IMPLANTABLE CARDIOVERTER DEFIBRILLATOR

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The best measure of quality is not how well or how frequently a medical service is given, but how closely the result approaches the fundamental objectives of prolonging life, relieving distress, restoring function and preventing disability.

P.A. Lembcke
INTRODUCTION

The implantable cardioverter-defibrillator (ICD) is highly effective in the management of life threatening ventricular arrhythmias, with benefits shown in both primary and secondary prevention studies.1-5

The National Institute for Clinical Excellence has recommended a major increase in their use in the UK. It also recommended "a rehabilitative approach to aftercare, which includes psychological preparation for living with an ICD".6 Little work has been done on the psychosocial sequelae of life threatening arrhythmias and subsequent ICD implantation in the UK.

Cardiac rehabilitation is established for patients with ischaemic heart disease with reported benefits for exercising ability, psychological functioning, and prognosis.8 Patients with chronic heart failure show improvements in exercise performance and autonomic function with exercise training alone.9-10

Several groups have suggested that patients with ICDs may also benefit from structured rehabilitation, including exercise training, but the effects of this have not been studied.11-13

The British Association for Cardiac Rehabilitation, consistent with other major cardiac rehabilitation organisations, recommends the use of "comprehensive" cardiac rehabilitation (CCR), the key components of which are exercise, education, and psychological support.14
BACKGROUND

SCD has been defined as death occurring unexpectedly within one hour of onset of symptoms. 14
Sudden cardiac death occurs in approximately 70,000 to 100,000 people annually in the UK and approximately 250,000 to 400,000 people each year in the U.S.104, 105. SCD represents over half of the deaths attributable to cardiovascular disease 4, 5.
In an unselected adult population over the age of 33 years, the risk of sudden cardiac death is approximately 1 to 2 per 1,000 population ( 0.1 to 0.2 %); however, application of various cardiac risk factors may identify subgroups who are at significantly greater risk of experiencing SCD.

In the Western cultures, the most frequent causes of sudden death in an adult population include coronary artery disease (approximately 80%) and cardiomyopathy (dilated and hypertrophic; approximately 10-15%).

Possible risk factors for sudden cardiac death include:

- coronary artery disease, particulary associated with myocardial infartion;
- congestive heart failure;
- cardiomyopathy;
- reduced left-ventricular function;
- sustained ventricular arrhythmia induced during electrophysiologic stude (ESP)
- electrocardiographic abnormalities such as frequent ventricular premature contractions, ventricular late potentials, reduced heart rate variability, QT prolongation or dispersion, and T wave alternans;
- or history of asymptomatic, non sustained ventricular tachycardia.
Myerburg and Castellanos (2001) emphasize that reduced left ventricular ejection fraction (LVEF; i.e. < 40%) is independently associated with SCD, and for reduction of LVEF to < 30% is the “single most powerful independent predictor for SCD, but it has low specificity.”

Sudden cardiac death is frequently associated with ventricular tachyarrhythmia, which includes ventricular tachycardia (VT) and ventricular fibrillation (VF). The spectrum of ventricular arrhythmias includes isolated ventricular ectopic beats, nonsustained ventricular (NSVT), sustained ventricular tachycardia, which may or may not be associated with symptoms, and ventricular fibrillation and polymorphic ventricular tachycardia (torsade de pointes), which are generally life-threatening.

Unlike coronary heart disease, the mortality rates for SCD do not appear to be falling. Outcomes of out of hospital resuscitation are generally poor (about 3-10% survive in most studies), and those people who survive a first episode of a life threatening ventricular arrhythmia are at high risk of further episodes. 50% will be rehospitalised within 1 year, and 40% will die within 2 years.

In the UK, fewer than 5% of people survive the initial cardiac arrest. Subgroups of patients with the highest relative risk for SCD (survivors of cardiac arrest, low left ventricular ejection fraction) are a small proportion of the total population burden of SCD, making identification of those patients that could potentially most benefit from ICD difficult.

The risk of SCD in the general population is 2 per 1000 persons per year, making population screening for risk factors a current challenge. Risk stratification using techniques such as ambulatory electrophysiological study (EPS), signal averaged ECG’s, heart rate variability have been used, although the evidence base for these is often not strong. Research is ongoing into the effectiveness of these techniques.

Aetiological determinants of SCD are those risk factors associated with coronary heart disease (80% of SCD) e.g. smoking, hypertension, exercise, raised cholesterol, genetic factors, diabetes mellitus, cardiomyopathies (10-15% of SCD), other structural heart defects (<5% of SCD) and molecular structure defects e.g. long QT syndrome. Transient risk factors are drugs, electrolyte imbalance, and ischaemia.
**EPIDEMIOLOGY**

Since the first ICD was implanted in 1980, more than 240,000 ICDs have been implanted worldwide. It has been estimated that in 1996, 262 patients in the UK received an ICD, which is half the average for Western Europe and less than 10% of the rate in USA. There have been no agreed UK guidelines for use of ICD. For local districts there has been an agreed number of ICD per head of population that was derived from debate and consensus between cardiologists locally and the Health Authorities. Most Authorities are operating at 10 per million population (for a typical Health Authority of 500,000 this represents approximately 4 annually). This practice is lower than other European countries and North America (See Table 1).

Table 1: Frequency and number of ICD implanted (1998 data, J. Morgan personal communication)

<table>
<thead>
<tr>
<th>Region/country</th>
<th>Estimated number of ICD inserted</th>
<th>Approximate ratio of ICD inserted to population</th>
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<tbody>
<tr>
<td>USA</td>
<td>16,900</td>
<td>185 per million</td>
</tr>
<tr>
<td>Germany</td>
<td>4,890</td>
<td>67 p.m.</td>
</tr>
<tr>
<td>Quebec Canada</td>
<td>175</td>
<td>48 p.m.</td>
</tr>
<tr>
<td>Denmark</td>
<td>140</td>
<td>27 p.m.</td>
</tr>
<tr>
<td>Sweden</td>
<td>180</td>
<td>23 p.m.</td>
</tr>
<tr>
<td>Australia</td>
<td>525</td>
<td>20 p.m.</td>
</tr>
<tr>
<td>Italy</td>
<td>1,010</td>
<td>20 p.m.</td>
</tr>
<tr>
<td>Spain</td>
<td>645</td>
<td>15 p.m.</td>
</tr>
<tr>
<td>UK</td>
<td>645</td>
<td>10 p.m.</td>
</tr>
<tr>
<td>France</td>
<td>565</td>
<td>9 p.m.</td>
</tr>
<tr>
<td>Netherlands</td>
<td>230</td>
<td>15 p.m.</td>
</tr>
</tbody>
</table>
Geographic differences:

ICD implantation per million inhabitants is 5 times higher in the United States (185 ICD implants per million) than in western European countries (average of 31 ICD implants per million inhabitants). The growth implantation rates continue to be faster in the United States. The question arises, therefore, whether this difference in implantation rates is a result of different economic backgrounds, interpretation of the guidelines for ICD implantation or differences in translating study results in clinical practice. The data suggest that the acceptance and translation of ICD study results into clinical practice were much higher in the United States compared with the western Europe.

In the year 2000, a total of 52,000 ICDs were implanted in the USA. However, based on the Maastricht data, estimated sudden cardiac death survival is about 13,700 patients.

The majority of patients in the United States (roughly 40,000 patients) received an ICD because of VT or for prophylactic reasons. Indications for ICD placement in the United States based on the American College of Cardiology/North American Society of Pacing and Electrophysiology (ACC/NASPE) 2001 survey are as follows: cardiac arrest 30%; spontaneous sustained VT 20%; syncope and inducible VT 14%; myocardial infarction 24%; long QT syndrome 3%; and other 3%. This is in contrast to the behaviour in the western Europe where, in the year 2000, 13,160 where implanted. However, the estimated number of sudden cardiac arrest survivors is 19,400 victims. The rate of estimated sudden cardiac death survivors is higher than the actual ICD implantation rate.

This clearly demonstrates that the underutilization of the ICDs in western Europe. In Germany, the European country with the highest ICD implantation rate, the indications for ICD placement are as follows:

- cardiac arrest 48.5%
- spontaneous sustained VT 31%
- syncope and inducible VT 6%
- myocardial infarction 6%
- other 10%

Despite concerns that the findings of Multicenter Automatic Defibrillator Implantation Trial Investigators (MADIT) and Multicenter Unsustained Tachycardia Trial Investigators (MUTTT), could not be generalized, prophylactic use of ICD was approved by the United States Food and Drug Administration.
A dramatic increase in ICD implantation in the USA then followed. This acceptance is seen in the shift in indications from fewer patients resuscitated after sudden cardiac death to more patients with monomorphic VT. Such an increase was not encountered in most European countries. Skepticism about the generalization of MADIT results and fear of the economic consequences of incorporation of MADIT results into clinical practice were two of the main reasons for this reluctance. 108. The rates of ICD implantation vary greatly among countries in western Europe, despite similar if not identical economic backgrounds. Germany has the highest implantation rate 67 implant per million. The United Kingdom and France have the lowest implantation rates 9 and 10 implants per million respectively.
**IMPORTANCE OF CARDIAC REHABILITATION**

In 1993 the World Health Organization (WHO) defined the aim of cardiac rehabilitation as follows: the rehabilitation of the cardiac patient encompasses the whole of activities required to favourably influence the cause of the disease, and above all to ensure that the patient is in the best possible physical, psychological and social position to return to and maintain his or her normal place in society.

In addition to optimal somatic performance, this definition addresses both psychological and social rehabilitation and (secondary) prevention. The positive impact of cardiac rehabilitation has received considerable attention in the literature.

Cardiac rehabilitation programmes aimed at physical fitness, healthy living and stress reduction have been shown to contribute to a reduction in mortality 27, an improved exercise tolerance 28, a slowing of atherosclerotic processes and a reduction of risk of new cardiac incidents. 28,29 The effect of cardiac rehabilitation on the return to work is not as obvious. Cost effectiveness analyses have shown that cardiac rehabilitation has a beneficial effect on medical consumption. 27-29 By assessing each patient’s individual needs and by formulating the rehabilitation programme accordingly, an optimally effective rehabilitation programme can be achieved.

**IMPORTANCE OF PHYSIOTHERAPY**

The physiotherapist is responsible for coordinating the exercise component of the rehabilitation programme.

Patients are individually assessed prior to commencing the programme. This assessment is also conducted on completion of the programme and six months following completion.

The supervised exercise training sessions are comprised of four components.

These includes:
- Warm up and stretches
- Circuit strength training
- Aerobic fitness
- Cool down and stretches
The physiotherapist also provides three education sessions. Topics covered include:

- Benefits of exercise
- Guidelines on exercising independently and safely
- Introduction and awareness to the importance of CPR
- Progression of exercise.

Premises for “cardiac rehabilitation made to measure”

There are grounds for cardiac rehabilitation if a discrepancy exists between present and optimal performance and/or in the presence of detrimental habits open to influence. In this context optimal means desirable: the attainable level of performance required for the patient’s fullest possible return to his or her normal place in society. Functional deterioration or limitation can be objective, e.g. diminished exercise tolerance, or subjective, e.g. fear of exertion.

In order to allow cardiac rehabilitation “made to measure”, it is essential to assess whether or not there are grounds for rehabilitation and which means are required for the best possible result in each individual patient. This necessitates the assessment of the patient’s performance using objectifiable and evaluable criteria. Both the present and desired level of performance should be quantifiable.

An individual rehabilitation programme can subsequently be formulated. Patients are selected for cardiac rehabilitation based on five standard screening questions. Rehabilitation sub-goals are formulated based on the answers to these questions. The sub-goals are subsequently translated into an individual rehabilitation programme consisting of one more modules, combined with individual coaching as necessary. Four group modules have been developed; two exercise modules of which one short (8-10 contact hours) and one long (18-24 hours), each of which can be provided with or without training on an ergometer; one information module, compromising a number of educational gatherings; and a psycho-educational prevention module in which the gatherings are in the form of intensive workgroups. Various programmes can be constructed by combining these modules. The exercise and information modules are available in most hospitals. The expectation is that non-complex rehabilitation such as this will prove sufficient for most patients to return to daily life. In certain centres, the PEP module and other more extensive forms of cardiac rehabilitation will require collaboration on a regional scale. A small number of patients requires referral to a specialized centre for cardiac rehabilitation due to complex somatic, psychological and social problems.
Phases ICD patients:

Phase I

Rehabilitation starts soon after your heart attack or surgery, while you're still in the hospital. You'll begin with non-strenuous activities such as sitting up in bed and working your way up to walking and limited stair climbing. It is also important to begin to plan a new lifestyle. Phase I ends when you leave the hospital.

Phase II

The next phase of your rehabilitation may begin as early as a few days after leaving the hospital and should begin within four to six weeks and will last for a maximum of 12 weeks. Phase II rehabilitation takes place at Roper or St. Francis. During this time you gradually increase your general activity level under supervision. This phase features three supervised exercise sessions per week, continuous EKG monitoring during exercise, a comprehensive cardiac educational series and personal attention from trained professionals.

Phase III & IV

The main difference from Phase II will be decreased continuous monitoring. Patients in this phase may require closer attention to meet physical goals than patients in the long term Phase IV program. Many patients are able to progress directly to Phase IV.

This phase lasts indefinitely, and in some ways it's the most important part in rehabilitation. At this point, the patient should regain your independence and work toward a lifelong commitment to the changes you started earlier in the recovery. Periodic visits with the rehab team can help reinforce your heart-healthy lifestyle.

Cardiac Rehab Staff

The cardiologist, who serves as medical director, oversees program operation and assures an optimal and safe treatment plan. The patient will be guided by a dedicated staff, which includes a nurse, PT, dietitian, vocational rehabilitation counselor and psychologist.
Sub-goals in cardiac rehabilitation

For group of sub-goals can be differentiated in rehabilitation: somatic, psychological, social and secondary prevention. Sub-goals are defined during rehabilitation screening, and used in the compilation of the rehabilitation programma. These sub-goals are assessed and if necessery adjusted during interim evaluation.

Somatic sub-goals

1. To become familiar with one’s somatic limitations
2. To learn to cope with somatic disabilities
3. To optimize exercise tolerance
A cardiac incident can lead to a (sometimes severe) reduction of exercise tolerance. Rehabilitation is undertaken in an attempt to return this to the desired level. In addition, the patient should become familiar with his or her limitations, and (in particular in the case of permanent disability) learn to ration his or her strength over the day in the best possible way. In the event of the patient’s actual disabilities.

Psychological sub-goals

5. Conquering the fear of exertion. Following a cardiac incident, the patient’s opinion of his or her exercise tolerance is often inferior to what the objective situation might predict. The fear of provoking cardiac symptoms prevents the patient from exercising, to such a degree that unnecessary limitations are selfimposed (such as sexual abstinence).
6. Regaining emotional stability. A cardiac incident is often followed by reactions of fear, agression and depression, which are often associated with sleep and eating disorders, fatigue, emotional instability, loss of libido, and memory and concentration disturbances. Dealing with a loss of social position can play a role. Some patients require assistance in regaining their emotional stability. Without treatment, fear and depression may persist. A certain degree of emotional stability is essential if social and preventie sub-goals are to be attained.
7. Dealing with cardiac disease in a constructive manner. The patient must learn to take his or her cardiac disease into account, without being subjected to unnecessary limitations. A coping mechanism such as denial may be functional in the acute phase, but forms an impediment both to dealing with the disease and finding the proper level of physical exertion in the long run. On the other hand, some patients overestimate the severity of disease-related disability.

Social sub-goals.

The patient’s environment plays a cardinal role in the social sub-goals.
8. Regaining emotional stability and dealing with cardiac disease in a constructive manner within the relationship and social context. The patient’s partner and/or environment may be either patronizing or overconcerned; on the other hand, they might demand too much of the patient. Such reactions can represent either a hindrance or an unnecessary burden to the patient: conquering the fear of exercise, regaining emotional stability and dealing with cardiac disease in a constructive manner.
9. Optimal return to work and/or domestic duties.
10. Optimal resumption of leisure activities.
11. Optimal restoration of family and social roles.
Difficulties in fulfilling social obligations are often secondary to physical disability or psychological problems. On the other hand, the patient’s environment (e.g. the employer) may stand in the way of a return to optimal social performance.

Secondary prevention sub-goals.

One educational sub-goal and four concerning reversible behavioural factors can be distinguished.
12. Awareness of the nature of the disease and risk factors.
13. Stopping smoking.
14. Maintaining/developing a physically active lifestyle
15. Developing healthy dietary habits.
16. Developing compliance in regard to prescribed medication.

Difficulties in fulfilling social obligations are often secondary to physical disability or psychological problems. On the other hand, the patient’s environment (e.g. the employer) may stand in the way of a return to optimal social performance.

Awareness of risk factors is essential if the patient is to be motivated to pursue a healthier lifestyle. In patients who smoke, giving up this habit is the single most effective means to improve prognosis. Regular physical exercise
also improves prognosis. Healthy diet has a positive impact on the risk factors of obesity, hypercholesterolemia and hypertension. If patients have difficulty in taking medication as prescribed, extra information is required.
**IMPLANTABLE CARDIOVERTER DEFIFRILLATOR:**

What is it?

Implantable cardioverter defibrillators are small devices that are put into the upper chest below the left shoulder. Leads from the device go into the heart where they:

- Monitor the heart,
- Control the rate of the heart beat (pace),
- Sense an irregular heart beat and deliver a small electric shock to return the heart beat to its normal rhythm (defibrillate)

![Diagram of a Single-Chamber Implantable Cardioverter–Defibrillator System](image)

*Figure 1. Diagram of a Single-Chamber Implantable Cardioverter–Defibrillator System.*

The pulse generator is usually placed in a subcutaneous pocket in the pectoral region. It contains a header with ports for leads, the battery and capacitors, memory chips, integrated circuits and microprocessors, and the telemetry module. The transvenous right ventricular lead contains the shock coils and pacing electrodes. Additional leads may be connected for right atrial or left ventricular pacing.
How does it work?

An implantable cardioverter defibrillator checks the heart continuously until an arrhythmia (a variation from the normal rhythm of the heart beat) is recognised, then the device delivers the appropriate treatment to the heart.

Fitting of the device requires the patient to have a local anaesthetic and stay in hospital for around 2 to 4 days. The devices are battery operated and the battery lasts for up to 9 years, depending on the number of treatments the device delivers. The devices may be programmed to meet the specific needs of the individual patient. In 1995, the first dual function implantable cardioverter defibrillators were produced. These combine the functions of a pacemaker and an implantable cardioverter defibrillator in one device. This is particularly important for those patients who need to take drugs to prevent arrhythmias, as well as having an implantable cardioverter defibrillators fitted. This is because these drugs sometimes don't allow the heart rate to change in response to exercise. In these circumstances the dual function device acts as a pacemaker and controls the rate of the heartbeat.

The original implantable cardioverter–defibrillator was designed to detect only ventricular fibrillation, by means of a wave-form analysis termed a probability-density function. Use of this device indicated that therapy for organized ventricular tachycardia was also important. Subsequently, the rate of R waves detected by the defibrillator’s ventricular-sensing circuit became the standard measurement used to identify cardiac rhythm. In the present generation of defibrillators, the ventricular bipolar sensing circuit filters the incoming signal to eliminate unwanted low-frequency components (e.g., T waves and base-line drift) and high-frequency components (e.g., skeletal–muscle electrical activity). One or more tachycardia-detection zones may be programmed. The fastest rate, or ventricular-fibrillation zone, is treated by delivery of a shock. Zones with lower rate boundaries may be treated with antitachycardia pacing or low-energy synchronized shocks or, in some cases, just observed. Because the amplitude of the bipolar electrogram may be low or unstable during ventricular fibrillation, all implantable cardioverter–defibrillators allow sensitivity-gain adjustment during intervals when an R wave is not sensed, in order to detect low-amplitude signals when ventricular fibrillation does occur. In many cases, the rates of sinus tachycardia or of other supraventricular arrhythmias may be within the zones set for detection of ventricular tachycardia or ventricular fibrillation, which may result in inappropriate delivery of the therapy. Therefore, most implantable defibrillators can be programmed to enhance the discrimination between supraventricular and ventricular arrhythmias. 84,85,86
Single-chamber devices most commonly can distinguish the sudden onset of sinus tachycardia from ventricular tachycardia. They can also identify the stability of cardiac-cycle lengths in order to detect atrial fibrillation and can characterize morphology and width in electrograms. In dual-chamber devices, information from the atrial electrogram may be included in the algorithm used to perform the analysis. Features that enhance detection are primarily used in ventricular-tachycardia zones, where even a transient inhibition of the delivery of the appropriate therapy is undesirable. Early models delivered therapy after the criteria for detecting arrhythmia had been met, which could lead to the delivery of unnecessary shocks when the arrhythmia was spontaneously terminated. Therefore, defibrillators now reanalyze the rhythm before delivering shocks and painlessly dump the stored charge when the criteria for detection are no longer met.

In an implanted cardioverter–defibrillator, two basic methods are used to terminate arrhythmias: antitachycardia pacing and direct-current shocks. Physicians select the method to be used first to deliver therapy in each tachycardia-detection zone. Antitachycardia pacing is a standard electrophysiological technique that is useful for terminating monomorphic tachycardias. The electrophysiologist can program the device to deliver one or more bursts of pacing in an attempt to terminate the tachycardia. The characteristics of the bursts can be programmed and may vary, depending on the detection zone. Antitachycardia pacing is painless for the patient and, because the capacitor does not need to be charged, can be delivered rapidly. However, antitachycardia pacing is not always effective, and it can accelerate ventricular tachycardia or, if applied during a supraventricular rhythm, induce a ventricular arrhythmia. Thus, delivery of a shock is always included in the prescription for therapy when antitachycardia pacing is ineffective.

All implantable cardioverter–defibrillators can be programmed to deliver either synchronized, usually low-energy shocks (less than 5 J) or unsynchronized high-energy shocks. Low-energy shocks may have very short charge times, but they may accelerate ventricular tachycardia and, in spite of the low energy, are uncomfortable for the patient. High-energy shocks are used in the zone with the highest rate and in zones with lower rates, if antitachycardia pacing or low-energy shocks are either unsuccessful or not programmed. Traditionally, the energy of the first shock is set at least 10 J above the threshold of the last defibrillation measured. Early models used monophasic wave forms, but the use of biphasic wave forms improved defibrillation thresholds. Defibrillation administered by transvenous systems that deliver up to about 30 J can be successful in most patients, but in rare cases, alternative lead configurations or high-energy devices may be necessary to deliver the therapy.
Other Functions of Implantable Defibrillators

In current models of implantable defibrillators there are a number of features that are not directly related to the analysis of or the delivery of therapy for ventricular arrhythmias. All models now have pacing modes similar to those in single- or dual-chamber pacemakers. All models routinely store electrograms for sensed arrhythmias, a feature that is extremely helpful during follow-up for analysis of the therapies delivered and for detection of many malfunctions that may occur in the device. Information about battery voltage, lead impedance, and the time needed to charge the capacitor is stored for later analysis. Some models can detect atrial arrhythmia and deliver the appropriate therapy (shock or antitachycardia pacing). A dedicated atrial defibrillator has been developed and tested in limited clinical trials in patients with atrial fibrillation, but it is not yet available as a separate unit. The most recent major innovation in implantable cardioverter–defibrillators is implementation of biventricular pacing to achieve cardiac resynchronization in patients with advanced congestive heart failure and intraventricular conduction delays, especially left bundle-branch block.

Patient characteristics

Five criteria have to be met by a patient to qualify for a defibrillator implant:

1. At least one episode of cardiac arrest due to ventricular tachycardia (VT) or ventricular fibrillation (VF) accompanied by loss of consciousness and other symptoms of haemodynamic deterioration. Cardiac arrest within 18 hours after acute myocardial infarction is excluded.

2. Protection from life-threatening ventricular arrhythmias by drug therapy is uncertain or there are reasons for deciding against drugs. These may also include:
   – absence of parameters to evaluate drug therapy (frequent recurrence of spontaneous or inducible VT/VF) or;
   – persistent inducibility of VF or haemodynamically intolerable VT or;
   – serious side effects.
3. Impossibility of applying map-guided nonpharmacological procedures (e.g.,
endocardial resection catheter ablation) either on technical grounds
(polymorphic VT/VF with an anatomically unidentifiable substrate making
surgery impossible; polymorphic or rapid monomorphic VT or VF contra
indicative for catheter ablation) or because a poor left ventricular function
indicates a high surgical risk.

4. Absence of frequent VT/VF recurrences requiring defibrillation and
cardioversion. Many discharges have an unfavourable effect on the ‘quality of
life’ and lead to rapid battery depletion.

5. Life expectancy after implantation is at least one year.

Estimates of the costs of implantable-defibrillator therapy depend strongly on
the design used in the analysis.70
Implantable-defibrillator therapy has both a large up-front cost and
considerable additional costs throughout the life of the device. If the estimates
of costs and benefits used in a clinical trial are truncated at the close of the
study, the result will overestimate the cost per year of life saved. Long term
data from the meta-analysis 26 of the results of the AVID, CASH, and CIDS
trials suggest that the survival benefits of defibrillator therapy for secondary
prevention, in comparison with those of drug therapy, decrease over time and
are negligible after about six years. Long-term economic data from trials on
the primary prevention of sudden death are not yet available.

Although complex models for the economic assessment of defibrillator
therapy have been described, the results have varied, owing to the wide range
of assumptions made regarding the risk of death from arrhythmias in the
patient population and the relative effectiveness of therapies examined.72-74
An economic analysis conducted by the CIDS investigators75 suggested that
the cost per year of life saved might be acceptable if implantable defibrillators
were prescribed only for persons with at least two of the following risk
factors: an age of 70 years or more, an ejection fraction of 35 percent or less,
and advanced heart failure. Others have reported similar analyses.76
In the United States, the greatest number of out-of-hospital to in- hospital
death from cardiac causes are seen in the oldest age groups; in 1999, 37.3
percent and 28.4 of 465,000 such deaths that occurred out-of –hospital or in
emergency departments were persons over 85 years of age and between 75
and 84 of age respectively.
The appropriate intervention of an intervention as expensive as implantable
cardioverter defibrillator therapy remains an unsettled issue, and one that is
influenced political, ethical, philosophical, social, economic, an medical
factors. Although some have called on manufactures to market low-cost implantable defibrillators, such marketing would require a change in the current business model, which features competition among large manufactures on the basis of technological innovation and intensive support to patients and physicians.

**COST-EFFECTIVENESS.**

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**Tests**

**Exercise tests:**

Modern exercise testing with ECG monitoring remains a cornerstone of cardiovascular evaluation, providing a valuable source for several types of information.

1. Changes in the ECG pattern—especially depression of the ST segment—indicate the presence and often the severity of myocardial ischemia.
2. When combined with ECG changes, symptoms of dyspnea and chest pain, limitation of maximum performance, and BP response provide valuable markers of the presence and severity of disease and its prognosis. Combined with the history and physical examination, a prognostic index indicative of low risk for future cardiovascular events may allow the clinician to avoid aggressive and costly procedures such as cardiac catheterisation.
3. Maximum effort tolerance is useful in gauging work and recreational limitations and for use in monitoring efficacy of treatment and in prescribing a safe exercise program.
4. Diagnostic and prognostic data derived in this way can supplement those obtained through simultaneously performed imaging techniques, ie, stress echocardiography or nuclear perfusion study.116

The stress test combined with ECG was originally used primarily for the detection of ST changes secondary to myocardial ischemia. Modern exercise testing, however, is not limited to observation of these changes. Important information is derived from exercise capacity, BP response, development of arrhythmias, and whether or not symptoms such as chest pain develop during exercise. This allows for assessment of presence and severity of ischemia, prognosis, overall functional capacity, and efficacy of therapeutic interventions. Although stress testing is often combined with radionuclide or echocardiographic imaging.

The major indications for performing a stress test are summarized in Table 1. Table 2 lists the generally accepted contraindications for such testing, as adapted from the guidelines provided by the American College of Cardiology/American Heart Association Task Force in 1997.[1]
**Table 1--Reasons for Stress Testing**

1. Diagnosis of CAD in patients with chest pain that is atypical for myocardial ischemia.
2. Assessment of functional capacity and prognosis of patients with known CAD.
3. Assessment of prognosis and functional capacity of patients with CAD soon after an uncomplicated myocardial infarction (before hospital discharge or early after discharge).
4. Evaluation of patients with symptoms consistent with recurrent, exercise-induced cardiac arrhythmia.
5. Assessment of functional capacity of selected patients with congenital or valvular heart disease.
6. Evaluation of patients with rate-responsive pacemakers.
7. Evaluation of asymptomatic men [is greater than] 40 years with special occupations (airline pilots, bus drivers, etc).
8. Evaluation of asymptomatic individuals [is greater than] 40 years with two or more risk factors for CAD.
9. Evaluation of sedentary individuals (men [is greater than] 45 years and women [is greater than or equal to] 55 years) with two or more risk factors who plan to enter a vigorous exercise program.
10. Assessment of functional capacity and response to therapy in patients with ischemic heart disease or heart failure.
11. Monitoring progress and safety in conjunction with rehabilitation after a cardiac event or surgical procedure.

**Table 2--Contraindications to Stress Testing**

1. Very recent acute myocardial infarction (generally [is less than] 3-4 days).
2. Angina pectoris, which is unstable or present at rest.
3. Severe symptomatic or unstable left ventricular dysfunction.
4. Potentially life-threatening cardiac dysrhythmias.
5. Acute pericarditis, myocarditis, or endocarditis.
6. Acute pulmonary embolus or infarction.
7. Severe aortic stenosis.
8. Noncardiac illness that precludes physical exertion, ie, acute thrombophlebitis or deep vein thrombosis, serious general illness, dissecting
aneurysm, neuromuscular or arthritic conditions, and inability or lack of desire or motivation to perform the test.

Safety of exercise testing

Stress testing is a relatively safe procedure. Before 1980, an overall mortality rate of 1 in 20,000 tests was observed. In the contemporary era, however, this frequency has been found to be even lower, generally less than 1 in 50,000.[2] Nonfatal complications, such as myocardial infarction, occur at the rate of less than 4 per 10,000 tests.[2] In subjects with histories of ventricular tachycardia or fibrillation, serious but nonfatal arrhythmias occurred during 2.3% of the tests.[3] In the absence of such a history, the incidence of such complications is approximately 0.05%.

Types of stress test

The most commonly performed stress test is the graded exercise test, using either the treadmill or cycle ergometer. The patient is generally subjected to increasing workloads at 2- or 3-min intervals. The test is stopped for any of the reasons listed in Table 3. The ECG is monitored not only during exercise but also afterward, for 5 to 11% of patients with abnormal responses may not display such findings until reaching the recovery period[4,5] (see below).

Table 3--Indications for Terminating Exercise Testing

1. Drop in systolic BP of greater than 10 mm Hg from baseline BP despite an increase in work load, especially when accompanied by symptoms or signs of ischemia.

2. Moderate-to-severe angina.

3. Increasing nervous system symptoms (eg, ataxia, dizziness, or near syncope).

4. Signs of poor perfusion (cyanosis or pallor).

5. Maximum fatigue or patient's desire to stop.
6. Sustained ventricular tachycardia, increasing multifocal ventricular ectopy, supraventricular tachycardia, heart block, or bradyarrhythmias.

7. ST elevation ([is greater than or equal to] 1.0 mm) in leads without diagnostic Q waves (other than AVR).

8. Excessive ST depression ([is greater than] 2 mm horizontal or downsloping), especially if accompanied by chest pain or other signs of ischemia.

9. Excessive BP rise ([is greater than] 250 mm Hg systolic aim [is greater than] 115 mm Hg diastolic).

The protocol used for treadmill testing varies among different institutions. One of the most widely used is that of Bruce and Hornsten,[6] but the procedure may be customized to allow for 6 to 12 min of exercise.[7] A modified version of this protocol is detailed in Table 4 and is especially useful because it facilitates extrapolation from maximum treadmill performance to levels of work and recreational activity. It also allows for estimation of severity of cardiac decompensation (New York Heart Association classes). The estimated workload is reported in metabolic equivalents (METs), a unit that facilitates comparison of different exercise protocols as well as allowing for comparison with work or recreational effort requirements. This term actually represents the energy cost of activity in multiples of resting oxygen consumption (1 MET = 3.5 mL/kg/min). Inasmuch as oxygen consumption is determined primarily by cardiac output in the absence of pulmonary or skeletal limitations, this information allows for rough estimates of cardiac function. Although oxygen uptake is not actually measured in most clinical laboratories, one can estimate these approximate values simply by consulting published information derived from the various treadmill workloads. Increasing age and deconditioning reduce normal maximum values, so in some clinics, the test is stopped at an arbitrary target point of 85% of the predicted maximal heart rate for the subject's age. This maximal rate is estimated by subtracting the subject's age from 220. This practice is no longer recommended in favor of stressing individuals to the point of exhaustion or the development of warning signs or symptoms (Table 3).[1] If the subject can continue, I usually terminate the test on reaching 100% of the expected maximum heart rate for age.
<table>
<thead>
<tr>
<th>Treadmill Level</th>
<th>METS (Approx.)</th>
<th>Class (NYHA)</th>
<th>Equivalent Environmental Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.7 mph 0% grade</td>
<td>1.8</td>
<td>IV</td>
<td>Minimal: wash/shave, dress, desk work, writing, sewing, piano playing, walk 1.5 mph</td>
</tr>
<tr>
<td>1.7 mph 5% grade</td>
<td>3</td>
<td>III</td>
<td>Very light: drive car, clerical and assembly work, shuffleboard, billiards, walk 3 mph</td>
</tr>
<tr>
<td>1.7 mph 10% grade</td>
<td>5</td>
<td>II</td>
<td>Light: clean windows, rake, wax floors, paint, stock shelves, light welding and carpentry, golf, dancing (waltz), table tennis, walk 3.5 mph</td>
</tr>
<tr>
<td>2.5 mph 12% grade</td>
<td>7</td>
<td>I</td>
<td>Moderate: light gardening, lawn mowing (level), slow stair climbing, exterior carpentry, doubles tennis, badminton, walk 4 mph</td>
</tr>
<tr>
<td>3.4 mph 14% grade</td>
<td>9-10</td>
<td>0</td>
<td>Heavy: saw wood, heavy shoveling, tend furnace, moderate stair climbing, canoeing, fencing, singles tennis, jogging 5-6 mph</td>
</tr>
<tr>
<td>4.2 mph 16% grade</td>
<td>11-12</td>
<td>0</td>
<td>Very heavy: carry loads upstairs, rapid stair climbing, heavy labor, racquetball, basketball, ski touring, run 6 mph</td>
</tr>
</tbody>
</table>
The ECG and BP are monitored throughout exercise and for several minutes thereafter. In most instances, the test may be conducted by a properly trained nonphysician,[2] especially with subjects at low risk for cardiac events. In subjects at high risk, ie, with chest pain suggestive of angina pectoris or with known heart disease, a physician should be in attendance or in close proximity during the test. In all instances, a physician should be near enough to be readily available should there be an emergent need.

**6.minute walk test (6MWT)**


According to the ATS, the most popular clinical exercise tests in order of increasing complexity are stair climbing, a 6MWT, a shuttle-walk test, detection of exercise-induced asthma, a cardiac stress test, and a cardiopulmonary exercise test. The ATS states that the 6MWT is easy to administer, better tolerated, and more reflective of activities of daily living than the other tests. Because most activities of daily living are performed at submaximal levels of exertion, the test may better reflect the functional exercise level for daily physical activities.

The 6MWT can be used to measure the response to medical interventions in patients with moderate to severe heart or lung disease, as well as a one-time measure of functional status of patients and a predictor of morbidity and mortality.

The ATS points out that the test should be performed in a location where a rapid, appropriate response to an emergency is possible. A crash cart should be within easy access, and a telephone or other device should be in place to enable a call for help. Physicians are not required to be present during all tests. The physician ordering the test or a supervising laboratory physician may decide whether physician attendance at a specific test is required. However, the person administering the test should be certified in cardiopulmonary resuscitation (CPR) with a minimum of Basic Life Support by an American Heart Association-approved CPR course. Finally, if patients are receiving chronic oxygen therapy, oxygen should be given at their standard rate or as directed by a physician or a protocol.
Most 6MWTs can be done before and after intervention, and the primary question to be answered after both tests have been completed is whether the patient has experienced a clinically significant improvement. With a good quality-assurance program, with patients tested by the same technician, and after one or two practice tests, short-term reproducibility of the distance walked in the 6MWT can be excellent.

QOL Questionnaires:

There seems to be little consensus in the literature regarding the definition of QOL (Duits, Boeke, Taams, Passchier, & Erdman 1997; Frisch, 1998; Lukkarinen & Hentinen, 1998). Frisch (1998) defines QOL as being synonymous with life satisfaction and states that QOL “refers to a person’s subjective evaluation of the degree to which his or her most important needs, goals, and wishes have been fulfilled”. Moreover, health-related QOL is more than just a description of a patient’s health status. Gill and Feinstein (1994) define this construct as “a reflection of the way that patients perceive and react to their health status and to other nonmedical aspects of their lives”. They posit that QOL not only encompasses health-related factors (e.g., physical and mental wellbeing), but also nonhealth related elements (e.g., employment, family, friends, social functioning). Taylor (1999) states that QOL is a multidimensional construct that comprises several factors: physical functioning, psychological status, psychosocial functioning, and symptoms resulting from medical treatment. In response to the multidimensionality of QOL, several reliable and valid measures have been developed to assess individuals’ QOL (Taylor, 1999). For example, Ware, Snow, Kosinski, and Gandek (1993) developed the Short Form-36 Health Survey (SF-36) to assess general health status in patient populations. The SF-36 is a 36-item, self-report, multidimensional scale that assesses both mental and physical components of QOL. That is, the scale not only assesses patients’ physical functioning (e.g., bodily pain), but it also assesses their mental functioning (e.g., psychological distress). The scale is considered to be a generic instrument designed to be applicable to a variety of conditions, including heart disease. There are several reasons for the need to study the multidimensional healthrelated QOL of various patient populations, especially
heart patients. Taylor (1999) suggests four main reasons to assess patients’ QOL: (a) to document how illness affects the patients’ daily activities (e.g., social, vocational), (b) to help determine which types of problems are likely to emerge with particular diseases, (c) to measure the effect of treatments and interventions on QOL, and (d) to compare the impact of different treatments on QOL. Thus, assessing patients’ QOL is important in pinpointing the physical and psychosocial difficulties of patients and in evaluating the effectiveness of treatments. In summary, it is necessary to study the QOL of patient populations, in particular heart patients, given that the assessment of QOL is important both in pinpointing the physical and psychosocial difficulties of patients and in evaluating the effectiveness of their treatments (Taylor, 1999).

The most reliable QOL questionnaires for ICD patients are:

1. 10-item Implantable Cardioverter Defibrillator Quality of Life Questionnaire: the objective of this questionnaires is to assess Cardioverter Defibrillator tolerance and effects of its implantation on patients’ current well-being
2. 8-item Implantable Cardioverter Defibrillator-specific Quality of Life Questionnaire: to assess the psychological profile of patients with malignant ventricular tachyarrhythmias
COMPREHENSIVE CARDIAC REHABILITATION PROGRAM

Comprehensive cardiac rehabilitation program following an acute cardiac event has been advocated by both the World Health Organisation and the NHFA for the past 5 years. The statements from these organisations are based on published research findings that attendance at cardiac rehabilitation can reduce subsequent mortality and in long-term programs alter risk factors for ongoing coronary disease.

The program is designed to provide medical evaluation, prescribed and monitored exercise, cardiac risk factor modification methods, education and counseling. The goal is to improve the overall health and physical condition and to reduce morbidity and mortality. Medical personnel trained in emergency treatment supervise cardiac rehabilitation and monitor the individual by electrocardiographic (ECG) equipment.

Program Goals

Cardiac Rehabilitation is recommended for individuals who are recovering from a heart attack or heart surgery, who have chest pain, or who have several risk factors for heart disease. Benefits of participation include modification of cardiac risk factors, increased capacity for daily activity and a better understanding of heart disease.

Our ultimate goal is to offer participants a professional and motivational atmosphere where they can reach their full potential. Roper and Bon Secours break this goal down into four phases.

Exercise training program

12 week CCR programme on exercise capacity and psychosocial functioning.

Exercise testing
Exercise tolerance was assessed using a symptom limited treadmill exercise test with a continuous 12 lead ECG and regular blood pressure monitoring. A modified Kattus protocol16 was used, starting at 1.6 km/h (1.0 mph) with increments of 0.8 km/h (0.5 mph) every two minutes up to a maximum of 7.2 km/h (4.5 mph) at a constant gradient of 10%. The incremental stages were shortened from three to two minutes in order to increase the workload more
rapidly and reduce the likelihood of patient fatigue becoming the test end point. It was intended to determine the patients’ ability to perform aerobic exercise ideally for a minimum of six minutes in order to plan their exercise regimens.

Aerobic training was performed 2 days/week at an intensity of 70–85% maximal heart rate for 40 minutes (10 minutes warm-up/cool down plus 30 minutes of treadmill walking or cycle ergometers). To ensure patient safety, continuous ECG (telemetry) and intermittent blood pressure measurements were acquired while exercising during the first 2 weeks of training. Subjects were also encouraged to perform "unsupervised" home exercise training (totalling 4–5 days/week) after completing the second week of the program. Approximately 25% to 30% of the patients were also prescribed light to moderate resistance training as part of their program. More specifically, after completing 4–6 aerobic training sessions, patients performed two circuits (10 repetitions/set) using the following exercises using free weights (chest flys, pullovers, side raises, bent over flys, arm curls and tricep extensions). Patients were encouraged to gradually increase the number of repetitions to 15 before a third circuit was added. Finally, as part of the overall program, a series of 5 weekly education classes that addressed a wide variety of heart-health lifestyle topics was provided.
## META-ANALYSIS

<table>
<thead>
<tr>
<th>Study (Ref)</th>
<th>Method</th>
<th>Participants</th>
<th>Notes</th>
<th>score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fichet et al. 2003</td>
<td>RCT, No information about blinding</td>
<td>16 patients with ICD’s, they randomized the group among 73 patient’s with ICD of the Manchester Heart Centre</td>
<td>Comprehensive Cardiac Rehabilitation appears to be safe for patients with ICD’s, they can improve exercising ability and lower the levels of psychological distress</td>
<td>Score: 61</td>
</tr>
<tr>
<td>Vanhees et al. 2001</td>
<td>No RCT, Preliminary study to compare exercise performance and the effect of exercise training in cardiac patients with and without ICD</td>
<td>8 patients, from the ambulatory cardiac rehabilitation of the University Hospitals of Leuven, with ICD and 16 without performed maximal exercise testing before starting the rehabilitation program and were reevaluated after 3 months</td>
<td>According to the authors exercise performance and the favorable response to a 3 month exercise training program are comparable in patients with and without ICD. Tachyarrhythmias during exercise and training requires special attention</td>
<td>Score: 59</td>
</tr>
<tr>
<td>Study</td>
<td>Type of Study</td>
<td>Participants</td>
<td>Key Findings</td>
<td>Score</td>
</tr>
<tr>
<td>------------------------------</td>
<td>---------------</td>
<td>--------------</td>
<td>------------------------------------------------------------------------------</td>
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</tr>
<tr>
<td>Friedman et al. 1996</td>
<td>No RCT</td>
<td>2 patients</td>
<td>Cardiac rehabilitation can improve cardiovascular performance as well as give the patient confidence. Physicians need to carefully evaluate these patients for both atrial and ventricular arrhythmias.</td>
<td>13</td>
</tr>
<tr>
<td>Menard-Rothe et al. 1986</td>
<td>No RCT</td>
<td>2 patients</td>
<td>Patients with ICD should be considered to participate in phase I and II of cardiac rehabilitation. Psychologic benefits are very valuable.</td>
<td>25</td>
</tr>
</tbody>
</table>
**DISCUSSION**

The main findings of this study are that comprehensive cardiac rehabilitation of patients with ICDs produces improvement in exercising ability and reduces levels of anxiety and depression.

Patients with ICDs comprise one group that has not been offered comprehensive rehabilitation to date. Indeed patients with a history of ventricular arrhythmias have been excluded from the exercise components of CCR programmes because of safety concerns. However, most published work to date concerns maximal exercise tests in order to assess ischaemic heart disease burden, predisposition to arrhythmias, or efficacy of antiarrhythmic drug treatment. Significant rates of ventricular arrhythmias have resulted.

The aim of our CCR is exercise training and not diagnosis. The prescribed exercise is aerobic and individually tailored in order to avoid the extra adrenergic load and predisposition to arrhythmias that maximal exercise would produce.

A small amount of work has been published on exercising patients with ICDs. Friedman and colleagues reported cases of two ICD patients benefiting physically and psychologically from attendance at a cardiac rehabilitation programme. They recommended deactivation of the device during exercise testing. Lampman and colleagues also recommended deactivation of the ICD during baseline exercise testing before prescribing exercise.

In contrast, we believe that all exercise should be performed with the ICD activated in order to reinforce positive feedback that such exercise is safe and can be continued away from the controlled environment of the CCR programme.

A graduated “cool down” period was built into each patient’s exercise tests, with exercise being terminated abruptly only if clinical circumstances dictated. Cool down was also implemented during supervised exercise and encouraged when exercising in the community. A gradual “cool down” rather than abrupt cessation of exercise may offer a degree of protection to susceptible individuals. Observational evidence for this is provided by a survey of 71,914 maximal exercise tests performed at a single medical centre between 1971 and 1987. Six major cardiac complications, including one death, occurred in the period before 1979, following which a “cool down” period of three minutes for normal tests and five minutes for abnormal tests was introduced. No complications occurred in the ensuing 45,000 tests over the next 10 year period.

Significant improvements in exercise time were seen following attendance at the CCR programme and were maintained for at least 12 weeks afterwards. It is likely that improvements in both physical and psychological status provided positive feedback to enhance one another and increase exercising ability.
An improvement in cardiorespiratory function was suggested by the increases in exercise time seen without increase in heart rate or rate of perceived exertion. However, as neither cardiovascular nor ventilatory function was formally assessed, their contribution to the reduction of anxiety resulting from physical training is unclear. When formally measured, improvements in cardiorespiratory function and exercise time have been demonstrated following maximal exercise training in patients with controlled heart failure.\textsuperscript{116}

The exercise testing component of the CCR was labour intensive, requiring a technician, a specialist physiotherapist, and a cardiologist. Exercise tests were essential in planning exercise regimens and appeared to provide reliable exercise times on the second test.

Psychological benefits Increased levels of anxiety and depression have been described in between 20–58\% of patients after ICD implantation.\textsuperscript{117}. It is likely that reductions in psychological distress played a significant role in the patients’ enhanced functional status. Such reductions probably reflected a combination of positive feedback resulting from an enhanced ability to exercise and psychological support/intervention. Kohn and colleagues reported a reduction in trait anxiety and major depressive episodes with cognitive behavioural therapy alone after ICD implants.\textsuperscript{116}

Benefits of support groups Following ICD implantation, many patients report subjective benefit from attendance at patient support groups, but objective evidence of this is lacking. This suggests that psychological benefits gained from structured CCR are above and beyond those from supportive therapy alone.
Conclusion and future recommendations:

The ICD represents an important advance in the prevention of SCD, and there is great temptation to extend the indications for its use beyond what has been demonstrated. Compared with conventional antiarrhythmic drugs or best medical care, the ICD reduces mortality rates in certain patient at risk for SCD, those with ischemic LV dysfunction, and spontaneous or inducible life-threatening arrhythmias with the magnitude of benefit related to the severity of LV dysfunction 120,121. However, data on exercise performance and the effect of exercise training in patients with an implantable cardioverter-defibrillator (ICD) are extremely scare. Some reports with special consideration and recommendations for maximal exercise testing and training in with malignant ventricular arrhythmias and ICDs have been published.93,94 Other studies report mainly on the safety and feasibility of physical activity and on exercise-related complications in patients with malignant ventricular arrhythmias. 95,96 To our knowledge, small amount of work has been publish on exercising patients with ICDs. Kathryn Menord-Rother and colleagues in the year 1986 concluded after a study with 40 subjects that patients with an AICD are able to participate in phases I and II of the cardiac rehabilitation. 97 Also stated that cardiac rehabilitation helps ICDs patients to increase their functional capacity and also to reinforce self-pulse monitoring during exertional activities as well as helps the patient to achieve a better understanding of and confidence their exercise and activity abilities.

Ten years later, Friedman and colleagues, reported cases of two ICD patients benefiting physically and psychologically form attendance at a cardiac rehabilitation programme 98. They recommend deactivation of the device during exercise testing. Lampman and colleagues also recommended deactivation of the ICD during baseline exercise testing before prescribing exercise 7.

Vanheess and colleagues compared an exercise performance and the effect of exercise training cardiac patients with (n= 8) and without (n=16) an implantable cardioverter-defibrillator 99. Unfortunately, one ICD patient developed uneventful ventricular tachycardia at the end of the post-training exercise test, and another during training. They concluded that selected patients with ICD can be encouraged to participate in medically supervised exercise training programs.
Lastly, in the present year, Fitchet and colleagues investigated the effects of a 12 week comprehensive cardiac rehabilitation (CCR) programme on patients who have undergone implantation of the device 100. No ventricular arritmias or ICD discharges occurred during the exercise components of the CCR. Furthermore, they concluded that not only the CCR appeared to be safe patients with ICDs it also can improve exercising ability and lower the levels of psychological distress. Therefore, under careful supervision, automatic implantable cardioverter defibrillator patients can participate in specific rehabilitation exercises programs that could lead to similar benefits as in other cardiac patients. However, more studies with larger patients groups must be evaluated further to confirmed this study.
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GLOSSARY

- **Testing**
  - Arrhythmia: dysrhythmia or abnormal heart rhythm
  - Balke-type protocol: constant speed (2.0 to 3.0 miles/hour), variable grade treadmill exercise test
  - Bruce-type protocol: variable speed and grade treadmill exercise test (incremental speed and grade increase every 3 minutes)
  - CAD (coronary artery disease): coronary heart disease, MI, CABG, coronary angioplasty, and myocardial ischemia
  - Calories (kilocalorie): amount of energy required to raise temperature of 1 kg of water by 1°C Calories/min: (METs x body weight in kilograms)/200
  - Exercise capacity: functional capacity, training, or conditioning level; level of fitness
  - Isometric/static exercise: muscle contraction with no movement (see “resistance exercise” below)
  - Isotonic/dynamic exercise: muscle contraction producing movement
  - J-junctional (J-point) depression: depression at the beginning of ST segment
  - Kilopond-meter (kpm): kilogram-meter of work 51 J (10 ergs)
  - MET: metabolic equivalent (3.5 mL · kg⁻¹ · min⁻¹ of oxygen uptake) 0.1 mV 51 mm (provided calibration is set at 10 mm/mV)
  - Predictive value: percentage of those with or without disease who are identified correctly
  - PTCA: percutaneous transluminal coronary angioplasty
  - Rating of perceived exertion: Borg scale of 6 to 20 or 1 to 10
  - Resistance exercise: muscle contraction with limited movement
❖ Sensitivity: percentage of persons who have disease who will have a positive test

❖ Specificity: percentage of persons who do not have disease who will have a negative test

❖ ST depression: horizontal or downsloping (0.10 mV/ms) segment, measured from isoelectric PR level

❖ Training: physical activity and conditioning leading to fitness

❖ Ventilatory threshold: a measure of relative work effort that represents the point at which ventilation abruptly increases despite linear increases in oxygen uptake

❖ V̇ O₂: oxygen uptake

❖ V̇ O₂ max: maximal oxygen uptake

- Training

❖ Aerobic: exercise in which energy needed is provided by using oxygen inspired to combust metabolites

❖ Anaerobic: exercise in which energy needed exceeds oxidative processes and non-aerobic metabolism begins

❖ Cardiac output: volume of blood ejected from heart in liters per minute (normal is 4 to 6 L/min at rest, depending on body size)

❖ Cardiovascular exercise: predominantly dynamic exercise using large-muscle groups Ejection fraction: ratio of LV stroke volume to end-diastolic volume (or percentage of end-diastolic volume ejected with each cardiac contraction); normal is 60% to 75%

❖ Flexibility activity: activity designed to enhance range of motion of joints

❖ Medical supervision: physician readily available (the presence of a properly trained nurse in the exercise room is acceptable if physician is not available in the exercise room)
NYHA class: New York Heart Association classification
Class 1: heart disease without symptoms
Class 2: heart disease with symptoms during ordinary activity
Class 3: heart disease with symptoms during less than ordinary activity
Class 4: heart disease with symptoms at rest

Occupational activity: on-the-job activity, such as a job requiring lifting of loads 20 pounds at least hourly throughout the day or constantly moving any size load from place to place without mechanized aid

Strength activity: muscular contraction against resistance designed to increase skeletal muscle strength

Stroke volume: amount of blood ejected from the heart with each contraction; normal is 80 to 90 mL at rest in a 70-kg man