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RESEARCH ARTICLE

Application of ICD guidelines and indications in a community-based academic hospital: a case series-based discussion

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Background: Implantable cardioverter defibrillators (ICDs) are indeed beneficial in selected patients as evidenced by multiple large randomized controlled trials (RCTs) since 1980. A systematic method for stratification of patients and hospital-wide criteria/guidelines to ascertain appropriate device implantation became necessary.

Methods: Major ICD/CRT (cardiac resynchronization therapy) clinical studies and relevant guidelines were reviewed, and an institution-wide inclusion and exclusion criteria for ICD/CRT was formulated. A retrospective analysis of selected cases was performed to discuss the criteria and special clinical situations.

Results: We have translated the evolving ICD/CRT studies into a standard of care at our hospital by formulating a standard, practical, and update-to-date ICD inclusion and exclusion criteria. Thirteen cases were selected to represent major indications and contraindications of ICDs in our practice. These cases cover indications of ICD for secondary prevention of sudden cardiac death (SCD), primary prevention of SCD in patients with CHF resulted from either ischemic or non-ischemic cardiomyopathy, as well as for infiltrative cardiomyopathy and inherited conditions. We discussed the application of CRT in patients with CHF associated with prolonged QRS duration. We then covered the potential benefits of ICD with/without CRT in certain special populations of patients that have not been adequately evaluated by currently available RCTs; these include alcoholic, elderly, female, and ESRD/HD patients. Finally, we addressed risks, complications and contraindications of ICD, as well as application of an external wearable defibrillator in AMI, or status post-CABG patient during the mandatory waiting period for an ICD.

Conclusions: Establishment of the ICD/CRT criteria represents a practical translation of emerging CRTs and helps to standardize patient care in our hospital. It also improves cost-effectiveness as well as appropriate utilization of institute and device resources.

Keywords: *implantable cardioverter–defibrillator*; *cardiac resynchronization treatment*; *sudden cardiac death*; *criteria*; *electrophysiology*

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Since the first clinical use of the implantable cardioverter–defibrillator (ICD) in 1980, multiple large randomized controlled trials (RCTs) have been conducted, and ICD guidelines and indications for various patient populations have been emerging as these RCTs conclude. ICDs are indeed beneficial in selected patients; hence, a thorough understanding of indications is critical for daily practice.

In this article, we present a retrospective analysis on how evolving ICD/cardiac resynchronization therapy (CRT) studies have translated into a standard of care at our community-based hospital by guiding us to formulate standard, practical, and update-to-date ICD inclusion and exclusion criteria. Before the establishment of these criteria, there was no systematic method for stratification of patients, and decisions were limited to the discretion of the cardiologist, sometimes with little or no involvement of the cardiac electrophysiologist. This situation necessitated a hospital-wide policy to ascertain appropriate device implantation criteria and guidelines for all patients. After the establishment and execution of the criteria that will be discussed in detail in this paper, the adherence and compliance with current recommendations from CRT trials and standard national guidelines has become close to 100% in our hospital. Cost-effectiveness has greatly improved; institute and device resources are now better utilized.

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Clinical trial review

Since 1980, multiple large RCTs have been conducted. AVID (Antiarrhythmic Versus Implantable Defibrillator) (1) concluded that the ICD is superior to medication for secondary prevention of ventricular tachycardia (VT)/ventricular fibrillation (VF). The survival benefit with ICD implantation in comparison with standard medical therapy for secondary prevention of VT/VF has been replicated by two smaller trials [CIDS (2) and CASH (3)]. These findings have established the secondary prevention of sudden cardiac death (SCD) as a Class I indication for ICD placement.

As for primary prevention of SCD, the MADIT (4), MADIT-II (5), and MUSTT (6) trials showed that ICDs significantly improved survival in high-risk patients with coronary artery disease (CAD) and ischemic cardiomyopathy. High risk is defined as: CAD, prior myocardial infarction, left ventricular ejection fraction (LVEF) no greater than 35%, non-sustained VT on ambulatory monitoring, VT inducible by programmed stimulation, and failure of intravenous procainamide to prevent inducibility. In contrast, CABG Patch (7) showed ICDs do not improve survival in high-risk patients after CABG up to 32 months; DINAMIT (8) showed ICD therapy does not reduce overall mortality in high-risk patients who have recently had acute myocardial infarction (AMI) up to 40 days.

The DEFINITE trial (9) showed a strong trend toward ICD benefit over the standard-therapy group for non-ischemic cardiomyopathy. SCD-HeFT (10) was the largest primary prevention ICD clinical trial, which recruited patients with either non-ischemic or ischemic cardiomyopathy, LVEF $<35\%$, and New York Heart Association (NYHA) functional Class II or III congestive heart failure (CHF). It concluded that ICD reduced overall mortality by 23% in CHF patients. SCD-HeFT also defined patient selection for ICD therapy to patients with LVEF $<35\%$ and NYHA Class II or III CHF.

Despite the lack of large-scale RCTs, ICDs are usually a Class IIa recommendation for patients with uncommon conditions such as infiltrative and inherited diseases that are associated with a high risk of SCD. Infiltrative diseases include cardiac sarcoidosis, and less commonly, amyloidosis. An ICD is indicated when the conditions are accompanied by sustained or non-sustained VT, regardless of LVEF. Inherited cardiac diseases include hypertrophic cardiomyopathy (HOCM), arrhythmogenic right ventricular dysplasia, Brugada syndrome, long QT syndrome, and catecholaminergic polymorphic VT.

MIRACLE (11), COMPANION (12), and MADIT-CRT (13) established the base for CRT. The COMPANION study enrolled patients with low LVEFs, QRS duration >120 ms, and NYHA Class III or IV (the only study to evaluate ICDs in NYHA Class IV), and showed that CRT improved LVEF, heart failure symptoms, and reduced the mortality rate in patients with NYHA Class III–IV heart failure and wide QRS interval regardless of ischemic or non-ischemic etiology. MADIT-CRT showed ICDs decrease non-fatal heart failure events in mild CHF (NYHA Classes I and II), LVEF $<30\%$, and QRS duration >130 ms. It further proved that patients with a QRS duration >150 ms benefit from CRT the most.

Methods

Translating the results of these emerging studies became critical to our clinical practice for patient care at a community-based hospital. We established ICD/CRT inclusion/exclusion criteria in our hospital by integrating the results of these major trials.

Over 450 patients who were admitted to our hospital during the past year for either ICD implantation or for ICD-related events were extensively reviewed; among these, 13 cases were selected to represent major indications and contraindications of ICDs in our practice. These cases presented here cover ICD indications for the secondary prevention of SCD, primary prevention of SCD in patients with CHF that resulted from either CAD or non-ischemic cardiomyopathy, and indications for infiltrative cardiomyopathy and inherited conditions. A greater than 1 year of life expectancy with reasonable functionality is a prerequisite to qualify for a device. We also discussed the potential benefits of ICDs with and without CRT in certain populations of patients that have not been adequately evaluated by currently available RCTs, including alcoholic, elderly, female, or end-stage renal disease (ESRD)/hemodialysis (HD) patients. Finally, we addressed the risks, complications, and contraindications of ICDs, as well as the application of an external wearable defibrillator, which has comparable survival benefit with ICDs (14), in AMI or status post (s/p)-CABG during the mandatory waiting period for an ICD.

Results

Table 1 shows the inclusion/exclusion criteria of ICD/CRTs in our hospital. These criteria are based on updated CRT results and recommendations. Execution of these criteria improves the adherence and compliance of ICD guidelines for daily patient care in our hospital.

In Table 2, we list 13 cases representing the most common clinical situations encountered in our clinical practice during last year. For each case, a brief clinical history, the electrophysiology study results leading to a guideline-supported device indication (as referenced in Table 1), and the final treatment delivered are outlined. A 12-lead EKG for each case is also shown following the table. Major categories of patients include: 1) patients who meet primary or secondary ICD criteria; 2) patients who meet exclusion criteria; 3) patients who

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Table 1. Easton Hospital ICD criteria

Secondary prevention
1. Documented episodes of cardiac arrest due to VT/VF, not due to a transient or reversible cause
2. Documented sustained VT, either spontaneous or induced by EP, not associated with AMI and not due to a transient or reversible cause.

Primary prevention
1. Documented familiar or inherited conditions with high risk of life-threatening VT, such as long QT syndrome, hypertrophic obstructive cardiomyopathy, etc.
2. CAD with all of the following:
   Prior MI >40 days (MADIT I & MUSTT)
   LVEF <35%
   VT/VF inducible and sustained at EP study
   EP study greater than 4 weeks post-qualifying MI
3. Prior MI with all of the following (MADIT II):
   LVEF <30%
   NYHA Class II or III
   No cardiogenic shock or hypertension in stable rhythm
4. Ischemic dilated cardiomyopathy with both of the following (SCD-HeFT):
   NYHA Class II or III
   LVEF <35%
5. Non-ischemic dilated cardiomyopathy with all of the following (SCD-HeFT):
   Documented duration >3 months
   NYHA Class II or III
   LVEF <35%
6. Severe CHF with all of the following:
   Meets coverage requirements for CRT
   NYHA Class IV
   QRS >120 ms

Exclusion criteria
1. MI <40 days
2. CABG or PCI <90 days
3. NYHA Class IV who do not meet requirements for CRT Rx
4. Candidate for coronary revascularization
5. VT/VF or CHF due to reversible cause
6. No reasonable expectation of survival with a good functional status for more than 1 year.

Class I recommendation for CRT
LVEF <30%
Dilated LV cavity with severe systolic dysfunction
Recurrent CHF (NYHA Class III or ambulatory Class IV) despite optimal medical therapy, >3–9 months in duration
QRS duration >120 ms (best responders: LBBB and QRS-d >150 ms)
Ventricular tachyarrhythmia (VT/VF)
Sinus rhythm best response (AV synchrony and VV synchrony)

CHF, congestive heart failure; CRT, cardiac resynchronization therapy; ICD, implan cardioverter defibrillator; LVEF, left ventricular ejection fraction; NYHA, New York Heart Association; Rx, treatment; VF, ventricular fibrillation; VT, ventricular tachycardia.

need mandatory waiting time; and 4) patients who meet criteria for CRT.

Special considerations

The potential benefits of ICDs with/without CRT in certain patient populations have not been adequately evaluated by currently available RCTs.

Alcoholic cardiomyopathy and ICD

The ICD is indicated for cardiac arrhythmia and/or CHF associated with alcoholic cardiomyopathy. Alcohol can trigger atrial fibrillation, which can make an ICD fire inappropriately. Although new versions of ICD can distinguish atrial fibrillation from other lethal arrhythmias and therefore have less inappropriate firings, abstaining from alcohol is a must for patients with alcoholic cardiomyopathy.

Age, gender, and ICDs

Both the elderly (>80 years old) and female patients are underrepresented in current ICD trials, even though about 20% of ICDs are implanted in these two patient populations. Meta-analysis data from available trials suggest that ICDs do not reduce overall mortality in the elderly, which is likely due to a higher incidence of non-arrhythmic death as compared with younger patients (15). However, due to small population sizes in these studies as well as wide confidence intervals (95% CI, 0.29–1.08), we do not consider age to be exclusion criterion in our practice. Similarly, meta-analysis data also found that ICDs do not confer significant overall mortality benefit in women (16). This is believed to be because SCD has a weaker impact on total mortality in women than in men – hence, the higher ICD benefit in men. Further larger-scale studies focusing on these patient populations are warranted, and careful risk stratification in clinical practice is important to avoid overgeneralization of current ICD recommendations.

ESRD and ICD

While up to 10% of ESRD patients have an ICD implanted, the survival benefit in this population is unclear (17), most likely due to the presence of multiple severe comorbidities. Transvenous ICD leads are associated with central vein stenosis resulting in significant adverse consequences for arteriovenous access (in up to 20% of ESRD patients). Infections associated with ICD leads are more frequent and associated with worse outcomes in ESRD patients (18). An external wearable defibrillator is an alternative for ESRD patients who do not yet meet criteria for permanent ICD therapy or are experiencing serious side effects.

Complications

Other than venous stenosis and systemic or local infections, patients can experience discomfort associated with

ICD implantation and shocks. ICD shocks can also lead to anxiety as well as panic disorders and even agoraphobia. One of our recent studies showed that underlying malignancy is also a significant risk factor for ICD pocket infection (19).

Conclusions

The ICD has a wide spectrum of clinical applications. A thorough understanding of its indications is critically important in daily practice. At our hospital, ICD inclusion and exclusion criteria have been established based

Table 2. Cases discussion of the criteria described in Table 1

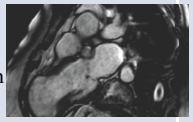
#	Clinical vignette	EPS etc	Indication	Rx
1	74 yo M, w/ remote MI; recurrent CHF despite max med Rx, NYHA class III, LVEF <20%	HV: 74msec, inducible sustained VT, Abnl SA node fxn. QRSd: 128mSec	SP-2, PP-2,3,4; CRT	BiV-DDDR/ ICD
2	52 yo M w/ h/o heavy alcohol abuse p/w recurrent CHF, NYHA II-III, cardiac cath negative for CAD, LVEF 10–15%	Inducible sustained VT deteriorating to VF, abnl SA node fxn	SP-2, PP-5	DDDR/ICD
3	35 yo W developed recurrent CHF post-partum despite max medical therapy, non-compliant w/ med, NYHA class worsens from II to III, LVEF deteriorate from 40% to 20%	Inducible sustained PMVT, abnl SA node fxn. QRSd: 138 mSec	SP-2, PP-5; CRT	BiV-DDDR/ ICD
4	74 yo M, h/o severe ischemic cardiomyopathy, recurrent CHF, p/w elevated troponin. On optimal med. LVEF <25%. Cardiac cath: severe 3 vessel disease not amendable to revascularization.	SA & AV node dysfunction Sustained PMVT. QRSd: 127 mSec	EC-1➔ SP-2, PP-2,3	Life-Vest for 40days➔BiV-DDDR/ICD
5	37 yo M p/w recurrent near syncope. Documented sustained monomorphic VT. Cardiac cath and echo nl. He's diagnosed with right ventricular dystrophy. Had recurrent VT despite VT ablation for scar modification.	Heart MRI: pachy fibrofatty replacement of the RV myocardium	SP-2	VT ablation DDDR/ICD
6	27 yo W w/ h/o TOF, s/p definitive repair and PV replacement, p/w recurrent near syncope. No CAD on cardiac cath and LV fxn nl	Sustained macro-renetrant monomorphic VT	SP-2	DDDR/ICD
7	86 yo W p/w dizziness and hypotension with monomorphic VT that required immediate cardiovertion. Cardio cath showed 80% RCA stenosis, for which she got 3 BMS. LVEF: 30%. QT interval: 450 mSec	LV aneurysm 	EC-2 ➔ SP-1,2	Life-Vest for 90days➔BiV-DDDR/ICD
8	47 yo W developed acute CHF (NYHA III) after URI. Echo: LV dilation, LVEF< 10%. No CAD on cardiac cath. Responded to med & LVEF back to 55%. LVEF dropped to <15% after 1 year off meds, but back to >45% 4 months after meds are resumed.	Normal EPS study	EC-5	Life-Vest for 4 months No ICD indicated
9	29 yo AAM p/w SOB, palpitation. Non-sustained WCT on EKG. Sarcoidosis suggested by chest CT and confirmed by bronchial Bx	Cardiac MRI: delayed gadolinium enhancement in myocardium. EPS: Sustained PMVT.	SP-2	DDDR/ICD
10	35 yo W p/w recurrent near syncope. h/o type 1 myotonic dystrophy.	HV: 101 msec. Sustained monomorphic VT.	SP-2	DDDR/ICD
11	41 yoM p/w palpitations and near-syncope, h/o severe HOCM evidenced by TTE. LVEF 50-55%. Family history positive for HOCM. He developed recurrent A-fib.	Abnl SA node fxn. Sustained monomorphic v-tach.	SP-2, PP-1	DDDR/ICD
12	59 yoM w/ h/o osteosarcoma on chronic methadone, admitted for "flu" symptoms, transient confusion and unresponsiveness. Developed two episodes of sustained PMVT requiring immediate cardioversion while in house. Cardio cath: no significant CAD, LVEF 50-55%.	temporary pacemaker to prevent bradycardia-induced symptomatic polymorphic v-tach.	EC - 5	life-vest, tapering methadone
13	34 yoM w/ h/o recurrent syncope p/w cardia arrest due to v-fib. Successful ACLS. EKG: Brugada, type 1.	inconclusive	SP-1, PP-1	DDDR/ICD

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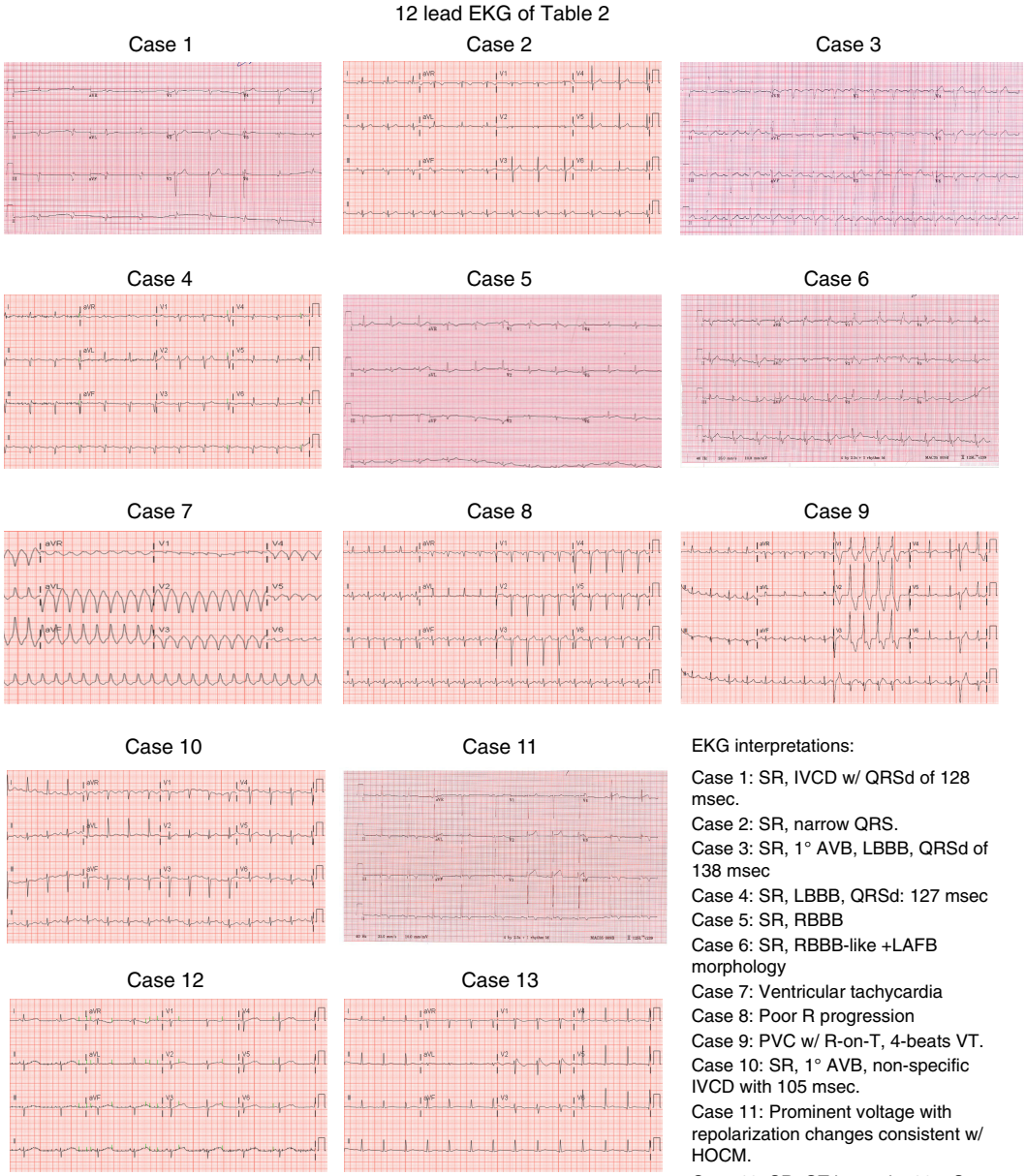
Table 2. (*Continued*)



on data from major RCT results. These criteria are practical and up to date. They help to standardize patient care in terms of ICD/CRT implantation. It is evident from our cases that we stress on contraindications, mandatory waiting periods and maximal/optimal medical therapy prior to device implantation. Case 8 and 12, in particular, highlight reversible causes of VT/VF as exclusion criteria. We believe this represents a practical translation of emerging CRTs that results in better patient care in our practice at a community-based hospital. Further study is certainly necessary to assess the impact of the ICD Criteria in our institution by comparing implant appropriateness both before and after the institution of the criteria with significant randomized samples sizes.

ICDs are indeed beneficial in selected patients. Mortality benefits have not been proven in female patients, the elderly, ESRD, and non-ischemic cardiomyopathy patients. In addition, ICD shocks can be painful, reduce quality of life, and increase anxiety in patients. Patients should be well informed of all benefits and risks of the ICD before implantation.

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Conflict of interest and funding

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