

# Unrecognized visual field deficits in children with primary central nervous system brain tumors

M. J. Harbert · L. A. Yeh-Nayre · H. S. O'Halloran ·  
M. L. Levy · J. R. Crawford

Received: 14 July 2011 / Accepted: 21 November 2011 / Published online: 4 December 2011  
© Springer Science+Business Media, LLC. 2011

**Abstract** Visual field deficits can be a consequence of brain tumor location or treatment. The prevalence of unrecognized visual field deficits in children diagnosed with brain tumors is not known. All children at a single tertiary care pediatric children's hospital diagnosed with a primary brain tumor were tested for visual field deficits by a child neurologist and neuro-ophthalmologist over 16 months. Children with reproducible visual field deficits on two separate occasions were included in the analysis. Patients with optic glioma, craniopharyngioma, or previously known visual field deficits were excluded. Fourteen of 92 (15.2%) children (average 8.9 years, 8 girls) had undiagnosed visual field deficits. Average time between diagnosis of tumor and unrecognized visual field deficit was 3.7 years (range 0–13 years). Unrecognized visual field deficits were not associated with age ( $P = 0.27$ ) or

gender ( $P = 0.38$ ). Visual field deficits were attributed to direct tumor infiltration ( $n = 8$ ), postoperative complications ( $n = 5$ ) and post-radiation edema ( $n = 1$ ). Deficits included bitemporal hemianopsia ( $n = 2$ ), homonymous hemianopsia ( $n = 9$ ), quadrantanopsia ( $n = 2$ ), and concentric visual field loss ( $n = 1$ .) Tumor location included temporal lobe ( $n = 9$ ), parietal lobe ( $n = 2$ ), posterior fossa ( $n = 2$ ), hypothalamic-chiasmatic ( $n = 2$ ) and multifocal areas ( $n = 4$ ). Children with temporal lobe tumors were more likely to have unrecognized visual field deficits ( $P = 0.004$ ). In all 14 patients, visual field deficits were determined by examination only and were not reported by either the patient or caregiver regardless of age. The prevalence of unrecognized visual field deficits in children with brain tumors can be surprisingly high. Serial neuro-ophthalmologic evaluation of children with brain tumors is often required to diagnose a visual field deficit since patient or caregiver reporting may be limited.

M. J. Harbert  
Department of Neurosciences, University of California, San Diego and Rady Children's Hospital, San Diego, USA

L. A. Yeh-Nayre  
Division of Hematology, Oncology, Rady Children's Hospital, San Diego, USA

H. S. O'Halloran  
The Department of Ophthalmology, University of California, San Diego and Rady Children's Hospital, San Diego, USA

M. L. Levy  
Department of Neurosurgery, University of California, San Diego and Rady Children's Hospital, San Diego, USA

J. R. Crawford (✉)  
Department of Neurosciences and Pediatrics, University of California, San Diego and Rady Children's Hospital, San Diego, CA, USA  
e-mail: jrcrawford@mail.ucsd.edu

**Keywords** Visual field · Pediatric · Brain tumor

## Introduction

Primary childhood central nervous system brain tumors occur at an incidence of 4.9 cases per 100,000/person-years in the US according to data from the Central Brain Tumor Registry [1]. Children with optic pathway tumors, suprasellar tumors, and tumors of the posterior fossa often have visual complaints as a presenting feature [2]. Snyder et al. [3] reported 20 of 101 adult and pediatric patients presenting to the emergency room with a newly diagnosed brain tumor had associated visual complaints. Another study of 200 childhood brain tumor patients revealed 10% incidence of visual difficulties as a presenting sign and

38% had visual difficulties at any point in their course of treatment [4]. More recently, Armstrong et al. [5] reported a 15-year 18% cumulative index of blindness in 240 childhood low grade glioma survivors. Previous studies have focused largely on visual acuity and have not specifically addressed the prevalence of visual field deficits which can go unnoticed by patients and parents alike. We sought to expand upon these observations by studying the prevalence of undiagnosed visual field deficits in a single institutional cohort of children with primary brain tumors. Our findings exemplify the importance of routine visual field testing in the ongoing care of childhood brain tumors.

## Patients and methods

### Study design

All children diagnosed with a primary central nervous system brain tumor from 2008-present at Rady Children's Hospital San Diego were available for analysis and approved by the Institutional Review Board. Children diagnosed with optic glioma, craniopharyngioma, neurofibromatosis and those with prior visual field deficits as determined by neuro-ophthalmologic examination were excluded.

### Data collection

The following clinical data was collected for each patient: age at tumor diagnosis, gender, tumor pathology, tumor location, neuro-ophthalmologic examination, age at diagnosis of visual field deficit, and likely etiology of field deficit. Visual field testing was performed by a board-certified child neurologist (JC) and pediatric neuro-ophthalmologist (HO) using age-appropriate methods. Confirmatory formal perimetry testing was performed on a subset of patients (depending on age and level of cooperation) using an Amsler grid or Goldmann kinetic perimetry. Specific visual acuity deficits did not constitute a visual field deficit in our series and were not analyzed.

### Statistical analysis

Data were analyzed using Fisher's exact test to compare proportions. Statistics were performed using GraphPad QuickCalcs Software (San Diego, CA) and Stata Version 11 (College Station, TX).

## Results

Ninety-two of 173 patients diagnosed with a primary brain tumor actively followed over a 16-month period at Rady Children's Hospital San Diego were examined by a board

**Table 1** Primary brain tumor cohort by tumor pathology and location

Tumor pathology	Number of patients
Juvenile pilocytic astrocytoma	22
Medulloblastoma	23
Ependymoma	9
Oligodendroglioma	0
Other astrocytomas	8
Glioblastoma multiforme	2
Cortical primitive neuroectodermal tumor	3
Atypical teratoid/rhabdoid tumor	2
Other	23
Tumor location	
Posterior fossa	46
Diencephalon	5
Multiple hemispheric	4
Ventricle	4
Frontal lobe	9
Midline	6
Brainstem	8
Parietal lobe	1
Temporal lobe	6
Basal ganglia	1
Other (tumors with diffuse infiltration, usually from one hemisphere to the other)	2

certified child neurologist and neuro-ophthalmologist for the presence of unrecognized visual field deficits (Table 1). The mean age of tumor diagnosis of the cohort was 7 years (range 0–18 years, 41 girls.) Of the 92 children who met inclusion criteria, 14 (15.2%) had unrecognized visual field deficits as shown in Table 2. The average age at tumor diagnosis was 5.5 years (range 0–16 years, eight female.) The duration of time from tumor diagnosis to detection of visual field deficits ranged from the immediate pre/post-operative period to upwards of 13 years in a patient with cortical ependymoma, hemispheric infarction and developmental delay. The average delay in diagnosis of a visual field deficit in our cohort was 3.7 years (range 0–13 years). The median age at diagnosis of a visual field deficit was 3.5 years. Confirmatory formal visual field testing in those patients who were cooperative showed 100% concordance with the bedside clinical examination. The most common tumor type associated with unrecognized visual field deficits was juvenile pilocytic astrocytoma (4 children, 28.6%). Undiagnosed visual field deficits did not significantly correlate with age ( $P = 0.27$ ) or gender ( $P = 0.38$ .) Tumor location was an important variable for association with undiscovered visual field deficit, particularly for temporal lobe lesions ( $P = 0.004$ ) and hemispheric lesions ( $P = 0.0004$ .) Of the four children in our cohort with large

**Table 2** Clinical characteristics of children with unrecognized visual field deficits

Patient #	Age at tumor diagnosis (years)	Age at diagnosis of field deficit (years)	Visual field deficit	Pathology	Location	Treatment related etiology
1	2	2	Left hemianopsia	Low-grade glioma	Temporal	None
2	16	16	Right superior quadrantanopia	Dysembryoplastic neuroepithelial tumor	Temporal	Post-surgical
3	3	5	Bitemporal hemianopsia	Malignant neuroepithelial tumor	Midline	None
4	12	13	Left hemianopsia	Juvenile pilocytic astrocytoma	Temporal	Radiation edema
5	15	15	Left inferior quadrantanopia	Papillary tumor of the pineal region	Midline	None
6	0.8	8	Bitemporal hemianopsia	Juvenile pilocytic astrocytoma	Other	None
7	10	10	Bilateral concentric vision loss	Juvenile pilocytic astrocytoma	Posterior fossa	Infection
8	0.9	1.7	Right hemianopsia	Atypical choroid plexus papilloma	Ventricle	None
9	4	17	Left hemianopsia	Juvenile pilocytic astrocytoma	Temporal	None
10	1.25	2	Left hemianopsia	Atypical choroid plexus carcinoma	Hemisphere	None
11	0	0.3	Left hemianopsia	Desmoplastic infantile ganglioglioma	Hemisphere	Post-surgical
12	5	12	Right hemianopsia	Diffuse fibrillary astrocytoma	Posterior fossa	Cerebral infarct
13	1	14	Right hemianopsia	Ependymoma	Hemisphere	None
14	6	8	Left hemianopsia	Primitive neuroectodermal tumor	Hemisphere	Multiple cerebral infarcts

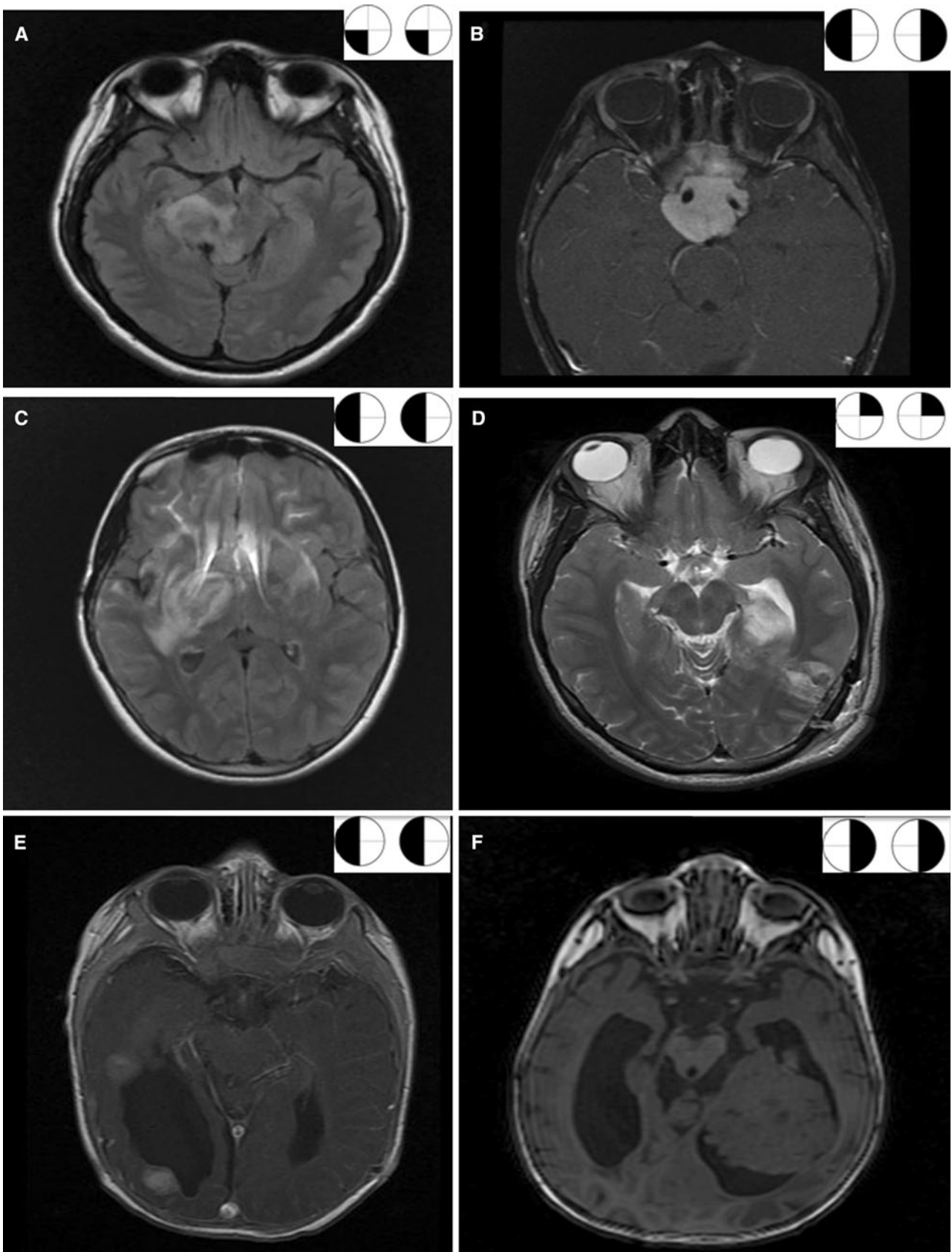
hemispheric tumors, all had undiscovered visual field deficits. Figure 1 demonstrates magnetic resonance imaging from six of the 14 children with unrecognized visual field deficits and their corresponding visual field deficit. Figure 1b demonstrates a patient with a hypothalamic chiasmatic low grade glioma, who was included in the analysis because despite the obvious location, a visual field deficit was not previously identified. No single tumor pathology was associated with an unrecognized visual field deficit including: juvenile pilocytic astrocytoma ( $P = 0.74$ ), ependymoma ( $P = 1.0$ ), primitive neuroectodermal tumor ( $P = 0.39$ ) or atypical teratoid/rhabdoid tumor ( $P = 1.0$ ). Medulloblastoma was least likely to be associated with an unrecognized visual field deficit ( $P = 0.017$ ). There were several children in our series with less common brain tumors, such as papillary tumor of the pineal region or desmoplastic infantile ganglioglioma that were significantly more likely to have an unrecognized visual field deficit ( $P = 0.049$ ) due to their location. In all 14 children, visual field deficits were determined by examination only. Neither the patient nor caregiver was aware of the specific visual field deficit prior to neuro-ophthalmologic examination. The presence of a visual field deficit was independent of patient age, as evidenced by

three cooperative teenagers in our series who were unaware of their specific visual field deficits prior to neuro-ophthalmologic examination.

## Discussion

We report that a significant percentage of children with primary central nervous system brain tumors can have visual field deficits that go unrecognized by patients, parents, and clinicians alike. To the best of our knowledge this is the first study that addresses the prevalence of unrecognized visual field deficits in a large cohort of children diagnosed with primary brain tumors. The high prevalence of visual field deficits in our study is not reflective of our entire brain tumor cohort, since children with optic pathway glioma, craniopharyngioma, neurofibromatosis and those with known visual field deficits were excluded. The major reason for the exclusion of this subset is that children with tumors located along the visual pathway or those with genetic syndromes predisposed to optic pathway tumors are more likely to be screened for visual field deficits.

One explanation for the surprisingly high prevalence of unrecognized visual deficits is that our neuro-oncology



◀ **Fig. 1** Magnetic resonance imaging of brain tumors associated with previously undiscovered visual field deficits. **a** papillary tumor of the pineal region, **b** malignant neuroepithelial tumor, **c** juvenile pilocytic astrocytoma, **d** dysembryoplastic neuroepithelial tumor, **e** desmoplastic infantile ganglioglioma, **f** atypical choroid plexus papilloma

patients were not always evaluated by a trained neurologist and formal visual field testing was not part of ongoing neuro-oncology management at our institution. A second explanation is the inherent difficulty and lack of specific expertise in recognizing visual field deficits in the young patients, particularly in those patients with chronic encephalopathy since visual field deficits are not always associated with a concomitant skew deviation or fixed gaze preference. Though it would be reasonable to expect that younger children would be more likely to have an unrecognized visual field deficit due to age alone, this was not the case in our study, as age was not significantly associated with unrecognized visual field deficits.

The largest delay of visual field deficit detection in our cohort occurred in children with post-operative infarctions and subsequent chronic encephalopathies, whose visual field deficits were not documented until several years following initial diagnosis. While patient or parental knowledge of the visual field deficits in our 14 patients was not known, this is not always the case, as patients with craniopharyngioma and optic glioma can present with primary ophthalmologic complaints. However, patient self-recognition of a visual field deficit can be elusive as evidenced by three cooperative teenagers in our series who had unrecognized deficits until formal neuro-ophthalmologic testing was performed. Our observations exemplify the fact that one cannot rely on patient or parent reporting alone no matter the age or neurocognitive status of the patient.

In spite of the inherent challenges of performing a neurological examination in a child, it is possible in young children to detect larger field deficits such as homonymous hemianopsia. Some prefer a two-person technique in which one examiner is in front of the child and maintains visual fixation with a colorful object while another introduces a second object in the periphery. The child's visual field is then monitored by an immediate saccade or head turn independent of sound. We prefer a one-person screening technique to assure that central visual fixation is maintained prior to the introduction of an object into the periphery. The greater ease in detecting homonymous hemianopsia in younger patients likely explains the significance of temporal lobe pathology in detection of a visual field deficit in our series.

While the biggest criticism of our study is the lack of prospective design and an artificially enriched cohort, our findings do provide significant insight into the need for a multidisciplinary, comprehensive approach to the diagnosis

and ongoing management of pediatric neuro-oncology patients. A significant limitation of our study was the difficulty in identifying the exact length of time and etiology of the unrecognized visual field deficit. Unfortunately, without a prospective study design, the relevance of visual field deficits with regards to tumor progression or outcome cannot be reliably determined. However, 7% of our patients diagnosed with an unrecognized visual field deficit had recurrent disease and therefore visual field deficits can be an early sign of disease progression and is worth studying in a prospective manner [6]. Our study raises compelling questions about how children with brain tumors should be monitored for neuro-ophthalmologic abnormalities. Most large multicenter cooperative clinical trials for pediatric brain tumors do not include routine ophthalmologic examinations as part of trial entry or continued monitoring post treatment. Only through mandatory monitoring of visual fields will we truly understand the prevalence of visual field deficits in pediatric brain tumors in the short and long term and whether there are any clinical implications with regards to disease outcome. In conclusion, we recommend that serial neuro-ophthalmologic examinations should be routinely performed on all children diagnosed with central nervous system tumors since patient or caregiver reporting may not be reliable in all cases.

**Acknowledgments** Dr. Harbert, Lanipua Yeh-Nayre, Dr. O'Halloran, and Dr. Crawford have nothing to disclose. Dr. Levy serves on the editorial advisory boards of *Neurosurgery*, *World Neurosurgery*, and the *Journal of Health Communication*; serves on a scientific advisory board for and holds stock/stock options in Stemedica Cell Technologies, Inc.; and is listed as author on a patent re: absorbable biowax (now owned by USC), for which he receives royalty payments from Children's Hospital Los Angeles.

**Conflict of interest** The authors report no conflicts of interest.

## References

- Porter KR, McCarthy BJ, Freels S, Kim Y, Davis FG (2010) Prevalence estimates for primary brain tumors in the United States by age, gender, behavior, and histology. *Neuro Oncol* 12:520–570
- Wilne S, Collier J, Kennedy C et al (2007) Presentation of childhood CNS tumours: a systematic review and meta-analysis. *Lancet Oncol* 8:685–695
- Snyder H, Robinson K, Shah D, Brennan R, Handrigan M (1993) Signs and symptoms of patients with brain tumors presenting to the emergency department. *J Emerg Med* 11:253–258
- Wilne SH, Ferris RC, Nathwani A, Kennedy CK (2006) The presenting features of brain tumours: a review of 200 cases. *Arch Dis Child* 9:502–506
- Armstrong GT, Conklin HM, Huang S et al (2011) Survival and long-term health and cognitive outcomes after low-grade glioma. *Neuro Oncol* 13:223–234
- Santamaría A, Martínez R, Astigarraga I, Etxebarria J, Sánchez M (2008) Ophthalmological findings in pediatric brain neoplasms: 58 cases. *Arch Soc Esp Oftalmol* 83:471–477