Bilateral Posterior Ischaemic Optic Neuropathy Secondary to Diabetic Ketoacidosis: An Unfortunate Cure for Diabetic Retinopathy

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Abstract

Purpose: To report a case of bilateral posterior ischaemic optic neuropathy secondary to diabetic ketoacidosis.

Methods: Case history with multimodal imaging, including colour fundus photography, fundus fluorescein angiography, optical coherence tomography, and magnetic resonance imaging with high resolution diffusion weighted imaging.

Results: We report a 29-year-old female with bilateral posterior ischaemic optic neuropathy following diabetic ketoacidosis resulting in no perception of light vision in both eyes, confirmed on magnetic resonance imaging with high resolution diffusion weighted imaging. We also document the resolution of proliferative diabetic retinopathy following the onset of bilateral optic nerve atrophy.

Conclusion: Bilateral posterior ischaemic optic neuropathy can occur following diabetic ketoacidosis, and proliferative diabetic retinopathy can resolve following the onset of optic nerve atrophy. If posterior ischaemic optic neuropathy is suspected, magnetic resonance imaging with high resolution diffusion weighted imaging may aid in confirming the diagnosis.

Keywords: Bilateral posterior ischaemic optic neuropathy; Diabetic ketoacidosis; Diabetic retinopathy; Diffusion weighted imaging

Introduction

Loss of vision secondary to Posterior Ischaemic Optic Neuropathy (PION) is uncommon. In this article, we report an extremely rare case of bilateral PION following Diabetic Ketoacidosis (DKA) resulting in No Perception of Light (NPL) vision in both eyes, followed by the development of bilateral optic nerve atrophy. We also document the resolution of proliferative diabetic retinopathy following the onset of optic nerve atrophy. To our knowledge, this is the first published case report of bilateral PION secondary to DKA to include multimodal imaging and magnetic resonance imaging with high resolution diffusion weighted imaging confirming the diagnosis.

Case

A 29-year-old female with a medical history including type 1 diabetes mellitus, Addison's disease and Coeliac disease, was first referred to the Perth ophthalmology service in April 2013 with a preliminary diagnosis of diabetic retinopathy. At that time, snellen visual acuity measured 6/9 unaided each eye. Anterior segment examination was healthy; however, dilated fundus examination revealed proliferative diabetic retinopathy in both eyes with New Vessels at the Disc (NVD) without vitreous haemorrhage (Figure 1). Fundus Fluorescein Angiography (FFA) confirmed NVD and peripheral capillary non-perfusion (Figure 2). Pan Retinal Photocoagulation (PRP) laser treatment was initiated, and scheduled to be completed over multiple laser sessions for which she was an infrequent attender.


Figure 1: Colour fundus photograph of the left eye displaying new vessels at the disc (NVD).
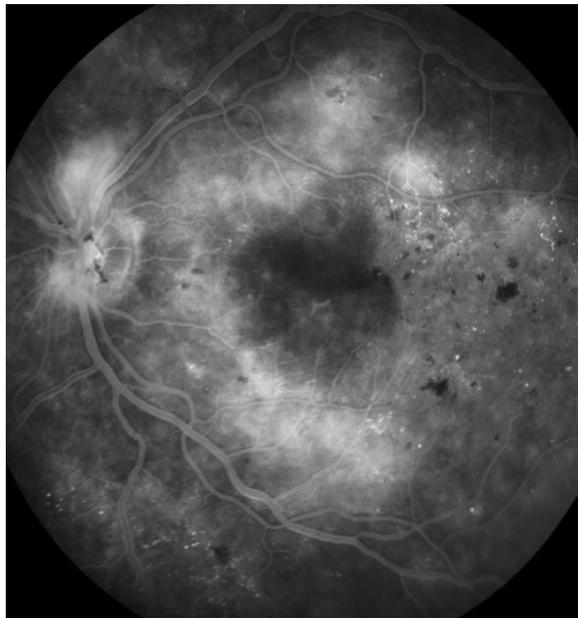
Figure 2: Fundus Fluorescein Angiography (FFA) of the left eye displaying new vessels and leakage at the disc with capillary non-perfusion beyond the arcades.

In August 2013 the patient was brought by ambulance to the emergency department after being found cold and unresponsive. On examination the patient was cool and peripherally shut down, with a Glasgow Coma Score (GCS) of 3. Blood pressure was very low ranging between 90/50 and 50/20. There was profound hypothermia with a temperature of 30.3°C. Arterial blood gas (ABG) testing confirmed metabolic acidosis with respiratory compensation, with an extremely high blood sugar level of 69 mmol/L.
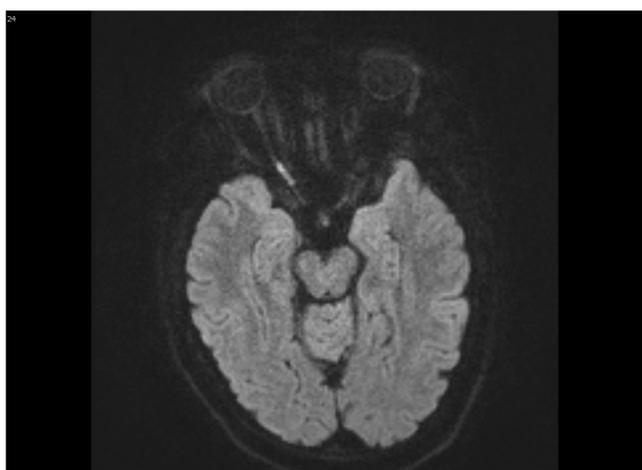

Figure 3: MRI DWI B1000 imaging demonstrating diffusion restriction (ischaemia) in the posterior intraorbital segment of the right optic nerve.
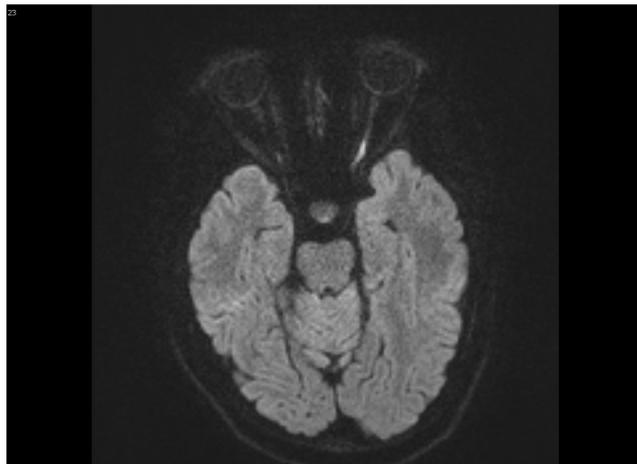
Figure 4: MRI DWI B1000 imaging demonstrating diffusion restriction (ischaemia) in the posterior intraorbital segment of the left optic nerve.

DKA management was initiated as per protocol with fluid resuscitation, an insulin/dextrose infusion and monitoring of potassium with replacement as necessary. The patient was intubated and ventilated, then admitted to the intensive care unit with noradrenaline inotropic support titrated to blood pressure. Two days later, after recovering metabolically, the patient was extubated and immediately reported visual loss in both eyes. Ophthalmic examination confirmed no perception of light (NPL) vision in both eyes. Both pupils were dilated with little response to light. Anterior segment and dilated fundus examination was unremarkable. Both optic nerve heads had a normal appearance at this stage apart from residual NVD.
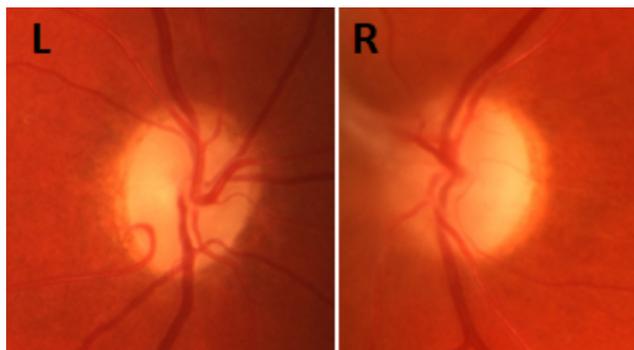
Figure 5: Colour fundus photographs displaying atrophy of the right and left optic nerves.

Standard T1/T2 MRI imaging of the brain and visual pathways appeared normal, however high resolution diffusion weighted imaging (DWI) through the optic nerves demonstrated diffusion restriction within the posterior intra-orbital portions of both optic nerves, involving approximately 14 mm of nerve on either side. This extended to, but did not involve, the intra-canalicular portions of both nerves.

(Figures 3 and 4). No other abnormalities within the brain or visual pathways were demonstrated.
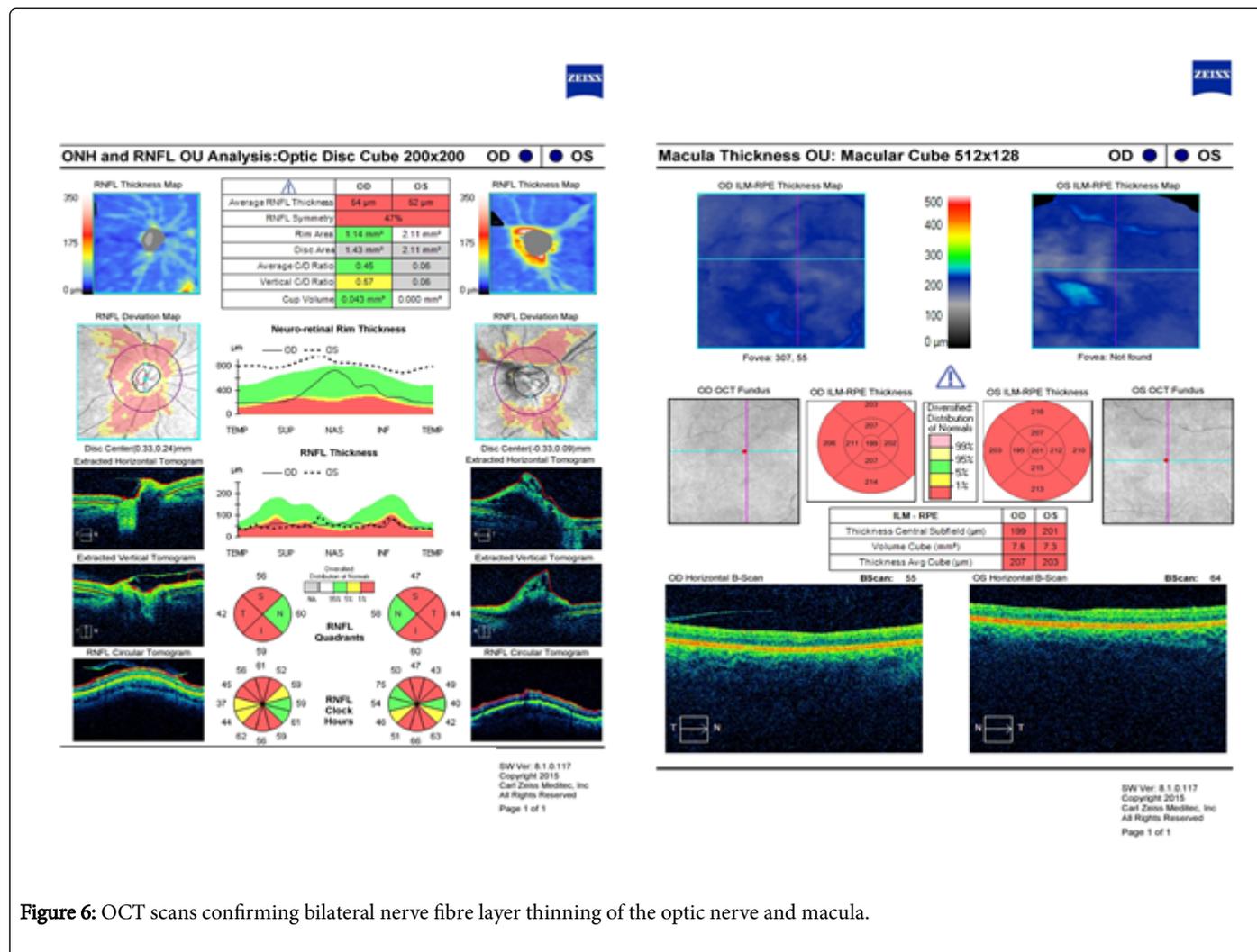

Figure 6: OCT scans confirming bilateral nerve fibre layer thinning of the optic nerve and macula.

Visual electrophysiology testing displayed reduced scotopic and photopic responses bilaterally. PERG, PVEPs and flash VEPs were grossly reduced consistent with severe bilateral optic neuropathies. The reduced ERG readings were thought to be secondary to diabetic retinopathy.
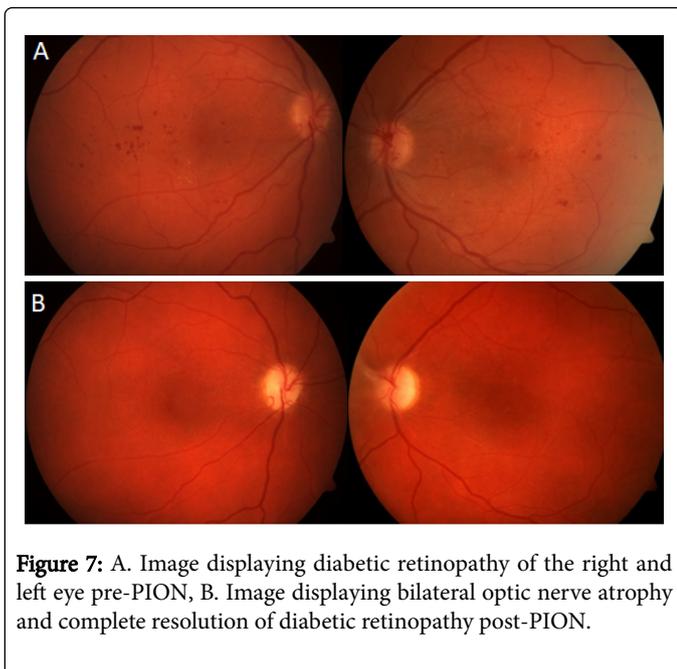
The patient remained in hospital for a total of 19 days and unfortunately did not recover any vision. Approximately 1-2 months after the episode of PION, bilateral optic nerve atrophy ensued (Figure 5). Nerve fibre layer thinning of the optic nerve and macula was confirmed on OCT scanning (Figure 6). Complete resolution of the proliferative diabetic retinopathy after the development of optic nerve atrophy occurred despite receiving minimal PRP laser treatment (Figure 7).

Discussion

Bilateral posterior ischaemic optic neuropathy following diabetic ketoacidosis is extremely uncommon, with very few published reports accessible in the literature [1-3]. However, posterior ischaemic optic neuropathy as a clinical entity has been well studied, in particular by Hayreh, who has documented in detail the anatomy of the optic nerve in relation to the clinical manifestations of optic neuropathy [4]. Hayreh also separated the optic neuropathies into two groups - Anterior Ischaemic Optic Neuropathy (AION) and Posterior Ischaemic Optic Neuropathy (PION) [4].

The various causes of PION can be divided into three main groups: surgical (hypotensive), arteritic (giant cell arteritis) related, and non-arteritic related [4]. Akin to the few other case reports of bilateral PION post diabetic ketoacidosis [2,3], we feel the most likely cause of PION in this case was prolonged systemic hypotension, reducing arterial perfusion pressure and oxygenation to the optic nerves, ultimately leading to ischaemic damage. During resuscitation, the blood pressure was noted to be very low ranging between 90/50 and 50/20. The patient also reports she may have been unconscious for approximately 12-24 h before admission to hospital, potentially prolonging the period of systemic hypotension.

Figure 7: A. Image displaying diabetic retinopathy of the right and left eye pre-PION, B. Image displaying bilateral optic nerve atrophy and complete resolution of diabetic retinopathy post-PION.

Hypotensive PION is most commonly seen in the perioperative setting with patients reporting profound visual loss in one or both eyes as soon as they become conscious, and usually associated with procedures where the patient has been exposed to prolonged hypotensive conditions [5]. Historically, many surgical procedures were performed under hypotensive conditions in an effort to reduce the risk of intraoperative bleeding [5]. However, in recent times there has been a shift away from hypotensive anaesthesia, with increased awareness amongst the anaesthetic community of the potentially devastating side effects of intraoperative hypotension. This shift is also perhaps due to well publicised medicolegal cases, where patients have developed major neurological complications following hypotensive anaesthesia [6].

Other risk factors for hypotensive PION have been reported including high intraocular pressure, increased orbital venous pressure related to prone positioning during surgery, the use of vasopressors to increase central arterial pressure (at the expense of downstream arterioles and capillaries), and decreased blood oxygen carrying capacity (anaemia/low blood volume/haemodilution) [7]. It is possible that in this case, the patient's mild anaemia (90 g/L), severe metabolic derangement, and the use of inotropic support may have contributed to the development of PION, however we still feel the main causative factor was the prolonged period of systemic hypotension.

It is interesting that in this case, and many other reports of hypotensive PION [7], the ischaemia was isolated to the posterior portion of the optic nerve, without any accompanying damage to the remainder of the visual pathway or central nervous system. This is most likely explained by the blood supply to the various segments of the optic nerve [4]. The optic nerve is divided into three segments: intraorbital, intracanalicular and intracranial. The most anterior segment of intraorbital optic nerve is exclusively supplied by the posterior ciliary arteries. It is this segment of nerve that is damaged in an anterior ischaemic optic neuropathy (AION).

PION occurs in the posterior portion of the intraorbital segment of the optic nerve, with this area displaying a much less definitive blood supply [4]. The posterior segment of the intraorbital optic nerve can be divided into two segments. The posterior segment is between the site of entry of the central retinal artery into the nerve. This part has two vascular systems for its supply including a peripheral centripetal vascular system that is always present, and an axial centrifugal vascular system that is present in 75% of optic nerves. The second segment of posterior optic nerve extends posteriorly from the entry of the central retinal artery, backwards to the orbital apex. This segment is supplied by the peripheral centripetal vascular system formed by the pial vascular plexus, supplied by multiple small collateral branches of the ophthalmic artery and occasionally the orbital arteries. Approximately 10% may have an axial centrifugal vascular system formed by branches of the central retinal artery.

Since the intraorbital portion of the optic nerve receives its blood supply from multiple sources, this creates potential "watershed" zones within the optic nerve, theoretically making this portion of the optic nerve more susceptible to changes in blood pressure and ischaemia. The anatomical variation in blood supply to the posterior optic nerve may also make some patients more vulnerable than others.

Resolution of PDR occurred following the onset of optic atrophy, despite this patient receiving incomplete PRP laser treatment. In studies of asymmetric diabetic retinopathy, optic nerve atrophy has been identified as a protective factor against PDR [8]. The exact mechanism for this "protective" effect is still under debate. In this case we confirmed inner retinal thinning on OCT scanning, and there is evidence to suggest that the cells of the inner retina, in particular the Muller cells, may play a large role in VEGF release and neovascularisation in diabetic retinopathy [9]. Another theory is that the atrophic neural tissue may reduce metabolic requirements, resulting in less ischaemic drive for proliferative disease [8].

Standard T1/T2 MRI imaging of the visual pathways appeared normal; however, ischaemia of the posterior optic nerve was confirmed on high resolution diffusion weighted imaging (DWI). DWI MRI sequences are available on every modern MRI scanner. The DWI sequence measures the random motion of water molecules in tissue (Brownian motion) and is used to identify areas of diffusion restriction [10]. Essentially tissue diffusion is measured by applying a strong radiofrequency gradient to the tissue first in one direction, and then an equal gradient in the opposite direction. If the water molecules have been able to move freely by diffusion between the two gradients there will be no signal, but if the molecules are unable to move freely (restricted) a strong signal is recorded. DWI has many applications and is especially useful in the early identification of ischaemic tissue in infarcts and the evaluation of cellular dense tumours. For the investigation of potential optic nerve ischaemia, high resolution DWI sequences over the optic nerves are recommended as the spatial resolution of standard DWI sequences may miss subtle areas of diffusion restriction.

In conclusion, this case emphasizes the importance of blood pressure management in the event of diabetic ketoacidosis and in the perioperative setting, as the posterior segment of the optic nerve may be more susceptible to hypotension and ischaemia than the rest of the visual pathway. This case also highlights the importance of the inner retinal cells in the development of proliferative diabetic retinopathy, and that diabetic retinopathy can resolve following the ischaemic optic neuropathy. Finally, if PION is suspected, MRI with high resolution DWI imaging may aid in confirming the diagnosis.

Acknowledgements

Conflicts of Interest

The authors have no proprietary interest in this study or conflicts of interest.

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