



Case Report: Herpes Simplex Virus Type 2 Acute Retinal Necrosis With Viral Encephalitis in Children

Luyao He, Jialiang Duan* and Qingli Shang*

Department of Ophthalmology, The Second Hospital of Hebei Medical University, Shijiazhuang, China

OPEN ACCESS

Edited by:

Alan G. Palestine,
University of Colorado Anschutz
Medical Campus, United States

Reviewed by:

Manabu Mochizuki,
Tokyo Medical and Dental
University, Japan
Amit Reddy,
University of Colorado Anschutz
Medical Campus, United States

*Correspondence:

Jialiang Duan
duanjialiang@hebm.u.edu.cn
Qingli Shang
qinglishang1966@126.com

Specialty section:

This article was submitted to
Ophthalmology,
a section of the journal
Frontiers in Medicine

Received: 15 November 2021

Accepted: 14 February 2022

Published: 16 March 2022

Citation:

He L, Duan J and Shang Q (2022)
Case Report: Herpes Simplex Virus
Type 2 Acute Retinal Necrosis With
Viral Encephalitis in Children.
Front. Med. 9:815546.
doi: 10.3389/fmed.2022.815546

Background: Few cases concerning acute retinal necrosis with viral encephalitis in children have been reported, especially cases where the fundus cannot be identified due to severe vitreous opacity in the early stage that makes diagnosis difficult.

Methods: We conducted a retrospective review of an unusual case of herpes simplex virus-2 (HSV-2) acute retinal necrosis with viral encephalitis in an immunocompetent child, along with a review of relevant literature published up to September 2021.

Result: An 11-year-old girl presented with an approximate 20-day history of ocular redness and decreased visual acuity in the left eye. Examination revealed anterior uveitis and vitreous opacity in the left eye. An anterior chamber tap was performed because the fundus could not be observed clearly, and the aqueous humor was positive for HSV-2 DNA. Cerebrospinal fluid also tested positive for HSV-2. She was diagnosed with acute retinal necrosis syndrome and viral encephalitis. The condition was controlled with timely antiviral and steroid therapy. She was also treated with prophylactic laser therapy to prevent retinal detachment during subsequent follow-up. The pathogenesis, diagnosis, and treatment of HSV-2 acute retinal necrosis in children and the association between acute retinal necrosis and viral encephalitis are further discussed, based on published literature.

Conclusion: HSV-2-related pediatric acute retinal necrosis may be due to the acquisition of subclinical infection with HSV-2 during parturition, followed by reactivation of the virus latent in the body on account of certain factors. Moreover, it may be complicated with viral encephalitis. For suspected cases with invisible fundus, early intraocular fluid examination is especially helpful for differential diagnosis. Early diagnosis, early treatment, and timely prophylactic laser treatment to prevent retinal detachment are key to a better prognosis. Physicians need to pay attention to such suspected cases during diagnosis and treatment.

Keywords: herpes simplex virus-2, immunocompetent population, viral encephalitis, vitreous opacity, retinal necrosis

INTRODUCTION

Acute retinal necrosis (ARN) syndrome is a viral infectious disease, clinically characterized by severe and extensive uveitis, vitritis, retinal vasculitis, retinal necrosis, and retinal detachment, which in combination indicate an advanced disease stage (1). ARN has an acute onset and rapid progression, and can develop at all ages. However, ARN is relatively more common in adults than

in children (2). Here, we present a child with ARN, viral encephalitis, and herpes simplex virus-2 (HSV-2) infection and a literature review of HSV-2 ARN in children.

MATERIALS AND METHODS

We present a case report of ARN with viral encephalitis in an immunocompetent child with HSV-2 infection. We also performed a PubMed database search of relevant publications in English up to September 2021, using the following keywords: “acute retinal necrosis,” “children,” and “herpes simplex virus” joined by the operator “AND.” We evaluated and reviewed all relevant literature and relevant reported cases.

CASE DESCRIPTION

An 11-year-old girl was admitted to our hospital with an approximate 20-day history of ocular redness and decreased visual acuity in the left eye. On admission, her best-corrected visual acuity (BCVA) was 20/20 in the right eye, and hand motion in the left eye. The patient’s intraocular pressures were 19 mmHg and 28 mmHg in the right and left eyes, respectively. Slit-lamp examination revealed conjunctival hyperemia, mild corneal edema, mutton-fat keratic precipitates in the middle and below the corneal endothelium, 3+ cells and 3+ flare in the anterior chamber (**Figure 1A**), and severe vitreous opacity in the left eye. The fundus could not be inspected because of the vitreous opacity (**Figure 2A**). Slit-lamp and fundus examinations of her right eye were unremarkable. Ultrasonography showed severe vitreous opacity, posterior vitreous detachment in the left eye, and thickening of the posterior wall of the left eyeball (**Figure 1B**). Serological test results for toxoplasmosis, rubella, cytomegalovirus (CMV), and herpes simplex virus indicated that the patient tested positive for HSV-2 immunoglobulin G (IgG), CMV IgG, and rubella virus IgG, and tested negative for other infections. The results of routine blood tests, liver function, renal function, syphilis, tuberculosis, and other laboratory tests showed no significant abnormalities. Granulomatous panuveitis was considered, and differential diagnoses included viral or bacterial infection and toxoplasmosis or *Toxocara canis* infection. After informed consent was obtained from her parents, a left eye anterior chamber tap was performed. The aqueous humor results were positive for HSV-2 DNA. Brain magnetic resonance imaging (MRI) scans showed abnormal signal intensity in the right temporal lobe, and dilatation of the right temporal horn when compared with the left temporal horn. After consultation with pediatricians, we performed a lumbar puncture and the cerebrospinal fluid tested positive for HSV antibodies.

According to Classification Criteria for Acute Retinal Necrosis Syndrome (3) key diagnostic criteria, our patient was diagnosed with ARN. She was also diagnosed with viral encephalitis (HSV-2), based on positive test results for HSV antibodies in the cerebrospinal fluid and on brain MRI results. Treatment included administration of intravenous acyclovir and dexamethasone, local steroid eye drops, and mydriasis eye drops. In addition,

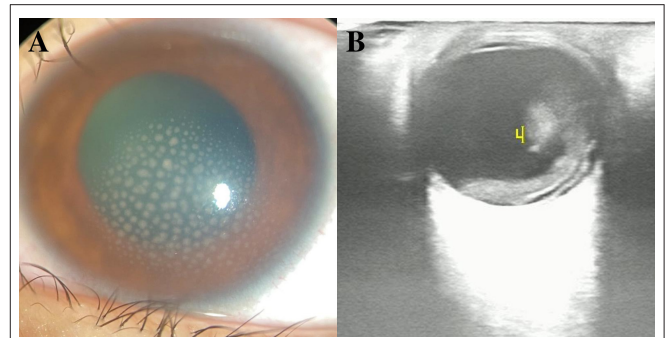


FIGURE 1 | (A) Slit-lamp examination revealed mutton-fat keratic precipitates in the middle and below the corneal endothelium and 3+ cells and 3+ flare in the anterior chamber. **(B)** Ultrasonography revealed severe vitreous opacity, posterior vitreous detachment in the left eye, and thickening of the posterior wall of the left eyeball.

she received intravitreal ganciclovir injections twice a week for 2 weeks.

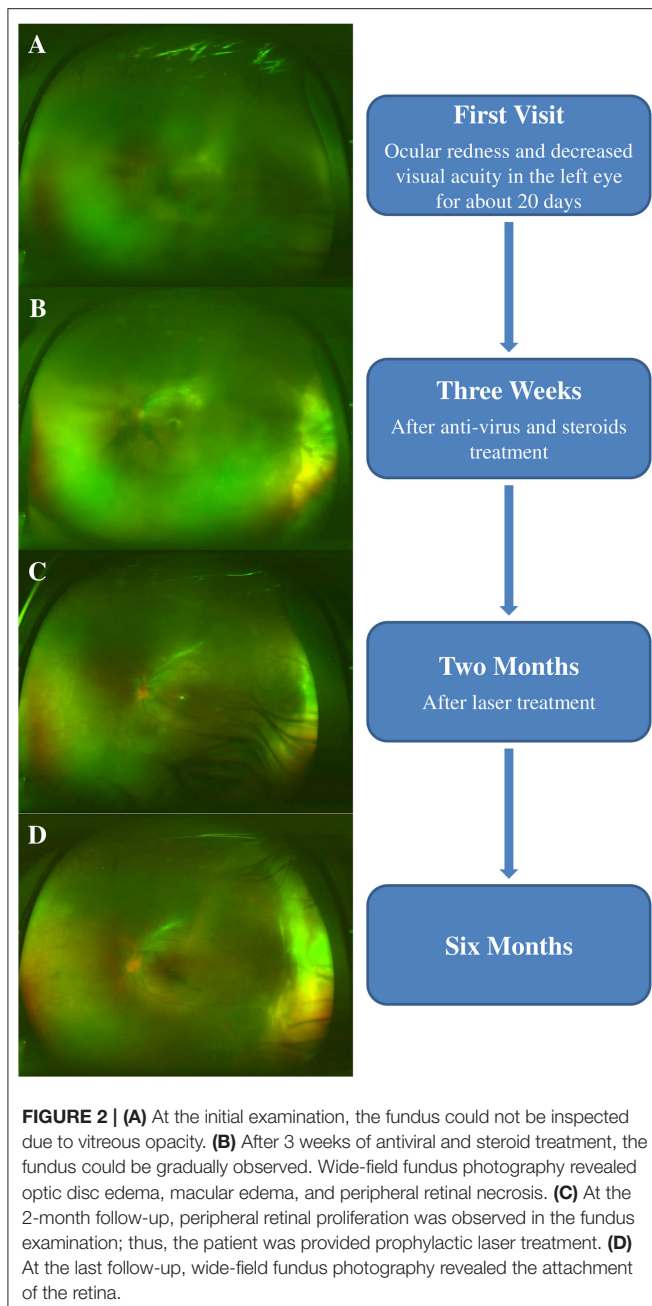
Following 3 weeks of treatment, the anterior inflammation was under control, and the left fundus could be gradually observed. Optical coherence tomography (OCT) and wide-field fundus photography showed optic disc edema, macular edema, and peripheral retinal necrosis (**Figures 2B, 3A**). The recommended time for antiviral therapy has been reported to be between 12 and 14 weeks (4). However, long-term use of antiviral drugs in children may have side-effects such as nephrotoxicity, gastrointestinal upset, and skin lesions (5). Further to a conversation with the patient’s parents, they consented to her continuing prophylactic anti-viral therapy; and renal function, blood routine results were closely monitored. She was discharged with a prescription for oral steroids and valacyclovir.

At 2 months, peripheral retinal proliferation was observed in the fundus examination, and the patient was administered prophylactic laser treatment (**Figures 2C, 3B**). Steroids and valacyclovir were discontinued after 3 months. At the last follow-up, her BCVA was 20/100 in the left eye, and the retina was attached but still had cystoid macular edema on OCT (**Figures 2D, 3C**).

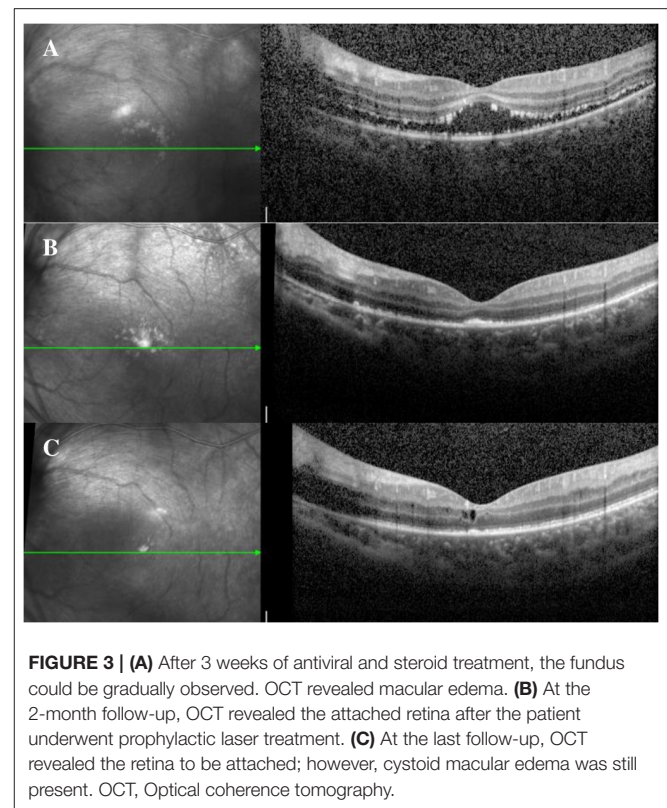
DISCUSSION

ARN syndrome is a serious viral infectious disease, and its main pathogenic viruses are varicella zoster virus (VZV), herpes simplex virus types 1 or 2, CMV, and the Epstein-Barr virus (EBV) (6–8). ARN can occur in both adults and children; however, it occurs more commonly in adults, with an average age of onset reported to be between 20 and 60 years (9). Several studies have reported that adult ARN is mainly due to VZV and HSV-1 (10). In contrast, there are significantly fewer reports related to pediatric ARN, and the main causative virus has been reported to be HSV-2 (11–13).

We reviewed the relevant literature concerning ARN, and identified 14 cases of pediatric ARN due to HSV-2 (10, 14–23). Pediatric ARN due to HSV-2 was first reported in 2001 (14). Details concerning 15 cases (including the present case)



are summarized in **Table 1**. The median age of the 15 children was 6.59 years (range, 23 days to 14 years) with no sex predominance (7 boys; 8 girls). Of these 15 patients, 11 patients had unilateral disease and 4 patients had bilateral disease. The fundus of one patient could not be observed due to synechiae between the pupil and the lens, whereas our patient had severe vitreous opacity resulting in an inability to observe the fundus. All the other patients' fundi could be observed, aiding diagnosis. Five patients had combined viral encephalitis (33.3%), and one patient had been diagnosed with neonatal HSV meningoencephalitis after birth and had developed ARN



when she was 9 years old. Seven patients had retinal detachment complications (46.7%). Eleven patients were immunocompetent, except for one patient whose information was not available; thus, her immune status could not be determined. Moreover, three patients were immunocompromised due to prematurity. Seven patients had a clear history of neonatal HSV-2 infection, Six patients' mothers had a history of HSV-2 infection, and 10 patients had other herpes virus infection-like manifestations prior to ARN.

HSV-2 ARN is similar to ARN, due to viruses such as HSV-1 and VZV, in terms of clinical manifestations, treatment, and prognosis in children. However, these two conditions also differ slightly. HSV ARN is mostly associated with viral encephalitis compared with VZV ARN (11, 24) (**Table 1**). However, after a review of the case summaries, our findings indicated that 11 of 15 patients with HSV-2 ARN were immunocompetent (**Table 1**), which corroborated the reported claim that patients with HSV ARN are usually immunocompetent (6). However, some studies have shown that patients with VZV, CMV, and EBV ARN may be in an immunosuppressed state in association with diseases such as human immunodeficiency virus infection, congenital heart disease, and leukemia (25, 26).

ARN can be due to direct viral infection or reactivation of a latent virus, or can occur secondary to diseases such as viral encephalitis, varicella, and herpetic keratitis (27). HSV-2 is mainly transmitted sexually. Direct infection in childhood is relatively rare, and neonatal infection often results from vertical maternal transmission. In this case, the child had no history

TABLE 1 | Published cases of pediatric ARN with HSV-2.

References	Age	Sex	Affected eye	Initial visual acuity	Whether the fundus could be seen in the early stage	Immune status	Neonatal herpes infection	Other systemic illnesses	Whether it was complicated with meningitis or encephalitis	Treatment	Complications	Prognosis
Tan et al. (14)	9 yr	F	Right	20/60	YES	Immunocompetent	N/A	Annual recurrences of right earlobe blistering since 5	NO	Systemic antiviral	NO	20/40
Tan et al. (14)	10 yr	M	Left	20/30	YES	Immunocompetent	N/A	Cold sores	HSV encephalitis	Systemic antiviral	RD	CF
Tran et al. (15)	11 yr	M	Left	CF (OD)	YES	Immunocompetent	N/A	Oral herpes at 3 months, RD (OD) at 9, extracapsular cataract extraction	NO	Systemic and topical antiviral and steroid	NO	20/40
Landry et al. (16)	9 yr	F	Left	HM (OS) HM	NO (Posterior synechiae)	Immunocompetent	YES*	Neonatal HSV meningoencephalitis	NO	Systemic antiviral, topical steroid, vitrectomy with scleral buckle, laser	NO	20/60
Khurana et al. (17)	14 yr	F	Right	CF (OD)	YES	Immunocompetent	N/A	Perinatal herpetic keratitis (OS)	NO	Systemic antiviral and steroid, laser	RD	20/50
Khurana et al. (17)	10 yr	F	Left	20/40	YES	Immunocompetent	Yes	HSV-positive vesicular scalp dermatitis at 8-day-old	NO	Systemic and topical antiviral	RD	20/200
Charles (10)	8 yr	F	Right	N/A	YES	N/A	Maybe	Developmental delay	NO	Systemic antiviral	NO	N/A
King et al. (18)	9 yr	F	Left	20/200	YES	Immunocompetent	Maybe*	NO	NO	Systemic and topical antiviral, systemic steroid	Vitreous hemorrhage, RD	20/40, RAPD, a central posterior subcapsular cataract
Chiquet et al. (19)	4 yr	M	Right	20/200	YES	Immunocompetent	Maybe	Axial muscular hypotony at 2 months, chickenpox at 3, a right non-granulomatous panuveitis at 5 months	NO	Systemic antiviral and steroid, topical steroid and cycloplegic	RD	N/A
Tanaka-Kitajima et al. (20)	3 yr	M	Left	20/50	YES	Immunocompetent	Maybe*	Periocular trauma	NO	Systemic antiviral and steroid	NO	20/20
Gupta et al. (21)	25 days	M	Both	N/A	YES	Immunocompromised	YES*	Premature, twin birth, twin brother died, crusted skin eruptions with ulceration	HSV encephalitis	Systemic antiviral, laser	RD(OS)	N/A

(Continued)

TABLE 1 | Continued

References	Age	Sex	Affected eye	Initial visual acuity	Whether the fundus could be seen in the early stage	Immune status	Neonatal herpes infection	Other systemic illnesses	Whether it was complicated with meningitis or encephalitis	Treatment	Complications	Prognosis
Gupta et al. (21)	25 days	M	Both	N/A	YES	Immunocompromised	YES*	Premature, twin birth	Encephalitis	Systemic antiviral	dead	dead
Hsu et al. (22)	29 weeks	F	Both	N/A	YES	Immunocompromised	YES*	Premature, dichorionic diamniotic twins, a vesiculopapular rash at birth	NO	Systemic antiviral, laser	RD	Macular pigmentary disturbances, mild optic atrophy
Ren et al. (23)	23 days	M	Both	N/A	YES	Immunocompetent	YES	Bulging fontanel, nuchal rigidity, skin lesions	HSV-2 encephalitis	Systemic antiviral, intravitreal ranibizumab injection	NO	N/A
Present case (2021)	11 yr	F	Left	HM	No (Severe vitreous opacity)	Immunocompetent	NO	NO	HSV encephalitis	Systemic and topical antiviral and steroid, cycloplegic, laser	NO	20/150

N/A, Not available.

*Mother had a determined history of HSV-2 infection. RD, retinal detachment; RAPD, relative afferent pupillary defect; HSV, herpes simplex virus.

of HSV-2 infection. For children without a known history of neonatal HSV-2, the pathogenesis of HSV-2 ARN has not been clarified. The generally accepted mechanism is that newborns are infected with HSV-2 at delivery through the birth canal in parturients with genital herpes. The virus may enter the body through sensory nerves located in the conjunctiva or nasal epithelium and travel in neural tissues, such as the olfactory and trigeminal nerves (10). The virus lies latent in newborns but does not cause symptoms of infection, and newborns remain in a state of subclinical HSV-2 infection. At some future point, latent infection can escalate to overt infection due to certain triggers, such as periocular trauma (20), neurosurgery, high-dose corticosteroids, and immunosuppressive agents (24). The virus reactivates and travels to the eye, causing ARN.

Viral encephalitis can be caused due to the reactivation of HSV-2 in the brain or through a retrograde passage of the virus activated in the eye to the brain (28). ARN has been found to be associated with viral encephalitis in several studies. According to previous literature, approximately 13.5% of patients with ARN have combined viral encephalitis, of which 57.1% involves herpes simplex encephalitis (29). Moreover, this proportion also appears to be high among children. Of 15 pediatric patients with HSV-2 ARN, five (33.3%) were found to have viral encephalitis after a retrospective analysis of the relevant cases (14, 21, 23) (Table 1). This may be related to the fact that children have lower immunity than adults, and that they cannot accurately describe the symptoms in time, thus increasing the incidence of complications. Therefore, ophthalmologists should be aware of whether patients have central nervous system infections especially when diagnosing and treating children with ARN.

ARN syndrome generally has a poor prognosis (9) and can quickly affect the other eye if left untreated (30). Early diagnosis and therapy are key to maintaining vision and preventing the involvement of the other eye (16). The diagnostic criteria for ARN include single or multiple retinal necrosis lesions (22). However, in this case, it had not been previously determined that our patient had severe vitreous opacity in the early stage as her fundus could not be observed, which posed a major challenge to our diagnosis. After a timely anterior chamber tap, the diagnosis was confirmed. We consider that the cause of severe vitreous opacification in this patient was possibly due to her normo-immune system. After the virus is activated in the eye, the immune system begins to function. Immune cells engulf the virus (31) and activate other associated cells (32). They also produce cytokines and mediate inflammatory reactions (33), which cause severe intraocular inflammatory reactions and severe vitreous opacification. Therefore, for suspected cases with invisible fundus, early intraocular fluid examination is especially helpful for the differential diagnosis.

The basic treatment methods for ARN mainly include systemic antiviral, anti-inflammatory, and antithrombotic therapy, and local application of cycloplegic eye drops (8). Currently, there are no clear criteria for the treatment of ARN in children although treatment in children has been similar to that in adults. In this case, the child was mainly administered a systemic intravenous infusion and intravitreal injection of drugs in the left eye as part of antiviral therapy, and steroids as part of

anti-inflammatory therapy. Early and comprehensive treatment promptly inhibited further retinal damage, and prevented involvement of the other eye.

ARN complications have been found to mainly include retinal detachment, with a general detachment rate in patients with ARN of 49% (34). Retinal detachment was also observed in seven (46.7%) of the 15 pediatric cases of ARN due to HSV-2 in our study (14, 17–19, 21, 22), as shown in **Table 1**. Once retinal detachment occurs in children, it predisposes them to more serious consequences than those occurring in adults. There can be several reasons why children may present late to an eye clinic after a long period of retinal detachment. In such cases, at presentation, the lesions in these children are prone to involve the macula, accompanied with serious complications, such as proliferative vitreoretinopathy. Prophylactic laser treatment at the earliest possible time has been reported to significantly reduce the risk of retinal detachment in ARN (35, 36). However, it remains to be elucidated whether prophylactic laser treatment is fully effective in preventing retinal detachment (2). In our young patient, prophylactic laser treatment was performed in time to prevent retinal detachment when the child was followed up for 2 months, which enabled subsequent stabilization and recovery. However, the long-term effects of prophylactic laser treatment in preventing retinal detachment in this young patient require further follow-up.

In conclusion, we report a case of ARN with viral encephalitis in an immunocompetent child with HSV-2 infection. The pathogenesis of HSV-2 ARN in children may be due to the acquisition of subclinical infection with HSV-2 during parturition, followed by reactivation of the latent virus in the body due to certain factors. The unique feature of this case was that our patient had severe vitreous opacity in the early stage, making the fundus unobservable, which made diagnosis challenging. Early diagnosis was confirmed using a timely anterior chamber tap. Early administration of antiviral drugs for comprehensive treatment curbed the development of the disease, prevented involvement of her other eye, and achieved a good therapeutic effect. A subsequent prophylactic laser retinopathy may have helped prevent a retinal detachment

in the affected eye. This outcome suggests that early diagnosis, early treatment, and subsequent prophylactic laser treatment may improve the prognosis of pediatric ARN. Moreover, in the process of diagnosis and treatment, it is particularly important to assess the presence of central nervous system infection. The low incidence of pediatric ARN increases the chances of this disease being missed during diagnosis and treatment by both pediatricians and ophthalmologists.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article, further inquiries can be directed to the corresponding authors.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Second Hospital of Hebei Medical University. Written informed consent to participate in this study was provided by the participant's parents. Written informed consent was obtained from the participant's parents for the publication of any potentially identifiable images or data included in this article.

AUTHOR CONTRIBUTIONS

LH consulted literature, curated the data, and drafted the manuscript. QS diagnosed, treated, and followed up our patient. JD diagnosed and treated our patient, proposed the idea for the case report, followed up our patient, collected photos, and reviewed the article. All authors contributed to the article and approved the submitted version.

ACKNOWLEDGMENTS

We appreciate the patient's willingness to participate in this study and the skillful assistance of physicians and nurses at the Department of Ophthalmology, the Second Hospital of Hebei Medical University.

REFERENCES

- Kanoff J, Sobrin L. New diagnosis and treatment paradigms in acute retinal necrosis. *Int Ophthalmol Clin.* (2011) 51:25–31. doi: 10.1097/IIO.0b013e31822d6864
- Cochrane TF, Silvestri G, McDowell C, Foot B, McAvoy CE. Acute retinal necrosis in the United Kingdom: results of a prospective surveillance study. *Eye.* (2012) 26:370–7. doi: 10.1038/eye.2011.338
- Standardization of Uveitis Nomenclature (SUN) Working Group. Classification criteria for acute retinal necrosis syndrome. *Am J Ophthalmol.* (2021) 228:237–44. doi: 10.1016/j.ajo.2021.03.057
- Kolacny D, Stalmans P, Wouters C, Van Ranst M, Casteels I. Bilateral acute retinal necrosis in a 12-year-old girl. *J AAPOS.* (2005) 9:599–601. doi: 10.1016/j.jaapos.2005.07.010
- Luck S, Sharland M, Griffiths P, Jenkins SM. Advances in the antiviral therapy of herpes virus infection in children. *Expert Rev Anti Infect Ther.* (2006) 4:1005–20. doi: 10.1586/14787210.4.6.1005
- Silva RA, Berrocal AM, Moshfeghi DM, Blumenkranz MS, Sanislo S, Davis JL. Herpes simplex virus type 2 mediated acute retinal necrosis in a pediatric population: case series and review. *Graefes Arch Clin Exp Ophthalmol.* (2013) 251:559–66. doi: 10.1007/s00417-012-2164-8
- Chan EW, Sun V, Eldeeb M, Kapusta MA. Epstein-Barr virus acute retinal necrosis in an immunocompetent host. *Retin Cases Brief Rep.* (2021) 15:412–6. doi: 10.1097/ICB.0000000000000819
- Gallego-Pinazo R, Harto M, Garcia-Medina JJ, Serra I, España E, Pinazo-Duran MD. Epstein-Barr virus and acute retinal necrosis in a 5-year-old immunocompetent child. *Clin Ophthalmol.* (2008) 2:451–5. doi: 10.2147/OPTH.S1757
- Pikkel YY, Pikkell J. Acute retinal necrosis in childhood. *Case Rep Ophthalmol.* (2014) 5:138–43. doi: 10.1159/000363130

10. Charles G. Acute retinal necrosis caused by herpes simplex virus type 2 in children: reactivation of an undiagnosed latent neonatal herpes infection. *Semin Pediatr Neurol.* (2012) 19:115–8. doi: 10.1016/j.spen.2012.02.005
11. Ganatra JB, Chandler D, Santos C, Kuppermann B, Margolis TP. Viral causes of the acute retinal necrosis syndrome. *Am J Ophthalmol.* (2000) 129:166–72. doi: 10.1016/S0002-9394(99)00316-5
12. Van Gelder RN, Willig JL, Holland GN, Kaplan HJ. Herpes simplex virus type 2 as a cause of acute retinal necrosis syndrome in young patients. *Ophthalmology.* (2001) 108:869–76. doi: 10.1016/S0161-6420(01)00556-5
13. Morse LS, Mizoguchi M. Diagnosis and management of viral retinitis in the acute retinal necrosis syndrome. *Semin Ophthalmol.* (2009) 10:28–41. doi: 10.3109/08820539509059977
14. Tan JCH, Byles D, Stanford MR, Frith PA, Graham EM. Acute retinal necrosis in children caused by herpes simplex virus. *Retina.* (2001) 21:344–7. doi: 10.1097/00006982-200108000-00008
15. Tran THC, Rozenberg F, Fillet AM, Bodaghi B. Diagnostic and therapeutic management of a severe acyclovir-resistant acute retinal necrosis in a young child. *Graefes Arch Clin Exp Ophthalmol.* (2005) 243:266–8. doi: 10.1007/s00417-004-0985-9
16. Landry ML, Mullangi P, Nee P, Klein BR. Herpes simplex virus type 2 acute retinal necrosis 9 years after neonatal herpes. *J Pediatr.* (2005) 146:836–8. doi: 10.1016/j.jpeds.2005.02.025
17. Khurana RN, Charonis A, Samuel MA, Gupta A, Tawansy KA. Intravenous foscarnet in the management of acyclovir-resistant herpes simplex virus type 2 in acute retinal necrosis in children. *Medical Sci Monit.* (2005) 11:CS75–8.
18. King J, Chung M, DiLoreto DA. A 9 year-old girl with herpes simplex virus type 2 acute retinal necrosis treated with intravitreal foscarnet. *Ocul Immunol Inflamm.* (2007) 15:395–8. doi: 10.1080/09273940701486431
19. Chiquet C, Bodaghi B, Mougini C, Najioullah F. Acute retinal necrosis diagnosed in a child with chronic panuveitis. *Graefes Arch Clin Exp Ophthalmol.* (2006) 244:1206–8. doi: 10.1007/s00417-005-0233-y
20. Tanaka-Kitajima N, Iwata N, Ando Y, Sakurai H, Iwami M, Tsuzuki K, et al. Acute retinal necrosis caused by herpes simplex virus type 2 in a 3-year-old Japanese boy. *Eur J Pediatr.* (2009) 168:1125–8. doi: 10.1007/s00431-008-0878-8
21. Gupta A, Rani PK, Bagga B, Dore P, Mittal A, Jalali S. Bilateral herpes simplex-2 acute retinal necrosis with encephalitis in premature twins. *J AAPOS.* (2010) 14:541–3. doi: 10.1016/j.jaapos.2010.08.011
22. Hsu C, Moïnfar N, Lipman B, Capone A, Trese M. Acute retinal necrosis in a neonate. *Retin Cases Brief Rep.* (2013) 7:406–8. doi: 10.1097/ICB.0b013e318297f6d5
23. Ren ZX, Xu F, Yao ZW, Li BY, Chang YQ, Zhang ZY, et al. Acute retinal necrosis in a neonate with HSV II encephalitis. *Pediatr Neonatol.* (2019) 60:344–5. doi: 10.1016/j.pedneo.2018.06.001
24. Tran THC, Stanescu D, Caspers-Velu L, Rozenberg F, Liesnard C, Gaudric A, et al. Clinical characteristics of acute HSV-2 retinal necrosis. *Am J Ophthalmol.* (2004) 137:872–9. doi: 10.1016/j.ajo.2003.12.036
25. Chou HD, Teh WM, Sun MH, Chen KJ. Epstein-Barr virus retinitis in an immunocompromised child: a case report. *Eur J Ophthalmol.* (2020). doi: 10.1177/1120672120926855
26. Choi SI, Kim JR, Ra H. Necrotizing herpetic retinopathy in an immunocompromised pediatric patient with minimal signs of inflammation: case report. *BMC Ophthalmol.* (2016) 16:85. doi: 10.1186/s12886-016-0253-x
27. Smith LK, Kurz PA, Wilson DJ, Flaxel CJ, Rosenbaum JT. Two patients with the von Szily reaction: herpetic keratitis and contralateral retinal necrosis. *Am J Ophthalmol.* (2007) 143:536–8. doi: 10.1016/j.ajo.2006.10.040
28. Kim SJ, Kang SW, Joo EY. An unusual case of herpes simplex viral encephalitis following acute retinal necrosis after administration of a systemic steroid. *J Epilepsy Res.* (2012) 2:21–4. doi: 10.14581/jer.12006
29. Vandercam T, Hintzen RQ, de Boer JH, Van der Lelij A. Herpetic encephalitis is a risk factor for acute retinal necrosis. *Neurology.* (2008) 71:1268–74. doi: 10.1212/01.wnl.0000327615.99124.99
30. Okunuki Y, Usui Y, Kezuka T, Takeuchi M, Goto H. Four cases of bilateral acute retinal necrosis with a long interval after the initial onset. *Br J Ophthalmol.* (2011) 95:1251–4. doi: 10.1136/bjo.2010.191288
31. Atherton SS, Cathcart HM. Anterior segment mechanisms of protection during herpes simplex virus 1 infection. *Jpn J Ophthalmol.* (2010) 54:182–6. doi: 10.1007/s10384-010-0798-9
32. Marshall JD, Heeke DS, Abbate C, Yee P, Van Nest G. Induction of interferon-gamma from natural killer cells by immunostimulatory CpG DNA is mediated through plasmacytoid-dendritic-cell-produced interferon-alpha and tumour necrosis factor-alpha. *Immunology.* (2006) 117:38–46. doi: 10.1111/j.1365-2567.2005.02261.x
33. Zheng M, Atherton SS. Cytokine profiles and inflammatory cells during HSV-1-induced acute retinal necrosis. *Invest Ophthalmol Vis Sci.* (2005) 46:1356–63. doi: 10.1167/iops.04-1284
34. Zhao XY, Meng LH, Zhang WF, Wang DY, Chen YX. Retinal detachment following acute retinal necrosis and the efficacies of different interventions: a systematic review and meta-analysis. *Retina.* (2020) 41:965–78. doi: 10.1097/IAE.0000000000002971
35. Lau CH, Missotten T, Salzmann J, Lightman SL. Acute retinal necrosis features, management, and outcomes. *Ophthalmology.* (2007) 114:756–62. doi: 10.1016/j.ophtha.2006.08.037
36. Han DP, Lewis H, Williams GA, Mieler WF, Abrams GW, Aaberg TM. Laser photocoagulation in the acute retinal necrosis syndrome. *Arch Ophthalmol.* (1987) 105:1051–4. doi: 10.1001/archoph.1987.01060080053027

Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's Note: All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

Copyright © 2022 He, Duan and Shang. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.