The implantable cardioverter defibrillator (ICD) is a device used to treat cardiac tachyarrhythmias, specifically ventricular tachycardia (VT) and ventricular fibrillation (VF). The goal of ICD therapy is the prevention of VF- and VT-induced sudden cardiac death or syncope via the delivery of therapeutic defibrillating shocks. Implantable cardioverter defibrillators have replaced pharmacotherapy and are now considered the treatment of choice for patients at high risk for life-threatening arrhythmias.¹

The first ICD was implanted in 1980.² For several years, implantation was limited to patients with documented cardiac arrest due to VF and was available in few centers. However, in 1985 the device was approved by the US Food and Drug Administration for human use, thus making it more accessible to the general population. The ICD has 2 components, the pulse generator and the cardiac leads or electrodes. The generator, which monitors the cardiac rhythm and generates the defibrillating current, is housed in a titanium or stainless steel case and contains the battery and circuitry used for shock generation, signal filtering, analysis, and data storage. The cardiac leads transmit electrical signals from the heart to the pulse generator for analysis and deliver the defibrillating current to the myocardium. This design allows the device to actively sense and terminate life-threatening ventricular tachyarrhythmias.

Implantable cardioverter defibrillator technology has evolved rapidly as greater experience with these devices was accumulated and evidence from the Antiarrhythmics Versus Implantable Defibrillators trial demonstrated the ICD to be superior to medication for this patient population.³ Modern-day ICDs have generators that are small enough to implant in prepectoral pockets. Furthermore, thoracotomy is no longer required because leads are now inserted into the myocardium via an entirely transvenous approach. These advances have transformed the implantation procedure from a 4- to 6-hour open chest operation to a far simpler procedure performed in the electrophysiology laboratory.⁴ Current generation devices can also act as pacemakers and have become multiply programmable, capable of sensor-mediated multiple chamber pacing with enhanced arrhythmia-detection algorithms and tiered defibrillation therapy. Battery life has now been extended to up to 9 years. The current indications for ICD implantation are rapidly evolving; however, at present the device is indicated for patients who have survived an episode of spontaneous VT that was not due to a readily reversible cause and an ever-increasing list of patients for whom the ICD represents prophylactic therapy.⁵

The number of patients eligible for ICD implantation is large and expanding. The number of ICDs implanted in the United States alone in 2002 was close to 100 000.⁶ It is expected that in 2006, the number of implanted ICDs will double that in 2003.⁷

ICDs AND OCULAR SURGERY

Given that the number of ICD patients is rapidly growing, it is increasingly likely that ophthalmologists will encounter a pa-
tient with an ICD who requires ocular surgery. Ophthalmic surgeons should be familiar with these devices and the issues of operating on a patient with an ICD whose device remains in an activated state during surgery. A patient with an activated ICD will receive therapy (defibrillation) if VT or VF is detected. It is important to be aware that patients with VT may or may not report any symptoms before therapy is administered. Although patients with rapid VT or VF often have altered sensorium or dizziness before the shock, this experience is unfortunately far from universal. It is not unusual in patients with VF to have the shock as their only symptom. The discharge of the device causes the patient's head and torso to unexpectedly convulse with varying degrees of severity depending on a number of factors, which include the body surface area of the patient and the amount of energy delivered by the defibrillator. If this occurs during ocular surgery, particularly if intraocular instruments are in use at the time, severe ocular injury could ensue. Implantable cardioverter defibrillator discharge has been reported during nonocular surgery (technical support divisions of St Jude Medical, St Paul, Minn; Medtronic Inc, Minneapolis, Minn; and Guidant, Indianapolis, Ind; oral communication, January 2005); therefore, this concern is more than theoretical.

Another ICD-related issue that ophthalmologists need to be aware of is that the bipolar and monopolar electrocautery often used during ocular surgery can interfere with the function of these devices in a number of ways through a phenomenon termed electromagnetic interference. Electromagnetic interference can also potentially affect pacemakers. Electrocautery generates electrical current with high-frequency signals that may be misidentified by the ICD as abnormal intrinsic heart activity (VF or VT), causing the device to deliver therapy when in fact none is indicated. The potential adverse effects of this inappropriate therapy are 3-fold. First, it could once again cause unexpected movement of the body, and second, this inappropriate stimulation of the heart can actually induce VT or VF. Third, electrocautery may interfere with device function by the creation of electrical noise. Electrical noise may block the ability of the ICD to monitor heart rhythm, creating the potential for malignant ventricular arrhythmias to go undetected and therefore untreated. Additional potential effects of electromagnetic interference include inappropriate antitachycardia pacing (if the device is a combined ICD and pacemaker) and, rarely, damage to or reprogramming of the pulse generator. Medtronic's package insert for its ophthalmic Wet-Field and Hemostatic Eraser Bipolar instrument warns that these devices may interfere with the operation of ICDs. Medtronic also warns of possible interference with other implanted devices such as cardiac pacemakers, deep brain stimulators, and neurostimulators.

Although less commonly encountered in the ocular operating theater than in years past, diathermy can have serious adverse consequences. Diathermy is the therapeutic application of radiofrequency energy. The energy is converted to heat as it penetrates the tissues, thereby producing a burn within the tissue. Ophthalmologists should be aware of a Food and Drug Administration public health notification regarding the interaction of diathermy with implanted leads and implanted systems with leads. This document warns that laboratory testing has shown that patients with any implanted metallic leads are at risk of serious injury when exposed to shortwave or microwave diathermy (as used in ophthalmology). This is true even if the implanted device is not turned on and even if the lead is no longer connected to an implanted system. Interaction of the diathermy energy with the implanted lead causes excessive heating in the tissue surrounding the lead electrodes. Insufficient testing has been done to determine whether there is a safe distance between the diathermy application and the implant system that might allow patients to be treated with diathermy without risk of injury. The notification recommends that shortwave or microwave diathermy should not be used on patients who have any implanted metallic leads or any implanted systems that may contain a lead. For the scope of this article, this would include ICDs but also holds true for pacemakers and noncardiac devices such as deep brain stimulators, cochlear implants, bone growth stimulators, spinal cord stimulators, and other nerve stimulators. The Food and Drug Administration has received reports of patients of deep brain stimulation dying after receiving diathermy therapy. Furthermore, shortwave or microwave diathermy should not be administered to a patient who has had an implant in the past unless it can be determined that all leads were removed at the time of removal of the implant because leads are often left in place despite implant removal.

PREOPERATIVE AND INTRAOPERATIVE MANAGEMENT

Preoperative management of the ophthalmic surgery patient should include questioning the patient about any implantable devices. If an ICD is in place, then consultation with the managing cardiologist is indicated. The cardiologist may want to consult with a device manufacturer representative. To avoid the potential complications of electromagnetic interference, the emerging consensus appears to be that the ICD’s antitachycardia functions should be inactivated during surgery if electrocautery is to be used during a surgical procedure. This can be accomplished either with an ICD programming device or more commonly by placing a magnet over the pulse generator during surgery and then removing it at the conclusion of the procedure. It should be noted that the manner of application of a magnet can be devicespecific; and if possible, the manufacturer of the device should be ascertained preoperatively. Communication between the ophthalmologist, cardiologist, and anesthesiologist (and if necessary, the device manufacturer) is the most effective means to achieve maximal safety. If
the device is inactivated, appropriate backup emergency support must be available and should include continuous electrocardiographic monitoring and external defibrillation. The cardiologist should provide guidance as to whether the device's function needs to be evaluated (interrogated) after surgery.

Given the inherent delicate nature of both ophthalmic surgery and the structure of the eye, the 3 major ICD manufacturers recommend that these devices be inactivated during eye surgery regardless of whether the use of cautery is planned because of the potential for iatrogenic injury to the eye should the device discharge (technical support divisions of St Jude Medical, Medtronic Inc, and Guidant; oral communication, January 2005). None of the manufacturers are aware of such an incident, and a Medline search also did not identify any such cases. It is likely that the risk of intraoperative ICD-related ocular complications is low. Nevertheless, as the number of ICD patients grows, the potential for device-related ocular complications will increase. The duration and types of ophthalmic surgical procedures are vast. This article is not meant to set absolute guidelines for ophthalmologists, but rather to raise the awareness of ICD-related issues in the ophthalmic community. Final decisions regarding intraoperative device management should be based on the combined judgment of the ophthalmologist and the treating cardiologist.

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Correspondence: Glenn L. Stoller, MD, 2000 N Village Ave, Suite 402, Rockville Centre, NY 11570 (gstoller@ocli.net).
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