

Editorial

Electroretinography — Are We Misusing an Excellent Diagnostic Tool?

It was nearly 30 years ago that I first experienced the power and many of the frustrations associated with the use of the electroretinogram (ERG) to evaluate the function of the retina in normal and diseased eyes. At that time I was carrying out a research project at the University of Pennsylvania examining the effect of Vitamin A deficiency on retinal function in dogs. In that study, weaned puppies were placed on purified diets deficient in Vitamin A and then evaluated by sequential ERGs. I performed the ERG using an electroencephalograph machine to measure retinal responses elicited with a Grass PS-2 photic stimulator. After many months on the deficient diet, the serum and liver Vitamin A levels reflected a profound deficiency state; oddly, though, I found the ERG responses between the deficient and the Vitamin A-supplemented controls to be indistinguishable. Common sense did not suggest that this lack of distinction was because of a yet unknown resistance of the dog retina to Vitamin A deprivation. The problem lay instead in my improper understanding of the physiology of the retina and of the stimulating conditions needed to elicit the ERG. I set about to modify the Grass stimulator—to the dismay of the machinist in the biomedical electronics workshop—by attaching a large, metal gasoline funnel to the front housing of the stimulator and placing a neutral filter holder in the narrowed exit pathway of the light. With this very crude device I was then able to detect a 2-log-unit difference in dark-adapted threshold between the deficient and supplemented dogs and this difference increased as the study continued.

The ERG equipment that is now available to veterinary ophthalmologists is certainly more refined than a homemade optical stimulator held together with a shoestring and a prayer. ERG responses can be elicited using a variety of stimulators among which are optical benches¹² or modified Grass stimulators.³ When used with appropriate testing protocols, the ERG has been found to be extremely reliable and essential for the early diagnosis of many hereditary retinal degenerations. Examples are rod-cone dysplasia types 1 and 2 (rcd1; rcd2) in Setters and Collies;^{4,6} rod dysplasia (rd),^{1,7} and early retinal degen-

eration (erd)⁸ in Elkhounds; progressive rod-cone degeneration (pred) in Poodles, Cocker Spaniels,⁹ and Labrador Retrievers;¹⁰ photoreceptor dysplasia (pd)² in Schnauzers; hereditary cone degeneration in Malamutes;¹¹ congenital stationary night blindness in Briards;¹² and progressive retinal atrophy in Tibetan Terriers,¹³ Dachshunds,¹⁴ and Portuguese Water Dogs.¹⁵

Ironically, the availability of new and powerful technology for eliciting and recording the ERG has increasingly become the rationale for its misuse in veterinary ophthalmology. I am concerned about a trend toward modifying the ERG procedure in ways that disregard basic retinal physiology and are therefore unlikely to yield any meaningful or reliable results. The reasoning for this trend appears to be based on the principle that the greater the cost or the signal-averaging capabilities of a piece of equipment, the less the need to worry about the testing protocols. Taking this argument further, some posit that anesthesia is not required because it affects the ERG unpredictably and because the ability to signal-average eliminates the muscle potential, 60-Hz electrical interference, and all other artifacts that interfere with the proper interpretation of the ERG. Some inhalation anesthetics do affect the ERG amplitude and the rate of dark-adaptation of the rods, but this effect is predictable¹⁶ and is not a limiting factor. Others argue that optical benches, with or without fiber optic guides, or modified stroboscopic stimulators are not necessary, and place the emphasis on the hardware associated with recording and signal-averaging the responses rather than on controlling how those responses are generated. Are we forgetting the time-tested computing principle of "garbage in/garbage out?" It is important to remember that the ERG response to light, as evident in a V/log I curve, is a saturating response. To obtain some measure of sensitivity in assessing the degree of outer-retinal damage, it is essential to reduce the light intensity of most photic stimulators by several log units. In this way, the stimulus elicits a response in the linear range and not the saturating end of the V/log I curve, and it is easier to assess damage to the ERG generators.

Continued

I have been asked several times to list those factors that are essential for doing ERG in animals. These are:

- Thorough knowledge of retinal physiology and of the equipment being used.
- Strict adherence to a reproducible protocol.
- General anesthesia or very deep sedation.
- Use of optical bench or modified photic stimulator.
- Proper control of light/dark adaptation status.
- Elimination of 60-Hz interference.
- Use of reliable ERG electrodes.
- Use of appropriate recording equipment.
- Signal averaging.

The low priority I give to recording hardware is usually met with disbelief. While very sophisticated and powerful new instruments are available for recording the ERG, more modest recording equipment made up from new or used components can be used with equal reliability. In fact, my favorite oscilloscope for electroretinography is an old Tektronix 564B storage tube oscilloscope. This equipment was at the cutting edge of technology in the mid-1960s. To make sure that we are able to use this instrument well into our retirement years, we have been fortunate to stockpile several used models that can serve as replacements as needed.

In last place on my list is signal averaging. It is very useful for recording and evaluating very low-amplitude (less than 5 μ volt) signals, or complex responses that need to be separated into individual components by subtraction following signal averaging. While we have found its use necessary for examining the receptor-mediated responses in erd-affected Elkhounds,⁸ and to analyze the wave form and components of the very small signal recorded from the retina of Briards with congenital stationary night blindness, it is not necessary for the diagnosis of these diseases. In fact, signal averaging is not necessary or useful for the great majority of ERGs performed to identify the presence of an inherited or acquired retinal disease.

A recent editorial on the uses and limitations of ERG¹⁷ indicated that there is no general agreement about what constitutes a "standard" protocol or technique for ERG in dogs, and suggested that there is a need to generate information on the impact of several variables (e.g., anesthesia, sedation, stimulation, etc.) on the ERG in order to improve its clinical application. I agree that many of the published protocols for ERG testing are time-consuming, and it would be ideal to shorten and standardize these procedures so that reliability is not compromised for the sake of efficiency; however, modification of these protocols will take time, must be done by comparing the published vs. the modified protocol, and must be done with the examiner masked as to the retinal status of the tested dogs. Until such modified protocols are developed

and published in peer-reviewed scientific journals, we have to take the cautious approach and continue to follow protocols that have been shown to be effective and reliable. This is only fair to our patients, to the owners and breeders who depend on our skill and judgment, and to our specialty.

Veterinary ophthalmology is not alone in facing issues raised by the variability of ERG testing methods and interpretation of results. This has been an area of intense debate in medical ophthalmology. With respect to retinitis pigmentosa, there has been a move to standardize the terminology and the methods of examination.¹⁸ More recently, the International Society for Clinical Electrophysiology of Vision (ISCEV) has established a protocol for standardizing the clinical ERG.¹⁹ This protocol establishes standardized methods that must be followed for ERG testing. This protocol does not set limits on what can be recorded, but does set minima, a move that helps standardize results obtained between different institutions and laboratories. It is high time that veterinary ophthalmology followed the initiative created by our sister specialty and began to set standards for ERG testing in animals. This initiative should be supported by the ACVO, ASVO, ESVO, ISVO, and all other organizations that represent the field of veterinary ophthalmology. ■

Gustavo Aguirre
James A. Baker Institute
Ithaca, New York

REFERENCES

1. Aguirre GD and Rubin LF: Progressive Retinal Atrophy (Rod Dysplasia) in the Norwegian Elkhound. *JAVMA* 158:208, 1971.
2. Parshall C, et al: Photoreceptor Dysplasia: An inherited Progressive Retinal Atrophy of Miniature Schnauzer Dogs. *Prog Vet Comp Ophthalmol* 1:187, 1991.
3. Acland G: Electroretinography: Choosing and Using the Appropriate Hardware. *Proceedings of the American College of Veterinary Ophthalmology*, 1979.
4. Aguirre GD, Rubin, LF: Rod-Cone Dysplasia (Progressive Retinal Atrophy) in the Irish Setter. *JAVMA* 166:157, 1975.
5. Wolf ED, et al: Rod-Cone Dysplasia in the Collie. *JAVMA* 173:1331, 1978.
6. Acland GD, et al: Non-allelism of Three Genes (rd 1, rd 2 and erd) for Early-Onset Hereditary Retinal Degeneration. *Exp Eye Res* 49:983, 1989.
7. Aguirre GD: Retinal Degenerations in the Dog. I. Rod Dysplasia. *Exp Eye Res* 26:233, 1978.
8. Acland GM and Aguirre GD: Retinal Degenerations in the Dog: IV. Early Retinal Degeneration (erd) in Norwegian Elkhounds. *Exp Eye Res* 44:491, 1987.
9. Aguirre GD, Acland GM: Variation in Retinal Degeneration Phenotype Inherited at the *prd* Locus. *Exp Eye Res* 46:663, 1988.
10. Kommonen B, Karhunen U: A Late Receptor Dystrophy in the Labrador Retriever. *Vision Res* 30:207, 1990.
11. Aguirre GD, Rubin LF: The Electroretinogram in Dogs With Inherited Cone Degeneration. *Invest. Ophthalmol* 14:840, 1975.
12. Narfström K, et al: The Briard Dog: A New Animal Model of Congenital Stationary Night Blindness. *Brit J Ophthalmol* 73:750, 1989.
13. Millichamp NJ, et al: Progressive Retinal Atrophy in Tibetan Terriers. *JAVMA* 192:769, 1988.
14. Curtis R, Barnett KC: Progressive Retinal Atrophy in Miniature Longhaired Dachshund Dogs. *Br Vet J* 149:71, 1993.
15. Aguirre G, Nitroy S: ERG Study on the Portuguese Water Dog. *The Courier* Aug/Sept, 1992, p 67.
16. Acland G, et al: Halothane Effects on the Canine Electroretinogram. *Proc Am Coll Vet Ophthalmol*, 1981.
17. Miller, TR: Guest Editorial—The Uses and Limitations of the Electroretinogram in Veterinary Practice. *Br Vet J* 149:3, 1993.
18. Marmor MF, et al: Retinitis Pigmentosa—A Symposium on Terminology and Methods of Examination. *Ophthalmol* 190:126, 1983.
19. Marmor MF, et al: Standard for Clinical Electroretinography. *Arch Ophthalmol* 107:816, 1989.