Indications for implantable cardioverter defibrillator (ICD) therapy

Study Group on Guidelines on ICDs of the Working Group on Arrhythmias and the Working Group on Cardiac Pacing of the European Society of Cardiology

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Introduction

Last year was the 20th anniversary of the first defibrillator implantation in a human being\(^1\). Since then, the number of new defibrillator implants has gradually increased following an exponential curve. In 1998, nearly 50,000 new ICD implants were carried out worldwide. This tremendous increase was due to technological improvements in the device and the effectiveness of ICD therapy. Technological improvements in devices and leads included a gradual reduction in the size of the device, the introduction of the endocardial approach in 1988, the biphasic waveform and antitachycardia pacing in 1991, pectoral implantation in 1995, inclusion of DDD pacing in 1996 and finally, inclusion of DDDR and also atrial defibrillation in 1998.

Efficacy assessment started with observational studies. In 1985, FDA approval for ICD implantation was obtained. Results of prospective randomized studies, which assessed the effectiveness of ICDs, were obtained in the late 1990s. The first reported trial was essentially an analysis of cost-effectiveness, which compared ICD implantation as first-choice therapy vs conventional strategy starting with antiarrhythmic drugs in post-infarct sudden death survivors\(^2\). If drugs failed, the patient was treated with endocardial resection or a late defibrillator implant. The cost-effectiveness ratio, defined as costs per day of life, was significantly in favour of early ICD implantation\(^3\). However, because the number of patients was relatively small, total mortality showed only a trend in favour of early ICD implantation.

Subsequently a second randomized trial was carried out in patients with coronary artery disease. This study, the MADIT (Multicenter Automatic Defibrillator Implantation) trial, was on the prophylactic indication for ICD implantation, since the patients had never had episodes of cardiac arrest or sustained ventricular tachycardia\(^4\). Patients were included who had a left ventricular ejection fraction of 35% or lower, spontaneous non-sustained ventricular tachycardia and inducible sustained ventricular tachycardia with programmed electrical stimulation, and required that the arrhythmia remained inducible while on procainamide.

Defibrillator implantation was compared with antiarrhythmic drugs, primarily amiodarone. This trial showed a significantly lower mortality with ICD implantation. The largest randomized study performed to date was the AVID (Antiarrhythmics Versus Implantable Defibrillators) trial\(^5\), which involved 1013 patients. Patients were included with either cardiac arrest, due to rapid ventricular tachycardia or ventricular fibrillation, or with symptomatic ventricular tachycardia. Patients were randomized to defibrillator implantation or antiarrhythmic drug treatment, primarily amiodarone. This trial also showed a mortality benefit in favour of defibrillator implantation. The left ventricular ejection fraction was 40% or less. Although other aetiologies could be included, 81% of the patients had coronary artery disease. The CABG Patch trial, studying the prophylactic use of the implantable defibrillator in patients at high risk for ventricular arrhythmias after coronary artery bypass graft surgery, had a different outcome. The left ventricular ejection fraction was 35% or less. Only patients with abnormality on signal-averaged electrocardiograms were included. Patients were randomized to a defibrillator group and a control group. This study showed no improved survival among patients with a defibrillator. This outcome may be explained by the fact that these patients were primarily...
threatened by acute ischaemia and this problem was solved by coronary artery bypass grafting[6].

Two further randomized prospective studies in patients with documented sustained ventricular tachycardia or ventricular fibrillation, CASH (Cardiac Arrest Study Hamburg)[7] and CIDS (Canadian Implantable Defibrillator Study)[8], compared ICDs with antiarrhythmic drugs. Both demonstrated a strong trend towards better survival with the ICD, but both were considerably smaller compared with AVID and lacked the power to show statistical significance. Finally, in terms of prophylactic indications, the recently published MUSTT (Multicenter Unsustained Tachycardia Trial) study[9], in patients closely resembling the MADIT patients, also showed a significant mortality reduction with ICD therapy.

From the prospective randomized trials mentioned above, it must be noted that the favourable effects of ICD implantation were exclusively[2, 6, 7, 9], or predominantly[5, 7, 8], obtained from patients with coronary artery disease and with previous myocardial infarction. Although we have to be careful in extrapolating the results to other patient categories, additional retrospective and observational studies justify implantation in many of them. Another important point is the reduced left ventricular ejection fraction. In the majority of large randomized trials left ventricular ejection fractions below 40%, even 35% or lower, were used as inclusion criteria. This suggests that patients with a higher ejection fraction are not appropriate candidates for ICD implantation. Nevertheless, even patients with a normal left ventricular ejection fraction may be appropriate candidates. This is true, for example, in patients with idiopathic ventricular fibrillation without reliable parameters to predict outcome[10-12].

The indications for ICD therapy should be decided by a cardiologist trained in clinical electrophysiology and arrhythmia management and who is familiar with all treatment modalities for malignant ventricular arrhythmias. Required qualifications of physicians and implanting centres have been given in a previous Working Group Report[13].

**Aims of ICD therapy**

**Primary aim**

The primary aim of ICD implantation is protection against sudden cardiac death. It is well known that sudden cardiac death, is in the large majority of cases, due to ventricular tachyarrhythmia. Asystole as a secondary event may occur after long-lasting ventricular fibrillation. Primary asystole, as a cause of sudden death, is rarely found in patients with severely impaired left ventricular function[14]. The ICD is able to detect and terminate the arrhythmia by antitachycardia pacing or electric shock delivery and to pace in cases of bradycardia.

**Secondary aims**

In cases of not directly life-threatening monomorphic ventricular tachycardia, the arrhythmia may be terminated by antitachycardia pacing and if needed, by an electrical shock. Termination by antitachycardia pacing may even occur without patient awareness of an arrhythmia. This certainly has a favourable effect on quality of life. An electrical shock usually triggers body movements since the electric field between the electrodes is not limited to the heart. However, antitachycardia pacing is not associated with body movements, which in the absence of loss of consciousness contributes to fitness for car-driving. Expectation of reliability of the ICD in the protection against sudden cardiac death may contribute in an important way to the quality of life of the patient, the family and environment.

**Indications for ICD therapy**

The guidelines listed in this report are evidence-based if possible, or reflect the clinical experience of the Study Group. For ranking of the weight of evidence, as well as final recommendations for indications for ICD therapy. We mostly followed the task force of the American College of Cardiology and the American Heart Association[15]. The same ranking has been used by the German Society of Cardiology[16]. However, it was the opinion of the Study Group that observational data registries should be ranked at a lower level.

**Ranking of evidence**

- **Level A**: Data derived from multiple randomized clinical trials involving a large number of individuals.
- **Level B**: Data derived from one or two randomized studies involving only a small number of patients or non-randomized studies.
- **Level C**: Observational data registries or consensus opinion of experts.

**Final recommendations for indications**

- **Class I**: Conditions for which there is evidence and/or general agreement that ICD implantation is beneficial, useful, and effective. Other therapeutic modalities are less appropriate.
- **Class II**: Conditions for which there is conflicting evidence and/or a divergence of opinion about the usefulness/efficacy of ICD implantation.
- **Class III**: Conditions for which there is evidence/or general agreement that ICD implantation is not useful/ effective and in some cases may be harmful.

This classification is primarily valuable for the average patient with a specific disorder, but recommendations...
may be modified according to individual circumstances. ICD therapy has benefits, as shown above, but also drawbacks, such as (1) absence of cure and the feeling of being device dependent, (2) implantation and replacement associated with a certain, although low rate, of complications, (3) frequent shock delivery in patients with many arrhythmia recurrences, and (4) limitations on fitness to drive. As all the drawbacks are potentially associated with an unfavourable psychological impact, alternative treatment with other therapeutic modalities should always be considered. These include antiarrhythmic drug therapy, catheter ablation and surgical therapy such as revascularization if ischaemia is considered a causative factor for the occurrence of the arrhythmia, or a map-guided endocardial resection or cryo-surgery in cases of monomorphic ventricular tachycardia.

In this report, the indications for ICD therapy are related to clinical presentation. The indications by clinical presentation are listed in Table 1 and summarized below:

- Cardiac arrest, defined as signs of circulatory arrest requiring resuscitation
- Electrocardiographically documented ventricular tachycardia without cardiac arrest
- Syncope without documented ventricular tachycardia
- Prophylactic indication
- General contra-indications

Prophylactic indication means that the patient did not suffer cardiac arrest, sustained ventricular tachycardia or syncope, but is considered, nevertheless, to be at high risk for cardiac arrest. In Table 1, prophylactic indications are found under the heading 'Prophylactic indication', but also under the heading 'Electrocardiographically documented ventricular tachycardia without cardiac arrest' and then specifically 'non-sustained ventricular tachycardia'. For further clarification of Table 1, a section on indications related to aetiology was considered appropriate.

**Indications related to aetiology**

ICD therapy is not appropriate in cases where the cause of the arrhythmia is transient or reversible. Curative therapy should always be considered first, followed by defibrillator implantation with its potential drawbacks. Catheter ablation in a patient with Wolff–Parkinson–White syndrome is a good example, as well as surgical ablation in a patient with an old myocardial infarct with relatively preserved left ventricular function, a well circumscribed aneurysm, and inducible monomorphic ventricular tachycardia. Patients with acute ischaemia are preferably treated with revascularization. Other patients may be treated with drugs. Beta-blocking agents are the first choice in the majority of patients with congenital long QT syndromes, especially those who are symptomatic with increased adrenergic tone (LQT1). In general, patients with a short life expectancy, arbitrarily of 6 months or less, are not appropriate candidates for ICD implantation. Psychiatric disorders may interfere seriously with acceptance of ICD therapy and with ICD follow-up in the outpatient clinic.

**Coronary artery disease**

In most reports, the majority of ICD candidates have coronary artery disease with a previous, but not acute, myocardial infarction. Non-randomized studies in the 1980s and early 1990s have already suggested a benefit with ICD therapy[17-19]. Also, a case-control study from 1996, comparing defibrillator implantation with sotalol guided by electrophysiological testing, showed a favourable outcome with ICD therapy[20]. The previously mentioned randomized trials[2,5,7-9] demonstrated the superiority of ICD therapy in comparison with antiarrhythmic drugs. It should be noted that the patients in these studies had a left ventricular ejection fraction of 40% or less, or even 35% or less. No randomized studies are available in patients with relatively preserved left ventricular function. A comparison between map-guided surgery and ICD therapy in appropriate surgical candidates (relatively preserved left ventricular function, well-circumscribed aneurysm and inducible and mappable monomorphic ventricular tachycardia) is not available. Nowadays, patients with an old myocardial infarction, presenting with cardiac arrest or unstable sustained ventricular tachycardia, are usually typical candidates for ICD implantation. A minority of these patients may be candidates for surgical therapy. In patients with stable, sustained ventricular tachycardia, i.e. without haemodynamic compromise, and a left ventricular ejection fraction above 40%, no randomized studies are available to justify ICD implantation. Nevertheless ICD therapy may be an option in these patients in the absence of reliable alternatives. The MADIT and MUSTT studies[5,7,9] have shown that, even in patients with only non-sustained ventricular tachycardia, but with left ventricular ejection fraction 40% or less, ICD therapy is associated with a better survival than with antiarrhythmic drugs (MADIT) or no antiarrhythmic drugs (MUSTT). These studies, and the AVID trial[8] had a significant impact on the acceptance of ICD therapy in many patients with coronary artery disease. Prophylactic ICD implantation in patients undergoing CABG surgery appears to be inappropriate[6].

**Dilated cardiomyopathy**

Dilated cardiomyopathy is associated with a high mortality, between 20% and 30% per year[21]. About half of these deaths are sudden and unexpected[22]. Results of ICD therapy in prospective randomized trials are not available. Observational studies suggested that ICD
Table 1 Indications for ICD therapy related to clinical presentation

<table>
<thead>
<tr>
<th>Clinical presentation</th>
<th>Class</th>
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<tbody>
<tr>
<td></td>
<td>I</td>
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<tr>
<td>Cardiac arrest</td>
<td></td>
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<tr>
<td>Electrocardiographically documented VT/VF not due to transient or reversible cause</td>
<td>A</td>
</tr>
<tr>
<td>If due to transient, reversible or treatable cause, such as within 48 h after acute myocardial infarction, acute ischaemia or Wolff-Parkinson-White syndrome, or monomorphic VT amenable to map-guided surgery or catheter ablation</td>
<td>C</td>
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<tr>
<td>VT/VF not electrocardiographically documented, but presumed based on successful external defibrillation and/or inducible VT/VF, and/or other relevant clinical data, and arrhythmia not due to transient, reversible or treatable cause</td>
<td>B</td>
</tr>
<tr>
<td>If transient, reversible or treatable cause</td>
<td>C</td>
</tr>
<tr>
<td>Electrocardiographically documented ventricular tachycardia without cardiac arrest</td>
<td></td>
</tr>
<tr>
<td>Sustained VT with severe haemodynamic compromise (syncpe, near-syncpe, congestive heart failure, shock or anginal complaints)</td>
<td>A</td>
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<tr>
<td>Sustained VT without haemodynamic compromise</td>
<td></td>
</tr>
<tr>
<td>If left ventricular ejection fraction $\leq 40%$</td>
<td>B</td>
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<tr>
<td>If left ventricular ejection fraction $&gt;40%$</td>
<td>C</td>
</tr>
<tr>
<td>Incessant VT</td>
<td>C</td>
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<tr>
<td>Non-sustained VT</td>
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<tr>
<td>Left ventricular ejection fraction $\leq 40%$, 4 days or more after myocardial infarction with inducible VF or sustained VT at electrophysiological study</td>
<td>B</td>
</tr>
<tr>
<td>Patients at high risk for sudden death while awaiting cardiac transplantation and patients with hypertrophic cardiomyopathy with syncpe and/or family history of sudden death at young age</td>
<td>C</td>
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<tr>
<td>Patients not at high risk, or sustained on non-sustained monomorphic VT amenable to catheter ablation or map-guided surgery</td>
<td>C</td>
</tr>
<tr>
<td>Idiopathic monomorphic VT, either sustained or non-sustained</td>
<td>C</td>
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<tr>
<td>Syncope without documented ventricular tacharythmia</td>
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<tr>
<td>Inducible VF or VT at electrophysiological study with severe haemodynamic compromise (syncpe, near-syncpe, congestive heart failure, shock or angina) when drug therapy is ineffective, not tolerated or not preferred</td>
<td></td>
</tr>
<tr>
<td>If left ventricular ejection fraction $\leq 40%$</td>
<td>B</td>
</tr>
<tr>
<td>If left ventricular ejection fraction $&gt;40%$</td>
<td>C</td>
</tr>
<tr>
<td>VT/VF non-inducible with cardiac disorder known to be associated with ventricular arrhythmias such as long QT, hypertrophic cardiomyopathy or other diseases when other causes of syncope have been excluded</td>
<td>C</td>
</tr>
<tr>
<td>Without cardiac disorder</td>
<td>C</td>
</tr>
<tr>
<td>Prophylactic indication</td>
<td></td>
</tr>
<tr>
<td>Non-sustained VT 4 days or more after myocardial infarction with a left ventricular ejection fraction $\leq 40%$ and inducible VF or sustained VT at electrophysiological study</td>
<td>B</td>
</tr>
<tr>
<td>Familial or inherited conditions such as long QT syndrome, hypertrophic cardiomyopathy, arrhythmogenic right ventricular dysplasia, Brugada syndrome and other apparently genetic disorders, as well as some specific congenital disorders with an approved high risk for sudden cardiac death</td>
<td>C</td>
</tr>
<tr>
<td>Coronary artery disease with left ventricular dysfunction and prolonged QRS duration in the absence of spontaneous or inducible sustained or non-sustained VT, who are undergoing coronary bypass surgery</td>
<td>B</td>
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<tr>
<td>General contraindications</td>
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<tr>
<td>VT/VF associated with terminal illnesses with projected life expectancy $\leq 6$ months, or significant psychiatric illnesses that may be aggravated by device implantation or may preclude systematic follow-up, or NYHA class IV drug-refractory congestive heart failure in patients who are not candidates for cardiac transplantation</td>
<td>C</td>
</tr>
<tr>
<td>Patients who have severe neurological sequelae following cardiac arrest</td>
<td>C</td>
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</table>

A: derived from multiple randomized clinical trials with a large number of individuals; B: derived from a limited number of trials involving a small number of patients or from well designed data analyses of non-randomized studies; C: from observational data registries or consensus opinion of experts; VT = ventricular tachycardia; VF = ventricular fibrillation.
therapy may be beneficial compared with drug therapy in these patients. Preliminary results showed that patients with syncope and dilated cardiomyopathy, but without inducible ventricular tachycardia, received appropriate shocks from the implanted defibrillator\cite{23}. The reported efficacy of drug therapy is low and difficult to predict\cite{24}. Surgery is usually not appropriate. Implantation of an ICD is accepted in patients with cardiac arrest and those with sustained ventricular tachycardia and may be appropriate in patients with syncope. ICD implantation can be used as a bridge to transplant. Even without the possibility of cardiac transplantation, patients with severe left ventricular dysfunction may have a beneficial effect from ICD implantation since a reduced short-term mortality has been demonstrated\cite{25}. However, in cases of severe haemodynamic compromise without the possibility of haemodynamic stabilization, ICD implantation is not useful in the absence of a bridge to cardiac transplantation.

**Arrhythmogenic right ventricular dysplasia**

Randomized trials are not available. Patients with cardiac arrest are treated with ICD implantation. Usually, however, patients have monomorphic ventricular tachycardia and the first choice of treatment is antiarrhythmic drugs and, in case of failure, catheter ablation or ICD implantation.

**Hypertrophic cardiomyopathy**

Prospective randomized trials are not available in hypertrophic cardiomyopathy. The disease is often the cause of sudden death in young athletes\cite{26}. Sudden death is often due to ventricular arrhythmia\cite{27}. Protection against sudden death by improving haemodynamic factors has never been demonstrated. Empiric use of amiodarone is associated with improved survival\cite{28}, and in patients with ventricular ectopy and non-sustained ventricular tachycardia on Holter recording. A beneficial effect of amiodarone in patients with sustained ventricular arrhythmias and cardiac arrest has never been demonstrated. Thus, sudden death survivors and patients with sustained ventricular tachyarrhythmias should be considered for ICD implantation. In patients with hypertrophic cardiomyopathy without sustained ventricular arrhythmias or syncope, prophylactic ICD implantation may be considered, where there is a family history of sudden cardiac death at young age\cite{29}.

**Valvular heart disease**

Sudden death may occur in patients with mitral valve prolapse\cite{29}. In many patients with mitral valve prolapse and arrhythmias, beta-blocking agents are the first choice. However, high-risk patients without inducible ventricular tachyarrhythmia during control study, or without suppressed inducibility while on drug therapy, should be treated by ICD implantation. The risk of sudden death is independent of the severity of mitral valve incompetence. Sudden death may also occur in patients with other valvular diseases, such as aortic valve disease. Serious ventricular arrhythmias may also occur after valvular replacement. It is conceivable that hypertrophy developed prior to valve replacement is still responsible for post-operative arrhythmogenicity.

**Long QT syndromes**

These are genetic disorders associated with the occurrence of polymorphic ventricular tachyarrhythmias and sudden death\cite{30,31}. In many cases beta-blocking agents are first choice, in some cases combined with left cervicothoracic sympathectomy or pacing to avoid bradyarrhythmia. However, some patients need ICD implantation, as recently reported\cite{32}. A family history of sudden death at young age may contribute to prophylactic ICD implantation.

**Idiopathic ventricular fibrillation**

In about 10% of patients resuscitated from cardiac arrest, no structural heart disease or other well-known entity such as the Wolff–Parkinson–White syndrome or the long QT-syndrome can be identified\cite{30-12,33}. These patients are considered to have idiopathic ventricular fibrillation. Unlike patients with coronary artery disease, recurrences occur at relatively long intervals, frequently many years. Since many patients are young, the outcome is unfavourable. Ventricular arrhythmias are inducible in about half of the patients, usually polymorphic ventricular tachycardia or ventricular fibrillation. In one study\cite{10} this subgroup was often suppressible with class IA drugs. However, the long-term efficacy of drug therapy remains unknown. The majority of patients with idiopathic ventricular fibrillation are ideal candidates for ICD implantation. The prognosis should be excellent with appropriate protection against sudden death, since these patients have no structural heart disease. Recently, a minority of these patients showed the typical characteristics of the Brugada syndrome, characterized by a right bundle branch block-like appearance, with ST-segment elevation in $V_1$ and $V_2$. The severity of the electrocardiographic abnormalities show a dynamic behaviour, ranging from apparently normal towards highly abnormal\cite{34}. This syndrome has a genetic background, thus, multiple family members may be affected. Prophylactic ICD implantation may be considered in selected subsets of patients with typical electrocardiographic characteristics and if family members died young with similar electrocardiographic characteristics. Patients with idiopathic monomorphic ventricular tachycardia frequently originating from the right.
ventricular outflow tract or the apicoseptal area of the left ventricle, are not candidates for ICD implantation. After drug failure, these patients are typical candidates for catheter ablation.

**Device selection**

In addition to the basic therapeutic principles of internal ventricular cardioversion and defibrillation above a pre-specified rate, ICDs are offered with other therapeutic options and detection criteria\[35\]. Meanwhile all ICDs have both VVI-pacing and antitachycardia pacing available. Whether patients presenting with cardiac arrest could receive a device without antitachycardia pacing has been discussed. However, comments have been confined to the question in which patients should antitachycardia pacing not be activated directly after ICD implantation\[36–39\].

Avoiding inappropriate ICD therapy, due to supraventricular tachycardias, has been identified as a major goal to improve quality of life in ICD patients\[40\]. Several studies suggest that classic additional detection criteria, such as stability and onset pattern of ventricular tachycardia, help to reduce inappropriate ICD therapies but do not eliminate inappropriate discharges\[41–45\]. Theoretically appealing detection criteria, which use morphological changes (QRS width, template matching) of the ventricular signal during ventricular tachycardia, produce unstable results in many patients and require complicated follow-up procedures\[46–48\]. However, in patients with highly regular conduction to the ventricles, such as atrial flutter with 2:1 conduction and other forms of stable supraventricular tachyarrhythmias with sudden onset, or exercise-induced supraventricular tachycardias, these criteria might be considered in patients without bundle branch block. In patients without chronic atrial fibrillation, inclusion of an atrial signal into the detection algorithm has been shown to differentiate supraventricular tachycardia from ventricular tachycardia in many cases\[49,50\].

However, new problems might be introduced due to the additional lead needed, e.g. dislocation, or the detection algorithm used, e.g. inappropriate therapy in patients with long PR intervals due to the original PR Logic algorithm. Dual chamber algorithms differ significantly between manufacturers and the physician has to study an algorithm in detail before he decides to implant a certain device. Currently, implanting a dual chamber ICD in every patient not presenting chronic atrial fibrillation is not justified. The results of ongoing prospective randomized studies comparing single and dual chamber detection algorithms are awaited. However, in general all patients who would need dual chamber pacing due to established pacemaker guidelines should receive a dual chamber ICD.

Avoiding appropriate ICD shocks due to ventricular tachyarrhythmias is another major goal to improve quality of life in ICD patients. Generous use of antitachycardia pacing might reduce painful shocks\[51\]. In some patients with the congenital long QT syndrome ventricular tachycardia might be suppressed by AAI (DDD) pacing at sufficiently high rates\[52\]. Preliminary data suggest that a smoothing algorithm using dual chamber pacing might avoid short–long RR-interval combinations and thus also avoid initiation of ventricular tachyarrhythmia in other ICD patients\[53\].

ICD patients with severe symptoms of heart failure (NYHA III), despite optimal medical treatment, might improve if they are paced simultaneously at the right ventricular apex and the lateral left ventricle\[54\] or the lateral left ventricle alone\[55\]. Candidates for ICDs including biventricular pacing have to show sinus rhythm and a significant prolongation of excitation of the left ventricle (at least 150 ms) with a left bundle branch block pattern. Biventricular pacing can be achieved by an additional coronary sinus lead or an epicardial lead. In patients with hypertrophic obstructive cardiomyopathy, haemodynamic improvement might be achieved by introducing a left bundle branch block by pacing the right ventricular apex in DDD mode\[56,57\]. ICDs offering preventive pacing for atrial fibrillation/flutter, therapeutic pacing or even cardioversion to terminate atrial fibrillation/flutter are available\[58\]. However, their impact on quality of life or even overall mortality is unknown and thus their use should be limited to exceptional patients and experienced centres.

It should be realized that the described guidelines have only limited value. Guidelines will change in the future, as new data become available. Finally, again these are only guidelines. Guidelines may help, but decision-making in the individual patient is also based on his or her specific circumstances.

**References**


Appendix

This Working Group Report, first drafted by Richard Hauer, Michael Block and Alessandro Capucci, underwent extensive review by all members of the Study Group on guidelines on ICD of the Working Group on Arrhythmias and the Working Group on Cardiac Pacing of the European Society of Cardiology. Members of this study group are: Etienne Aliot, Michael Block, Alessandro Capucci, Richard Hauer (chairman), Berndt Lüderitz, Massimo Santini and Panos Vardas. The manuscript was extensively discussed and improved during meetings of the Nucleus of the Working Group on Arrhythmias with representatives of the Nucleus of the Working Group on Cardiac Pacing in August and October 2000. Suggestions and comments on several aspects were added. Thanks are due to those who contributed with their constructive criticisms.