

Avoid Blind Spots in Surgery While Utilizing Less Energy

Principals from the “green” movement are applied to endoillumination.

BY MICHAEL BENNETT, MD; AND DANTE PIERAMICI, MD

It is becoming increasingly difficult to live through a typical day without seeing, coming in contact with, or hearing about some new energy-efficient, eco-friendly something-or-other. The problem is that the majority of these items create more questions than answers about exactly what is eco-friendly. With our senses buzzing, “green” has become the latest rage. A 2007 TerraChoice Environmental Marketing survey, however, found that 99% of the typical eco-claims were misleading in some fashion.¹

The greenwashing debate will likely continue at least through the next presidential election, but as always there appear to be deeper, less comfortable issues lurking in the background. More than half of the eco-friendly labels hype some narrow advantage while they conveniently omit mentioning more significant drawbacks. This phenomenon has become the “sin of the hidden trade-off.”

So what does this have to do with retinal surgery? As retinal surgeons, we are more familiar with these trade-offs than we usually care to admit. One of the main areas of trade-off for the retina surgeon is illumination. We need light to see in the back of the eye for surgery, but at what cost to the health of the patient’s eye? With the ever-changing medical and surgical landscape, we are confronted with situations that all too often do not fit neatly within our proverbial box. The challenge to retinal

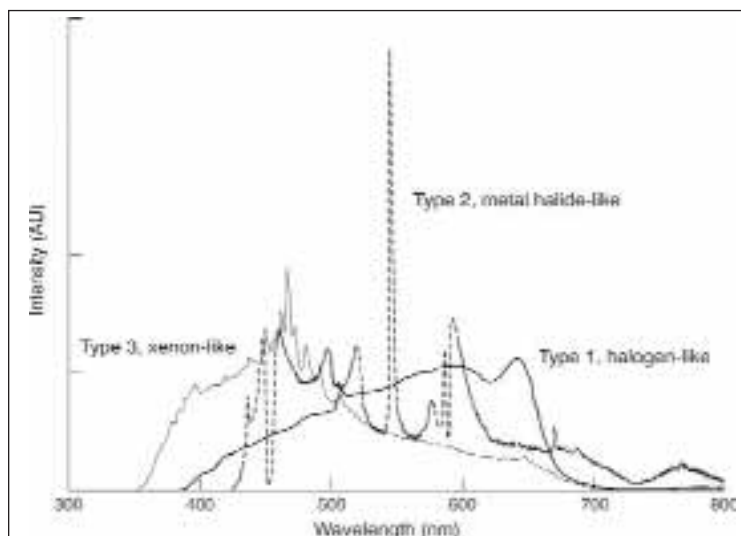


Figure 1. The spectral distributions are normalized to their integrated radiances.

Reprinted from van den Bijsen ER, Berenschot TJ, Verdaasdonk RM, van Weelden H, van Norden. Endoillumination during vitreotomy and photocoagulation thresholds. *Br J Ophthalmol*. 2000;84:1372-1375. With permission from BMJ.

surgeons is similar to that of our new green world: Achieve the best result by using the least amount of stuff and energy. The crux is that, like those searching for eco-friendly items, we must sort through a mountain of information on toxicity and as large a mountain of products that seek to make the best of our trade-off.

TOXICITY BY THE NUMBERS

Words without numbers are meaningless, as are numbers without words; *Microtrends* author Mark Penn aptly

Figure provided courtesy of Alcon.

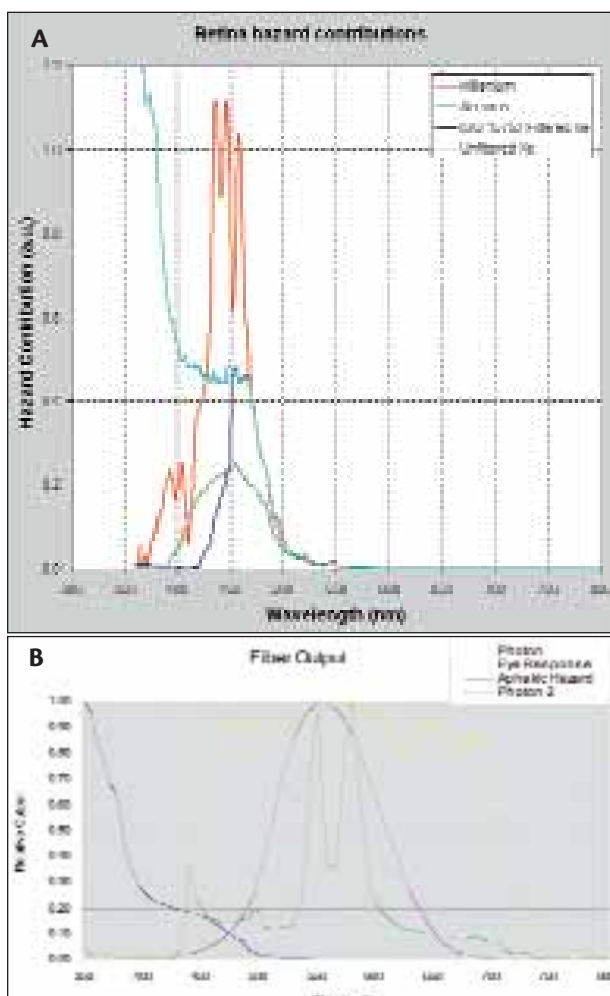


Figure provided courtesy of Synergetics.

Figure 2. Spectrally-weighted photochemical aphakic source hazard. The unfiltered xenon light approximates the aphakic hazard (A). Photon and photon 2 spectral output on a relative scale (maximum output scaled to 1). This relative output scale allows the photopic response curve and aphakic hazard to be properly displayed on the same chart (B).

expresses a healthy mistrust of numbers, because some people misuse them in efforts to advance an agenda. He coined the term “scaretistics” and says that a level of skepticism will help to separate the wheat from the chaff.²

Endoillumination light toxicity has caused concern for vitreoretinal surgeons for years. The potential for damaging effects of light to the retina was recognized by Verhoeff in 1916 and substantiated by Noell in 1966.³ With concerns about retinal phototoxicity and in efforts to provide safety margins, a group from the Netherlands tested the commercially available light sources for endoillumination during vitrectomy.⁴ The absolute power, spectral distribution, and filter combinations were measured,

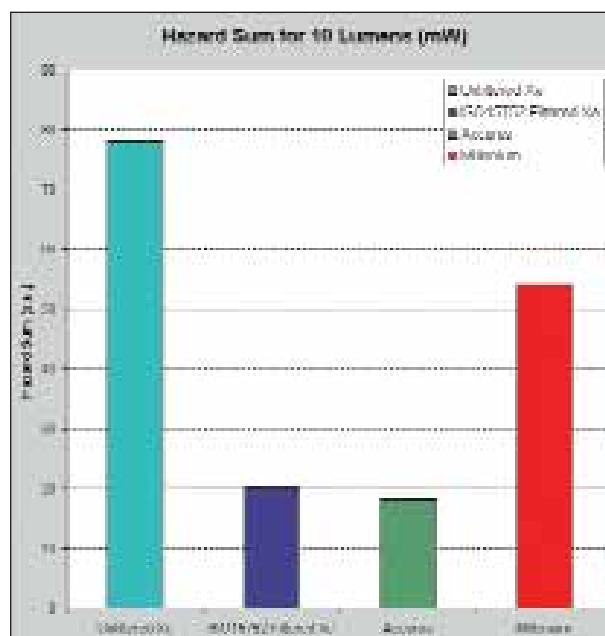


Figure 3. Alcon's spectrally-weighted photochemical hazard sum for tested light sources.

and the maximum exposure times based on the International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines were calculated. The results showed that all of the commercially available light sources exceeded the safety guidelines, and retinal damage by visible light was exceeded within 3 minutes. Figure 1 demonstrates the three types of lights investigated in this study.

Given these results, it was not surprising to learn that numerous authors have reported retinal pigment epithelial damage that has been attributed to light toxicity from endoillumination. In a controlled series for macular hole repair, up to 7% of the patients experienced visually significant phototoxicity.⁵⁻⁷

Light damage to the retina occurs through three general mechanisms involving thermal, mechanical, or photochemical effects.

PHOTOTOXICITY: MECHANISMS OF DAMAGE

Light damage to the retina occurs through three general mechanisms involving thermal, mechanical, or photochemical effects. The particular mechanism depends on the wavelength and exposure duration. Energy confine-

Figure provided courtesy of Synergetics.



Figure 4. Synergetics Photon II.

ment is a key concept, as the effect of absorbed light (either laser or incoherent source) depends on the rate of energy deposition. If the rate of deposition is too low to produce a significant temperature change, then any resulting damage occurs via a chemical, oxidative reaction induced by the absorption of photons (photochemical damage). If the rate of energy deposition is faster than thermal diffusion (thermal confinement), tissue temperature rises. If a critical temperature rise occurs, usually 10° C above basal, then thermal damage is realized. Lastly, if light energy is deposited faster than mechanical relaxation can occur (stress confinement), then a thermoelastic pressure wave occurs and the tissue is disrupted by shear forces or by cavitation-nonlinear effects.⁸

INDUSTRY FOCUSES ON OUR CONCERNS

The newer xenon and mercury illumination systems that drive our current endoilluminators are significantly brighter and, when compared to their earlier predecessors, clearly safer. Safety is optimized when xenon and mercury illumination systems are normalized with respects to both the

TABLE. CALCULATED TOXICITIES

Illumination System	Lumens per Hazard Watt
Synergetics Photon (II)	2214
Synergetics Photon (I)	1922
Alcon Halogen	1921
B&L Millennium	1343
Alcon Xenon	1238

Calculated toxicities are measured by the numbers of lumens produced for 1 W of hazardous power. Theoretically, the higher the lumen output the better.



Figure provided courtesy of Alcon.

Figure 5. Alcon's Accurus xenon system.

aphakic hazard function (ISO 15752:2000; Figure 2) and hazard sum for low lumen power (Figure 3).

With efforts to reduce phototoxicity, both the Photon II (Figure 4 [Synergetics, O'Fallon, MO]) and the Accurus (Figure 5 [Alcon, Fort Worth, TX]) have been able to maximize the luminous output while minimizing the power input into the eye (Table). Another important consideration was to achieve this while maintaining the best possible color properties and color balance (Figure 6).

ILLUMINATED INSTRUMENTS, INFUSION CANNULAS, AND CHANDELIER LIGHTING

The concept of bimanual surgery is not foreign in vitreoretinal surgery, but with products like the Tornambe Torpedo (Insight Instruments, Stuart, FL), the Synergetics Awh chandelier and the other dual functioning illuminated 20- to 25-gauge infusion cannulas and instruments, the ease of visualization has never been better.

For complex bimanual delamination of proliferative vitreoretinopathy (PVR) or tractional diabetic detachments, combining a wide-angle diffuse light source (like the products mentioned above) with a focal spectral source like an illuminated light pick provides for unprecedented controlled micromanipulation and visualization. The chandelier's diffuse source fills the posterior segment with a soft, broad light, and the pick's concentrated directional illumination highlights

subtle contour changes and tractional planes. This approach, however, can become costly both to the surgeon and the environment. But, as “Uncle Tony” (Antonio Capone, MD) would say, success in a vitreoretinal case is all about visualization; get control of the eye or it will take control of you.

When using the self-retaining chandelier systems, the directional fiber positioning is critical. I am in complete agreement with Allen Ho, MD, when he wrote “be mindful of the fiber. ... Determine its angle and determine how well you are illuminating [the retinal surface]. ... If you are angled too anteriorly, the lens or positional glare can be distracting.”⁹

SURGICAL CONSIDERATIONS

Here are some points to consider when using your light source in surgery:

- (1) Modern endoillumination can be used safely, but phototoxicity is a factual consideration.
- (2) Minimize retinal exposure time (cumulative light energy). Damage is a direct product of time and energy.
- (3) Be aware of the output power from the fiber optic; ideally aim for 10-20 mW.
- (4) Minimize the time that the fiber optic tip is less than 8-10 mm from the retinal surface.
- (5) Depending on the light source, power and exposure, RPE and photoreceptor damage can occur within a matter of minutes.
- (6) Xenon and mercury lamp illumination systems provide exceptionally bright light through very small fibers.
- (7) Power output range from 24 lumens for stiff 25-gauge light probes to over 80 lumens on some chandeliers.
- (8) Direct the chandeliers posteriorly to minimize distracting glare.
- (9) Bend and secure the chandelier fiber with a steri-strip; otherwise the light will invariably end up pointing at the lens.
- (10) Use of intraoperative dyes, such as indocyanine green, or systemic medications, such as tetracycline, may alter the threshold for damage.
- (11) Remember that a fresh bulb will increase the power output.
- (12) Consider turning off the chandelier when it is outside the eye.

Figure provided courtesy of Alcon.

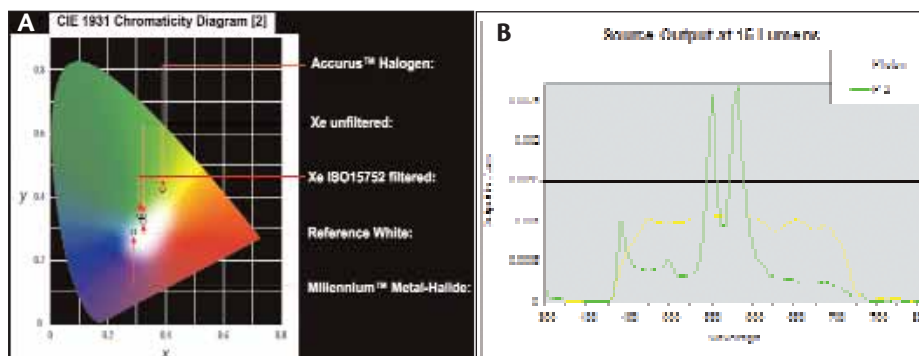


Figure 6. Color properties (A). Photon and Photon II scaled to actual power output when both are adjusted to 15 lumens. Note the large increase in the power in green wavelength with a significant reduction in the red and most blue wavelengths. The blue spike that has been left on the photon 2 is reported to help with color balance (B).

Figure provided courtesy of Synergetics.

(13) Try to vary the directionality and intensity of light throughout the case; combining diffuse and tangential “spot” lighting will allow better visualization and will make dense cataract and otherwise “poor view” cases easier.

Lastly, remember the challenge of our new green world—keep it simple; achieve the best result by using the least amount of stuff and energy. ■

Michael D. Bennett, MD, is Vitreoretinal Surgeon at the Retina Institute of Hawaii in Honolulu and an Associate Professor in the Department of Surgery at the University of Hawaii, John A. Burns School of Medicine. Dr. Bennett states that he is a paid consultant for Alcon, Genentech, OSI/Eyeteq, and Pfizer. He can be contacted via phone: +1 808 955 0255; fax: +1 808 955 4155.



Dante Pieramici, MD, is Co-director, California Retina Research Foundation and California Retina Consultants in Santa Barbara, CA. He states that he is a paid consultant for Genentech, Novartis, and QLT.

1. TerraChoice Environmental Marketing, Inc. The six sins of greenwashing: a study of environmental claims in North American consumer markets. Available at: http://www.terrachoice.com/files/6_sins.pdf. Accessed March 13, 2008.
2. Penn MJ, Zalesne EK. *Microtrends: The Small Forces Behind Tomorrow's Big Changes*. New York, NY: Hachette Book Group USA; 1982.
3. Ho AC. Xenon dual illumination vitrectomy system and bimanual surgical maneuvers. Presented at Retina 2006; January 15-20, 2006; Maui, Hawaii.
4. van den Biesen PR, Berenschot T, Verdaasdonk RM, et al. Endoillumination during vitrectomy and phototoxicity thresholds. *Br J Ophthalmol*. 2000;84:1372-1375.
5. Poliner LS, Tornambe PE. Retinal pigment epitheliopathy after macular hole surgery. *Ophthalmology*. 1992;99:1671-1677.
6. Michels M, Lewis H, Abrahms GW, et al. Macular phototoxicity caused by fiberoptic endoillumination during pars plana vitrectomy. *Am J Ophthalmol*. 1992;114:287-292.
7. Banker AS, Freeman WR, Kim JW, et al. Vision-Threatening complications of surgery for full-thickness macular holes. *Ophthalmology*. 1997;104:1442-1453.
8. Glickman RD. Phototoxicity to the retina: mechanisms of damage. *Int J Toxicol*. 2002;21:473-490.
9. Ho AC. Newer endoilluminators ease 25-gauge surgery. *Retina Today*. 2006;Fall:22-24.