SAFETY ISSUES IN LASER SURGERY

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I. INTRODUCTION

The introduction of lasers into the medical environment poses several unique problems, as with electrical or electronic equipment. Potential hazards of electrical shock exist requiring appropriate grounding, and other electrical safety procedures are essential. However, there are no particular unique electrical safety problems associated with laser use and biomedical engineers and bioelectronic technicians familiar with safe installation of electrical and electron equipment in hospital and health care environments should have no difficulty in providing guidance for the safe electrical use of laser equipment. As already said in the first chapter, the use of proper radiometric terminology and interaction mechanisms is recommended. Unfortunately, the misuse of radiometric terms such as fluence (for radiant exposure) and fluence rate (for irradiance) continue in the literature. These two terms should only be used for flux densities in tissue. The principal radiometric concepts used to describe laser-tissue interactions and the laser interaction mechanisms used in laser surgery are represented in Figures 1 and 2, respectively the dosimetric terms and the laser tissue interactions; approximate thresholds for laser interactions as a function of pulse duration are shown in Figure 3. Since thresholds actually depend also somewhat upon focal image size, the above values are only approximate and represent values developed from extensive research on laser retinal injury.

Unlike conventional surgical techniques a laser can produce potentially hazardous fumes and vaporized tissues. Vaporized tissue in sufficient quantities must receive special attention, and local exhaust ventilation will be required. The one hazard that is truly unique to the laser and which requires special attention is that resulting from the laser beam itself - the optical radiation hazard. Unlike other light sources the laser beam may be collimated and directed over some distance; hence, the area of potential hazard may not be limited to the immediate surgical site. Unwarranted fears often accompany the introduction of lasers for the first time into the surgical theater or the clinical environment. Therefore a proper appreciation of the real laser beam hazard is necessary for each member of the medical staff so that realistic safety precautions are followed.

Laser hazards depend upon the laser in use, the environment, and the personnel involved with the laser operation (the operator, ancillary per-
sonnel and patient). The laser hazard is roughly defined by the hazard classification (1 through 4), whereas the other factors must be analyzed in each situation. A basic understanding of laser biological effects and hazards is necessary to intelligently assess laser hazards in the operating room. Once the hazards are understood, the safety measures are obvious.

II. BIOLOGICAL HAZARDS OF LASER BEAMS

II.1. Hazards to the eye

Because of the special optical properties of the human eye, that organ is considered the most vulnerable to laser light. Aside from the oral mucosa, the only living tissue exposed to the environment is the cornea and conjunctiva. Without the comparative protective features of the stratum corneal of the skin, the eye is exposed to the harsh environment of sun, wind, dust, ultraviolet radiation and intense light. The eye has a natural protective mechanism in its lid reflex which limits the exposure to the retina of very intense visible light or to intense exposure from infrared rays, which raise the temperature of the cornea. However, some laser beam