Pulse ICG: A New Technique for Administering ICG During Choroidal Angiography

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Introduction

Recording the wide swings of ICG intensity during the early and late phases of fundus camera based digital ICG choroidal angiography is problematic. Standard retinal angiography technique requires a bolus injection of fluorescein dye.[1] When the same bolus injection technique is used for choroidal angiography, the relatively high initial post injection concentration of circulating ICG often causes portions of the transit phase to become overexposed. To compensate, the photographer adjusts the fundus camera flash intensity or the digital gain control, modifying the exposure in direct response to the angiographic screen image. As the test progresses, the amount of circulating dye decreases dramatically, requiring the ophthalmic photographer to maximize both the flash intensity and camera sensitivity.[2]

Because the ophthalmic photographer manipulates the exposure and sensitivity scales during the choroidal angiogram to create a successful image, the tonalities within each of the images are based on different light intensity and camera sensitivity values. Consequently, in choroidal angiography, the intensity of early phase and the intensity of late phase hyperfluorescence are not comparable, as they are during fluorescein angiography.

This paper describes a pulse ICG injection technique which better matches the illumination range of the fluorescing ICG to the exposure range of fundus camera based digital angiography.

Methods

Choroidal angiography was performed using a Canon 60UVI Fundus Camera (Lake Success, New York) with an OIS (Ophthalmic Imaging System, Sacramento, CA) digital angiography system on twelve consecutive patients. Flash and digital camera sensitivity settings were modified as required to obtain a well-exposed image. An experienced ophthalmic photographer (PJS) evaluated

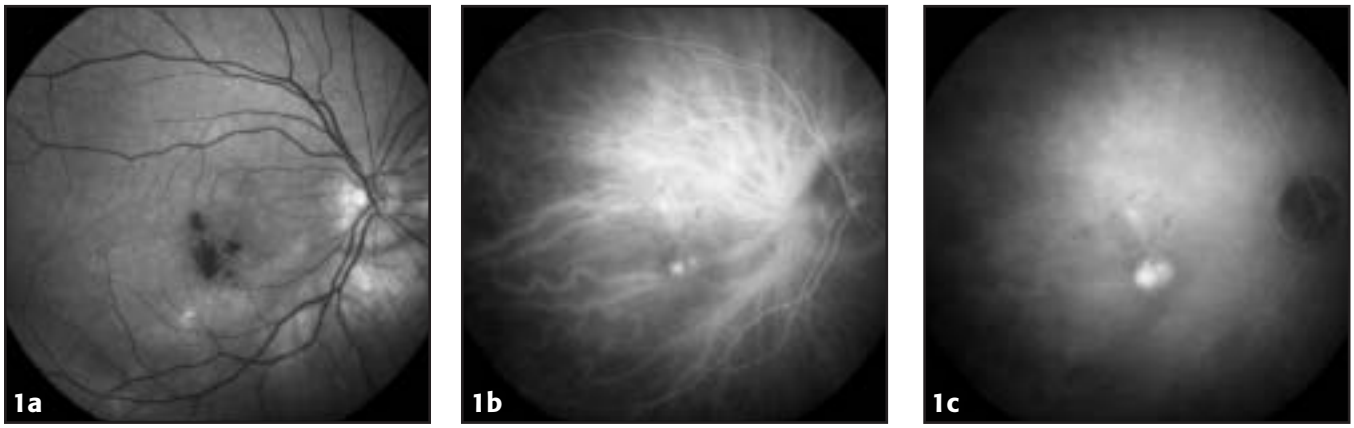

Figure 1: Frames from a sample pulse ICG. (a) Red free photograph documenting hemorrhage overlaying suspected CNVM. (b) 6 minute frame shows area of suspected hyperfluorescence. (c) 25 minute late frame confirms area of late hyperfluorescence.

and adjusted the exposure for each angiographic frame. The exposure settings during the transit, and at the 5, 10, and 25-minute pictures were recorded.

Each patient was injected with 50mg of ICG dye reconstituted in 3.5cc of diluent. This dose was part of our standard bolus ICG angiography technique. It produced adequate late phase photographs with our combination of fundus camera, exciter and barrier filters, and digital angiography system. "Even numbered" patients received the ICG injected at 3 consecutive 30 second intervals in 1.5cc, 1cc, and 1cc increments. "Odd numbered" patients received a standard bolus dye injection of ICG (injection duration: approximately 5 seconds). Late landmark injections were not performed.[3]

Vascular details in early and late images were examined by experienced retinal specialists (RAS, JCC).

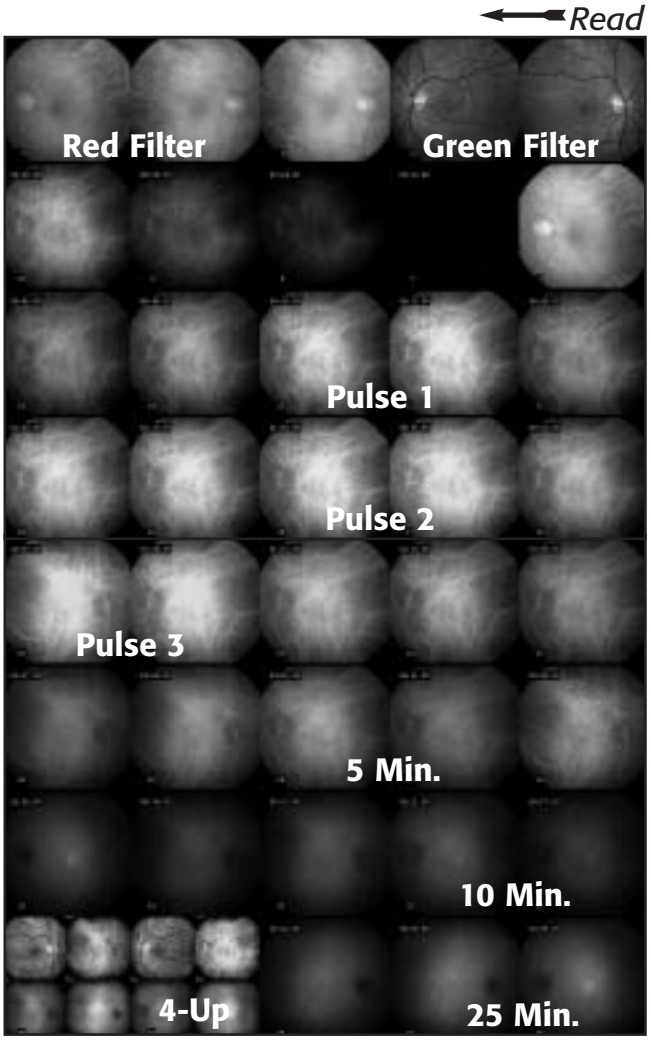

Figure 2: A complete pulse ICG angiogram. Note the pulse nature of the injection and the full complement of standard ocular angiography phases.

Table 1
Is there a statistically significant difference in the exposure level required for successful choroidal angiography when pulse injection of ICG is compared with bolus injection of ICG?

Transit phase	No	p = 0.26
5 minute recirculation	Yes	p = 0.03
10 minute recirculation	Yes	p = 0.02
25 minute recirculation	Yes	p = 0.01

Results

Using the two sample Wilcoxon rank-sum (Mann-Whitney) test, there was a statistically significant decrease in the level of exposure needed for adequate late recirculation phase photographs using the pulse injection technique (Table 1). Using the two sample Wilcoxon rank-sum (Mann-Whitney) test, there was no statistically significant difference in the level of exposure needed for adequate transit phase images.

The ophthalmic photographer experienced less exposure variability and fewer flash setting changes when using the pulse ICG injection technique. Interpreting physicians noted increased choroidal vascular detail and earlier identification of subsequent late hyperfluorescence when the pulse technique was used (Figure 1).

The pulse nature of the ICG injection was seen as 3 distinct sequential episodes of bright choroidal fluorescence during the transit phase (Figure 2: pulse 1-3). All standard choroidal angiography phases were identified in each study.[4]

No additional complications or adverse reactions from either the dye or the injection technique were identified.

Discussion

Standard retinal angiography technique records the dynamic nature of the ocular circulation after a bolus injection of sodium fluorescein. When the same bolus injection technique (Illustration 3a) is utilized in ICG angiography, the brightest (*) transit images are often overexposed, while late images require maximal flash intensity and camera sensitivity.

ICG pharmacokinetics are described as a two compartment open model.[5] The initially high concentration of circulating ICG immediately after injection is rapidly cleared by the liver, leaving small amounts of the dye in the plasma. Pulse ICG injection (Illustration 3b) effectively lowers the initial overexposure, while increasing the amount of dye available for late imaging of the choroid.

With the pulse technique, only the first ⅓ of the ICG dye creates the transit phase exposure peak. With less dye, the exposure is at a slightly lower, more manageable level, and the transit phase is less likely to be overexposed. The next ⅓ of the dye is then introduced, peaks and clears. Finally, the third stream of ICG dye is introduced, peaks and clears. In effect, the choroid is bathed in not one, but three sequential applications of ICG dye. The pulse method increases transit phase choroidal vas-

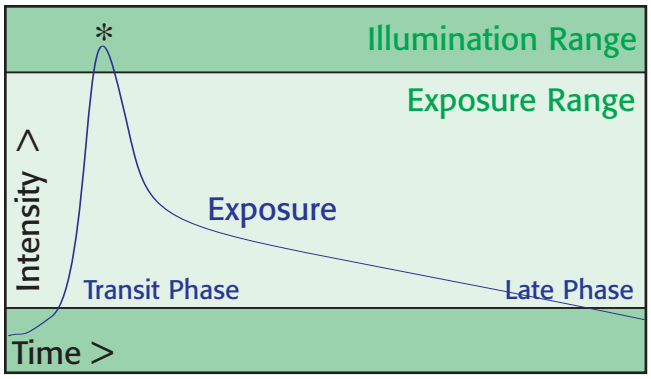

Figure 3a: Angiographic exposure for bolus ICG injection

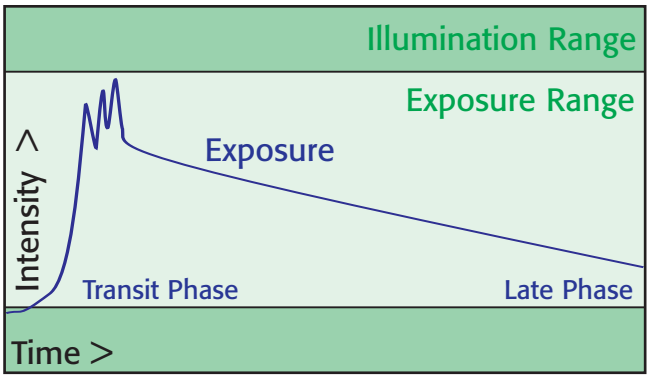

Figure 3b: Angiographic exposure for pulse ICG injection

cular detail by decreasing the circulating ICG dye early in the angiogram. It increases the amount of ICG dye available for imaging during the late recirculation phase, resulting in lower camera sensitivity requirements for the late photographs. When these mechanisms are combined, less photographer manipulation of exposure variables is required.

Both retina physicians reviewing these cases noted an earlier than expected appearance of hyperfluorescent areas. This earlier discrimination of hot spots improves both physician visualization of the disease process and success with digital overlay, because the retinal vasculature is more clearly visible early in the angiogram. The earlier appearance of hyperfluorescence is a direct result of the increased availability of choroidal ICG. When a single bolus injection is used, there is but one pass of the dye. The pulse injection shows greater detail both earlier later because there are multiple passes of dye.

There are many clinical applications for this method of administering ICG dye. In an ophthalmic practice with an older or less efficient ICG system, using this technique will produce more evenly exposed and later images during choroidal angiography. Practices with newer, more efficient systems may be able to reduce their ICG dosage when using this technique. Choroidal angiography is more sensitive to exposure reducing factors (example: patients with small pupils) than retinal angiography; pulse ICG angiography can be used to improve images in these patients. Because of the increased visualization of retinal vascular detail and the earlier appearance of hyperfluorescent areas, pulse ICG should become the technique of choice when the use of digital overlay is contemplated.

The pulse injection method differs from the previously described landmark injection method.[3] The pulse injection increases the ICG dye available for imaging while retaining the standard ocular angiography phases. The landmark injection creates useable late images by reintroducing fresh dye, in essence creating a new transit phase. Practically speaking, while the pulse injection requires a small additional amount of time on the part of the injector, it is accomplished with a single needle stick and without additional injection supplies which can accompany a landmark injection.

We suggest that using a pulse injection technique will increase the clinical information available in ICG angiograms. Divide the usual ICG dye dose into thirds, inject the first third, wait 30 seconds, inject the second third, wait 30 seconds, and then inject the final third. The transit images will be more evenly exposed, the late phase ICG photographs will be easier to image, and areas of late hyperfluorescence will often be visualized earlier.

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