C8–T1 (Figure 2). A central Horner syndrome caused by damage to any of these structures is ipsilateral to the lesion, is almost always unilateral, and often produces hemihypohidrosis of the entire body.

Lesions of the hypothalamus, such as tumor or hemorrhage, can cause an ipsilateral Horner syndrome with contralateral hemiparesis and contralateral hypesthesia. Lesions of the thalamus result in contralateral ataxic hemiparesis, contralateral hypoesthesia, vertical gaze paresis, and dysphasia. The combination of a unilateral Horner syndrome and a contralateral trochlear nerve paresis suggests a lesion of the dorsal mesencephalon. The lesion injures either the trochlear nucleus on the side of the Horner syndrome or the ipsilateral fascicle. Pontine lesions can produce a Horner syndrome associated with an ipsilateral abducens nerve paresis; however, bilateral abducens nerve palsies in this setting have also been reported.

Correspondence: Neil R Miller
Wilmer Eye Institute, The Johns Hopkins Hospital, Woods 458, 600 North Wolfe Street, Baltimore, MD 21287, USA
Tel +1 410 502 3213
Fax +1 410 502 3214
Email nrmiller@jhmi.edu
Lateral medullary infarction can cause several neurological deficits, including a central Horner syndrome. Among 33 consecutive patients with lateral medullary infarction, Horner syndrome was found in 91%, ipsilateral ataxia in 85%, and contralateral hypalgesia in 85%. These features form the clinical triad known as the Wallenberg syndrome. Other neurological features, such as vertigo, dysphagia, nystagmus, and facial weakness, are less common. Wallenberg syndrome most often is caused by thrombotic occlusion of the ipsilateral vertebral artery, although isolated posterior inferior cerebellar artery disease also can produce this condition. In a series of 130 patients with lateral medullary infarction, the pathogenesis was large-vessel infarction in 50%, arterial dissection in 15%, small-vessel infarction in 13%, and cardiac embolism in 5%. Demyelinating disease of the medulla has also been reported to be the cause of Wallenberg syndrome.

Lesions of the lower cervical or upper thoracic spinal cord can cause a central Horner syndrome. Occasionally, Horner syndrome may be the only neurological abnormality at presentation. Spinal cord lesions that may cause a central Horner syndrome include trauma, inflammatory or infectious myelitis, vascular malformation, demyelination, syrinx, syringomyelia, neoplasms, and infarction. Patients with the Brown-Séquard syndrome from trauma or cervical

Figure 1 Right Horner syndrome in a 65-year-old man. Note right-sided upper lid ptosis, right miosis, and “upside-down” ptosis (i.e., elevation) of right lower lid.

Figure 2 Drawing showing the anatomy of the oculosympathetic pathway.

Notes: Sympathetic fibers in the posterolateral hypothalamus pass through the lateral brain stem and to the ciliospinal center of Budge and Waller in the intermediolateral gray column of the spinal cord at C8–T1. Preganglionic sympathetic neurons exit from the ciliospinal center of Budge and Waller and pass across the pulmonary apex and ascend up the carotid sheath to the superior cervical ganglion. The postganglionic sympathetic neurons originate in the superior cervical ganglion and travel up the wall of the internal carotid artery. Once the fibers reach the cavernous sinus, they travel with the abducens nerve before joining the ophthalmic division of the trigeminal nerve and entering the orbit with its nasociliary branch. From here, they divide into two long ciliary nerves to reach the iris dilator muscle. Copyright © 1978 Wolters Kluwer. Reproduced with permission from Glaser JS, editor. Neuro-ophthalmology. 1st ed. Hagerstown MD, USA: Harper & Row; 1978.

Abbreviations: a, artery; n, nerve.
disk herniation also have been noted to have a central Horner syndrome on the same side as the loss of light touch and motor function and contralateral to the side with the loss of temperature and pain sensation. A phenomenon termed alternating Horner syndrome (ie, alternating oculosympathetic deficit) can be seen in patients with cervical cord lesions and in some patients with systemic dysautonomias.

Preganglionic (second-order neuron) Horner syndrome

The preganglionic sympathetic neurons exit from the ciliospinal center of Budge and Waller and pass across the pulmonary apex. They then ascend through the stellate ganglion and up the carotid sheath to synapse at the superior cervical ganglion, located at the level of the bifurcation of the common carotid artery and the angle of the jaw.

In a series of 450 patients with Horner syndrome, 270 (65%) were found to have an identifiable cause. Of the patients with a detectible etiology, 13% had a central lesion, 44% had a preganglionic lesion, and 43% had a postganglionic lesion. In another large series, malignancy was the cause of about 25% of cases of preganglionic Horner syndrome. The most common tumors were lung and breast cancer. Horner syndrome usually presents long after the diagnosis of cancer has been established and only rarely has been part of the initial presentation.

Apical lung lesions that spread locally to the region of the superior thoracic outlet can cause symptoms of ipsilateral shoulder pain, paresthesias along the medial arm, forearm, and fourth and fifth digits, weakness/atrophy of the hand muscles, and a preganglionic Horner syndrome. This combination of signs is called the Pancoast syndrome. The most common cause of Pancoast syndrome is non-small cell lung carcinoma; however, other primary apical tumors such as adenoid cystic carcinoma, hemangiopericytoma, and mesothelioma, have also been reported to cause this syndrome. Despite advances in neuroimaging and other diagnostic tests, as many as 28% of preganglionic Horner syndromes have no identifiable etiology.

Postganglionic (third-order neuron) Horner syndrome

The postganglionic (third-order) sympathetic neurons originate in the superior cervical ganglion, travel in the wall of the internal carotid artery, and continue on to the cavernous sinus. Within the cavernous sinus, the fibers briefly travel with the abducens nerve before joining the ophthalmic division of the trigeminal nerve and entering the orbit with its nasociliary branch (Figure 3A and B). The sympathetic fibers in the nasociliary nerve divide into the two long ciliary nerves that travel with the lateral and medial suprachoroidal vascular bundles to reach the anterior segment of the eye and innervate the iris dilator muscle.

Lesions of the internal carotid artery classically present with unilateral head and/or neck pain, focal cerebral ischemic symptoms, and a Horner syndrome. This form of Horner syndrome is often referred to as an incomplete Horner syndrome because it consists of ptosis and miosis but not anhidrosis. This is because the lesion affects the sympathetic fibers in the internal carotid plexus but spares the external carotid plexus that innervates the facial sweat glands. This painful Horner syndrome most often is caused by a traumatic or spontaneous dissection of the cerebral internal carotid artery. In a large series of 146 patients with such lesions, a Horner syndrome was the most common finding, and in half of these cases was the initial and sole manifestation.

Internal carotid artery lesions other than dissections that are associated with a Horner syndrome include atherosclerosis, severe atherosclerosis, acute thrombosis, fibromuscular dysplasia, Ehler–Danlos syndrome, Marfan syndrome, and arteritis. In addition, mass lesions in the neck, such as paraganglioma, and mediastinal tumors or cysts can also cause a preganglionic Horner syndrome.

Injury to the brachial plexus or spinal roots, pneumothorax, fracture of the first rib, or neck hematoma are potential causes of a preganglionic Horner syndrome following trauma. In addition, the preganglionic sympathetic chains are vulnerable to iatrogenic injury. The varied anesthetic, radiologic, and surgical procedures that can produce an iatrogenic Horner syndrome include coronary artery bypass surgery, lung or mediastinal surgery, carotid endarterectomy, insertion of a pacemaker, epidural anesthesia, interpleural placement of chest tubes, internal jugular catheterization, and stenting of the internal carotid artery.

Despite advances in neuroimaging and other diagnostic tests, as many as 28% of preganglionic Horner syndromes have no identifiable etiology.
tumors, inflammatory masses, enlarged lymph nodes, and ectatic jugular veins, can compress the carotid sympathetic neurons, resulting in a Horner syndrome.\(^{56,57}\)

Damage to the superior cervical ganglion can cause a postganglionic Horner syndrome as the ganglion lies about 1.5 cm behind the palatine tonsil and can be damaged by traumatic penetrating intraoral injury or even procedures such as tonsillectomies, intraoral surgery, and peritonsillar injections.\(^{58,59}\) Skull base lesions can cause a postganglionic Horner syndrome that typically is associated with a variety of cranial nerve deficits. A middle fossa mass encroaching on Meckel’s cave and the internal carotid artery at the foramen lacerum can produce a Horner syndrome associated with trigeminal pain or sensory loss. A basal skull fracture involving the petrous bone can cause a Horner syndrome with an ipsilateral abduction deficit, facial palsy, and sensorineural hearing loss.\(^{60}\) Any lesion in the cavernous sinus may produce a postganglionic Horner syndrome in conjunction with one or more ocular motor nerves. The presence of an abducens palsy and a postganglionic Horner syndrome is highly suggestive of a lesion in the posterior cavernous sinus.\(^{61-65}\)

Cluster headaches are severe lancinating unilateral headaches characterized by ipsilateral tearing, nasal stuffiness, conjunctival injection, and ptosis. A transient postganglionic Horner syndrome can be seen in 5%–22% of these patients, and permanent oculosympathetic paresis has been reported in some patients who experience repeated attacks.\(^{66,67}\) Raeder paratrigeminal neuralgia, a painful postganglionic Horner syndrome accompanied by ipsilateral trigeminal neuralgia, is associated with lesions in the middle cranial fossa medial to the trigeminal ganglion.\(^{68-70}\)
Clinical perspectives on Horner syndrome

Horner syndrome in children

The causes of Horner syndrome in children are usually classified as congenital or acquired (Figure 4). In addition to iris heterochromia, infants with Horner syndrome can demonstrate contralateral hemifacial flushing and ipsilateral hypohidrosis, called Harlequin syndrome. Congenital Horner syndrome is usually caused by birth trauma. In these cases, a history of delivery using forceps, vacuum extraction, shoulder dystocia, fetal rotation, and/or limb manipulation can usually be elicited. Concomitant brachial plexus injury is sometimes identified. Other etiologies include congenital tumors, postviral damage, and internal carotid artery agenesis, hypoplasia, and fibromuscular dysplasia.

In a large study of 73 pediatric patients, 42% were noted to be congenital in nature, and 42% were acquired after a surgical procedure involving the thorax, neck, or central nervous system. Of the other 15% of acquired Horner syndromes, the etiologies included spinal cord tumors, neuroblastoma, rhabdomyosarcoma, brachial plexus trauma, intrathoracic aneurysm, embryonal cell carcinoma, and brainstem vascular malformations.

Neuroblastoma is the most common occult malignancy associated with Horner syndrome, with an incidence of one in 7,000 children younger than the age of 5 years. Early detection of neuroblastoma is crucial as the prognosis for survival declines if the diagnosis is made after the age of 1 year. Hence, in a child with Horner syndrome in whom there is no clear history of surgery or birth trauma, a careful physical examination combined with urinary catecholamine testing and magnetic resonance imaging of the brain, neck, and chest is recommended. Using this principle, Jeffery et al found that 55% of children with an acquired Horner syndrome had a potentially fatal underlying disease, and Mahoney et al identified an underlying mass lesion in 21% of their patients. Nevertheless, it should be noted that a significant number of pediatric Horner syndromes are idiopathic. George et al found no etiology in 16 of 23 (70%) infants with Horner syndrome identified in the 1st year of life, and Smith et al could not identify an etiology in 35% of children with a Horner syndrome who were followed for a mean period of 5 years.

Clinical features

Ptosis

The ipsilateral upper eyelid appears slightly drooped due to paresis of the Müller muscle, a sympathetically innervated smooth muscle that also functions as an upper eyelid retractors and is responsible for about 2 mm of upper eyelid elevation. Nonetheless, this ptosis may be subtle, variable, and go unnoticed. In addition, one study noted that in 12% of patients with Horner syndrome, the ptosis was in fact absent (Figure 1).

The smooth muscle fibers of the lower eyelid retractors also lose their sympathetic supply in patients with Horner syndrome and, thus, the lower eyelid appears slightly elevated. This appearance has been termed “upside-down ptosis” or “reverse ptosis”. The combination of the upper eyelid ptosis and the lower eyelid elevation narrows the palpebral fissure, giving rise to an apparent enophthalmos. Several authors have since proven that this apparent enophthalmos is not of measurable significance, and hence is not true enophthalmos.

Pupillary signs

Oculosympathetic paresis results in weakness of the iris dilator muscle on the affected side. The unopposed parasympathetic action of the iris constrictor muscle produces a smaller ipsilateral pupil. The resulting anisocoria is most apparent in darkness and may, in fact, be overlooked if the patient is evaluated in bright light.

Several factors influence the degree of anisocoria in patients with Horner syndrome. For example, when a patient is fatigued or drowsy, the size of the pupils and the degree of anisocoria diminish as the hypothalamic sympathetic outflow to both eyes subsides and uninhibited parasympathetic outflow augments. The actual degree of anisocoria in Horner syndrome thus varies with the resting size of the pupils, the patient’s alertness, the patient’s fixation at distance and at near, the brightness of the examiner’s light, the completeness of the injury, and the concentration of circulating adrenergic substances in the blood.

Paresis of the iris dilator muscle also impairs pupillary movement during dilation, termed dilation lag. Dilation lag can be seen clinically by illuminating the patient’s eyes tangentially from below with a hand-held flashlight and then abruptly

Figure 4 Infant with right Horner syndrome, demonstrating ipsilateral upper lid ptosis, “upside-down” ptosis of the lower lid, and anisocoria, with the right pupil smaller than the left. Both pupils reacted briskly to light stimulation.
turning the room lights out. The normal pupil will immediately dilate, but the Horner pupil begins to dilate several seconds later. The difference in anisocoria is greatest after 4–5 seconds in the darkness. Thereafter, the Horner pupil slowly dilates from decreasing parasympathetic tone and eventually catches up in size to the normal pupil. Thus, if both pupils are observed simultaneously for 15–20 seconds after turning off the room light, one sees an initial increase in the degree of anisocoria, followed by decreasing anisocoria. Continuous recording pupillography has demonstrated that anisocoria is more marked at 4–5 seconds in darkness than it is at 10–12 seconds.\(^9\) Taking photographs in darkness at 5 seconds and again at 15 seconds can reveal decreasing anisocoria in the later phase of dilation.\(^9\) Videography with infrared illumination can also demonstrate this phenomenon.\(^9\) Others have reported that a single measurement of anisocoria taken within the first 5 seconds of darkness is adequate for identifying dilation lag. One study reported that 0.6 mm or more at 4 seconds was 82% sensitive for diagnosing a unilateral Horner syndrome.\(^9\) Using binocular infrared video pupillometry with continuous recording of pupil diameters, Smith and Smith found that after a light flash, a delay in the time needed to recover three-quarters of the baseline pupil size had a 70% sensitivity and 95% specificity in detecting unilateral Horner syndrome.\(^9\) These investigators also found this method to be useful in detecting cases of bilateral Horner syndrome.\(^9\) However, using this technology, Crippa et al noted that dilation lag is only intermittently present in patients with Horner syndrome,\(^9\) being present in 53% at the first determination and in 87% at some point during four determinations. They concluded that although dilation lag is a notable characteristic of Horner syndrome, it may not always be evident. Thus, a diagnosis of Horner syndrome should not be made in the absence of a demonstrable dilation lag of the smaller pupil.

Iris hypochromia
Sympathetic innervation is thought to be required for the formation of melanin by stromal melanocytes.\(^7\) Interruption of the sympathetic supply can lead to iris hypochromia on the affected side. This is a typical feature of congenital Horner syndrome. It is also occasionally seen in patients with a long-standing, acquired Horner syndrome, but never in patients with an acute or recently acquired Horner syndrome.\(^9\)

Accommodation
A few authors have noted that patients with Horner syndrome can experience an increase in accommodative amplitude on the ipsilateral side.\(^100,101\)

Anhidrosis
Characteristic vasomotor and sudomotor changes of the facial skin can occur on the affected side in some patients with Horner syndrome. Immediately following sympathetic denervation, the temperature of the skin rises on the side of the lesion because of loss of vasomotor control and consequent dilation of blood vessels. Additionally, there may be facial flushing, conjunctival hyperemia, epiphora, and nasal stuffiness in the acute stage.\(^93,102,103\) Some time after the injury, the skin of the ipsilateral face and neck may have a lower temperature and may be paler than that of the normal side. This occurs from supersensitivity of the denervated blood vessels to circulating adrenergic substances, with resultant vasoconstriction.\(^10\) However, in modern temperature-controlled spaces, patients with Horner syndrome rarely complain of disturbances of sweating or asymmetric facial flushing.

Paradoxical unilateral sweating with flushing of the face, neck, shoulder, and arm can be a late development in patients with a surgically induced Horner syndrome following cervical sympathectomy. Some axons in the vagus nerve normally pass into the superior cervical ganglion. These parasympathetic axons can establish, by collateral sprouting, anomalous vagal connections with postganglionic sympathetic neurons to the head and neck.\(^10\)

Diagnosis
The diagnosis of Horner syndrome should be considered in any patient with anisocoria associated with what appears to be normal pupillary constriction to light in both the larger and smaller pupil. The presence of dilation lag of the smaller pupil, when present, is also helpful in making the diagnosis. Patients in whom a Horner syndrome is suspected should be evaluated for evidence of cranial nerve dysfunction, particularly an ipsilateral abducens nerve paresis that may indicate a lesion of the cavernous sinus or, in very rare cases, of the brain stem. Anhidrosis can be diagnosed in some patients from a history that when they exercise, they perspire on one side of the forehead but not on the other. In other patients, the presence of unilateral anhidrosis can be easily assessed using a metal spoon or similar smooth metal object. Normal perspiration results in fairly smooth skin. A smooth metal object that is passed across the forehead, such the undersurface of a spoon, thus should slide smoothly; however, in a patient with a central or postganglionic Horner syndrome that produces anhidrosis, the spoon will “catch” as it crosses the forehead on the side of the presumed Horner syndrome. Pharmacological testing using several agents can establish
the diagnosis of a Horner syndrome in most cases and can also be used to localize the lesion (see below).

Pharmacological testing
Cocaine
Cocaine is highly effective in confirming the diagnosis of Horner syndrome. When there is an interruption to the sympathetic innervation, as occurs in Horner, norepinephrine is not released from the presynaptic nerve endings. Cocaine blocks the reuptake of the norepinephrine that is released from sympathetic nerve endings. This allows norepinephrine to accumulate at the receptors of the effector cells, thus producing dilation of a normal pupil. A Horner pupil, however, is sympathetically denervated and does not respond to the circulating norepinephrine (Figure 5A and B). In a normal eye, a 2%–10% solution of cocaine causes dilation of the pupil. One study noted a mean pupil dilation of 2.14 mm (range 0.6–4.0 mm) in normal eyes in response to a 5% cocaine solution. Forty-five minutes after instillation, an anisocoria of at least 0.8 mm should be considered indicative of Horner syndrome. However, if the smaller (ie, the suspected Horner) pupil dilates more than 2 mm, even if the post-cocaine anisocoria is greater than 0.8 mm, a Horner syndrome is unlikely.

The challenges with using cocaine are many. Because it is a controlled drug, it can be difficult to obtain and has to be kept in a secure, locked storage. Some authors also indicate that cocaine has a short shelf-life, although this has not been our experience, with positive responses being elicited despite using cocaine that has been sitting around for several months! On the other hand, metabolites of cocaine are excreted in the urine for up to 2 days after topical administration. This may pose difficulties for patients who have occupations requiring them to undergo random drug screening. One study of 50 patients found positive urine tests for benzoylecgonine (a cocaine metabolite) in 100% of patients 24 hours after topical administration, in 50% at 36 hours, and in 2% after 48 hours. In addition to these issues, a false-positive response to topical cocaine (ie, lack of dilation in a possible or presumed Horner pupil) can occur in patients who have a miotic pupil associated with severe stromal damage to the iris, neovascularization of the iris, posterior synechiae, or aberrant regeneration of the oculomotor nerve.

Apraclonidine
Apraclonidine is an alpha-2 adrenergic agonist that is sometimes used to lower intraocular pressure in patients with glaucoma; however, it also has a weak alpha-1 adrenergic effect. Thus, it minimally constricts a normal pupil but dilates a Horner pupil due to denervation supersensitivity of the alpha-1 receptors on its iris dilator muscle, producing a reversal of anisocoria in patients with unilateral Horner syndrome (Figure 6A and B). Koc et al compared 31 patients with Horner syndrome with 54 healthy controls using 0.5% apraclonidine. All the Horner pupils had a mean dilation of 2.04 mm (range 1–4.5 mm), whereas the pupils of control eyes had a mean constriction of 0.14 mm (range 0.5–1 mm). Also noted by these investigators was a mean elevation of 1.75 mm of the upper eyelid on the side of the Horner syndrome compared with 0.61 mm of elevation in the eyes of the control group. Eyelid elevation, however, is not specific to Horner syndrome alone.

Although apraclonidine has emerged as an excellent alternative to cocaine in the diagnosis of Horner syndrome, several safety concerns have been raised with respect to its use. Watts et al reported three infants under the age of 6 months who became drowsy after topical administration of 1% apraclonidine. They further described a 10-week-old infant who received 0.5% apraclonidine topically in both eyes and was unresponsive for several hours. Other alpha-adrenergic receptor agonists, such as brimonidine, have also been reported to cause bradycardia, somnolence, hypotension, and lethargy in young children. Chen et al reported no side effects with the use of topical 0.5% apraclonidine in all the Horner pupils had a mean dilation of 2.04 mm (range 1–4.5 mm), whereas the pupils of control eyes had a mean constriction of 0.14 mm (range 0.5–1 mm). Also noted by these investigators was a mean elevation of 1.75 mm of the upper eyelid on the side of the Horner syndrome compared with 0.61 mm of elevation in the eyes of the control group. Eyelid elevation, however, is not specific to Horner syndrome alone.

Although apraclonidine has emerged as an excellent alternative to cocaine in the diagnosis of Horner syndrome, several safety concerns have been raised with respect to its use. Watts et al reported three infants under the age of 6 months who became drowsy after topical administration of 1% apraclonidine. They further described a 10-week-old infant who received 0.5% apraclonidine topically in both eyes and was unresponsive for several hours. Other alpha-adrenergic receptor agonists, such as brimonidine, have also been reported to cause bradycardia, somnolence, hypotension, and lethargy in young children. Chen et al reported no side effects with the use of topical 0.5% apraclonidine in

Figure 5 Cocaine Testing for Horner Syndrome.
Notes: (A) Right Horner syndrome in a 72-year-old man. Note right ptosis and anisocoria with the smaller pupil on the right side. Both pupils reacted briskly to light stimulation. (B) After topical administration of 10% cocaine drops in both eyes, there is marked dilation of the left pupil but the right pupil dilates only very slightly. This response indicates that the patient has a right Horner syndrome.
Horner syndrome. In our opinion, one should use apraclonidine to try to establish a diagnosis in a presumed acute Horner syndrome. If there is a positive response (ie, reversal of anisocoria), this should be taken as indicative of a Horner syndrome. If there is a negative response, the physician must decide if the clinical picture warrants pharmacologic testing with cocaine or further evaluation.

**Hydroxyamphetamine**

Whereas both cocaine and apraclonidine are useful in the diagnosis of Horner syndrome, hydroxyamphetamine is useful in distinguishing central and preganglionic lesions from postganglionic ones.\textsuperscript{118–120} Hydroxyamphetamine releases stored norepinephrine from postganglionic adrenergic nerve endings, causing mydriasis in normal pupils. With central and preganglionic lesions, the postganglionic nerve endings are intact. Thus, after topical administration of a 0.5% solution of hydroxyamphetamine, a Horner pupil will dilate and may even become larger than the contralateral normal pupil. A lesion of the postganglionic sympathetic neurons results in loss of terminal nerve endings and their respective stores of norepinephrine. As such, the affected pupil will not dilate after topical administration of 0.5% hydroxyamphetamine.\textsuperscript{121} However, as is the case with apraclonidine, false-negative results can occur within a week of damage to the postganglionic neurons, as it takes time for the stores of norepinephrine in the neurons to dissipate.\textsuperscript{122}

**Phenylephrine**

Some authors believe that a Horner syndrome can be localized not only with hydroxyamphetamine but also with a 1% solution of phenylephrine or a 2% solution of epinephrine.\textsuperscript{123,124} These authors suggest that whereas neither a normal pupil nor a central or preganglionic Horner pupil will dilate when either of these solutions is instilled, a postganglionic Horner pupil will dilate after administration of either solution due to acquired adrenergic supersensitivity of the iris dilator muscle.\textsuperscript{123,124} However, it has also been suggested that regardless of the location of the lesion, the Horner pupil will show denervation supersensitivity.\textsuperscript{125} In addition, it must be noted that denervation supersensitivity may take days to weeks to develop. Thus, for these reasons, the test may not provide valid results in either the acute or the chronic setting.

**Bilateral Horner syndrome**

A bilateral Horner syndrome can be present in patients with a variety of systemic disorders, including diabetic autonomic neuropathy, amyloidosis, pure autonomic failure,
Anderson-Fabry disease, familial dysautonomia, and paraneoplastic syndrome.97 In a study of 150 patients with generalized autonomic neuropathy, 58 (38.6%) had evidence of a Horner syndrome. The syndrome was bilateral in 43 (74%) of these individuals.126

Differential diagnosis
Unilateral ptosis and miosis associated with normal pupillary constriction can have other etiologies. Physiological anisocoria occurs in up to 20% of the normal population, and some of these patients might have unilateral ptosis ipsilateral to the smaller pupil due to dehiscence of the levator tendon or other causes.127 Other causes of anisocoria, such as a tonic pupil, Argyll Robertson pupils, pharmacologic pupillary blockade, oculomotor nerve palsy, ocular surgery, and iris atrophy following inflammation or trauma should not be confused with a Horner syndrome as such pupils do not constrict or constrict very slowly to light stimulation. In addition to dehiscence of the levator tendon, unilateral ptosis can be caused by other neurologic, myopathic, mechanical, and neuromuscular conditions.

Evaluation
Once the diagnosis of a Horner syndrome has been confirmed, an appropriate evaluation should be performed. As noted above, in infants and children, this should involve a complete physical examination, magnetic resonance imaging of the brain, neck, and chest, and an assay for urinary catecholamines.82 In adults with an acquired Horner syndrome, a simple x-ray of the neck in flexion and extension can identify cervical spondylosis, a common cause of both central and preganglionic Horner syndromes. In addition, magnetic resonance imaging of the brain with contrast should reveal many other causes of a central or postganglionic Horner syndrome, including brainstem infarct, intracranial tumor, and demyelinating disease, whereas computed tomographic scanning of the chest can reveal tumors and other lesions of the lungs and thorax responsible for preganglionic Horner syndromes. In addition, computed tomography or magnetic resonance angiography can effectively evaluate the neck vasculature to rule out dissections and other lesions of the ipsilateral internal carotid artery that may cause both preganglionic and postganglionic Horner syndromes, largely obviating the need for invasive catheter angiography.128,129

Davagnanam et al have provided an algorithm to determine which patients with Horner syndrome should undergo urgent imaging.130 They have suggested that a patient with Horner syndrome with no history of trauma, no pain, and no localizing signs, does not require urgent imaging but instead can undergo non-urgent imaging performed within 6 weeks with clinical reassessment. Nonetheless, it should be noted that such patients may still have potentially life-threatening underlying pathology.131,132

Conclusion
The etiologies of Horner syndrome are numerous, with some being life-threatening. Thus, the physician who diagnoses a possible Horner syndrome must carefully assess the patient for other neurologic manifestations that may help confirm the diagnosis and be helpful in localizing the site of injury. In addition to a complete physical examination, pharmacological testing is a valuable tool that can aid not only with the diagnosis but also the localization of a Horner syndrome, so as to direct further testing and management of the patient.

Disclosure
The authors report no conflicts of interest in this work.

References


