ESC European Society of Cardiology

Europace (2023) **25**, 1–12
https://doi.org/10.1093/europace/euad091

VIEWPOINT

Spotlight on the 2022 ESC guideline management of ventricular arrhythmias and prevention of sudden cardiac death: 10 novel key aspects

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Received 22 February 2023; accepted after revision 13 March 2023

Abstract

Sudden cardiac death and ventricular arrhythmias are a global health issue. Recently, a new guideline for the management of ventricular arrhythmias and prevention of sudden cardiac death has been published by the European Society of Cardiology that serves as an update to the 2015 guideline on this topic. This review focuses on 10 novel key aspects of the current guideline: As new aspects, public basic life support and access to defibrillators are guideline topics. Recommendations for the diagnostic evaluation of patients with ventricular arrhythmias are structured according to frequently encountered clinical scenarios. Management of electrical storm has become a new focus. In addition, genetic testing and cardiac magnetic resonance imaging significantly gained relevance for both diagnostic evaluation and risk stratification. New algorithms for antiarrhythmic drug therapy aim at improving safe drug use. The new recommendations reflect increasing relevance of catheter ablation of ventricular arrhythmias, especially in patients without structural heart disease or stable coronary artery disease with only mildly impaired ejection fraction and haemodynamically tolerated ventricular tachycardias. Regarding sudden cardiac death risk stratification, risk calculators for laminopathies, and long QT syndrome are now considered besides the already established risk calculator for hypertrophic cardiomyopathy. Generally, 'new' risk markers beyond left ventricular ejection fraction are increasingly considered for recommendations on primary preventive implantable cardioverter defibrillator therapy. Furthermore, new recommendations for diagnosis of Brugada syndrome and management of primary

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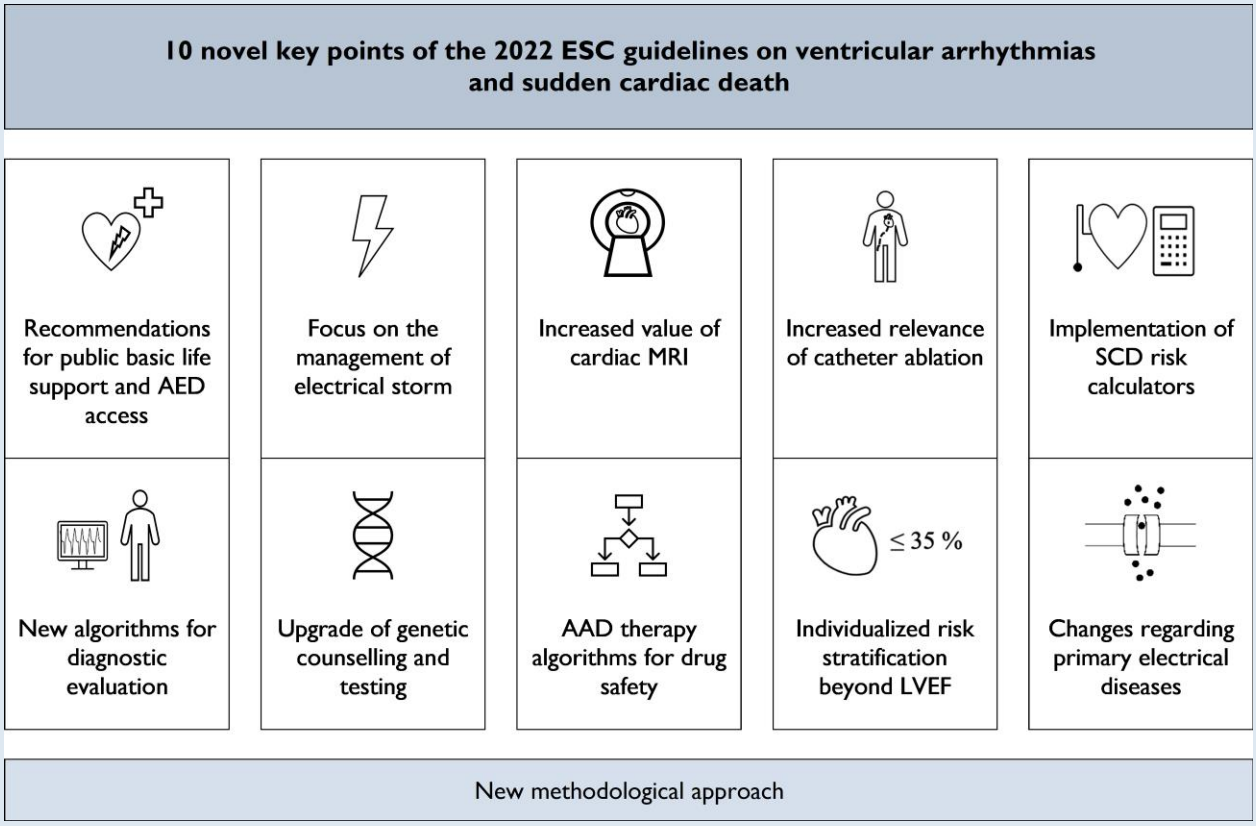
electrical disease have been included. With many comprehensive flowcharts and practical algorithms, the new guideline takes a step towards a user-oriented reference book.

Graphical Abstract



Overview on 10 novel key points of the 2022 ESC guideline on ventricular arrhythmias and sudden cardiac death compared to the 2015 ESC guideline. AAD, antiarrhythmic drug use; AED, automated external defibrillator; MRI, magnetic resonance imaging; LVEF, left ventricular ejection fraction; SCD, sudden cardiac death.

Keywords Ventricular arrhythmias • Sudden cardiac death • Guidelines • Comparison • ESC

What's new?

- Not applicable due to article type (State of the Art Review).
- Article type 'Clinical research article' was selected as instructed by Maud Swanson.

Introduction

Despite significant advances in prevention, diagnostics, and treatment in the past decades, cardiovascular diseases remain the leading causes of mortality worldwide with sudden cardiac death (SCD) being responsible for approximately 10–20% of all deaths.[1,2] Guidelines for the management of ventricular arrhythmias (VAs) and the prevention of SCD are periodically updated integrating the latest scientific evidence and translating it into clinical practice. Recently, the European Society of Cardiology (ESC) has published new recommendations for the management of VA and prevention of SCD.[3] This guideline serves as the update of the 2015 ESC guidelines on the same topic.[4] On more than 130 pages, the new guideline contains more than hundred new recommendations and various new chapters and sections. As a new feature, all recommendations are supported by a description of the studies that support each recommendation in the evidence table in the guideline's supplementary material, which can be accessed online. This review aims at pointing out 10 key aspects of the current guideline compared to the previous edition.

1. Public basic life support and access to automatic external defibrillators

Both the 2015 and 2022 guidelines acknowledge the high number of patients experiencing out-of-hospital cardiac arrest (OHCA) every year and recently estimated to be 300 000 persons in Europe.[5–7] At the same time, survival rates of OHCA victims continue to remain alarmingly low with an overall survival rate of less than 15%.[8] although survival rates vary across countries.[9] As bystander cardiopulmonary resuscitation (CPR) in combination with the use of public access defibrillators is linked to better outcome and survival of OHCA patients,[10–13] the guidelines recommend availability of public access defibrillation at sites

Table 1 Comparison of specific recommendations for genetic testing and counselling

General recommendations	Level of recommendation	
	2015 ESC guideline	2022 ESC guideline
Genetic testing in case of diagnosis of a condition in a living or deceased individual with a likely genetic basis and a risk of VA and SCD	—	I
Genetic testing of first-degree and symptomatic relatives and obligate carriers upon identification of a Class IV/V variant in a living or deceased individual with a condition that carries a risk of VA and SCD	—	I
Collection of blood samples of SCA survivors for potential genetic testing	—	I
Genetic testing for SCD when the cause is unknown or suspected to be heritable	IIa	I
Post-mortem genetic testing targeted to primary electrical disease following SADS, when the decedent is < 50 years and/or the circumstances and/or family history suspect a primary electrical disease	—	I
Genetic testing included in familial evaluation of SADS decedents when post-mortem genetic testing in a SADS decedent detects a pathogenic mutation	mentioned without recommendation	I
Post-mortem genetic testing for additional genes in the decedent following SADS	—	IIb
Hypothesis-free post-mortem genetic testing following SADS	—	III
Genetic testing in the context of structural heart disease		
Patients with DCM/HNDCM and • AV conduction delay at < 50 years or • Family history of DCM/HNDCM or SCD in a first-degree relative (at age < 50 years)	—	I
Patients with suspected or definitive diagnosis of ARVC	—	I
HCM patients	—	I
Patients with apparently sporadic DCM/HNDCM, who present at young age or with signs suspicious for an inherited aetiology	—	IIa
Genetic testing in the context of primary electrical diseases		
Patients with clinically diagnosed Long QT syndrome	—	I
Patients with suspected Andersen-Tawil-syndrome	—	I
Patients with Brugada syndrome (for SCN5A gene)	—	I
Patients with suspected or clinically diagnosed CPVT	(implied)	I
Patients with diagnosed short QT syndrome	—	I
Patients with idiopathic VF	—	IIb
Patients with early repolarization syndrome	—	IIb

ARVC, arrhythmogenic right ventricular cardiomyopathy; AV, atrioventricular; CPVT, catecholaminergic polymorphic ventricular tachycardia; HNDCM, hypokinetic non-dilated cardiomyopathy; DCM, dilated cardiomyopathy; SADS, sudden arrhythmic death syndrome; SCA, sudden cardiac arrest; SCD, sudden cardiac death; VA, ventricular arrhythmias; VF, ventricular fibrillation; —, no specific recommendation.

where cardiac arrest is more likely to occur, e.g. schools, sports stadiums, and transport stations. Beyond that, the 2022 ESC guideline devotes a separate chapter to this topic in which it places focus on the importance of prompt CPR by bystanders (class I) and additionally gives a class I recommendation for the promotion of community training in basic life support (BLS) to increase bystander CPR rate and use of automatic external defibrillators. Furthermore, a recommendation for phone-based alerting of BLS-trained bystander volunteers to assist nearby OHCA victims is given (class IIa), although organizational and legal questions regarding feasibility remain.

2. Clinical scenarios of initial presentation of ventricular arrhythmias for diagnostic evaluation

The latest ESC guideline not only incorporates a separate chapter for diagnostic tools including a systematic overview on risk stratification for VA/SCD in specific diseases but also proposes five frequently encountered clinical scenarios of first presentation with VA in patients without known cardiac disease. Based on these distinct scenarios that include the incidental finding of non-sustained ventricular tachycardias (NSVTs), first presentation of a sustained monomorphic ventricular tachycardia (SMVT), aborted SCD but also victims of sudden death and their relatives, evidence-based recommendations for the diagnostic evaluation are given and additionally presented as flowcharts for each scenario. The previous 2015 guideline also gave recommendations for invasive and non-invasive evaluation of patients with suspected or known VA but provided fewer recommendations for the diagnostic approach of family members of sudden unexplained or arrhythmic death syndrome.

3. New focus on managing electrical storm

For the first time, the new guideline devotes a separate chapter to the management of patients with electrical storm, which is defined as three

Table 2 Comparison of specific recommendations for the use of cardiac MRI

General recommendations for cardiac MRI	Level of recommendation	
	2015 ESC guideline	2022 ESC guideline
Survivors of sudden cardiac arrest without a clear underlying cause	—	I
Patients with newly documented VA and suspicion of a structural heart disease other than coronary artery disease after initial evaluation	—	IIa
Patients with VA when echocardiography does not provide accurate assessment of ventricular function and/or evaluation of structural changes	IIa	—
Relatives of sudden arrhythmic death syndrome-decedents	—	IIb
Cardiac MRI in the context of idiopathic PVC/VT and PVC-induced cardiomyopathy		
Patients with PVCs/VT and a presentation not typical for an idiopathic origin, despite a normal echocardiogram	—	IIa
Patients with suspected PVC-induced cardiomyopathy	—	IIa
Cardiac MRI in the context of structural heart disease		
Patients with suspected ARVC	—	I
Patients with HCM	—	I
Patients with DCM/HNDCM	—	IIa
Cardiac MRI in selected populations		
Athletes with a positive medical history, abnormal physical examination, or ECG alterations	I	I

ARVC, arrhythmogenic right ventricular cardiomyopathy; ECG, electrocardiogram; HNDCM, hypokinetic non-dilated cardiomyopathy; DCM, dilated cardiomyopathy; PVC, premature ventricular complex; SCA, sudden cardiac arrest; SCD, sudden cardiac death; VA, ventricular arrhythmias; VT, ventricular tachycardia; —, no specific recommendation.

or more separate sustained VA within 24 h each requiring termination by an intervention. Because the occurrence of an electrical storm is associated not only with enormous psychological stress but also with increased mortality,[14,15] its treatment is of outstanding importance. Although several specific recommendations and components of the management of electrical storm remain the same compared to the 2015 guideline, the approach has been significantly revised: the recommendations for diagnosis and treatment in this situation are now presented in a comprehensive algorithm based on the respective arrhythmia (polymorphic vs. monomorphic) and the underlying structural heart disease (SHD) or precipitating conditions. The current guideline especially highlights a multidimensional treatment approach that not only includes ICD interrogation and reprogramming, anti-arrhythmic drug (AAD) therapy, and catheter ablation of the ventricular tachycardia (VT) or triggering premature ventricular complexes (PVCs) but also sedation, autonomic modulation,[16] and mechanical circulatory support in case of cardiogenic shock. In patients with SHD and electrical storm, due to monomorphic VT amiodarone and non-selective beta-blockers are first-line therapy, along with mild to moderate sedation to address elevated sympathetic tone (each class I). In case of recurrent electrical storm, catheter ablation in experienced centres is preferred over deep sedation, autonomic modulation, and mechanical circulatory support. Overall, the recommendations indicate that a referral to a specialized centre should take place if additional treatment is required in patients with electrical storm.

4. Genetic counselling and testing

Hand in hand with an increased availability of clinical data as well as genetic testing at reduced cost due to massive parallel sequencing, the value of genetic counselling and testing as part of the diagnostic evaluation and for risk stratification of patients with VA has significantly increased from the 2015 to the current ESC guideline. Genetic testing was mentioned in the context of initial diagnostic work-up of patients with suspicion of inherited arrhythmogenic disease or cardiomyopathy as well as family members of sudden unexplained death syndrome victims in the 2015 ESC guideline. However, this latter only gave one specific recommendation for targeted post-mortem genetic analysis in all sudden death victims in whom a specific inheritable channelopathy or cardiomyopathy is suspected (class IIa). In contrast, the new guideline gives genetic counselling and testing a much higher priority. With the new guideline, genetic testing becomes routine part of the care in patients with genetic cardiomyopathies and arrhythmia syndromes (*Table 1*). This is reflected not only by a separate chapter on genetic testing as a diagnostic tool but also explicit recommendations of genetic counselling and testing in various scenarios.

Generally, genetic testing is recommended when a condition with a likely genetic basis and a risk of VA and SCD is diagnosed in a living or deceased patient (class I). Genetic testing is recommended for dilated cardiomyopathy (DCM)/hypokinetic non-dilated cardiomyopathy (HNDCM) patients with other risk factors or a family history of DCM (class I) as well as in apparently sporadic cases under suspicious circumstances for an inherited aetiology (class IIa)[17–19] as genetic causes can be found in up to 50% of DCM/HNDCM patients[20,21] and have an important impact for both prognosis and treatment. In this context, by proposing the new term 'hypokinetic non-dilated cardiomyopathy', which takes into account changing and diverging phenotypes, the new guideline emphasises the heterogenous, multi-faceted aetiology of dilated cardiomyopathies.

Genetic testing is also recommended for patients with suspected or definite diagnosis of arrhythmogenic right ventricular cardiomyopathy (ARVC),[22] hypertrophic cardiomyopathy (HCM),[23] clinically diagnosed long QT syndrome (LQTS), suspected Andersen-Tawil syndrome,[24] Brugada syndrome (BrS),[25] catecholaminergic polymorphic VT (CPVT), and short QT syndrome[26] (SQTS) (class I recommendations). Additionally, focused genetic testing may also be considered in patients with early repolarization syndrome and idiopathic

Table 3 Comparison of specific recommendations for catheter ablation in acute and long-term management of ventricular arrhythmias

Specific recommendations for catheter ablation in the acute treatment of ventricular arrhythmias	Level of recommendation	
	2015 ESC guideline	2022 ESC guideline
Incessant VT or electrical storm due to SMVT refractory to AAD	I	I
Recurrent episodes of PVT/VF triggered by a similar PVC, non-responsive to medical treatment or coronary revascularization	IIa	IIa
Recurrent episodes of PVT/VF triggered by a similar PVC non-responsive to medical treatment or coronary revascularization in the subacute phase of myocardial infarction	—	IIa

Recommendations on catheter ablation for the long-term management of ventricular arrhythmias	Level of recommendation	
	2015 ESC guideline	2022 ESC guideline
General recommendations		
Catheter ablation (or amiodarone) in patients with recurrent ICD shocks due to sustained VT	I	—
Patients with SMVT or SPVT/VF triggered by a PVC with similar morphology and an indication for ICD when an ICD is not available, contraindicated for concurrent medical reasons, or declined	—	IIb
Chronic coronary artery disease		
Recurrent symptomatic SMVT, or ICD shocks for SMVT despite chronic amiodarone therapy, in preference to escalating AAD therapy	—	I
Recurrent ICD shocks due to sustained VT	I	—
After a first episode of sustained VT in patients with an ICD	IIa	—
Recurrent symptomatic SMVT, or ICD shocks for SMVT despite betablockers or sotalol treatment	—	IIa
Haemodynamically well-tolerated SMVT and LVEF ≥ 40%, as an alternative to ICD therapy	—	IIa
Catheter ablation just before (or immediately after) ICD implantation to decrease subsequent VT burden and ICD shocks	—	IIb
Dilated cardiomyopathy/Hypokinetic non-dilated cardiomyopathy		
Bundle branch re-entrant tachycardia refractory to medical therapy	I	—
Recurrent, symptomatic SMVT or ICD shocks for SMVT, in whom AAD are ineffective, contraindicated, or not tolerated	IIb	IIa
Hypertrophic cardiomyopathy		
Selected patients with HCM and recurrent, symptomatic SMVT or ICD shocks for SMVT, in whom AADs are ineffective, contraindicated, or not tolerated	—	IIb
Arrhythmogenic right ventricular cardiomyopathy		
Recurrent, symptomatic SMVT or ICD shocks for SMVT despite beta-blockers (2015: frequent symptomatic PVC included)	IIa	IIa
Congenital heart disease		
Recurrent, symptomatic SMVT or ICD shocks for SMVT not manageable by medical therapy or ICD reprogramming	I	IIa
Patients with repaired TOF with SMVT or recurrent, symptomatic appropriate ICD therapy for SMVT	—	I
CHD patients with an ICD and symptomatic SMVT, as an alternative to drug therapy	IIa	—
Patients with repaired TOF with a preserved biventricular function and symptomatic SMVT, as an alternative to ICD therapy	—	IIb
Valvular heart disease		
Programmed electrical stimulation with standby catheter ablation in patients with aortic valve disease and SMVT to identify and ablate bundle re-entrant ventricular tachycardia, especially if it occurs following a valve intervention	IIa	I
Idiopathic ventricular fibrillation		
Recurrent episodes of VF triggered by a similar PVC non-responsive to medical treatment	I	IIa
Brugada Syndrome		
Catheter ablation of triggering PVCs and/or RVOT substrate in patients with recurrent appropriate ICD shocks refractory to drug therapy	IIb	IIa
Short-coupled torsade de pointes		
Catheter ablation for long-term suppression/prevention of electrical storm or recurrent ICD discharges	IIa	—
Neuromuscular diseases		
Symptomatic patients with bundle re-entrant ventricular tachycardia	I	I

Continued

Table 3 *Continued*

Recommendations on catheter ablation for the long-term management of ventricular arrhythmias	Level of recommendation	
	2015 ESC guideline	2022 ESC guideline
Inflammatory diseases		
Post-myocarditis patients with recurrent, symptomatic SMVT or ICD shocks for SMVT, in whom AADs are ineffective, contraindicated, or not tolerated	—	IIa
Patients with haemodynamically well-tolerated SMVT occurring in the chronic phase of myocarditis with preserved LV function and a limited scar amenable to ablation, as an alternative to ICD therapy	—	IIb
Cardiac sarcoidosis ICD-recipients with recurrent, symptomatic SMVT or ICD shocks for SMVT, in whom AADs are ineffective, contraindicated, or not tolerated	—	IIb
Idiopathic PVCs/VT		
First-line treatment for symptomatic idiopathic VT/PVCs from the RVOT	—	I
First-line treatment for symptomatic idiopathic VT/PVCs from the left fascicles	I	I
Symptomatic patients with idiopathic VT/PVC from the RVOT and/or failure of AAD therapy or decline in LV function due to RVOT-PVC burden	I	—
Catheter ablation for symptomatic idiopathic VT/PVCs from an origin other than the RVOT or the left fascicles	—	IIa
Catheter ablation of LVOT/aortic cusp/epicardial VT/PVC after failure of one or more sodium channel blockers or in patients not wanting long-term AAD therapy	IIa	—
Symptomatic patients with papillary muscle tachycardia, mitral and tricuspid annular tachycardia after failure of one or more sodium channel blockers or in patients refusing long-term AAD therapy	IIa	—
Asymptomatic patients with > 20% of idiopathic PVCs per day repeatedly at follow-up		IIb
PVC-induced or PVC-aggravated cardiomyopathy		
Cardiomyopathy suspected to be caused by frequent and predominately monomorphic PVCs	IIa	I
SHD patients in whom predominately monomorphic frequent PVCs are suspected to be contributing to the cardiomyopathy	IIa	IIa
Non-responders to CRT with frequent, predominately monomorphic PVCs limiting optimal biventricular pacing despite pharmacological therapy	—	IIa

AAD, anti-arrhythmic drug therapy; CHD, congenital heart disease; CRT, cardiac resynchronization therapy; ICD, implantable cardioverter-defibrillator; LVEF, left ventricular ejection fraction; LVOT, left ventricular outflow tract; PVC, premature ventricular complex; RVOT, right ventricular outflow tract; SHD, structural heart disease; SMVT, sustained monomorphic ventricular tachycardia; SPVT, sustained polymorphic ventricular tachycardia; TOF, tetralogy of Fallot; VF, ventricular fibrillation; VT, ventricular tachycardia; —, no specific recommendation.

ventricular fibrillation (VF).[27,28] In addition, post-mortem genetic testing targeted to primary electrical diseases is recommended (class I) and may be extended to testing of additional genes (class IIb) in SCD victims younger than 50 years or who had circumstances or family history supporting a primary genetic disease.[29–31] Recommendations also include familial evaluation with genetic testing when post-mortem genetic testing detects a pathogenic mutation and the collection of blood samples for genetic testing after aborted SCD (class I). Genetic testing of family members is now also recommended when pathogenic genetic variants have been identified in the index patient with a condition that carries a risk of VA and SCD (class I).

Future improvement in assessment of genetic variants is needed, as more and more genetic variants of uncertain significance (VUS) and likely pathogenic variants are identified in a rapidly increasing number of genetic tests. Therefore, the new ESC guideline highlights the use of an internationally accepted framework in the evaluation for pathogenicity putative causative genetic variants, its periodical reassessment, and the importance of expert multidisciplinary teams not only for genetic testing but also counselling on the potential consequences (both class I) as many previously likely pathogenic variants have been downgraded to VUS.[32]

5. Increasing relevance of cardiac magnetic resonance imaging

The value of cardiac magnetic resonance imaging (CMR) for diagnostic evaluation and especially for risk stratification and its role in the decision-making on primary preventive ICD therapy have been significantly upgraded with the latest guideline (*Table 2*). The 2015 ESC guideline recommended CMR as part of diagnostic workup of patients with VA when echocardiography did not provide accurate assessment of ventricular function and/or evaluation of structural changes (class IIa) and upon identification of abnormalities suggestive of SHD in the screening of athletes. Additionally, CMR was mentioned for detection of persistent myocardial inflammatory infiltrate after acute myocarditis as an additional indicator of increased SCD risk. In contrast, the recent guidelines recommend CMR not only for diagnostic evaluation of patients with newly documented VA when SHD not related to coronary artery disease is suspected (class IIa)[33,34] and patients with frequent premature ventricular contractions and/or VT that are not typical for an idiopathic origin[33] but also in all survivors of sudden cardiac arrest without a clear underlying cause (class I).[35,36] This includes relatives of decedents of sudden arrhythmic death syndrome (class IIb).[31,37] The recommendation for CMR as part of the diagnostic investigation

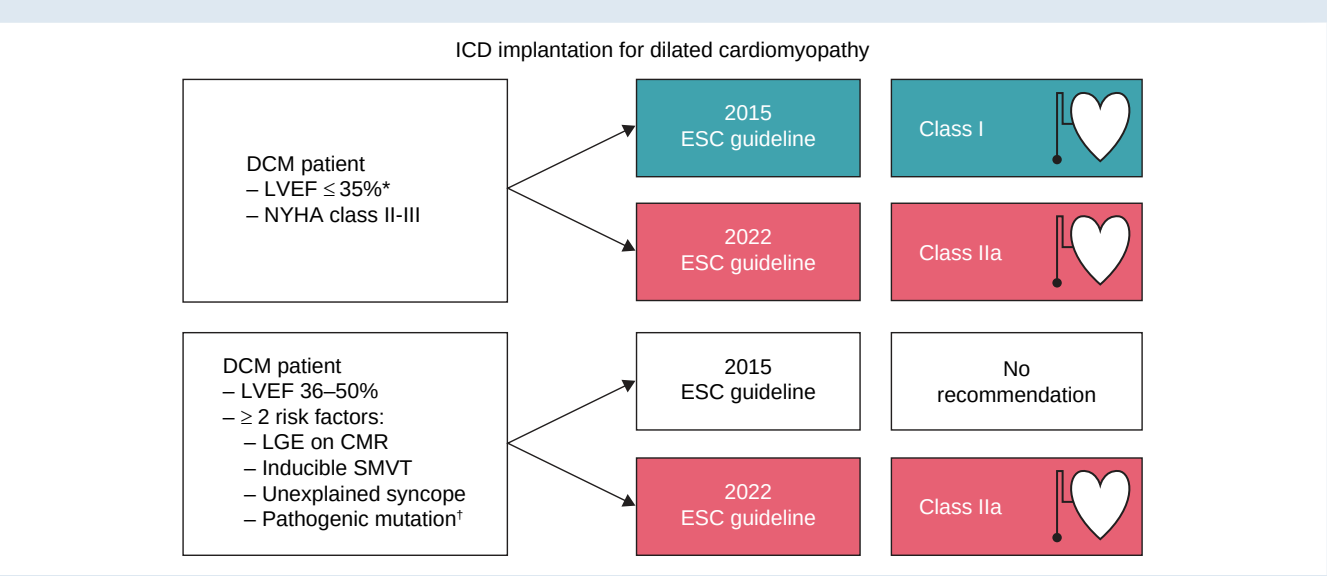


Figure 1 Illustrative example of different recommendations regarding primary preventive ICD therapy in selected patients with dilated cardiomyopathy between the 2015 and 2022 ESC guidelines. CMR, cardiac magnetic resonance imaging; ESC, European Society of Cardiology; DCM, dilated cardiomyopathy; LGE, late gadolinium enhancement; LVEF, left ventricular ejection fraction; NYHA, New York Heart Association; SMVT, sustained monomorphic VT. *After optimal medical heart failure treatment for ≥ 3 months; †Pathogenic mutations in *LMNA*, *PLN*, *FLNC*, and *RBM20* genes. Heart with sketched electrode: recommendation for primary preventive ICD therapy.

of athletes when a SHD is suspected remains unchanged.[38] Furthermore, the value of CMR has also increased in the diagnostic evaluation of patients with (suspected) specific SHD: The 2022 guideline gives class I recommendations for CMR for patients with suspected ARVC[39,40] and HCM.[41,42] Notably, LGE on CMR is not (yet) recommended as an additional risk marker in the HCM risk calculator, despite its association with an increased risk of VAs. Additionally, class IIa recommendations for CMR for diagnostic work-up and risk stratification in patients with DCM,[43,44] for which it is now one of the initial recommended steps for risk assessment, and patients with suspected PVC-induced cardiomyopathy[45,46] are given. Beyond that, significant late gadolinium enhancement (LGE) on CMR is now considered to be an additional indicator of increased risk of VA/SCD in patients with muscular dystrophy and cardiac sarcoidosis which may mimic ARVC.[47] Of note, the guideline does not review the discussion about imaging techniques, type, and amount of contrast media which complicate the setting of threshold values.

6. Algorithms for AAD therapy

Until today, no AAD except for beta-blockers has proven to reduce all-cause mortality. Nevertheless, AAD remain integral part of the management of VA as adjunctive therapy, especially for symptomatic patients with frequent VA. At the same time AAD carry the risk of adverse events, e.g. proarrhythmia.[48–51] While both the 2015 and 2022 ESC guidelines provide detailed practical information on frequently used AADs, the recent guideline for the first time includes algorithms for evaluation and follow-up of patients requiring sodium channel blocking agents and QT-prolonging drugs. As sodium channel blocking agents are contraindicated in patients with significant SHD and/or prior myocardial infarction[52] the proposed algorithm reviews those clinical conditions for which these drugs are contraindicated, but also identifies those for which precaution is warranted and provides a structured check-list/follow-up strategy to identify patients at risk. The algorithm regarding AAD associated with QT-prolongation focuses on identifying other proarrhythmic risk factors, e.g. electrolyte imbalances, liver, or renal failure, and concomitant treatment with other QT-prolonging drugs (https://www.crediblemeds.org/). The true incidence of drug induced LQTS is uncertain, yet one study estimated that between 5% and 7% of reported cases of VT, VF, and SCD are in fact drug induced TdP.[53,54] Similarly treatment with class IC AAD drugs may cause life-threatening VA, hence the proposed algorithm provides novel valuable guidance for clinical practice to improve drug safety.

7. Increasing value of catheter ablation in the management of VA

The recommendations of the new ESC guideline reflect an increasing relevance of catheter ablation in the acute and long-term management of VA in patients with and without SHD (*Table 3*). With the new guideline and the excellent general safety profile of catheter ablation for arrhythmias,[28,55] catheter ablation has become first-line treatment strategy (class I) in patients with symptomatic idiopathic VT and PVCs from the right ventricular outflow tract (RVOT) and the left ventricular fascicles.[56–58] Similarly, catheter ablation has gained importance as first-line treatment of patients with a PVC related CM independent of the presumed origin of the PVCs/VT (2015: Class IIa, 2022: class I).[56,59–61] As available evidence is not as positive for catheter ablation of symptomatic idiopathic PVCs/VT from other origins[56,62,63] the recent guideline (only) gives a class IIa recommendation for catheter ablation of PVCs/VT in this scenario given a normal left ventricular function. For the first time, catheter ablation is also addressed for asymptomatic patients with a high burden of PVCs (> 20%). Because PVC burden may change over time and a prognostic benefit of catheter ablation in this scenario has not been demonstrated, only a class IIb recommendation is given.

Catheter ablation also gained relevance in the management of patients with SHD and VA. Mainly integrating the results of the VANISH trial (Ventricular Tachycardia Ablation versus Escalation of Antiarrhythmic Drugs),[64] catheter ablation is now clearly preferred over escalating AAD therapy in patients with ischaemic heart disease (IHD) and SMVT despite chronic amiodarone therapy (class I) or beta-blocker or sotalol treatment (class IIa). Of note, results of a recent

sub-study of the VANISH trial imply that the effectiveness of VT ablation in IHD patients varies based on the location of myocardial infarction.[65] Beyond that, the new guideline gives a class IIb recommendation for an 'early' catheter ablation in IHD patients who are eligible for ICD therapy after a first VT episode just before or immediately after ICD implantation.

Yet, 'optimal' timing of VT ablation remains unclear: due to its publication date, results of the recent PARTITA trial (Does Timing of VT Ablation Affect Prognosis in Patients With an Implantable Cardioverter-Defibrillator?),[66] in which VT ablation after a first appropriate shock was associated with a reduced risk of the composite end point of total mortality or hospitalization for worsening heart failure, were not included. However, the link between ablation and survival was uncertain. Of the observed eight deaths, three were non-cardiac only three had cardiac causes, and two were of unknown cause. Thus, cardiovascular mortality was not reduced. Similarly, results of the recent PARTITA trial were not included; its results showed that VT ablation as first-line therapy in IHD patients with symptomatic VT and appropriate ICD shock reduced the composite endpoint of cardiovascular death, appropriate ICD shock, hospitalization due to heart failure, or severe treatment-related complications due to AAD. Results were mainly driven by a reduction of severe AAD treatment-related complications.[67] Results of the BERLIN VT trial (Preventive or Deferred Ablation of Ventricular Tachycardia in Patients With Ischemic Cardiomyopathy and Implantable Defibrillator) failed to show a prognostic benefit of preventive VT ablation.[68] Thus, timing of catheter ablation remains the subject of ongoing and future studies such as the VANISH 2 trial (Antiarrhythmics or Ablation for Ventricular Tachycardia 2).[69] For now, a careful risk-benefit assessment with thorough consideration not only of the individual patient, but also of the availability of a centre specialized in VT ablations, is advisable.

Data for catheter ablation in DCM patients with recurrent VA are less positive than in post MI patients.[70] Nevertheless, the new guideline proposes a class IIa recommendation for catheter ablation of VA in DCM patients with drug-refractory, symptomatic, recurrent SMVT while the previous guideline gave a more cautious class IIb recommendation.

For the first time, recommendations include catheter ablation as an alternative to ICD therapy in IHD patients with haemodynamically tolerated SMVT and preserved or mildly reduced left ventricular function[71,72] (class IIa), while the 2015 guidelines and other international guidelines[73] recommend ICD implantation in this scenario. Although the secondary preventive ICD trials did not show a survival benefit in patients with a left ventricular ejection fraction ≥35%,[74] ICDs are frequently implanted in this patient group. Notably, randomized controlled trials regarding the role of ICDs after successful catheter ablation of haemodynamically tolerated VT in IHD patients are lacking and the endpoints of VT ablation are yet to be clearly defined. Not only in IHD patients with severely impaired left ventricular ejection fraction (LVEF) and DCM patients, but also in HCM patients who experience haemodynamically stable VT catheter ablation is not considered to be an alternative to ICD implantation (all class IIa recommendations).

Furthermore, important changes in recommendations can be found regarding patients with BrS and drug-refractory recurrent appropriate ICD shocks in whom catheter ablation of VF-triggering PVCs and/or the characteristic RVOT epicardial substrate is now recommended more strongly (2015: class IIb, 2022: class IIa).[75–77]

8.Changes in SCD risk stratification

As identifying individuals at highest risk of SCD for successful primary preventive ICD therapy is challenging, criteria for primary preventive ICD therapy are among the most controversial and extensively discussed topics in both the 2015 and 2022 guidelines. In the 2022 guideline, more recommendations on SCD risk stratification in particular diseases have been provided since several new markers of an increased SCD risk have been identified not only for patients with SHD but also for primary electrical diseases. In the past, an impaired left ventricular function ≤ 35% with symptomatic heart failure has mainly been used as a marker of increased risk of SCD in patients with SHD. While the 2015 guidelines gave a class I recommendation for ICD implantation in DCM patients with symptomatic heart failure and LVEF ≤35% the new guidelines, mainly based on results of the DANISH trial (Defibrillator Implantation in Patients with Nonischemic Systolic Heart Failure),[78] downgraded that recommendation to a class IIa recommendation for ICD implantation. In this patient group, clinical parameters including the personal history regarding unexplained syncope, comorbidities, and life expectancy as well as biomarkers (e.g. NT-proBNP) and echocardiographic parameters as the global longitudinal strain might be considered but are not part of the recommended risk stratification as data are limited.

Beyond LVEF and NYHA class, the new guideline incorporates alternative risk markers such as unexplained syncope and inducibility of SMVT[79] in addition to criteria such as LGE on MRI[80] and certain genetic mutations in *PLN, FLNC,* and *RBM20* genes.[17,18] As a consequence, a new recommendation for ICD implantation in DCM patients with LVEF between 35% and 50% and ≥ 2 of these risk factors (*Figure 1*) has been introduced. Yet, prospective data on this issue are lacking. Notably, still none of the many ECG-derived parameters are part of the recommended risk stratification.

Similar evolution of recommendations can be found regarding coronary artery disease. In this context, programmed electrical stimulation (PES) experiences a renaissance: Not only is the recommendation for PES in patients with unexplained syncope and previous myocardial infarction upgraded to class I, but the new guidelines also recommend ICD therapy in patients with LVEF ≤40% and documented NSVT in whom SMVT is inducible by PES (IIa)[71,72] and, for the first time, recommends ICD therapy in ARVC patients with moderate right or left ventricular dysfunction and either NSVT or inducible SMVT.[81–84] PES is also mentioned (class IIb recommendation) for risk stratification in asymptomatic patients with a spontaneous type 1 Brugada ECG. Generally, these new recommendations blaze a trail from a strong focus on left ventricular function to 'new' risk markers which are also taken into consideration for refining the SCD risk in patients with intermediate risk.

9. Implementation of risk scores and risk calculators

Risk calculators provide prognostic information that may assist in identifying patients at highest risk for VA and SCD. In the 2015 guideline, recommendations regarding ICD therapy in patients with HCM aged 16 years and older were for the first time based on the estimated 5-year risks for VA and SCD calculated using the HCM risk-SCD calculator.[85] Over the last years, the field of prediction modelling developed considerably, and several new risk calculators were proposed after careful methodological evaluation of each risk calculator. Therefore, the recent guideline has implemented other risk calculators for VA and SCD in different inheritable arrhythmogenic diseases. For recommendations on primary preventive ICD therapy in HCM patients younger than 16 years the validated HCM Risk-Kids score[86,87] has been implemented. Recommendations for ICD therapy in patients with DCM and a pathogenic mutation in the *LMNA* gene are also guided by the estimated 5-year risk of life-threatening VA based on another risk calculator and adding cardiac phenotypes such as NSVT, LVEF <50%, or AV block.[88] Besides, recommendations for primary preventive ICD therapy in asymptomatic LQTS patients take the recently validated 1-2-3-LQTS-Risk calculator[89–91] into account to identify patients with a high-risk profile based on genotype and QT_c duration.

Notably, the 2022 guideline uses different cut-offs for 5-year risk of SCD and VA for indication of primary preventive ICD in different clinical scenarios which have been chosen by the guideline task force according to the original studies underlying the respective calculator. Since risk models and risk calculators are derived from patient cohorts, limitations may arise from unrepresentative, relatively small, too homogenous cohorts, and/or the lack of external validation. Additionally, different combined endpoints have been used in the respective risk models which do not equal SCD. Overall, there is the difficulty in applying rigid mathematical models to individual patients with heterogeneous cardiac disease. Thus, results of risk calculators can only provide guidance as part of the shared decision-making process. At the same time, systematic studies of the role of primary preventive ICD therapy in SHD patients with preserved or only mildly reduced ejection fraction as well as on primary preventive ICD therapy in LQTS patients in addition to beta-blocker- and genotype-specific therapy are lacking.

10. Changes in primary electrical diseases

In the field of primary electrical diseases, relevant changes are also apparent: New in the 2022 guidelines are specific criteria for an early repolarization pattern and the early repolarization syndrome. Furthermore, differentiated diagnostic criteria for idiopathic VF are available. Whereas the 2015 guideline allowed the diagnosis of BrS in patients with an induced type 1 Brugada ECG, the new guideline additionally demands clinical factors such as a survived cardiac arrest (class I), a positive family history, or history of arrhythmic syncope for the diagnosis of BrS. Similarly, diagnostic criteria for SQTS have changed, as other findings including specific pathogenic mutations, a family history of SQTS or of survived SCD due to VT/VF, are required in addition to a short QT_c interval $\leq$ 360 ms.

As expected, beta-blockers remain an important pillar of the therapy of symptomatic CPVT patients and genetically positive asymptomatic CPVT patients as well as of LQTS patients, but the new guideline explicitly prefers the non-selective beta-blockers nadolol and propranolol.[92,93] Mexiletine as a genotype-specific therapy for LQTS 3 patients is mentioned for the first time (class I),[94] whereas the 2015 guideline gave a IIb recommendation for mexiletine along with flecainide or ranolazine in this patient group. In CPVT, flecainide should be considered in addition to beta-blocker therapy in symptomatic patients with polymorphic or bidirectional VT, persistent exertional PVCs, or recurrent syncope irrespective of a proven presence of a disease-specific mutation.[95] Recommendations for left cardiac sympathetic denervation are upgraded not only in the context of LQTS but also in CPVT.

Beyond that, the recent guideline breaks new ground regarding SCD risk stratification: PES may be considered (class IIb) in asymptomatic patients with a spontaneous type 1 Brugada ECG for risk stratification.[96,97] Implantable loop recorders may assist risk stratification in young SQTS patients and patients with an ERP and additional risk features. Of note, Andersen-Tawil syndrome, previously classified as the LQTS7 subtype, is mentioned separately from other forms LQTS for the first time.

Conclusion

The recently published ESC guideline is a comprehensive update of the previous version from 2015 including many new sections and contents. New recommendations regarding BLS and access to automatic external defibrillators reflect efforts to improve survival rates for victims of OHCA. However, in up to 50% of SCD cases, this event is the first manifestation of cardiac disease,[98] therefore adequate screening methods for asymptomatic individuals in the general population are still needed in order to significantly reduce the number of SCD victims. Genetic counselling and testing as well as cardiac MRI have significantly gained relevance not only for diagnostic evaluation but also for SCD risk stratification. These changes will pose a significant challenge to healthcare systems in Europe due to limited capacities and high costs. For the acute and long-term management of patients with VA, new algorithms for therapy with QT-prolonging and class IC AADs aim to support safe AAD management. The recommendations of the new guideline furthermore emphasize a significant upgrade of catheter ablation not only in patients with idiopathic VA but also in patients with VA based on SHD, especially in the setting of failed chronic AAD therapy, although convincing evidence for a prognostic role of catheter ablation of VA is still lacking. For the first time, catheter ablation is recommended as an alternative to secondary preventive ICD therapy in selected patients with preserved or mildly reduced LVEF, although the role of ICD therapy in this scenario remains an important open issue since randomized controlled trials are not yet available. For SCD risk stratification and decision-making on primary preventive ICD therapy especially in DCM patients, the new guideline blazes a trail towards more individualized decision-making. 'New' risk markers such as specific pathogenic mutations and family history but also imaging criteria and inducible VA by PES are included while the LVEF as a risk marker is downgraded. At the same time, there are still many gaps regarding SCD risk stratification, especially in patients with preserved left ventricular function. The question of the role of primary preventive ICD therapy in a changing, older patient population and in an era of significantly improved heart failure therapy remains to be answered.

Apart from the revision of the content based on the most current scientific evidence available, a changed methodological approach is apparent: extensive supplementary data with a 'table of evidence' facilitate further literature research. The pre-existing structure of the recommendations based on the underlying heart disease is considerably elaborated by the current guideline, so that an even more disease-specific and thus individualized management is promoted. With the integration of many practical algorithms and comprehensive flowcharts, the guideline takes a further step towards a user-oriented reference book for daily clinical practice. The increasing involvement not only of cardiologists, but also of practitioners from genetics, imaging, pathology, etc. highlights the need for a multidisciplinary treatment approach for patients with or at risk of VA.

Funding: We acknowledge support from the Open Access Publication Fund of the University of Muenster.

Conflict of interest: We disclose that in the past 2 years, L.E. received lecture fees from Abbott, Bayer, Boston Scientific, Daichii Sankyo, Medtronic, Biotronik, Sanofi Aventis, Bristol Myers Squibb. K.Z. received funding from Biosense Webster for research in electrophysiology. J.L.M. received direct payment for his personal services from Sanofi Aventis, Boston Scientific, Medtronic and Microport and research funding from Abbott, Daichii Sankyo, Biotronik and Milestone, his department received payment from Biosense, Abbott, Boston Scientific, Medtronic and Biotronik. C.S. received direct payment for his personal services from Biosense Webster, Abbott, Microport, Boston Scientific, Medtronic and Biotronik, travel, and meeting support from Biotronik and research funding from Medtronic. J.T.-H. received travel and meeting support from Abbott and Medtronic and direct personal payment from Leo Pharma. N.D. and H.K. disclose that there is no possible conflict of interest.

Data availability

No datasets were generated or analyzed during the current study.

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