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Research Article

Bilateral Optic Nerve Infiltration Revealing Leukemic Relapse in a Child: The Role of Orbito-Cerebral MRI

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Received: February 18, 2026; **Published:** March 12, 2026

Abstract

T-cell acute lymphoblastic leukemia (T-ALL) is a malignant hematologic disorder that may be complicated by extramedullary involvement, particularly within the central nervous system. Leukemic infiltration of the optic nerve is rare and usually occurs in association with orbital, meningeal, or vascular involvement. Isolated bilateral optic nerve infiltration remains exceptional and represents a diagnostic pitfall, particularly when presenting with clinical features mimicking inflammatory optic neuritis.

We report the case of a 5-year-old child with T-ALL in complete remission for five months after chemotherapy, admitted for progressive bilateral blindness associated with headaches. Ophthalmologic examination was strictly normal. Complete blood count revealed hyperleukocytosis associated with bicytopenia. Brain computed tomography demonstrated bilateral optic nerve thickening without associated cerebral parenchymal abnormalities. Orbito-cerebral MRI revealed diffuse and marked thickening of both optic nerves along their entire course, appearing isointense on T2-weighted images, hypointense on STIR sequences, with intense and homogeneous enhancement after gadolinium administration. No intraconal fat infiltration or chiasmatic involvement was observed. Diffusion-weighted imaging was not contributive. Cerebrospinal fluid analysis and bone marrow aspiration confirmed leukemic relapse by demonstrating blast cells.

Leukemic optic nerve involvement represents a rare extramedullary localization and may constitute a diagnostic challenge for radiologists. MRI plays a pivotal role in differentiating tumor infiltration from other causes of optic nerve involvement.

Any optic nerve involvement in a pediatric patient with acute lymphoblastic leukemia, even during apparent remission, should raise suspicion for leukemic relapse. Prompt multidisciplinary management is essential to preserve visual function and overall prognosis.

Keywords: *Optic Nerve Leukemic Infiltration; Acute Lymphoblastic Leukemia; Bilateral Blindness; Orbito-Cerebral MRI; Orbital Radiotherapy*

Introduction

T-cell acute lymphoblastic leukemia (T-ALL) is a malignant hematologic disease characterized by uncontrolled clonal proliferation of abnormal and immature hematopoietic cells within the bone marrow, leading to suppression of normal hematopoiesis. It may extend to extramedullary sites, including the central nervous system, meninges, liver, spleen, bones, and lymph nodes.

Leukemic infiltration of the optic nerve has been described in T-ALL cases associated with orbital involvement or central retinal artery pathology. However, isolated bilateral optic nerve involvement remains rare.

Imaging, particularly magnetic resonance imaging (MRI), plays a crucial role in suggesting leukemic infiltration of the optic nerves and in detecting associated lesions such as central nervous system involvement or vascular thrombosis. Key imaging features must be identified to differentiate infiltrative optic neuritis from other possible etiologies, including infectious, autoimmune, or drug-induced causes.

Bone marrow aspiration and cerebrospinal fluid (CSF) analysis are necessary to demonstrate blast cells and confirm leukemic infiltration.

Case Report

We report the case of a 5-year-and-5-month-old child, born to non-consanguineous parents, second of three siblings, followed for T-cell acute lymphoblastic leukemia diagnosed two years earlier, initially revealed by bone pain, weight loss, and prolonged fever.

After 12 chemotherapy sessions, the patient was declared in complete remission. Five months later, he presented to the emergency department with progressive bilateral blindness associated with severe headaches. There was no history of trauma or similar previous episodes, and no other symptoms were reported, including fever or vomiting.

Clinical examination revealed a 4-kg weight loss and general condition deterioration in an afebrile context. Neurological examination was normal, with no signs of intracranial hypertension or meningeal syndrome. Complete blood count showed bicytopenia associated with hyperleukocytosis of 55,000 cells/mm^3.

Fundoscopic examination revealed a flat retina with normal macula and optic disc, normal vessel caliber, no central retinal artery occlusion, and no papilledema.

Figure 1: *This image shows the fundus on the right eye with no papillary pallor or oedema. The retinal vessels are permeable.*

Brain CT was performed before and after contrast injection, demonstrated (Figure 2):

- Bilateral thickening of the optic nerves involving both intra- and extraconal segments, with homogeneous contrast enhancement.
- No intraconal fat infiltration.
- Tortuous appearance of the optic nerves.
- Normal globes.

- Good opacification of vascular structures, particularly the ophthalmic artery and vein.
- No pathological cerebral parenchymal lesions or enhancement.

Figure 2: *Cerebral CT scan. Axial CT scans without injection (A) and after injection (B) showing thickening and tortuosity of the optic nerves, which show contrast enhancement. The red arrows indicate correct opacification of the ophthalmic arteries.*

Due to persistence of symptoms, Orbito-cerebral MRI was performed for better lesion characterization, revealing (Figure 3 and 4):

- Confirmation of the tortuous appearance of the optic nerves.
- Diffuse and marked thickening of the optic nerves along their entire course, appearing isointense on T2-weighted images and FLAIR, hypointense on STIR and T1-weighted images, with continuous and intense enhancement after gadolinium injection.
- No restriction on Diffusion-weighted imaging sequences.
- Focal enlargement of the optic nerve sheath at the ocular portion of the left optic nerve.
- No intraconal fat infiltration.
- Preserved optic chiasma.
- No abnormalities of the globes.
- Normal appearance of other cranial nerves.
- No cerebral parenchymal abnormalities.
- No arterial occlusion or venous thrombosis.

These findings were initially suggestive of bilateral optic neuritis.

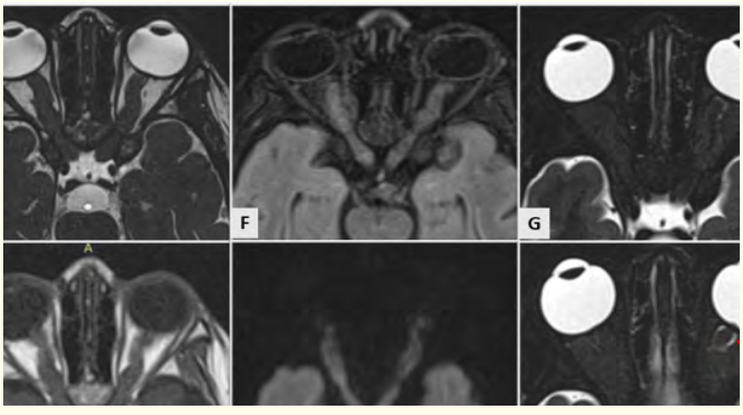

Figure 3: *Non injected orbital sequences. Axial T2-weighted (E) and FLAIR (F) images show an iso intensity from the swollen optic nerves and a T1 hypo intensity (H) and STIR (G) weighting, intraconal fat is preserved with a homogeneous hypersignal (H), no diffusion hypersignal (I) and the red arrow points to the enlargement of the nerve sheath.*

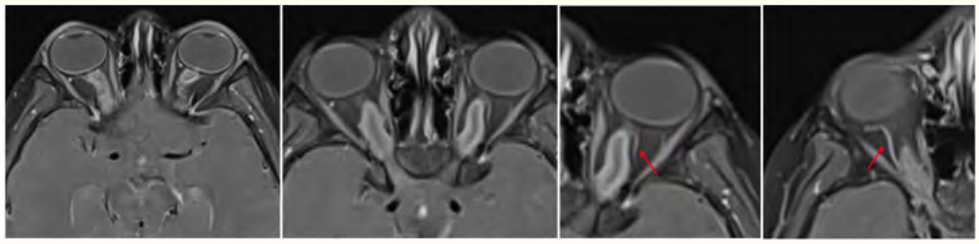

Figure 4: *Injected orbital sequences. On T1-weighted sequences with fat saturation, the enhancement of the optic nerves is noticed and the red arrows show the satisfactory and opacified appearance of the ophthalmic arteries bilaterally.*

Subsequent lumbar puncture revealed numerous blast cells in the CSF sediment, some undergoing lysis, with a high nuclear-to-cytoplasmic ratio. Bone marrow aspiration demonstrated 40% blasts and phagocytic cells. After multidisciplinary discussion, the optic neuritis was considered of tumoral origin, consistent with leukemic relapse involving the optic nerves.

Discussion

Acute lymphoblastic leukemia (ALL) is a blood cancer. It is characterized by an uncontrolled proliferation of lymphoblasts that infiltrate the bone marrow, leading to bone marrow dysfunction and disruption of normal blood cell production [1].

This results in bone marrow failure, which is manifested by anemia with pallor, palpitations, and fatigue (due to decreased red blood cells), recurrent infections particularly caused by opportunistic pathogens (due to decreased white blood cells), and mucosal bleeding, purpura, or hematomas (due to decreased platelets).

Accumulation of lymphoblasts in the bone marrow or lymphoid organs may also lead to other manifestations, including bone pain, lymphadenopathy, or splenomegaly. In rare cases, lymphoblasts cross the blood–brain barrier and infiltrate the cerebrospinal fluid, causing central nervous system, cranial nerve, or meningeal involvement. Diagnosis is guided by imaging and confirmed by CSF analysis and bone marrow examination.

Once the meningeal barrier is breached, neurological symptoms may occur, ranging from headaches and cranial nerve palsies to stroke-like presentations or altered mental status. Only a small proportion of patients (approximately 6.5%) initially present with isolated visual blurring, and even fewer with visual loss [2].

MRI is the reference imaging modality due to its superior tissue contrast and ability to provide morphological, dynamic, and functional information. CT remains valuable for detecting life-threatening complications such as tumor mass effect, hemorrhage, or vascular thrombosis resulting in a mortality rate of up to 60%.

Optic nerve involvement has been reported in cases described in the literature, occurring in both unilateral and bilateral forms, and Hirotoshi Nikaido, Hiromu Mishimapar., *et al*. explain that the optic nerve, although lined by meninges, remains resistant to systemic chemotherapy agents [3].

Lin and Chen explain bilateral ocular involvement by a vascular cause and point to occlusion of the central retinal arteries associated with infiltrative lymphoproliferative optic neuropathy, thereby leading to compressive edema resulting in blindness. In contrast to our patient, whose ophthalmologic examination was strictly normal, flow-sensitive and contrast-enhanced MRI sequences demonstrated well-opacified vascular structures without mural abnormalities or aneurysmal changes, thus excluding any underlying or associated vascular cause [4].

However, Shenoy., *et al*. reported a case of isolated optic nerve relapse despite negative cerebrospinal fluid analysis. In fact, the diagnosis was confirmed by vitreous biopsy.

Nevertheless, optic nerve biopsy is not recommended [5].

On MRI, optic neuritis is revealed by thickening of the optic nerve and a change in its normal signal characteristics. The features that favor tumoral involvement of the optic nerve are:

- Marked and fusiform thickening frequently involving the entire length of the optic nerve, which is usually only moderate in infectious or autoimmune involvement.
- Iso- to hypointensity on T2-weighted images and hypointensity on STIR sequences, suggesting lymphoid involvement.
- Diffusion restriction.
- Intense and homogeneous contrast enhancement.
- Associated involvement of the optic nerve sheath.
- Possible involvement of the optic chiasm.
- Fat infiltration is often absent unless an associated infiltrative tumoral mass is present.

MRI must also confirm or exclude the presence of meningeal enhancement and/or chloromas (granulocytic sarcomas). These are masses composed of primitive precursors of granulocytic cells, including myeloblasts, promyelocytes, and myelocytes. They occur mainly in patients with acute myeloid leukemia, although they may also be observed in other myeloproliferative disorders such as myelofibrosis with myeloid metaplasia [6].

MRI findings in our patient fulfilled almost all criteria for lymphoid infiltration of the optic nerves, apart from the absence of diffusion restriction, especially given that leukemic optic nerve infiltration is more frequent in children than in adults [7]. In reported cases, the average age of patients with extramedullary involvement of ALL is 7.3 ± 4.6 years, with a peak incidence between 2 and 5 years and a male predominance [8].

Nevertheless, the most concerning differential diagnosis in our case was drug-induced optic neuritis, which was ruled out due to the relatively long disease-free interval estimated at five months after treatment discontinuation, the fact that the optic nerve is considered a sanctuary site for chemotherapeutic agents as previously reported, and finally because cerebrospinal fluid analysis and bone marrow aspiration confirmed the diagnosis of leukemic relapse.

Despite the low probability of ocular infection, a bolus of corticosteroid therapy was administered to our patient, and rapid multidisciplinary management proved essential for initiating treatment of the isolated ocular relapse. Systemic chemotherapy and orbital radiotherapy were decided upon to preserve vision and survival. The same MoPAD protocol (Methotrexate, Vincristine, Pegylated Asparaginase, and Dexamethasone) was reinstated to treat the patient. This protocol leads to an estimated complete response rate of 76% according to the study by Wiernik., *et al*. involving 55 patients [9].

The clinical course of our patient was marked by clinical improvement after the second session, with a clear improvement in general condition.

Conclusion

Leukemic infiltration of the optic nerve should be considered in pediatric patients with acute lymphoblastic leukemia presenting with optic neuritis, even during apparent remission. Infiltration may be bilateral and present as progressive visual loss or bilateral

blindness. Brain MRI should be performed promptly to establish the diagnosis, exclude alternative causes of optic neuritis, and assess for associated parenchymal involvement. CSF analysis and bone marrow examination remain essential for definitive confirmation. Rapid multidisciplinary management combining chemotherapy and radiotherapy is crucial to preserve visual function and improve prognosis.

Funding Statements

I have no funding.

Conflict of Interest

This work has no conflict of interest.

Informed Consent

Written informed consent was obtained from the patient for publication of this manuscript and any accompanying images. All identifying information has been removed to ensure complete anonymity.

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Volume 15 Issue 4 April 2026