ELSEVIER

# Sixth Nerve Palsies in Children

**Michael S. Lee, MD*, Steven L. Galetta, MD*†, Nicholas J. Volpe, MD*†, and Grant T. Liu, MD*†**

**The causes of sixth nerve palsies in 75 children, all of whom had undergone modern neuroimaging, were reviewed. Neoplasms or their neurosurgical removal was the most common cause (n = 34 [45%]); elevated intracranial pressure (nontumor) (15%), traumatic (12%), congenital (11%), inflammatory (7%), miscellaneous (5%), and idiopathic (5%) causes represented other categories but were less commonly present. Isolated sixth nerve palsies were relatively uncommon (9%). On the basis of the relatively high risk of neoplasm, the authors suggest neuroimaging early in the clinical course of children with sixth nerve palsies, even if the palsy is isolated.** 

Lee MS, Galetta SL, Volpe NJ, Liu GT. Sixth nerve palsies in children. Pediatr Neurol 1999;20:49-52.

## Introduction

Most of the large studies analyzing the causes of sixth nerve palsy in children included patients seen in the 1950s and 1960s, before the advent of modern neuroimaging [1-4]. In these series, it is possible that in cases classified as idiopathic, demyelinating lesions, small benign tumors, and vascular insults were missed. A more recent study included only patients 7 years of age and younger because the investigators were primarily interested in the visual outcome of sixth nerve palsies in children [5]. The authors present a modern review of sixth nerve palsies in children up to 18 years of age, each of whom had undergone modern neuroimaging. The authors categorize the etiologies and offer management guidelines based on the analysis.

## Materials and Methods

Since July 1993, all inpatients and outpatients with neuro-ophthalmic diagnoses observed and examined by one of the authors (G.T.L.) in a pediatric neuro-ophthalmic practice at the Children's Hospital of Philadelphia have been entered into a database. A computer search for patients with the diagnosis of sixth nerve palsy was performed. Criteria for patient inclusion in this study were as follows: (1) age 18 years or younger at the onset of sixth nerve palsy; (2) complete chart documentation, including neuroimaging results; and (3) examination between July 1993 and March 1997. Sixth nerve palsies were defined as nonrestrictive, neurogenic abduction deficits. Thus, cases of pseudo-abducens palsies resulting from convergence spasm, myasthenia gravis, myopathy, nonparalytic strabismus, and restrictive processes were excluded.

Attention was given to the date of onset of palsy with respect to any surgery performed, associated neurologic abnormalities at diagnosis, and results of lumbar punctures and neuroimaging. Age, sex, and laterality of the palsy were also noted. Because some patients had limited follow-up, no effort was made to record recovery or results of strabismus surgery. The cases were divided into seven etiologic categories: neoplastic, elevated intracranial pressure (nontumor), traumatic, congenital, inflammatory, miscellaneous, and idiopathic to allow comparison with previous studies [1-5].

## Results

Seventy-five children were identified and their charts reviewed. All charts contained sufficient information for this study. Table 1 lists the various etiologies by type and frequency. There were 33 females (44%) and 42 males (56%). The average age of all patients at the time of diagnosis was 8 years old (range = 1 month to 18 years). Twenty-three palsies (30%) were on the left, 26 (35%) were on the right, and the remaining 26 (35%) were bilateral. The number of patients presenting with an isolated sixth nerve palsy without any other neurologic abnormality was seven (three idiopathic, two trauma, one tumor, one congenital) (9%). All patients with acquired sixth nerve palsy had documented neuroimaging (either computed tomography or magnetic resonance imaging).

Table 1 outlines the frequencies of each etiology seen and compares the results with those in previously published series. Table 2 presents the etiologies by the age at which the sixth nerve palsy was diagnosed.

From the *Department of Ophthalmology and †Division of Neuro-ophthalmology; The Children's Hospital of Philadelphia; Scheie Eye Institute; and the Hospital of the University of Pennsylvania; University of Pennsylvania School of Medicine; Philadelphia, Pennsylvania.

Communications should be addressed to:
Dr. Liu; Division of Neuro-ophthalmology; Department of Neurology; Hospital of the University of Pennsylvania; 3400 Spruce Street; Philadelphia, PA 19104.
Received March 16, 1998; accepted July 9, 1998.


PII S0887-8994(98)00090-3 • 0887-8994/99/$20.00

**Table 1. Etiologies of sixth nerve palsy in children from July 1993 to March 1997***

| | Robertson et al. 1970 (1952-1964) | Harley 1980 (1968-1979) | Afifi et al. 1992 (1966-1988) | Kodsi and Younge 1992 (1966-1988) | Aroichane and Repka 1995 (1985-1993) (age <7 yr) | CHOP (1993-1997) |
|---|---|---|---|---|---|---|
| Neoplasm | 52 (39)† | 17 (27) | 25 (19) | 18 (20) | 21 (33)* | 34 (45)† |
| Elevated ICP (nontumor) | 15 (11) | 3 (5) | 17 (13) | 2 (2) | 15 (23) | 11 (15) |
| Trauma | 26 (20) | 21 (34)† | 37 (28)† | 37 (42)† | 12 (19) | 9 (12) |
| Congenital | — | 5 (8) | 17 (13) | — | — | 8 (11) |
| Inflammation | 23 (17) | 8 (13) | 13 (10) | 5 (6) | 4 (6) | 5 (7) |
| Miscellaneous | 5 (4) | 4 (6) | 9 (7) | 13 (15) | 9 (5) | 4 (5) |
| Idiopathic | 12 (9) | 4 (6) | 14 (11) | 13 (15) | 3 (5) | 4 (5) |
| Total | 133 | 62 | 132 | 88 | 64 | 75 |

Numbers in parentheses are percentages.
* Literature and Children's Hospital of Philadelphia (CHOP).
† Most frequent etiology present in the respective study.

Abbreviation:
ICP = Intracranial pressure

### *Neoplasm*

Neoplasms, usually primary central nervous system tumors, were the most frequent cause of sixth nerve palsy in this series. Of 34 tumors, posterior fossa medulloblastoma was the most common (n = 13), followed by brainstem glioma (n = 10), skull base rhabdomyosarcoma (n = 4), and posterior fossa ependymoma (n = 3). Glioblastoma multiforme, cerebellar astrocytoma, ependymoblastoma, or metastatic adrenal neuroblastoma was the cause in one patient each. Most of the children who had a sixth nerve palsy in association with a tumor were 10 years of age or younger (Table 2).

**Table 2. Age at diagnosis of acquired sixth nerve palsy vs etiology**

| Age (yr) | Tumor | Trauma | Increased ICP | Inflammation | Miscellaneous | Idiopathic |
|---|---|---|---|---|---|---|
| 0-1 | 1 | 0 | 0 | 0 | 0 | 2 |
| 1 | 3 | 3 | 0 | 0 | 0 | 1 |
| 2 | 1 | 0 | 1 | 0 | 0 | 0 |
| 3 | 1 | 1 | 0 | 0 | 0 | 0 |
| 4 | 5 | 0 | 1 | 0 | 0 | 0 |
| 5 | 4 | 0 | 0 | 0 | 2 | 0 |
| 6 | 1 | 1 | 0 | 0 | 0 | 0 |
| 7 | 2 | 1 | 0 | 0 | 0 | 0 |
| 8 | 2 | 0 | 0 | 0 | 0 | 0 |
| 9 | 3 | 1 | 0 | 0 | 0 | 0 |
| 10 | 6 | 0 | 0 | 2 | 0 | 0 |
| 11 | 0 | 0 | 0 | 1 | 0 | 0 |
| 12 | 1 | 1 | 1 | 0 | 0 | 0 |
| 13 | 2 | 1 | 2 | 0 | 1 | 0 |
| 14 | 1 | 0 | 3 | 2 | 0 | 0 |
| 15 | 0 | 0 | 2 | 0 | 0 | 0 |
| 16 | 0 | 0 | 0 | 0 | 0 | 0 |
| 17 | 1 | 0 | 1 | 0 | 0 | 1 |
| 18 | 0 | 0 | 0 | 0 | 1 | 0 |

Abbreviation:
ICP = Intracranial pressure

The sixth nerve palsies associated with neoplasms were usually detected in one of three scenarios: as part of the tumor presentation, resulting from tumor resection or neurosurgical trauma, or evolving as the tumor progressed. Of the 18 patients who had surgical removal of their tumor, only three (17%) presented preoperatively with sixth nerve palsy—all of whom had a posterior fossa medulloblastoma; whereas 15 (83%) patients developed their palsy postoperatively, either as a result of surgery or as a consequence of tumor progression. Among the 16 who did not have surgical resection, nine (56%) had their sixth nerve palsy at the time of neoplasm diagnosis, and seven (44%) developed one later in the course of disease. The sixth nerve palsy was isolated in one patient with a medulloblastoma.

### *Elevated Intracranial Pressure (Nontumor)*

Eleven patients were identified in this category. Six were diagnosed with pseudotumor cerebri because of papilledema, normal neuroimaging, and documentation of elevated cerebrospinal fluid (CSF) pressure and normal CSF constituents. Another child had a failed shunt procedure for congenital hydrocephalus. Others included here were a patient with trigonencephaly, one with a lateral and sagittal sinus thrombosis, another patient with an interhemispheric empyema, and one with herpes encephalitis. Most patients in this category presented in their early adolescence (Table 2).

### *Trauma*

Nine children developed sixth nerve palsy after head trauma. In the five cases in which motor vehicles were involved, three patients were pedestrians hit by an automobile, and the other two were passengers in motor

vehicle accidents. One patient fell off his bicycle. In the remaining three patients the head trauma was considered to be nonaccidental. In two of the patients with trauma the sixth nerve palsy was the only neurologic finding.

### *Congenital*

Eight children with sixth nerve palsies were classified as congenital. Six patients had Duane's retraction syndrome, one had Möbius syndrome, and another had Turner's syndrome and an isolated sixth nerve palsy since birth.

### *Inflammation*

One patient developed a sixth nerve palsy from Lyme meningitis. In two others, multiple sclerosis and Miller-Fisher syndrome were responsible for the palsies. Another presented with encephalomyelitis. Finally, one child had a granulomatous suprasellar mass.

### *Miscellaneous*

Four patients fell in the miscellaneous category. These patients had a posterior circulation infarction (n = 2), a giant cavernous sinus aneurysm (n = 1), and a cerebellar hemangioma (n = 1).

### *Idiopathic*

There were four patients without an identifiable cause of their sixth nerve palsy. The sixth nerve palsy was the only finding in three, but one patient had sixth and seventh nerve palsies of unclear etiology. All had negative neuroimaging results, and two had normal CSF examination and serum serologic analysis.

## Discussion

Each sixth nerve nucleus, located within the genu of the facial nerve in the dorsal pons, issues sixth nerve fascicles that travel ventrally through the pontine tegmentum, then exit at the pontomedullary junction. After traversing the subarachnoid space, the sixth nerve climbs along the bony clivus before passing through Dorello's canal into the posterior cavernous sinus, where it is joined by the third, fourth, fifth, and sixth nerves. After exiting the anterior cavernous sinus, the sixth nerve passes through the superior orbital fissure into the orbit, where it innervates the lateral rectus muscle, which abducts the eye. Neoplasms may compress the sixth nerve anywhere along its path, but elevated intracranial pressure may produce an abducens nerve palsy by causing pressure or traction of the nerve at the skull base. Inflammatory and infectious disorders tend to affect the sixth nerve in the subarachnoid space. Traumatic sixth nerve palsies are often associated with skull base fractures.

The authors' results confirm those of Robertson et al. [1] and Aroichane and Repka [5]—that neoplasms are the most common cause of sixth nerve palsy in children (Table 1). By contrast, other investigators [2-4] found trauma to be the most common etiology. The authors found that elevated intracranial pressure was the second most common etiology, similar to Aroichane and Repka [5]. Congenital, inflammatory, miscellaneous, and idiopathic etiologies were also seen by the authors but were less common. By contrast, in adults, the most common identifiable cause of an acquired sixth nerve palsy is vascular insufficiency resulting from diabetes, hypertension, or atherosclerosis [6].

The frequencies of each etiology are probably influenced by referral bias at each institution. Referral bias is also influenced by the type of practice, which in the authors' case is an inpatient and outpatient consultative pediatric neuro-ophthalmic service. Thus the authors' study may have been weighed more heavily toward patients with more complicated disorders examined at a tertiary pediatric hospital. The other studies mentioned acquired patients in their studies from slightly different types of populations. Robertson et al. [1] and Kodsi and Younge [4] used the Mayo Clinic database. Harley [2], a pediatric ophthalmologist, studied patients seen at Wills Eye Hospital and St. Christopher's Hospital for Children (both in Philadelphia). Afifi et al. [3] searched the University of Iowa Hospital computer system. Aroichane and Repka [5] acquired patients from the Wilmer Eye Institute (Johns Hopkins) database.

In the authors' review, only seven patients (9%) presented with an isolated sixth nerve palsy without other neurologic abnormalities. This percentage highlights the relative infrequency of isolated sixth nerve palsies in children. Two of the patients had a history of head trauma, and their sixth nerve palsies were attributed to this trauma. In the other five, one had a posterior fossa medulloblastoma, one was congenital (the patient with the Turner's syndrome), and three were idiopathic. Therefore, there were only four children with acquired, nontraumatic, isolated sixth nerve palsies, and one of the four (25%) had a brain tumor. Of the large reviews [1-5], only Aroichane and Repka [5] analyzed the frequency of neoplasms among their isolated cases, and they found none.

There is no standard protocol for the management of children with acquired sixth nerve palsies, but the authors' results suggest one approach (Table 3). The history should focus on the clinical features of a mass lesion, elevated intracranial pressure, and trauma. Then a neurologic examination should be performed to exclude papilledema, focal hemispheric signs (e.g., aphasia, hemianopia), or focal posterior fossa signs (e.g., nystagmus, ataxia, or facial palsy). Many authorities [7] then recommend neuroimaging in all children with acquired sixth nerve palsies; others [8] have recommended neuroimaging only in nonisolated sixth nerve palsies and isolated cases that persist after 6 months of careful observation. The authors'

**Table 3. Suggested evaluation of a child with a sixth nerve palsy**

| | Attention Toward |
|---|---|
| History | Mass lesion (focal neurologic complaints) |
| | Elevated intracranial pressure (headache, nausea, vomiting) |
| | Head trauma |
| Physical examination | Papilledema |
| | Hemispheric signs (aphasia, hemianopia) |
| | Posterior fossa signs (ataxia, nystagmus, facial palsy) |
| Magnetic resonance imaging with and without gadolinium | Mass lesion |
| | Hydrocephalus |
| | Venous thrombosis |
| Lumbar puncture (if magnetic resonance imaging is normal) | Opening pressure |
| | Cell count, protein, glucose to exclude meningitis |
| Blood tests (if magnetic resonance imaging is normal) | Lyme titer |

experience suggests that it is reasonable to perform neuroimaging early in the clinical course of any child with a sixth nerve palsy, isolated or otherwise, because of the high risk of an underlying neoplasm. Neuroimaging should be performed emergently when there are focal neurologic signs or papilledema. In isolated cases, neuroimaging is less urgent but still should be obtained within 1 week. Magnetic resonance imaging is preferred, given the superior imaging capability of posterior fossa structures. If neuroimaging is normal, a lumbar puncture can be performed in appropriate instances, such as to measure the CSF in patients with papilledema and suspected pseudotumor cerebri or in those with possible meningitis. Serologic analysis, such as Lyme titers, can be performed in suspected cases without an identifiable etiology.

**References**


**[1]** **Robertson** DM, Hines JD, Rucker CW. Acquired sixth-nerve paresis in children. Arch Ophthalmol 1970;83:574-9.

**[2]** **Harley** RD. Paralytic strabismus in children: Etiologic incidence and management of the third, fourth, and sixth nerve palsies. Ophthalmology 1980;87:24-43.

**[3]** **Afifi** AK, Bell WE, Menezes AH. Etiology of lateral rectus palsy in infancy and childhood. J Child Neurol 1992;7:295-9.

**[4]** **Kodsi** SR, Younge BR. Acquired oculomotor, trochlear, and abducent cranial nerve palsies in pediatric patients. Am J Ophthalmol 1992;114:568-74.

**[5]** **Aroichane** M, Repka MX. Outcome of sixth nerve palsy or paresis in young children. J Pediatr Ophthalmol Strabismus 1995;32:152-6.

**[6]** **Rush** JA, Younge BR. Paralysis of cranial nerves III, IV, and VI. Arch Ophthalmol 1981;99:76-9.

**[7]** **Brodsky** MC, Baker RS, Hamed LM. Ocular motor nerve palsies in children. In: Pediatric neuro-ophthalmology. New York: Springer-Verlag, 1996:228-31.

**[8]** **Burde** RM, Savino PJ, Trobe JD. Incomitant ocular misalignment. In: Clinical decisions in neuro-ophthalmology. Philadelphia: CV Mosby, 1992:239-81.


**CONNECTIONS—Web Site Update**
**Provided by Steven M. Leber, MD, PhD and Kenneth J. Mack, MD, PhD**

Lumps, Bumps, and Holes: A Primer on Occult Spinal Dysraphism
**http://pedsurg.surgery.uab.edu/cme/lbh/lbhintro.htmhttp://pedsurg.surgery.uab.edu/cme/lbh/lbhintro.htm**
This is an interesting Internet presentation/course developed from a Surgical Grand Rounds given by Dr. Jerry Oakes at the University of Alabama at Birmingham in 1996. It uses text material, still images, computer graphics, video, and audio. CME credits are available from the University of Alabama for completing the course.