American Journal of Ophthalmology Case Reports 27 (2022) 101664

Contents lists available at ScienceDirect

American Journal of Ophthalmology Case Reports

journal homepage: www.ajocasereports.com/

Near infra-red reflectance videography in the evaluation of retinal artery macroaneurysm pulsatility

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ARTICLE INFO

Keywords:
Retinal artery pulsation
Retinal artery macroaneurysm
Near infrared reflectance videography

ABSTRACT

Purpose: To describe pulsations of the retinal arteries detected in the course of evaluation of an exudative non-pulsatile retinal arterial macroaneurysm using near infra-red reflectance videography.

Observations: A 68-year-old patient underwent slit lamp examination, color retinal imaging, optical coherence tomography, fluorescein videography, short wave-length and near infrared fundus autofluorescence of the left, and near infrared reflectance videography of both eyes. A 1309.3 × 955.1 μm exudative lesion with intraretinal hemorrhage and retinal edema secondary to a retinal arterial macroaneurysm was observed along the superior temporal arcade between the retinal artery and vein. Bilateral serpentine and expansile spontaneous retinal artery pulsations were detected along the retinal vascular tree and imaged using near infrared reflectance videography. Fluorescein video-angiography showed an irregular filling defect of the lesion with minimal angiographic leakage. Whereas pulsations of the retinal arteries were visualized, no pulsations of the retinal arterial macroaneurysm were detected with either dynamic imaging modality, therefore observation was recommended. Significant spontaneous lesion regression was observed at one month follow-up.

Conclusionand Importance: Detection of spontaneous retinal artery pulsation and the assessment of exudative maculopathy due to an underlying retinal arterial macroaneurysm could be facilitated by near infrared reflectance videography. This imaging modality can aid in clinical decision-making where a non-pulsatile macroaneurysm would favor conservative management.

1. Introduction

The traditional description of retinal artery pulsations is that they are observed solely in the presence of pathological disorders.[1] Modern imaging technology has facilitated the detection and measurement of physiological retinal vascular pulsations. These methods can be used to measure pulsations in retinal vessels, as well as their accompanying lesions, which can be of diagnostic, therapeutic, and prognostic significance, they include: Ophthalmoscopy,[2] ophthalmodynamometry and ocular-pneumatoplethysmography,[3] electrocardiography synchronized modified fundus imaging,[4] dynamic fluorescein[5] and indocyanine angiography,[6] near-infrared reflectance ophthalmoscopy,[7] swept-source optical coherence tomography,[8] adaptive optics imaging,[9] and the Dynamic Vessel Analyzer.[10] More recently, we described Modified Photoplethysmography as a non-invasive technique of measurement of the retinal vascular pulse amplitude and timing characteristics in the Fourier domain[11]

Assessment of pulsatility of a retinal macroaneurysm allows a distinction between an arterial and venous macroaneurysm, the latter which is non-pulsatile.[6] Pulsatility of a retinal arterial macroaneurysm (RAM) can also be used to classify the exudative from the hemorrhagic subtypes, where pulsation is more common in the exudative subtype. Furthermore, the presence of pulsatility in a retinal artery macroaneurysm is thought to be a sign of disease progression.[6] We describe a case where serpentine and expansile spontaneous retinal artery pulsation is associated with a non-pulsatile exudative RAM using near-infrared reflectance videography (NIR-RV), which in this case an absence of RAM pulsatility favored conservative management, thereby mitigated further therapeutic intervention.

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https://doi.org/10.1016/j.ajoc.2022.101664
Received 10 May 2022; Received in revised form 15 June 2022; Accepted 10 July 2022
Available online 19 July 2022

2. Case report

An asymptomatic 68-year-old woman attended a routine ophthalmic examination. Medical history included poorly controlled type II diabetes treated with insulin, "last HbA1C was 91 mmol/mol", hyperlipidemia, hypertension, non-alcoholic fatty cirrhosis without portal hypertension, and previous hepatitis B. Hepatocellular carcinoma was diagnosed in the hepatic segment VIII, which was treated with laparoscopic microwave ablation 5-years before the current consultation.

On examination, her weight, blood pressure, and pulse rate were 107.9 kg, 159/84 mmHg (pulse pressure 75 mmHg), and 81 beats per minute respectively. No cardiac murmurs were detected on auscultation. Visual acuity was 6/7.5 bilaterally and intraocular pressure was measured at 14 and 15 mmHg in the right and left eyes respectively. Dilated fundus examination of both eyes demonstrated minimal diabetic retinopathy. In the left eye a focal area of retinal hemorrhage along the superior temporal arcade located at the 12 oclock position between the superior temporal retinal artery and vein was noted. The lesion measured 1309.3×955.1 μm. There were accompanying hard exudates, especially along the superior margin, and a cotton wool spot on the upper pole of the lesion. A pale circumscribed non-pulsatile area was observed in the center of the hemorrhagic lesion Fig. 1A. Whereas retinal venous pulsations were detectable in the right eye at the optic disc, spontaneous retinal arterial pulsations were not detectable in either eye on slit-lamp biomicroscopy. Optical coherence tomography showed intraretinal hemorrhage and exudate involving multiple retinal layers, especially at the level of the outer nuclear layer (Fig. 1B) Short-wavelength fundus autofluorescence showed extension of the macular edema to the superior margin of the foveola (layer Fig. 1C). Near-infrared reflectance videography demonstrated a pulsatile retinal arterial tree in both eyes; the pattern varied with the vascular geometry. Noted in the left eye was a serpentine pulsatile S-shaped segment of the superior temporal retinal artery, expansile and lateral displacement of the inferior temporal and nasal arcades. The pulsatile regions are highlighted in Fig. 1D and observed in Video 1. A similar pattern of retinal arterial pulsatility was observed in the right eye, in addition to retinal venous pulsatility, which was observed at the optic disc (Video 2). Fluorescein video-angiography of the left eye confirmed pulsatility of the retinal arteries (Fig. 2 A-D, Video 3) also demonstrated were an irregular filling defect and leakage of lesion along the superior wall of the superior temporal retinal artery, punctate masking along the superior nasal boundary of the lesion consistent with the areas of hard exudates, and scattered microaneurysms along the superior temporal vessels. Late leakage was seen around the lesion, in addition to the temporal and perimacular areas secondary to underlying diabetic retinopathy. Computerized tomography of the chest and abdomen and echocardiography were performed in the course of follow-up of the hepatic disorder revealed neither aneurysms of the major vessels nor aortic valvular disease to explain the retinal arterial pulsatility. Due to the non-pulsatile nature of the retinal artery macroaneurysm with the dynamic imaging modalities, observation was recommended. Follow-up after one month demonstrated significant spontaneous resolution of the exudative lesion (Fig. 3A and B).

Supplementary video related to this article can be found at https://doi.org/10.1016/j.ajoc.2022.101664

3. Discussion

Our case highlights the importance of dynamic retinal imaging in the assessment of RAM and the use of NIR-RV in the visualization of retinal vascular pulsations. This imaging modality aided clinical decision-making in this case by establishing non-pulsatility of the RAM, which mitigated further interventions. In general, for vascular pulsations to occur two conditions should be met: The first is that a pressure gradient should exist between two locations either transmurally or intraluminally along the course of the vessel. The second is that the pressure gradient should generate a force magnitude both within the intraluminal pulse pressure range and sufficient to overcome vessel wall tension to allow cyclical mural deformation.[1] The mechanism of retinal arterial pulsations cannot be easily established in our case. Consequently, there are two plausible explanations.

1. Given that the pulse pressure was at the upper boundary of normal[12] (range 40–100 mmHg) this may have contributed to fluctuations in the intraluminal retinal arterial pressures of a sufficient magnitude to generate retinal arterial pulsations. However, this possibility is low due to the normal pulse pressure value combined with the likelihood of a pre-existing low retinal arterial compliance given the multiple vascular co-morbidities.
2. More significantly retinal venous pressure is likely to be elevated, particularly in the left eye as evidenced by the absence of spontaneous retinal venous pulsations. Structural circulatory changes are known to occur in diabetes secondary to large and small vessel wall remodeling of the endothelium, vascular smooth muscle, and extracellular matrix, together with increased local levels of endothelin can result in venous wall constriction, increased resistance, reduced venous compliance, and consequently increase pressure gradient between the retinal arterial and venous circulations.[13] In addition to local circulatory factors, increased cerebrospinal fluid pressure has been reported in diabetics,[14] this, in turn, may have augmented the rise in retinal venous resistance in our patient.

Biomicroscopically observable pulsatile RAMs have been described,[15] recent studies have shown that multimodality imaging can

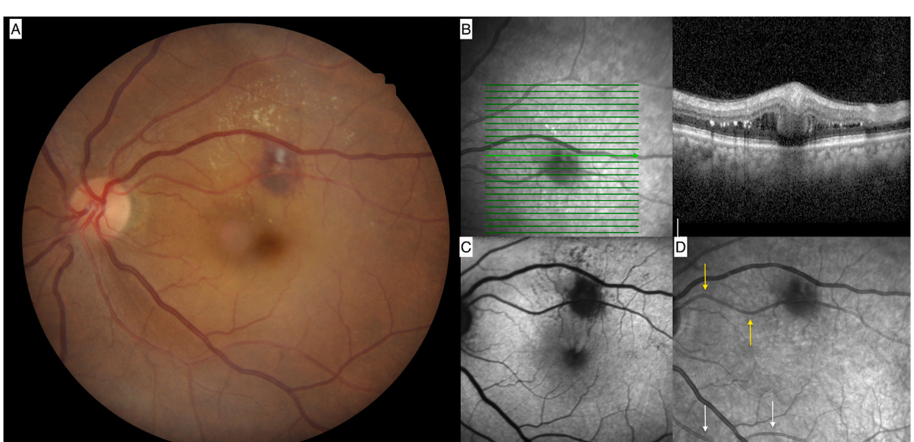

Fig. 1. A) Color fundus photograph of the left eye demonstrating an exudative retinal lesion located between the superior temporal retinal artery and vein. There is a cotton wool spot on the superior edge, a pale area in the center of the lesion, and hard exudates along the superior and nasal margins. B) Composite image showing near infra-red image and level of a B-scan optical coherence tomography of the exudative lesion predominately involving the outer nuclear layer with a cotton wool spot at the level of the nerve fiber layer. C) Short-wavelength fundus autofluorescence demonstrating the extension of the macular edema to the superior margin of the foveola. D) Near infra-red fundus autofluorescence, arrows highlight the serpentine (yellow) and expansive (white) pulsatile regions observed in Video 1.

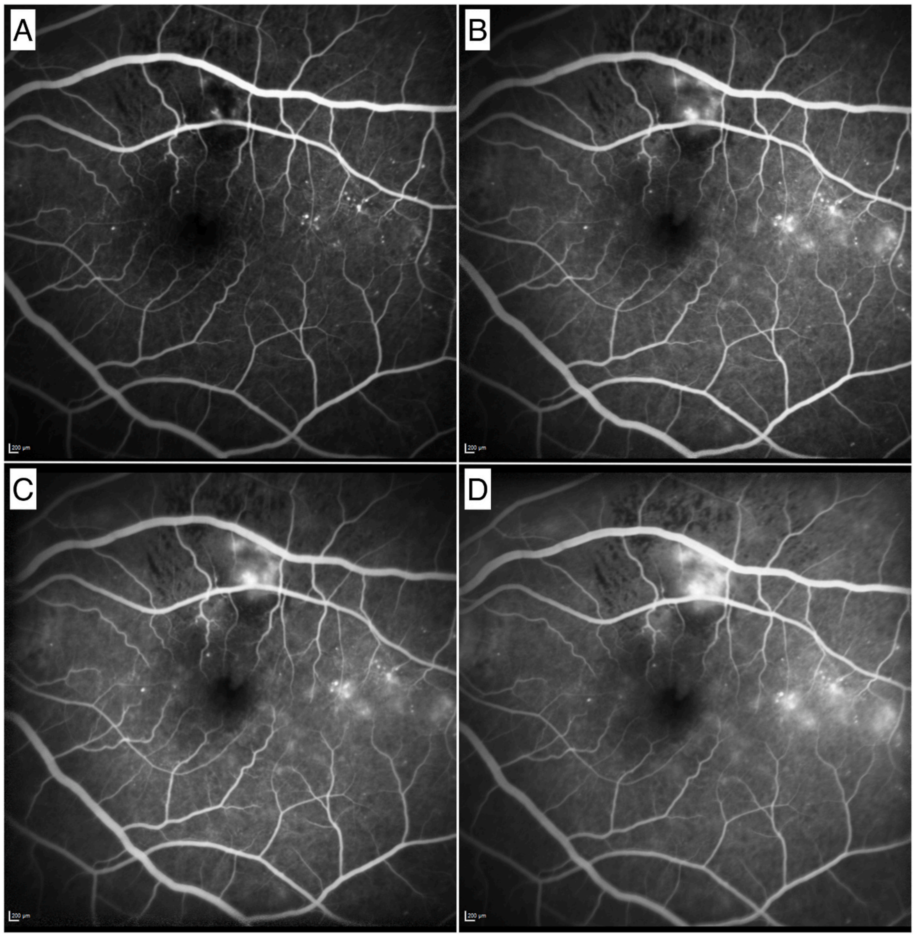

Fig. 2. Still images from fluorescein video-angiography from early to late A)-D) arteriovenous sequence. This demonstrates irregular filling and leakage of lesion along the superior wall of the superior temporal retinal artery, punctate masking along the superior nasal boundary of the lesion, and scattered microaneurysms. Late leakage is seen around the lesion, in the temporal and perimacular areas.

aid early diagnosis and prognostication. Zienkiewicz et al. used near-infrared reflectance imaging in the detection of fusiform thickening of the retinal wall arteriole three years before the clinical presentation of a retinal artery macroaneurysm.[16] Astroz et al. described the use of optical coherence tomography angiography to detect flow in the lesion implying activity in two cases.[17] However, detection of lesion pulsation is more challenging as a dynamic form of imaging is required to detect this sign. Schnider et al. reported the use of video-angiography,[18] more recently NIR-RV has emerged as a method of dynamic retinal imaging, particularly in the detection of spontaneous retinal venous pulsations.[19,20] The advantages of this technique include its availability as a standard imaging modality with Heidelberg optical coherence tomography devices. Because no contrast dye is used, NIR-RV imaging is safer and preserves visibility of the central vascular reflex; hence pulsations are more apparent compared to fluorescein video-angiography. The near-infrared imaging wavelength limits the impact of optical opacities on image quality making it applicable in the presence of cataracts, posterior capsular opacification, and mild vitreous hemorrhage. Finally, it has been demonstrated to be more accurate than ophthalmoscopy in highlighting pulsatile vascular segments. In a cross-sectional study on 105 patients with presumed normal intracranial pressure, spontaneous venous pulsation was detected in 97%–100% of subjects using NIR-RV, compared to a prevalence of 66% of normal healthy individuals when examined clinically.[21] Whereas the studies by Seo, Lee, and McHugh[19–21] reported the detectability of retinal venous pulsation using NIR-RV, the prevalence of retinal arterial pulsations was not reported.

Spontaneous retinal arterial pulsation was first observed in 1854 by Jaeger[22] five years after Helmholtz invented the ophthalmoscope. The best location to examine pulsations, according to Keyes and Hatcher, is near a bend in the course of a tortuous artery. They also identified four clinical types of retinal arterial pulsations.[23] 1) Pulsations at a bend of a retinal artery causing lateral movement of the vessel, nearly synchronous with the radial pulse. The movement of the vessel was described as toward the convexity of the curve, particularly noticeable at an s-shape curve as the vessel moves in opposite directions. 2) An expansive movement of the arteries which manifests itself by an alternate widening and narrowing of the arterial light reflex, which is usually the only type of pulsation visible in a straight segment. 3) A pulsating forward and lateral movement of a segment synchronous with the pulse observed at a bifurcation. 4) The rarest type of pulsation is alternate flushing and paling of the optic disc as associated with aortic regurgitation.[23] All three initial patterns were recognized in our case. Pulsatility of a RAM has both diagnostic and prognostic significance; this feature is more common in exudative compared to hemorrhagic subtypes. Shults et al. reported pulsatile retinal artery macroaneurysms in 3 of 5 (60%) of cases in their series,[15] all of which were classified as exudative subtypes. In another case series assessed using dynamic fluorescein angiography and indocyanine angiography, Cahuzac et al. reported pulsatile retinal artery macroaneurysms in 5 of 14 (36%) subjects, pulsations were detected in all the exudative cases in this series as well.[6] The authors reported that the presence of pulsatility was considered synonymous with disease progression and recommendations for conservative management were considered when a retinal artery macroaneurysm is non-pulsatile or when pulsatility disappears in the course of observation.[6] Other than

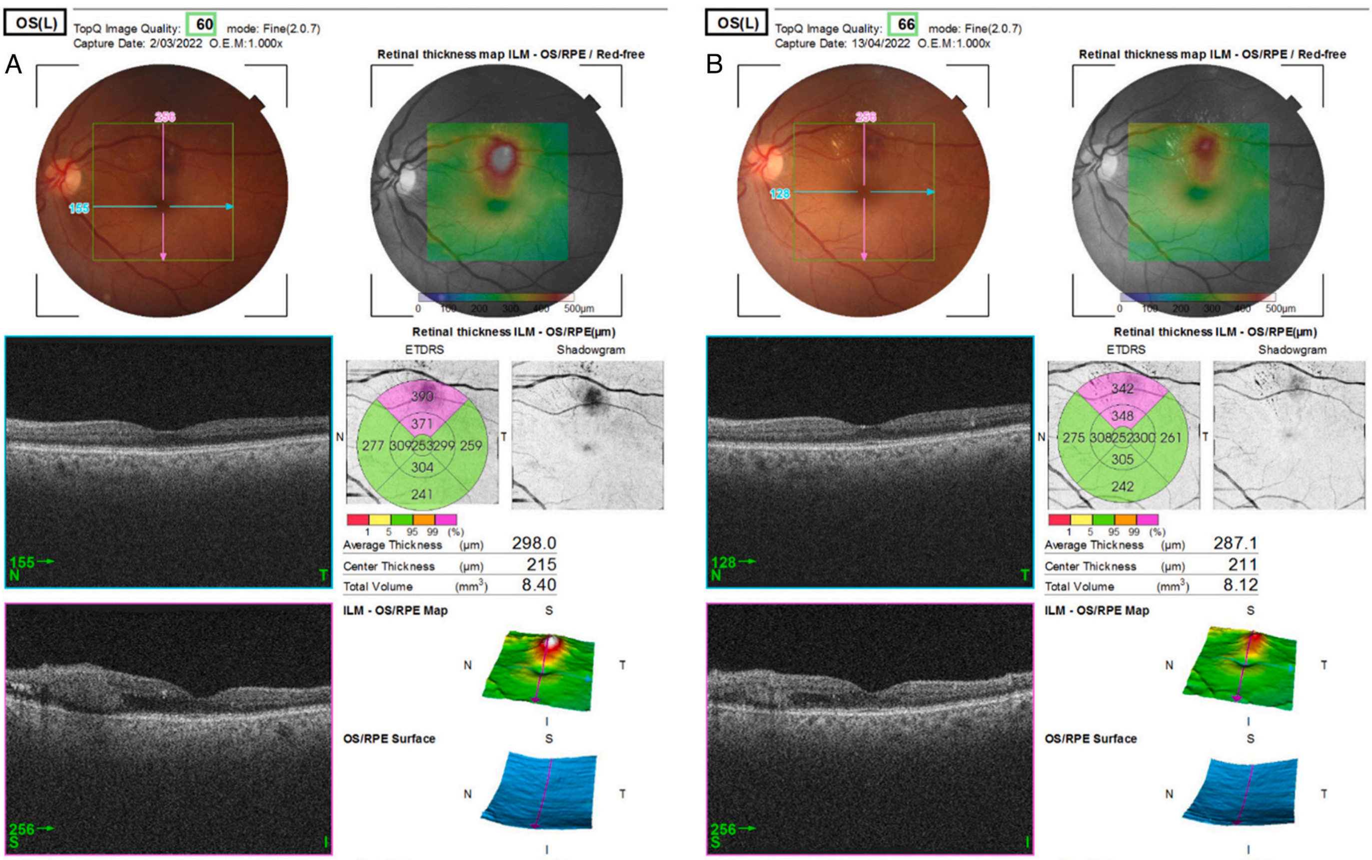

Fig. 3. A comparative optical coherence tomography image at the initial A) and at the one-month follow-up assessment B) demonstrating spontaneous resolution of the lesion.

intralesional blood flow, elevated blood pressure has been associated with the appearance of this sign. In a prospective six-month follow-up of 44 macroaneurysms in 40 patients, Lavin et al. reported that higher systolic blood pressure may explain RAM pulsatility.[24]

It remains unknown if our impressions on the occurrence of retinal arterial pulsations solely in association with circulatory pathological conditions are valid in the era of diagnostic imaging, and whether this sign is more prevalent in a presumed normal population than the ophthalmic literature would suggest. Moreover, the prognostic significance of this sign for the progression of diabetic retinopathy and in the prediction of retinal venous occlusion would be worthwhile future research questions.

4. Conclusions and importance

Detection of spontaneous retinal artery pulsation and the assessment of exudative maculopathy due to an underlying RAM could be facilitated by near-infrared reflectance videography. This imaging modality can aid in clinical decision-making where a non-pulsatile macroaneurysm would favor conservative management.

Patient consent

Consent to publish this case report has been obtained from the patient in writing.

Funding

No funding or grant support.

Authorship

All authors attest that they meet the current ICMJE criteria for Authorship..

Declaration of competing interest

The following authors have no financial disclosures: AAR, WM, DYU.

Acknowledgements

None.

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