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INDOCYANINE GREEN LASER RETINAL OXIMETRY: PRELIMINARY REPORT

Nicola Cardascia, Raffaele Tommasi, Michele Vetrugno, Giancarlo Sborgia, Pietro Mario Lugarà, Carlo Sborgia*

1. INTRODUCTION

It is known that any alteration in blood circulation such as seen in diabetic retinopathy, hypertension, sickle cell disease, and vascular occlusive diseases results in functional impairment and extensive retinal tissue damage.[1] However little is known about retinal oxygen distribution or consumption and how it changes in response to disease. Measuring these changes non-invasively may improve the ability to diagnose, or monitor the progression of, such eye diseases. Oxygen is monitored by using its effect on blood hemoglobin color, its concentration in gas, its pressure in blood or tissue and using infrared light through the scalp and skull. In the eye non-invasive optical methods have already been reported.[2] [3] These techniques depend on quantifying differences between hemoglobin (Hb) and oxyhemoglobin (HbO) light absorption.

2. PURPOSE

Most of the methods used to measure oxygen concentration are based on the relation between light transmission and oxygen saturation. We would suggest a new method to determine oxygen saturation in retina and choroid, not affected by the anatomical and physical characteristics of the eye.

3. METHODS

Our investigation is twofold: (1) to determine an angiographic dye that can modify its fluorescence according to blood oxygen concentration, and (2) to investigate the variation of fluorescence in different oxygen saturation.

* Nicola Cardascia, Dipartimento di Oftalmologia, Università di Bari, 70124 Bari, Italy. Raffaele Tommasi, Dipartimento di Biochimica Medica, Biologia Medica e Fisica Medica, Università di Bari, 70100 Bari, Italy. Michele Vetrugno, Dipartimento di Oftalmologia, Università di Bari, 70124 Bari, Italy. Pietro Mario Lugarà, Dipartimento interateneo di Fisica and Unità INFM, Università di Bari, 70126 Bari, Italy. Carlo Sborgia, Dipartimento di Oftalmologia, Università di Bari, 70124 Bari, Italy.

3.1 The Fluorescent Dye

In the eye, non-invasive methods are based on analysis of retinal reflectivity using appropriate light sources, chosen because of their spectral properties and availability.[4] Considering retinal reflectivity may influence spectral determination of oxygen saturation,[5] we prefer to consider the fluorescence of an angiographic dye. The selection of the dye is based on precise characteristics: (1) widely diffuse in clinical practice, (2) few adverse effects, (3) fluorescence not affected by pigment epithelium and other low reflective media.

We investigate, then, three fluorescent molecules: Sodium Fluorescein, Verteporfin and Indocyanine Green (ICG).

3.1.1 Sodium Fluorescein

The technique of Fluorescein Angiography was first demonstrated in the human eye by two medical students, Novotny and Alvis in 1961.[6] This paved the way for contrast studies of the ocular circulation which has become the gold standard of imaging for ocular circulation for the diagnosis of vascular disease. Moreover, retinal oxygen saturation was determined by means of fluorescein to obtain a map of relative oxygen saturation in retinal structures and the optic nerve head in nonhuman primate eyes.[7] Fluorescein dye leaks from vessels in several pathologies involving vascular disorders.[8 9]

Even through fluorescein has a long history of use in clinical practice[10] and adverse effects are well known,[11] we exclude it principally because the dye can impair vessel fluorescence leaking from vessel walls, affecting oxygen determination.

3.1.2 Verteporfin

Benzoporphyrin derivative, or verteporfin, is a modified porphyrin that has an absorption maximum near 690 nm and is phototoxic in vivo.[12] All porphyrins have fluorescent spectra in the red band and show oxygen fluorescence quenching.[13] Even though porphyrins have broad fluorescent spectra, their photo-toxicity induced us to exclude them to avoid irremediable damage of retinal and vascular structures.[14]

3.1.3 Indocyanine Green

Considering the strict inclusion criteria, ICG represents the ideal dye for our purpose. The inclusion characters of ICG are hereby discussed:

3.1.3a. Clinical practice. ICG is a dye employed in the photographic industry. It was first used in ophthalmology by Flower and Hochheimer in the early 1970s to image the choroidal circulation.[15] Although both experimental and clinical investigations with ICG continued, it was not until the early 1990s that it became an established method of investigation.[16] This was because of the increasing interest in the contribution of the choroid to retinal diseases and improvements in technology.

3.1.3b. Adverse effects. Adverse reactions to ICG are rarer than those with intravenous fluorescein angiography. Mild reactions such as nausea, vomiting, sneezing, and transient itching occur in 0.15% of cases.[17] More severe reactions such as urticaria, syncope, fainting, and pyrexia may also occur. Severe reactions such as hypotensive shock[18] and anaphylactic shock[19] have been reported. Crossover allergy to iodine can occur in patients with seafood allergies. Thus, seafood allergy is a contraindication to ICG angiography.