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# Electroretinography in Veterinary Ophthalmology

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# Electroretinography in Veterinary Ophthalmology

## **Disciplines**

Medicine and Health Sciences | Ophthalmology | Veterinary Medicine

## Electroretinography in Veterinary Ophthalmology

Gustavo Aguirre, V.M.D.

In clinical veterinary ophthalmology, assessment of vision is of great importance in the diagnosis, prognosis, and treatment of several ocular disorders. In an animal with normal vision, the integrity of the neuronal pathways from the retina to the lateral geniculate body and then to the striate (visual) cortex is taken for granted. In animals with subnormal or absent visual performance, however, it is important to determine the site or sites of the disease.

In animals with sudden unexplained blindness, with possible inherited retinal disease, or with opacities of the cornea or lens where the retina appears normal or is not visible at all, it is desirable to determine more specifically the functional integrity of the retina. Retinal disease could be ruled out as the cause of blindness or the presence of a normally functioning retina behind a dense cataract could be confirmed.

Although there is no one test that evaluates the functional integrity of all the retinal layers, the electroretinogram (ERG) comes closest to the ideal. The retinal response to sudden illumination is a complex one, resulting in bleaching of photosensitive elements in the retina and the initiation of nerve impulses which, when they terminate in the striate cortex, are translated into vision. The generation of the nerve impulses in response to sudden brief illumination results in extracellular electrical currents measurable on the corneal surface as the electroretinogram.<sup>(4,5)</sup> The ERG consists of a rapid negative a-wave followed by the positive b-wave and terminating in a very slow positive potential called the c-wave (Fig 1). By convention, and using the cornea as a reference point, deflections below the baseline are negative and corneal positivity includes those deflections above the baseline.

The ERG is a mass response equal to the retinal potential changes to light. For this reason it does not measure the activity of a single class of neurons, but, being less specific, reflects the activity of all units involved in generating the response.

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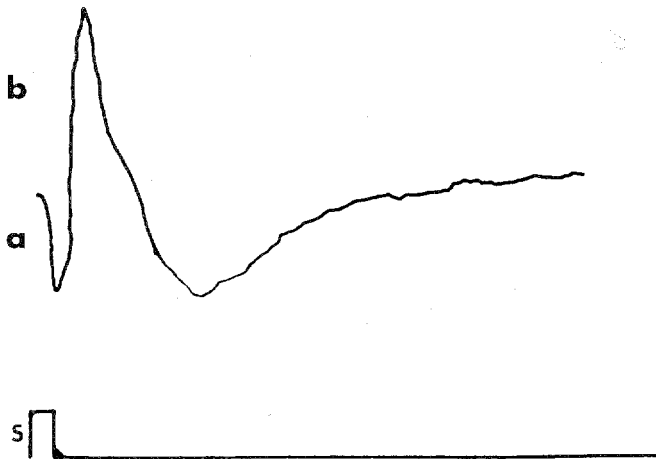


Fig 1 — The ERG recorded from a normal dark-adapted dog in response to a single flash of white light. The ERG consists of an initial negative a-wave (a) followed by the positive b-wave (b). The c-wave, which is small in the dog, is not elicited under these recording conditions. The rectangular wave (s) below indicates the stimulus duration.

The ERG is generated by cells in the outer retinal layers. In Fig 2 this is seen to comprise all the layers external to the inner plexiform layer (IPL). The photoreceptors, both rods and cones, generate the a-wave while the b-wave originates in the inner-nuclear layer and the c-wave in the pigment epithelium. The relative contribution of the rod and cone photoreceptor systems to the ERG is proportional to their numbers. Since in dogs and cats the rods outnumber cones (18:1 in dogs),<sup>(8)</sup> the ERG in these species primarily reflects the activity of rods rather than cones. Only with specialized techniques are cone components demonstrable in the ERG of dogs and cats.<sup>(2,3,4,9)</sup>

The relation between the ERG and vision should be emphasized. The ERG *per se* is not a measure of vision nor of visual acuity. The ERG does not indicate how information is processed by the retina before transmission to the optic nerve. The ERG measures non-specifically the functional integrity of the outer retinal layers. Through exhaustive correlation of the ERG responses recorded from normal animals and those affected with selective photoreceptor diseases it has been possible to ascribe certain characteristics, in terms of amplitude and time of occurrence of the different waveforms, to the normal ERG. Animals that differ from normal are easily detected and in most cases a specific diagnosis is possible.

The ERG does not measure visual function but is an accurate diagnostic method in retinal disease.

The ERG can be recorded from the corneal surface with a contact lens electrode. The responses are then amplified and displayed on a paper recorder or an oscilloscope. More sophisticated procedures use computer averaging techniques. The light stimulus used to elicit the ERG can be provided by numerous types of light sources.

To record the ERG the pupils must first be widely dilated with atropine or another long acting mydriatic to avoid recording artifacts produced by reflex pupillary constriction. Depending on the type of information desired, the dog may or may not be anesthetized. For example, if the ERG is to be recorded prior to cataract extraction in an adult (older than four years of age) dog, the dog need only be sedated with a mild tranquilizer. The information desired from the procedure is whether or not the retina is able to generate a normal response. The main disease to be ruled out is progressive retinal atrophy (PRA). This disease clinically affects the older animal and in a PRA-affected dog four years of age or older, the ERG would be, for all practical purposes, absent. If the ERG is normal, cataract extraction can be performed with the confidence that the retina is most probably normal.

The ERG obtained in the above case is referred to as a "clinical" ERG. It is a relatively simple procedure used to eliminate gross functional abnormalities of the retina. By virtue of its simplicity, it is not able to detect very subtle functional defects of the retina. To do very detailed electroretinographic examination, the animal must be anesthetized and in some cases the skeletal musculature transiently paralyzed. This allows for a smoother recording with less electrical "noise" and interference, thus permitting the responses to be thoroughly evaluated. The following case report illustrates the differences between the "clinical" ERG and more elaborate electroretinographic examination.

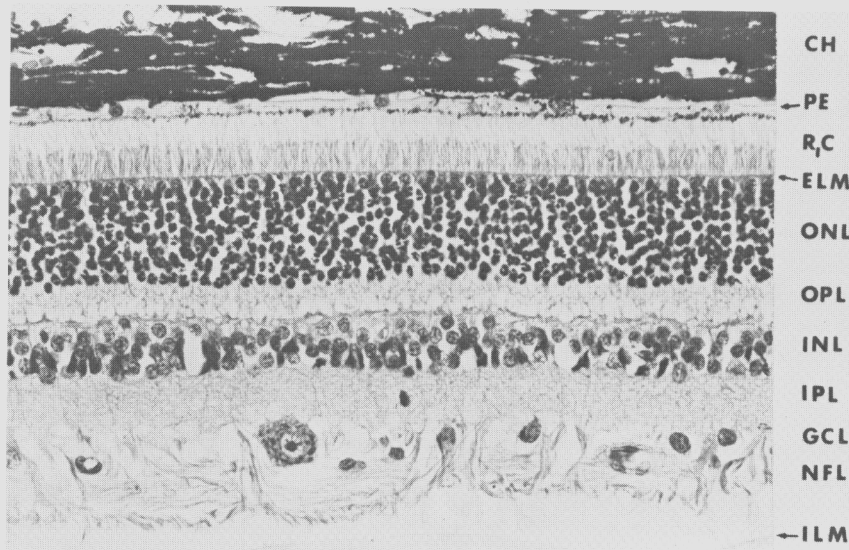


Fig 2 — Histological section of the dog retina. CH — Choroid; PE — pigment epithelium; R,C — rod and cone layer; ELM — external limiting membrane; ONL — outer nuclear layer; OPL — outer plexiform layer; INL — inner nuclear layer; IPL — inner plexiform layer; GCL — ganglion cell layer; NFL — nerve fiber layer; ILM — internal limiting membrane.

An eight-week old miniature poodle was presented to the clinic with a one-week history of sudden blindness. Examination revealed normal direct and consensual pupillary responses, a normal retina on ophthalmoscopy and a marked searching nystagmus. A tentative diagnosis of cortical blindness was made.

A normal single flash "clinical" ERG was recorded from both eyes. The dog was then anesthetized and paralyzed and detailed electroretinographic determination of rod and cone function was made. This indicated normal rod function, but completely absent cone function.

Complete absence of cone function explained the sudden onset of blindness. Retrospectively, the blindness was found to be entirely in daylight. The dog was visual in the dark. This point was missed by both the clinician in the anamnesis and the owner.

The preponderance of rods over cones in the

dog retina resulted in a normal "clinical" ERG, normal pupillary responses and normal appearing retina in the dog with selective cone dysfunction. A diagnosis of cortical blindness was initially favored on the basis of the ERG, pupillary signs and ophthalmoscopy. However, a definitive diagnosis of blindness of retinal origin was only possible with a detailed electroretinographic study.

From the previous discussion, some of the advantages and disadvantages of electroretinography should be evident. The equipment is expensive, the procedure is time consuming and requires specialized training for both the operation of the equipment and the interpretation of the results. This makes electroretinography a procedure to be used almost solely in an academic institution. There is no reason, however, for the institutional ophthalmologist not to cooperate with his colleague in the field. In those cases where a definitive diagnosis of retinal or extra-retinal disease is necessary, electroretinography is essential.

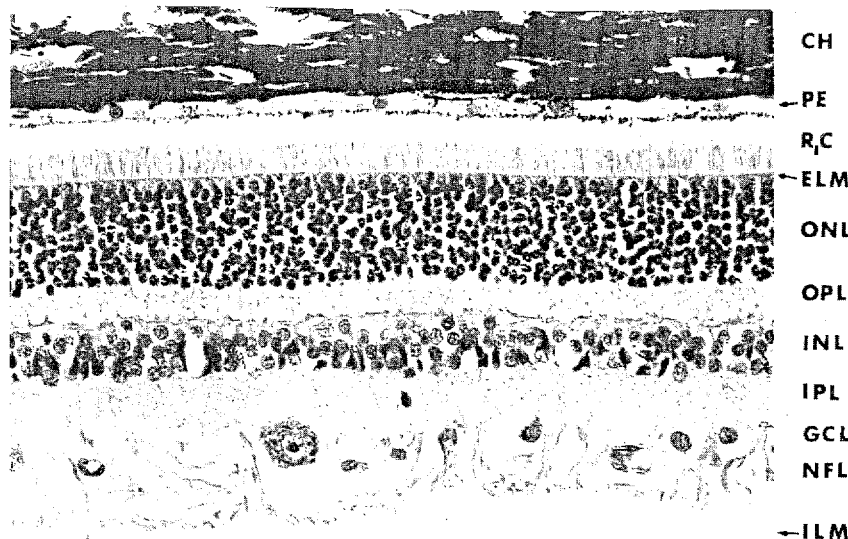


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**TABLE 1**  
Electroretinographic Findings in Selected Ocular Diseases

Disease	ERG Results	Comments
Cataract	ERG is normal to slightly reduced in amplitude in animals with a normal retina. <sup>(5)</sup>	ERG very important in determining if the retina is normal or severely diseased. Used before cataract extraction.
Complete Corneal Edema	ERG is normal to slightly reduced in amplitude in animals with a normal retina.	ERG very important in determining if the retina is normal or severely diseased.
Retinal Detachment	ERG usually absent. Small amplitude a-wave and absent b-wave seen in early cases. <sup>(5)</sup>	ERG of great importance in those cases where the retina can not be visualized.
Cortical Blindness	ERG normal. <sup>(5)</sup>	ERG useful in differentiating retinal from cortical blindness. ERG examination must evaluate rod and cone function.
Optic Neuritis and Optic Atrophy	ERG normal.	Clinical signs and ophthalmoscopy are often sufficient for diagnosis. ERG not useful.
Glaucoma	ERG normal in very early cases if the pressure is not markedly elevated. ERG absent in late cases.	In early cases, glaucoma produces ganglion cell loss with no change in ERG. In late cases, there is extensive retinal degeneration and absent ERG. ERG of no use in prognosis of glaucoma.
Hemeralopia (day-blindness)	Rod ERG is normal, cone ERG is absent. <sup>(6,7)</sup>	ERG is essential for definitive diagnosis of hemeralopia.
Feline Central Retinal Degeneration (FCRD)	Rod ERG is normal, cone ERG is depressed or absent. <sup>(9)</sup>	The diagnosis of FCRD is an ophthalmoscopic one. Electroretinography only indicates widespread cone degeneration not visible ophthalmoscopically.
Progressive Retinal Atrophy: a. Poodle b. Norwegian Elkhound c. Irish Setter	ERG in early cases: Rod and cone ERG present but abnormal. <sup>(3)</sup> Rod ERG absent, cone ERG normal. <sup>(1,2)</sup> Rod ERG absent, cone ERG present but abnormal.	The ERG is most useful in identifying those animals that will develop P.R.A. This is possible several months to years before the clinical disease is evident.

Table 1 lists the usefulness of electroretinography and the findings in selected ocular diseases.

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