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CASE REPORT

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Smoke-stack fluorescein leakage in a vitrectomised eye with proliferative diabetic retinopathy: a rare angiographic phenomenon

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Abstract

Background/Aim This case report aims to describe an unusual angiographic finding of smoke-stack leakage (SSL) in a vitrectomised eye of a patient with proliferative diabetic retinopathy (PDR).

Case description A 59-year-old male with a 17-year history of type 2 diabetes mellitus underwent fundus fluorescein angiography (FA) following vitrectomy for vitreous hemorrhage secondary to PDR. His visual acuity at the time of FA was 6/6 in both eyes. The examination focused on identifying neovascularization elsewhere (NVE) and analysing leakage patterns. FA revealed active NVEs in the left eye with late-phase leakage nasally and inferiorly to the optic disc, while the right eye exhibited a distinctive SSL pattern from residual proliferation. Interestingly, the leakage subsided in the late phase, leaving only staining of the residual fibrous tissue.

Conclusion The observed SSL in this vitrectomised eye underscores unique post-surgical dynamics of fluorescein diffusion. This case highlights the importance of recognizing altered leakage patterns in vitrectomised patients, which can impact the evaluation and management of retinal neovascularization in PDR.

Keywords Proliferative diabetic retinopathy, Smoke-stack leakage, Vitrectomy, Fundus fluorescein angiography, Neovascularization

Introduction

Proliferative diabetic retinopathy (PDR) is diagnosed primarily through the identification of neovascularization elsewhere (NVE) and/or at the disc on fundus fluorescein angiography (FA) [1]. Neovascularization typically exhibits early hyperfluorescence, with continuous vessel filling followed by late-phase leakage due to fluorescein extravasation. The extent of leakage correlates with the vascularity of the neovascular proliferation and the degree of traction from the posterior cortical vitreous [1, 2].

The "smoke-stack" pattern of leakage, classically associated with central serous chorioretinopathy (CSCR), is characterized by vertical spread of fluorescein in a plume-like configuration [3]. This leakage pattern in CSCR is attributed to convection currents caused by protein concentration gradients in the subretinal fluid. Interestingly, smoke-stack leakage (SSL) has also been reported in various retinal conditions, including ischemic retinopathies from PDR and sickle cell anemia, branch retinal artery occlusion, and vasoproliferative retinal tumours [4–6].

This case report describes a patient with PDR who exhibited SSL on FA after pars plana vitrectomy for

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secondary vitreous hemorrhage. Such a rare leakage pattern secondary to PDR following vitrectomy has not been reported in literature to the best of our knowledge. We explore the possible factors contributing to this rare and atypical angiographic finding.

Case description

A 59-year-old male with a 17-year history of type 2 diabetes mellitus presented for routine follow-up at the retina clinic. His visual acuity was 6/6 in both eyes. Three months prior, he underwent vitrectomy in the right eye for vitreous hemorrhage secondary to PDR. On examination, he was pseudophakic with posterior chamber intraocular lenses in both eyes. The anterior segment and intraocular pressures were normal. Fundus examination of the right eye revealed an attached retina, healthy macula and optic disc, and well-healed endolaser scars. There was a small area of residual fibrous proliferation temporal to the macula, with suboptimal laser coverage inferior to the horizontal meridian. The left eye showed an attached retina and well-covered pan-retinal photocoagulation (PRP) laser scars (Fig. 1).

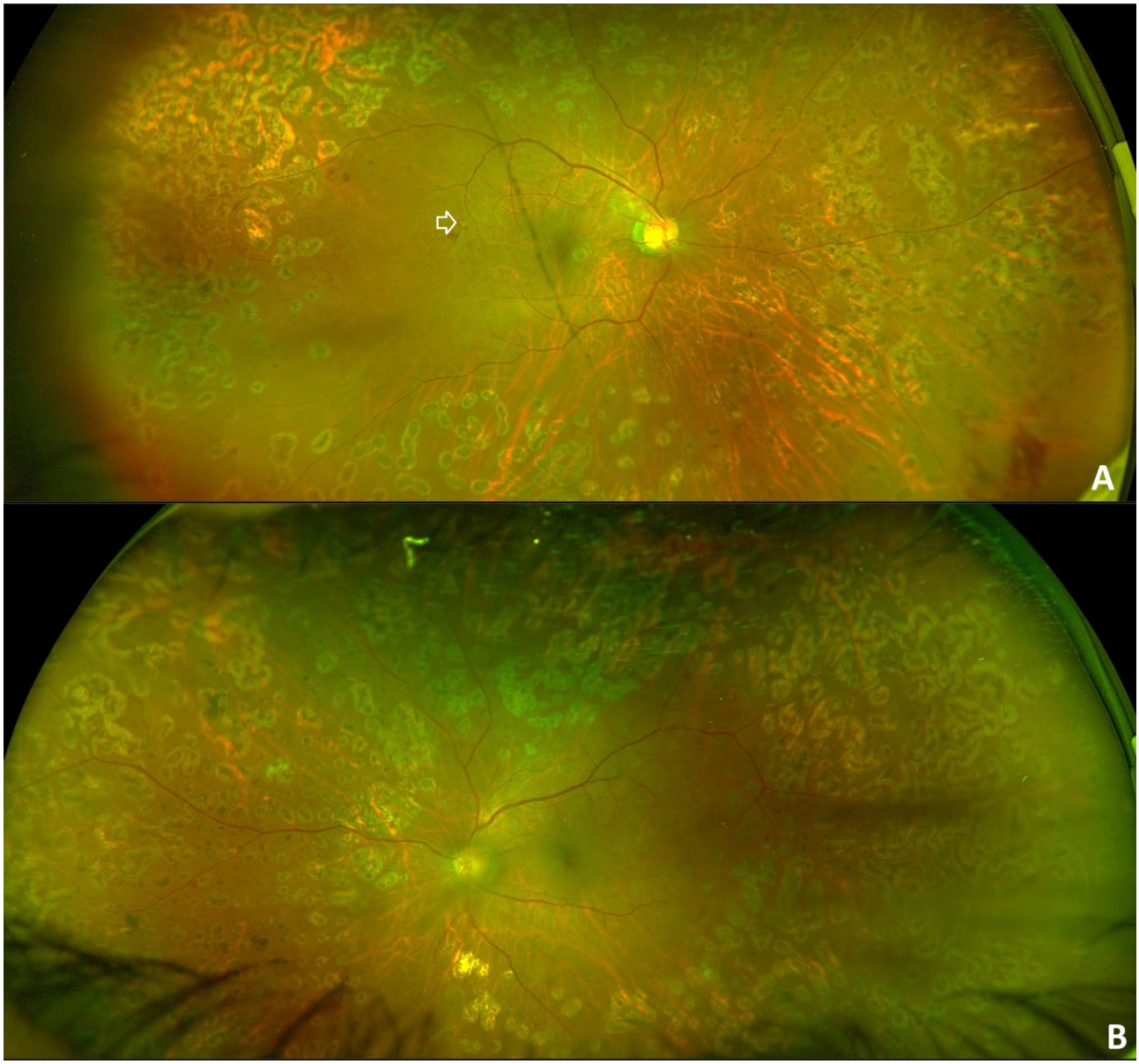

Fig. 1 Colour fundus photos of both eyes: **A, B**: Fundus photograph (Optos, Daytona, UK) of the right eye reveals a vitrectomised eye with an attached retina, a healthy macula, and optic disc, along with well-healed endolaser scars. A small residual fibrous proliferation is observed temporal to the macula (white arrow), with insufficient laser scars inferior to the horizontal meridian. The left eye shows an attached retina with well-distributed pan-retinal photocoagulation laser scars

Fig. 2 Fluorescein angiography images of the left eye: **A, B**: Fluorescein angiography (Spectralis, Heidelberg Engineering, Germany) of the left eye reveals multiple neovascular fronds with late-phase leakage nasal and inferior to the optic disc. Healed laser scars appear as hypofluorescent spots on the angiogram

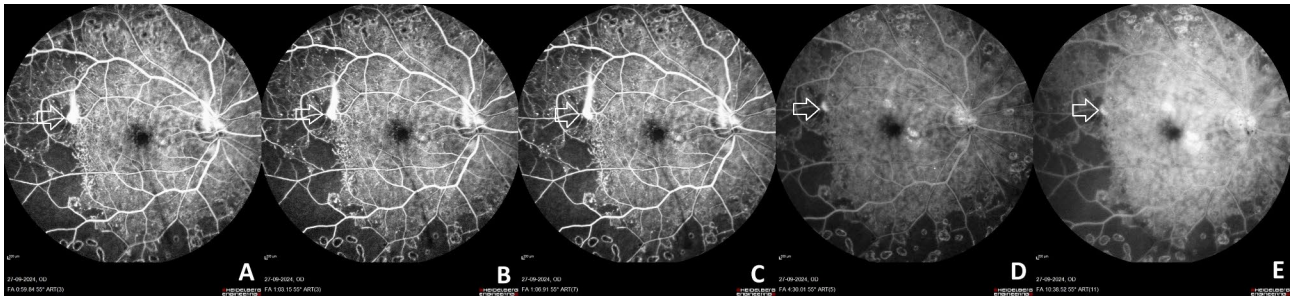

Fig. 3 Fluorescein angiography images of the right eye: **A-E**: Fluorescein angiography (Spectralis, Heidelberg Engineering, Germany) of the right eye displays an atypical "chimney-like" smoke-stack leakage originating from the residual fibrous proliferation temporal to the macula, extending into the superior periphery (white arrow). A similar leakage is observed at the superior margin of the optic disc. In the late phase, both leakages resolved, leaving only staining of the residual fibrous proliferation

Fundus FA (5 ml of 10% fluorescein) was performed to evaluate the NVE regression, particularly in the left eye. FA of the left eye demonstrated multiple NVEs with late-phase leakage nasally and inferiorly to the optic disc (Fig. 2). In the right eye, FA showed an unusual "chimney-like" SSL pattern from the trimmed, residual proliferation temporal to the macula, extending into the superior periphery. A similar leak was noted at the superior optic disc margin. In the late phase, both leaks subsided, leaving only staining of the residual proliferation (Fig. 3). The patient had no known history of CSCR and exhibited no clinical signs of current or past CSCR.

The patient was diagnosed with bilateral PDR, with active, leaking NVE in the left eye. Management included additional targeted laser photocoagulation to areas of capillary non-perfusion in the right eye and a combination of intravitreal anti-vascular endothelial growth factor (anti-VEGF) injection and supplementary laser photocoagulation to the NVE stumps in the left eye. At the six-month follow-up, best-corrected visual acuity remained stable at 6/6 in both eyes, with both eyes demonstrating a quiescent phase of PDR.

Discussion

While a "smoke-stack leakage" is a term often associated with CSCR on FA, it's not exclusively limited to that condition and can also be observed in other diseases, particularly ischemic retinopathy. The SSL in CSCR manifests itself as a point leakage from the retinal pigment epithelium at the arteriovenous or early venous phase of the FA, which gradually increases in size during the midphase and begins to ascend. After reaching a certain height, the dye may extend temporally and/or nasally in an umbrella or mushroom-like pattern. Bujarborua et al. studied the fluid dynamics of CSCR leakage by FA to explain the SSL pattern [3]. They observed that the increased choroidal hyperpermeability, breakdown of the outer blood retinal barrier, convection currents and increased protein concentration due to the hyperdense fibrin in the subretinal fluid play a major role in the production of SSL. In their study, fluid containing a low concentration of fluorescein ascended because of convection currents while highly concentrated dye descended. On the contrary, El Khatib et al. demonstrated seven eyes of SSL in cases not associated with CSCR and secondary to ischemic proliferative retinopathy [4]. Retinal neovascularization manifests as point leakage from the retinal capillaries, with fluorescein leaking into the vitreous cavity due to a breach in the vitreoretinal interface. The SSL pattern in these cases were typically attributed to micro convection currents in the vitreous cavity, driven by factors such as fluorescein's low molecular weight and concentration, protein content and oncotic pressure gradients, thermodynamic differences between the warmer retina and cooler vitreous, and an abnormal vitreoretinal interface in non-vitrectomised eyes [4–6]. The feeding by the high-flow collaterals to the neovascular complex could also be responsible for the SSL in retinal neovascularisation [7]. Our case demonstrated an unusual angiographic finding of SSL in a vitrectomised eye of a patient with PDR, a phenomenon not previously reported in literature.

We propose that retinal capillary non-perfusion and the absence of laser scars in the inferior retina contributed to the convection currents and the observed SSL in this case. In chronic diabetes, dysfunction of the retinal pigment epithelium (RPE) barrier is well documented [8]. Additionally, areas of retinal capillary non-perfusion lacking pan retinal photocoagulation (PRP) scars exhibit heightened metabolic activity of RPE cells, leading to increased production of pigment epithelium-derived growth factor and VEGF [9]. This metabolic hyperactivity may create a thermodynamic gradient between retinal hemispheres, promoting convection currents and SSL. Furthermore, the presence of large, high-flow neovascular complexes, perfused by high-flow collateral vessels, could also contribute to the unique SSL pattern observed in this case.

An intriguing observation in this case was the complete subsidence of leakage in the late phase of the angiogram, with only staining of the residual proliferative tissue remaining once the fluorescein dye had exited the ocular vasculature. This contrasts with the typical late-phase finding in PDR, where NVE exhibits persistent leakage even after the dye has cleared from the ocular blood flow. The distinct leakage pattern in this case is likely attributable to the post-vitrectomy status of the eye, which alters the dynamics of fluorescein diffusion and leakage.

This case highlights the importance of recognizing atypical FA leakage patterns in vitrectomised eyes, as altered fluorescein diffusion dynamics can mimic classic patterns seen in other retinal diseases. Understanding these post-vitrectomy changes is crucial for accurate interpretation of angiographic findings and guiding appropriate management of PDR.

Abbreviations

PDR	Proliferative diabetic retinopathy
NVE	Neovascularization elsewhere
FA	Fluorescein angiography
CSCR	Central serous chorioretinopathy
SSL	Smoke stack leak
PRP	Pan retinal photocoagulation
VEGF	Vascular endothelial growth factor
RPE	Retinal pigment epithelium

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None.

Author contributions

RV– conceptualizing the study, data acquisition, analysing the data, clinical management of the patient, interpreting the findings, writing & reviewing the manuscriptPG, RK, KG– Data acquisition and analysing the data VP, PH– critical review of the manuscriptAll authors read and approved the final manuscript.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Written informed consent was obtained from the patient for publication of this case report and any accompanying images. A copy of the written consent is available for review by the Editor of this journal.

Competing interests

The authors declare no competing interests.

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