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Clinical Assessment and Management of Patients With Implanted Cardioverter-Defibrillators Presenting to Nonelectrophysiologists

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Abstract—All physicians increasingly will encounter patients who have implanted cardioverter-defibrillators (ICDs) for protection from ventricular arrhythmias. This advisory provides a concise summary relevant to the assessment and management of patients with ICDs, including those who present to primary care or emergency department physicians with symptoms suggesting arrhythmia or ICD malfunction and those who require cardiac or surgical procedures. (*Circulation*. 2004;110:3866-3869.)

Key Words: AHA Science Advisories ■ defibrillators ■ arrhythmias ■ defibrillation

Implantable cardioverter-defibrillators (ICDs) are a first-line therapy for many patients who are at risk for sudden death from ventricular arrhythmias.¹ More than 100 000 such devices are implanted annually in the United States alone, and physicians in all specialties can expect to encounter an increasing number of patients with these devices. The purpose of this advisory is to provide a succinct overview of issues relevant to patient care for patients with ICDs.

Recognizing the ICD

ICDs are most often implanted in the left infraclavicular region and are usually palpable. Current ICDs are the size of dual-chamber pacemakers from the early 1990s (30 cm³, 60 g); older devices are substantially larger (up to 200 cm³). Occasionally the device is implanted in the right infraclavicular region or in the abdomen. For the past 10 years, the majority of devices have used transvenous lead systems, with one lead positioned in the right ventricular apex. Dual-chamber devices, which also provide atrial sensing and pacing, have a second lead secured in the right atrium. Devices that provide left ventricular pacing for treatment of heart failure (cardiac resynchronization therapy) also have a lead inserted into the coronary venous circulation. The complete system is easily visible on standard radiographs. All patients who receive an ICD receive an identification card

with the manufacturer and model number of the device, information that is needed to select the appropriate programmer for interrogation of the device. Current ICDs also may store useful clinical data, which can be retrieved with a programmer, that describe the implanted hardware, cardiac condition, medications, the implanting physician, and emergency contact numbers. Manufacturers offer 24-hour technical support by phone, maintain a registry of patients who have their device implanted, and have a staff of field engineers who are often available for help with the assessment, interrogation, and management of device function.

ICD Function

There are 4 major ICD functions: (1) sensing (recognition of local atrial and ventricular electrogram signals); (2) detection (classification of sensed signals according to programmable heart rate zones); (3) provision of therapy to terminate ventricular tachycardia (VT) or ventricular fibrillation (VF); and (4) pacing for bradycardia and/or cardiac resynchronization therapy. The latter is the same as that provided by a standard pacemaker. VT/VF detection is based on the heart rate sensed from the ventricular electrode in the right ventricle. The rate and duration of a rhythm that defines an arrhythmia and elicits therapy are programmable. A number of other sophisticated detection enhancements may be pro-

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grammed to discriminate true ventricular tachyarrhythmias from rapidly conducted supraventricular tachyarrhythmias.

When detection criteria are satisfied, one of 2 types of therapy to terminate the arrhythmia is initiated. High-energy shocks (1 to 40 J) can be delivered between the coil electrode in the right ventricle and the ICD casing and/or another electrode. Although substantially less energy is used than is used for external cardioversion or defibrillation, these shocks are painful if the patient is conscious.

Antitachycardia pacing (ATP) may be enabled to manage VT. ATP commonly consists of a burst of pacing (eg, 6 to 10 beats) at a rate faster than the VT rate. ATP may be felt but is painless and often terminates VT before the patient develops symptoms of the arrhythmia. ATP is usually the initial preferred treatment, even for fast VTs, with shocks programmed as a backup if ATP fails.²

Routine Patient Follow-Up

All patients should receive periodic follow-up by ICD specialists, typically every 1 to 6 months, depending on the device, battery status, and arrhythmia frequency. Interrogation and testing of the pacing functions of the device allow detection of infrequent lead and device failures. ICDs store a record of arrhythmias detected and therapies delivered, which allows the relation of patient symptoms to detected arrhythmias to be assessed. Some ICDs also store physiological data trends such as atrial tachyarrhythmia frequency and physical activity logs (based on activity sensors). Battery longevity is typically 4 to 7 years (dependent on use) and is assessed from interrogation of battery voltage.

Patients With Suspected ICD Therapies

A patient who reports a shock from his or her ICD has experienced one of 3 situations: appropriate therapy, inappropriate therapy, or a phantom shock. An appropriate therapy is one elicited by VT or VF that satisfies detection criteria. More than one third of patients with a history of VT/VF will have an appropriate therapy within 2 years of ICD implantation.³ Inappropriate therapies can be caused by a supraventricular tachycardia that satisfies VT/VF criteria (usually because of rapid rate) or sensing of environmental electrical noise, such as may rarely occur when the patient lingers in the field of a theft-detection device.⁴ Rapid supraventricular tachycardias are particularly a problem in children and athletic individuals in whom exercise or reductions in medications that slow heart rate, such as β -blockers, are commonly encountered causes of inappropriate shocks from sinus or supraventricular tachycardia. Inappropriate therapy can also be an indication of malfunction of the system due to sensing of electrical noise produced by a lead fracture. Patients who have received painful shocks occasionally suffer from phantom shocks, which are the perception of a shock in the absence of any arrhythmia or therapy from the ICD.

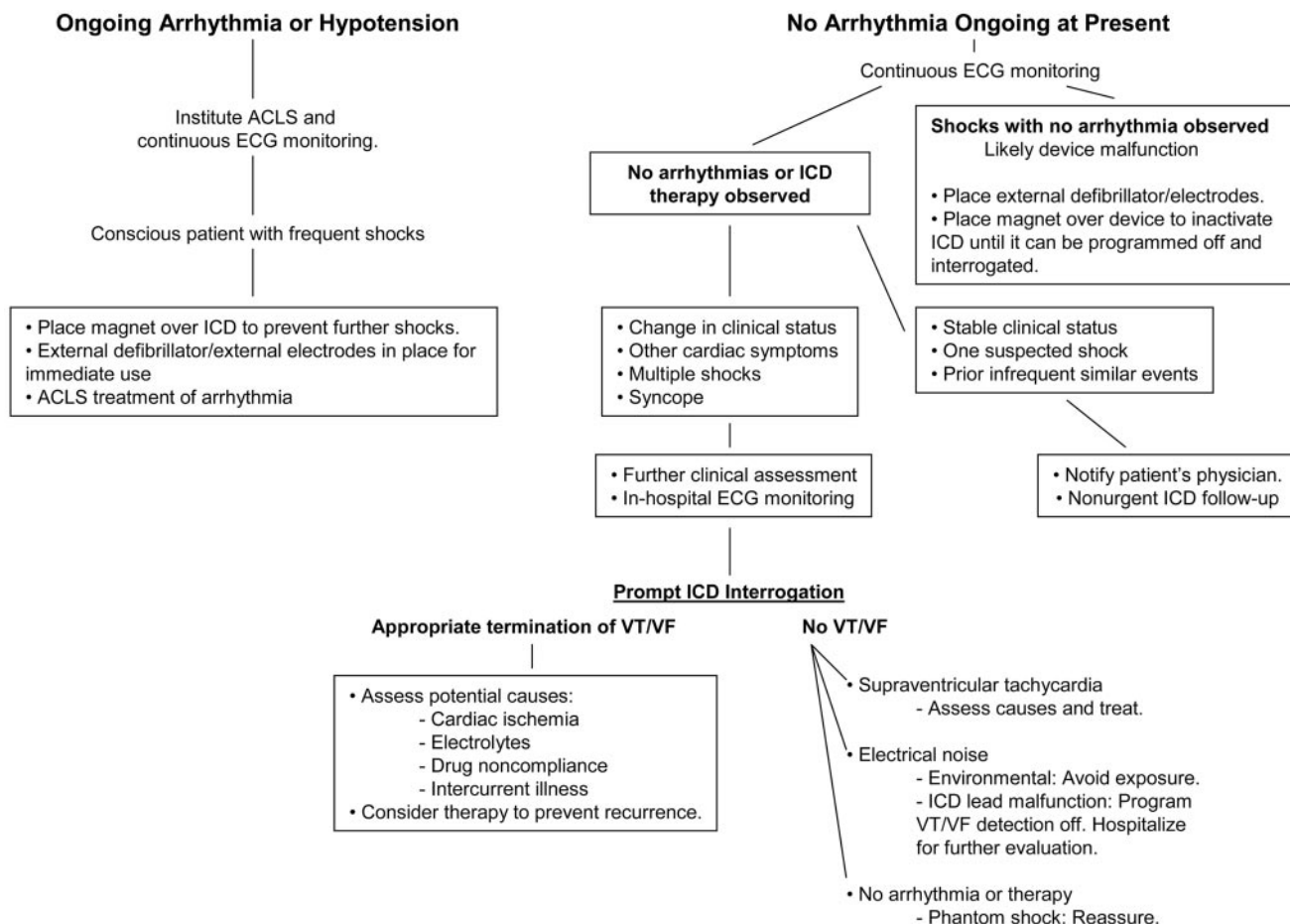
ICDs provide a safety net in that they terminate arrhythmias when they occur, but they do not prevent the arrhythmia. Patients who report a shock have often experienced an episode of VT that was appropriately recognized and treated by the device. Those who report an isolated shock with no symptoms to suggest a change in health status otherwise

should be reassured and do not require emergent evaluation, particularly if they have had such events previously separated by long periods of stability. This decision usually should be made in consultation with the electrophysiologist who monitors the patient.

Patients who experience a shock but feel unwell after the event or who receive more than one symptomatic ICD therapy within a short period of time (minutes to hours) require emergent evaluation for several reasons.⁵ The arrhythmia may be ongoing and not adequately treated by the ICD. An intercurrent illness, such as myocardial infarction or hypokalemia, may be increasing the frequency of arrhythmia and warrant medical attention. The ICD may be malfunctioning and sensing electrical noise, such as may occur from a lead fracture. In that case, not only may the ICD be oversensing noise, but it may also be incapable of providing therapy if VT/VF were to occur. Emergency medical teams should be called to transport the patient to the nearest emergency medical facility. A change in patient status with ICD therapies warrants interrogation of the ICD to ensure appropriate function and assess the nature of the arrhythmias that have elicited ICD therapies.

Patients who have an ongoing arrhythmia when evaluated emergently should be managed according to advanced cardiac life support (ACLS) guidelines regardless of the presence of an ICD (Figure). Although in the vast majority of instances, ICD function will be found to be appropriate, this cannot be assumed. External shocks and antiarrhythmic medications should be administered per ACLS guidelines. Placement of electrodes for external shocks should avoid the area directly over the ICD because occasional damage to ICDs can occur. Caregivers should wear gloves during resuscitation; a shock may be perceptible to those in skin-to-skin contact with the patient at the time of an ICD shock but is not a health risk.

Repeated shocks from an ICD are painful and distressing to the patient and can cause depression and posttraumatic stress syndrome.^{3,6} Appropriate therapies of arrhythmias to prevent further shocks should be implemented immediately. When repeated inappropriate shocks are elicited by rapid supraventricular arrhythmia, such as atrial fibrillation, slowing the rhythm or restoring sinus rhythm will likely prevent future episodes. Failure of ICD shocks to convert atrial fibrillation does not indicate that external cardioversion will also be ineffective, because the shock strength and current vectors for the ICD are often not optimal for atrial defibrillation. Repeated ICD therapy can also be interrupted by placement of a magnet directly over the ICD. This suspends VT/VF detection but allows backup bradycardia pacing to continue; in contrast to pacemakers, magnet application does not cause asynchronous pacing (ie, does not elicit DOO or VOO pacing). While a magnet is in place, neither supraventricular tachycardias nor VT/VF will be detected, so the patient must remain monitored in an appropriate environment to treat VT/VF with external cardioversion if required. Most ICDs resume normal function after the magnet is removed, but some can be programmed to remain disabled, which leaves the patient unprotected after the magnet is removed. This magnet response is not the nominal setting in current ICDs,



Emergency department evaluation of patients with ICDs and symptoms of acute arrhythmia or ICD shocks.

but if there is any uncertainty as to whether the ICD is active after magnet removal, it is necessary to interrogate the ICD with its programmer. Antiarrhythmic drug therapy is often needed to reduce ICD therapies for either VT or supraventricular tachycardia, but in some cases, this can impair ICD effectiveness for detecting and terminating arrhythmias. Continued therapy with antiarrhythmic drugs should always be coordinated with an electrophysiologist. ICD reprogramming and testing may be required.

Patients who report hearing a periodic tone from the ICD should be evaluated promptly. Some ICDs perform automatic self-checks and emit a tone in the event of impending battery depletion, when a safety parameter (such as lead impedance) is outside acceptable range, or when therapy has failed to terminate an arrhythmia.

Diagnostic Evaluations in Patients With ICDs

Strong magnetic fields of MRI can interfere with ICD functioning and induce electrical current flow in the ICD lead that can initiate an arrhythmia or be sensed as an arrhythmia and precipitate spurious therapies. In general, patients with an ICD should not be placed in an MRI field. Ongoing work is aimed at developing MRI-compatible ICDs. There is no such problem with fluoroscopy, CT imaging, or nuclear-based imaging.

Left-heart catheterization can be performed in the usual manner in the ICD patient. Right-heart catheterization should be performed with awareness that manipulation of catheters in the right heart can dislodge ICD leads that have not yet become fibrosed to the myocardium, typically those placed within the previous several months. Caution should be exercised with the use of guidewires in the right heart. A wire that comes in contact with the ICD electrodes can induce electrical noise that triggers inappropriate therapy and can potentially damage the ICD if a shock occurs while the guidewire is in contact with the ICD electrodes. Use of metal guidewires in the right ventricle should be avoided unless ICD arrhythmia detection is disabled.

Exercise testing should be performed with the realization that increasing the heart rate above the programmed VT/VF detection rate is likely to elicit therapy from the ICD. Discussion with the patient's electrophysiologist is usually warranted before exercise testing is done, especially so that the tester is advised of the ICD arrhythmia detection rate. During the test, if that rate is approached, the test should be stopped to avoid the delivery of inappropriate therapy, especially a shock.

Surgery in Patients With ICDs

ICDs are sensitive to electromagnetic interference produced by electrical cautery, which is sensed as VF and potentially

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causes inappropriate shocks. Management of the ICD for surgery should be discussed with the patient's electrophysiologist. If a magnet is placed over the ICD and taped in place, it will suspend detection without interrupting backup bradycardia pacing. Should VT/VF occur intraoperatively, simple removal of the magnet will cause the ICD to resume detection and deliver therapy, typically in <10 seconds, provided that the device does not have a feature for permanent inactivation with magnet placement. This approach also avoids delays in reactivation of the ICD after surgery imposed by waiting for individuals skilled in the use of the ICD programmer. Many centers prefer to program tachyarrhythmia detection and therapy "off" before surgery and then reprogram them "on" after surgery. With either approach, however, all ICD patients should have external defibrillation pads in place and attached to an external defibrillator throughout the surgical procedure. Initiation of arrhythmia management according to ACLS guidelines should not be delayed to await a response from the ICD.

Postoperative atrial fibrillation in a patient with an ICD that provides atrial and ventricular pacing may result in a rapid ventricular rate due to pacing at the upper programmed rate of the pacemaker function, which requires reprogramming for heart rate control.

Infections and Other Complications

Complications from ICD implantation include bleeding into the pulse generator pocket, perforation with pericardial effusion and/or tamponade, pneumothorax, and thrombophlebitis. ICD infections can involve the generator pocket, leads, or both. The incidence is greater than that observed with pacemakers and is more likely after a recent generator replacement.⁷ Prompt referral to a specialist is warranted. In

almost all cases, explantation of the device and all leads is required. Endocarditis prophylaxis with antibiotics is not generally warranted.

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