Practice viewpoints: AICD, who and when?

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ABSTRACT
Automatic implantable cardioverter-defibrillator (AICD) is a costly but effective treatment modality for the prevention of sudden cardiac death (SCD). Causes of SCD are age-dependent, disease-specific and affected by racial/ethnic differences. Atherosclerotic heart disease (ASHD) is the most frequent underlying disease in individuals ≥35 years old. Available information suggests that Asians have a lower rate of SCD compared with African black individuals and Caucasians. Whether it is for secondary or for primary prevention, physicians should be educated to perform a thorough diagnostic work-up and be able to identify transient and/or reversible causes of lethal ventricular tachyarrhythmias such as acute myocardial infarction, residual ischaemia, electrolyte imbalance, adverse effect of drugs, valvular heart diseases, etc before contemplating AICD implantation. Correction of these reversible causes may avoid the necessity of AICD implantation. The status of left ventricular function is not sufficiently specific for guiding AICD implantation in ASHD patients after acute myocardial infarction. The urgent need is to develop better biological or physiological markers for risk stratification so that patients who would actually benefit from AICD implantation can be readily identified. Such an approach will make the use of AICD more cost-effective. Based on molecular genetic data obtained from patients with inherited structural cardiovascular diseases and malignant arrhythmogenic disorders in which the risk of SCD appears to be gene- and/or mutant-specific, a continuous search for genetic markers for better risk stratification is warranted in patients suffering from ASHD.

Implantation of automatic implantable cardioverter-defibrillator (AICD) is a well-established therapeutic modality for the prevention of sudden cardiac death (SCD), but its cost and follow-up care are expensive. The estimated cost per AICD implantation is about USD $30 000 ($10–15 000 in Asia), and the average AICD replacement time is 5 years due to its short life. The median cost of AICD replacement is $10 000 (USD $30 000 in Asia), and the average AICD replacement time is 5 years due to its short life. The median cost of AICD replacement is $10 000 (USD $30 000 in Asia), and the average AICD replacement time is 5 years due to its short life.

For practical purposes, a diagnostic workup such as exercise testing with or without thallium-201 imaging aimed at identifying the presence or absence of active myocardial ischaemia in patients with atherosclerotic heart disease (ASHD) should be included. The Coronary Artery Bypass Graft (CABG) Patch trial has shown that implantation of AICD is not beneficial in patients who have already undergone CABG. Additionally, the Clinical Outcomes Utilizing Revascularization and Aggressive Drug Evaluation (COURAGE) Trial Nuclear Substudy has revealed that the extent of residual myocardial ischaemic burden under optimal medical therapy with or without percutaneous coronary intervention positively and proportionally predicts future occurrence of cardiac events. Taken together, it appears that total revascularisation or maximal reduction in the ischaemic burden ought to be considered as an important therapeutic goal for the prevention of SCD.

SECONDARY PREVENTION OF SUDDEN CARDIAC DEATH
For the management of patients who have already experienced a serious sustained ventricular tachyarrhythmia (secondary prevention), the indication of AICD implantation is relatively clear, as AICD is highly effective in terminating ventricular tachycardia/ventricular fibrillation, thereby aborting SCD. In this regard, AICD implantation is very likely underused in Asia. Taking Taiwan and Hong Kong as examples, with respective populations of 23 million and 7 million, the numbers of new AICD implantations are approximately 160 and 210 per year, respectively (Meditronics, The Asian representatives, personal communication). Despite its being underused for secondary SCD prevention, clinicians should be educated to meticulously exclude non-cardiac causes of abortive sudden death (eg, asthma, heat stroke, drowning, head trauma, ruptured cerebral artery, blunt chest trauma, aortic dissection, pulmonary embolism, etc) and to rule out acute myocardial infarction and all reversible causes of lethal ventricular arrhythmias such as electrolyte imbalance, drug-induced proarrhythmia and valvular heart disease (eg, severe aortic stenosis) before contemplating AICD implantation.

Since patients who survive a cardiac arrest are often older with multiple or severe comorbidities at risk of death resulting from causes other than recurrent ventricular tachyarrhythmias, clinicians should be aware that there are subgroups of patients who may not benefit from AICD implantation: those who may die without or prior to the first appropriate AICD therapy (eg, patients with advanced CHF) and those who would never manifest a sustained ventricular arrhythmia. Most information regarding SCD has emanated from the US and Europe. A critical question to ask is that “should we, as Asians, follow the guidelines for AICD implantation set forth by American Heart Association (AHA)/American College of Cardiology (ACC)/Heart Rhythm Society (HRS)?”
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PRIMARY PREVENTION OF SUDDEN CARDIAC DEATH

For primary SCD prevention, the indication of AICD implanta-
tion remains debatable. While ASHD is the most common cause
of SCD in individuals who are 35 years or older, the risk of SCD
is highest during and immediately following acute myocardial
infarction (AMI) and then declines thereafter. 16 Nevertheless,
one-fourth of arrhythmic deaths still occur in the first 3 months
and one-half within the first year after AMI, especially those
with left ventricular dysfunction. 16 Accordingly, the 2008 ACC/
AHA/HRS guidelines1 recommend that AICD be implanted
prophylactically in ASHD patients with left ventricular ejection
fraction ≤35% at least 40 days following acute myocardial
infarction. However, it was noted in one study17 that only 50%
of patients who had had AICD implanted for primary SCD
prevention received appropriate AICD therapy for ventricular
tachyarrhythmias compared with 74% of patients for secondary
SCD prevention during a follow-up period of 3 years. And in
another study,18 appropriate AICD therapy was found to be
twice as likely in patients receiving AICD for secondary
prevention compared with those for primary prevention of
SCD during a follow-up period of 7 years. Thus, it appears that
not all patients recovering from AMI with left ventricular
dysfunction would need prophylactic AICD implantation, as
some of them may not manifest sustained ventricular tachyar-
rhythmias.

Furthermore, an important issue to ponder is that there are
indeed racial/ethnic differences in the rate of SCD. Based on the
1998 USA (US) Vital Statistics data, 19 SCD occurred in 456 076
(63%) of 719 456 cardiac deaths aged ≥35 years, and ASHD was
the most frequent underlying disease (58.9–62.9%) followed by
cardiomyopathy and arrhythmia (8.8–11.6%). Notably, Asian/
Pacific Islanders were found to have the lowest rate (213 per
100 000) of SCD compared with American Indian/Alaskan
native (259 per 100 000), white (407 per 100 000) and African–
Americans (503 per 100 000). Also of note, in the State of
Hawaii, it was observed that non-Hawaiians, mainly Asian
ancestry groups (eg, Filipino and Japanese), had significantly
lower cardiovascular mortalities compared with Hawaiians
(68.5 vs 375.9 per 100 000) despite having similar cardiovascular
risk factors (eg, diabetes, hypertension, hyperlipidaemia, etc). 14
And in a community population-based cohort of 3602 residents
(age ≥35 years, 47% male) in Taiwan, a 10-year follow-up
analysis17 showed an SCD rate of 73 per 100 000, which was
much lower than that of the US as described above. We realise
that the data of a small community may not represent the
entirety of a country with a population of 23 million. Nonetheless, it does urgently call for further epidemiological
studies on the incidence of SCD in many other regions in Asia.

ROLE OF MEDICAL THERAPY IN THE PREVENTION OF SUDDEN CARDIAC DEATH WITH AND WITHOUT AICD IMPLANTATION

Antiarrhythmic drug therapy is usually applied as an adjunctive
therapy in AICD patients who experience frequent shocks or
less commonly as primary therapy in patients who refuse or are
not candidates for AICD implantation. Under these circum-
cstances, amiodarone is frequently the drug chosen for this
clinical setting. 16 Another relevant aspect of medical therapy is
that AICD therapy often shifts arrhythmic death to non-
arrhythmic death, especially CHF in this subset group of
patients. The Defibrillator in Acute Myocardial Infarction Trial
(DINAMIT) study19 reported that prophylactic AICD implanta-
tion in patients with left ventricular dysfunction and impaired
cardiac autonomic function 6–40 days after AMI did not alter
the overall mortality; the AICD group had a substantially lower
rate of death due to arrhythmia than the control group (1.5% vs
5.5% per year) but had more deaths from non-arrhythmic
causes, mostly CHF, compared with the control group (6.1% vs
3.5% per year). Consequently, an aggressive medical regimen
against CHF should be implemented in patients who are
candidates for AICD implantation. A list of pharmacological
agents including beta-adrenergic blocking agents, angiotensin II-
converting-enzyme inhibitor, angiotensin II-receptor blockers,
statins and aldosterone antagonists have individually been
shown to improve CHF and reduce rates of total mortality and
SCD. 20 In fact, these agents should be given soon after AMI
to reduce ventricular remodelling if there are no contraindica-
tions.

ROLE OF MOLECULAR GENETICS IN THE RISK STRATIFICATION OF SUDDEN CARDIAC DEATH

In patients who are 35 years or younger, there is an increasing
incidence of SCD caused by inherited structural cardiovascular
diseases and malignant arrhythmogenic disorders. 21 In the
former, most frequently encountered are hypertrophic cardio-
myopathy (HCM), arrhythmogenic right ventricular dysplasia/
cardiomyopathy and dilated cardiomyopathy, and in the latter,
genital long QT syndrome (LQTS), Brugada syndrome, catecholaminergic polymorphic ventricular tachycardia (CPVT)
and short QT syndrome. The risk of SCD in these various
inherited diseases/disorders appears to be gene- and/or mutant-
specific and affected by racial and ethnic differences. 22

For examples, Brugada syndrome, also referred to as “sudden unexpeced nocturnal death syndrome,” is endemic in east
and southeast Asia, particularly in northeastern Thailand,
Philippines and Cambodia with a mortality as high as 38/100 000. Approximately 30% of patients with such a syndrome
have mutations in SCN5A resulting in reduced Na+ current. Interestingly, the prevalence of the Brugada-type ECG pattern
in the asymptomatic South East Asian population is also higher
(1–3%) compared with European (0.05%) and Japanese (0.45%) populations. 23 CPVT is caused by mutations in the gene
encoding either the ryanodine receptor (RyR2) or calsequestrin
(CASQ2). 24 Ventricular tachycardia usually occurs during
enhanced sympathetic tone (eg, physical activity or acute
emotional distress), and the mortality is as high as 30–50% by
the age of 40.

In LQTS, LTQT1 (KCNQ1, 30–35%), LTQT2 (KCNH2, 25–30%)
and LTQT3 (SCN5A, 5–10%) constitute the majority of the
cases. 25 In LTQT1, A341V patients are more likely to have cardiac
events compared with non-A341V patients (75% vs 24%)
having a rate of SCD as high as 14%. 25 LTQT7 and LTQT8 are
rare subtypes of LTQT, also known as Andersen–Tawil
syndrome and Timothy syndrome, respectively. 26–28 LTQT7 is
caused by mutations in KCNJ2 which encodes the cardiac
skeletal muscle inward rectifier K+ channel, Kir2.1, and LTQT8 is
due to mutations in CACNA1C that encodes the pore-forming
α-subunit of the cardiac L-type Ca2+ channel. LTQT7 patients
may live into adulthood, but in contrast, LTQT8 patients seldom
survive beyond 3 years of age.

In HCM, cardiac myosin binding protein C (MYBPC3) and
beta-myosin heavy chain (MYH7) are most frequently found,
42% and 40%, respectively. 29 In 22 index cases with a malignant
course, MYH7 was the most prevalent gene (45%) followed by
MYBPC3 (18%), cardiac troponin I (TNNI3) (14%) and myosin
ventricular regulatory light chain2 (MYL2) (14%). In each
protein, “hot spots” associated with malignant prognosis have
been identified—for example R405, R719 and R663 in MYH7,
R502, D778 in MYBPC3, R162 in TNNI3 and R58 in MYL2. 26 Of

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interest, a subset of HCM patients with mutations in the cardiac troponin T (TNNT2) gene have a high risk of SCD associated with no or mild left ventricular hypertrophy, and another subset of HCM patients with mutations in MYH7 and TNNI3 may exhibit a restrictive phenotype associated with a poor prognosis because of severe physical limitations, diastolic heart failure and high rates of atrial fibrillation/flutter and stroke.

Chinese HCM patients have certain features distinctively different from those of Caucasian patients. Specifically, they have a high percentage of phenotypic expression of non-obstructive apical hypertrophy in the left ventricle (41% vs 3% in non-Asians and 15% in Japanese) and a high incidence of atrial fibrillation (35% vs 20%) but a relatively low annual mortality (1.6% vs 5.6% in the literature). In contrast to the experience of non-Asian patients, HCM appeared to be more severe in Chinese women, as the female sex is the only independent predictor of mortality. Genetically, MYH7 and MYBPC3 are also found to be the predominant genes similar to those reported in the Western world, but the most common hot and malignant mutation R808Q in MYH7 identified in Caucasians has not been documented.

To date, no genetic markers of SCD can be demonstrated in patients with ASHD. Nevertheless, among various ethnicities (black, white, Asian and Hispanic), certain variants of SCN5A and distinct variants in LQTS-causing K+ channel genes (KCNQ1, KCNH2, KCNE1 and KCNE2) can be found exclusively in the black cohort. Similarly, in studies searching for genetic factors predisposing to arrhythmias associated with myocardial ischaemia/infarction, five rare missense variants in SCN5A (A572D, Gl615E, F2004L, A572D and A572F) can be seen in 10% (6/60) of white elderly female SCD cases (age 60.8) but in 0% (0/55) of the male counterpart (age 66.5). All these genetic variants may alter the repolarisation properties of cardiac tissues, thereby mediating an increased susceptibility to arrhythmias in the settings of diseases or drug ingestion.

**CONCLUSION**

The decision as to “who and when for AICD implantation” poses a clinical challenge. Because causes of SCD are age-dependent, disease-specific and affected by racial and ethnic differences, the decision-making should be individualised. A detailed medical history and a thorough physical examination along with functional diagnostic work-ups remain the mainstay for the decision-making process. Apart from having a different spectrum of causes of SCD, Asians seem to have a relatively lower rate of SCD compared with African black individuals and Caucasians. Current ACC/AHA/HRS guidelines’ expanding indications for prophylactic AICD implantation do not appear to be readily applicable in Asians.

It is apparent that left ventricular dysfunction is not a sufficiently specific parameter for guiding AICD implantation after AMI. The urgent need is to develop better biological and/or physiological markers for risk stratification so that patients who would actually benefit from AICD implantation can be readily identified. Such an approach will make the use of AICD more cost-effective. As inferred from molecular genetic data obtained from patients with inherited diseases/disorders causing SCD, a continuous search for genetic markers for better risk stratification is warranted in patients with ASHD.

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**REFERENCES**