The Changing Epidemiology of Sudden Cardiac Death

Avi Fischer and Valentin Fuster

Sudden cardiac death (SCD) is a devastating complication of myocardial infarction. The global incidence of coronary artery disease and heart failure has been increasing greatly in recent years. As a consequence, there is expected to be an increase in the incidence of SCD manifesting as a shared worldwide public health problem. This article summarizes SCD epidemiology, with a focus on the anticipated global rise in incidence.

Advances in Cardiopulmonary Resuscitation

Demetris Yannopoulos, Kostantinos Kotsifas, and Keith G. Lurie

This article focuses on important advances in the science of cardiopulmonary resuscitation (CPR) in the last decade that have led to a significant improvement in understanding the complex physiology of cardiac arrest and critical interventions for the initial management of cardiac arrest and postresuscitation treatment. Special emphasis is given to the basic simple ways to improve circulation, vital organ perfusion pressures, and the grave prognosis of sudden cardiac death.

Public Access Defibrillation

Robert W. Rho and Richard L. Page

In the United States, 250,000 people die from a cardiac arrest every year. Despite a well established emergency medical response system, survival from out-of-hospital cardiac arrest remains poor in United States cities. Paramount to achieving successful resuscitation of a cardiac arrest victim is provision of early defibrillation. Among patients that arrest due to a ventricular fibrillation, the likelihood of survival decreases by 10% for every minute of delay in defibrillation. In 1995, the American Heart Association challenged the medical industry to develop a defibrillator that could be placed in public settings, used safely by lay responders, and provide earlier defibrillation to cardiac arrest victims. Over the last decade, there have been significant technological advancements in automated external defibrillators (AEDs), and clinical studies have demonstrated their benefits and limitations in various public locations. This article discusses the technologic features of the modern AED and the current data available on the use of AEDs in public settings.
communities to make sure these links function in an efficient, timely, and coordinated fashion. This article reviews how quality is defined for each link, how communities can strengthen each link, and how communities can forge a strong relationship between each link. By optimizing local leadership and stakeholder collaboration, communities have the potential to vastly improve outcomes from this devastating disease.

Risk Stratification for Sudden Cardiac Death: The Need to Go Beyond the Left Ventricular Ejection Fraction

Devi Gopinath and Otto Costantini

Sudden cardiac death (SCD) accounts for as many as 450,000 deaths yearly in the United States. Over the last 15 years, many clinical trials have established the effectiveness of an implantable cardioverter-defibrillator (ICD) in reducing sudden and total mortality in patients with structural heart disease. However, controversy remains about exactly how to identify the patients most likely to benefit from an ICD, as well as those who may safely do without an ICD implant. The first primary prevention ICD trials used an abnormal electrophysiological study in addition to a low left ventricular ejection fraction (LVEF) as high-risk markers for SCD. More recent ICD trials selected patients based on the presence of a low LVEF alone. Ideally, noninvasive electrophysiological markers that more directly reflect arrhythmia substrates may better identify patients for prophylactic ICD implant. Several of these markers have been associated with the risk of SCD, but all have yielded contradictory outcome results or have not been tested prospectively. This review focuses on the most promising tests to date, their clinical significance, and their possible use to improve efficacy and efficiency of risk stratification for SCD.

End-Stage Renal Disease and Sudden Cardiac Death

Rahul Sakhuja, Ashok J. Shah, Swapnil Hiremath, and Ranjan K. Thakur

Patients with end-stage renal disease (ESRD) are at a high risk for sudden cardiac death (SCD). SCD is the most common cause of death in this population and, as in the general population, ventricular arrhythmias seem to be the most common cause of SCD. The increased risk of SCD in ESRD is likely due to factors that are unique to the metabolic derangements associated with this state, as well as the increased prevalence of traditional risk factors. Despite this, the evidence base for the assessment and management of SCD in these patients is limited. This article reviews the current data on underlying risk factors for SCD in patients with ESRD, the role of common medical and device-based therapies for the prevention and treatment of SCD, and the applicability of common methods of risk stratification to patients with ESRD.

Implantable Cardioverter Defibrillator in Patients with Coronary Artery Disease

Ilan Goldenberg and Arthur J. Moss

Patients with ischemic left ventricular dysfunction are at a high risk for ventricular tachyarrhythmias and sudden cardiac death. Randomized clinical trials have demonstrated that pharmacologic management with antiarrhythmic drugs has limited efficacy for the prevention of arrhythmic mortality in this high-risk population, whereas the implantable cardioverter defibrillator (ICD) has significant life-saving benefit in primary and secondary prevention trials. However, secondary analyses of these studies have identified some limitations of the ICD in subsets of patients with coronary artery disease, including limited defibrillator efficacy early after coronary revascularization and acute myocardial infarction. We review current knowledge from
primary and secondary prevention clinical trials regarding the benefit and limitations of the ICD in high-risk patients with coronary artery disease.

**Implantable Cardioverter Defibrillator Therapy for Primary Prevention of Sudden Cardiac Death—an Argument for Guideline Adherence**

Eric N. Prystowsky, Richard I. Fogel, Benzy J. Padanilam, and David Rardon

Sudden cardiac death is the leading cause of death among adults in the United States. Multiple randomized controlled trials have provided clear-cut data on appropriate subgroups of patients whose survival has improved through primary prevention therapy with an implantable cardioverter defibrillator. Current guidelines specify a class I indication in patients with reduced left ventricular ejection fractions with both ischemic and nonischemic cardiomyopathy under various conditions. Cardiac resynchronization therapy has also been demonstrated to reduce mortality in selected patient subgroups and should be combined with an implantable cardioverter defibrillator in appropriate patients. Adherence to these guidelines should result in a reduction in sudden-death mortality.

**Implantable Cardioverter-Defibrillator Therapy for Primary Prevention of Sudden Cardiac Death: an Argument for Restraint**

Roderick Tung and Mark E. Josephson

Although it is estimated that a total of 220,000 patients undergo implantable cardioverter-defibrillator (ICD) implantation per year, only 10% to 20% of these patients experience life-saving therapy; this leaves up to 90% of the targeted population as “nonresponders,” who do not derive clinical benefit but incur all of the risks from ICD implantation. This article reviews the landmark primary prevention trials to assess the incidence of sudden death and the absolute magnitude of benefit derived from ICD therapy. The discrepancy between trial patients and real-world implementation of ICD therapy is examined, and the potential for risks incurred from ICD implantation is presented. The natural history of patients who receive appropriate ICD therapy and the durability of ICD benefit with respect to cost-effective analyses are discussed, to support the authors’ position that ICD therapy should not be routinely used for the primary prevention of sudden cardiac death.

**Development and Industrialization of the Implantable Cardioverter-Defibrillator: A Personal and Historical Perspective**

Robert G. Hauser

The implantable cardioverter-defibrillator (ICD) is the standard of care for preventing sudden cardiac death. Contemporary ICDs are capable of providing a variety of therapeutic functions and can automatically gather and store diagnostic data that can guide both device and drug therapy and alert caregivers of impending battery depletion or lead problems. Moreover, much of the diagnostic data can be monitored remotely, so that many patients can be evaluated in their homes. This article, by a former chief executive officer of the first company to commercialize the ICD, traces the history of the device from its beginnings in the early 1980s.

**The Wearable Cardioverter Defibrillator—Bridge to the Implantable Defibrillator**

Helmut U. Klein, Iwona Cygankiewicz, Christian Jons, Frank Buhtz, and Steven Szymkiewicz

The wearable cardioverter defibrillator (WCD) was introduced into clinical practice about 8 years ago as an alternative approach to protect patients with a temporary high risk of sudden arrhythmic death. The WCD has the characteristics of an implantable defibrillator (ICD) but does not need to be implanted, and it has
similarities with an external defibrillator, but does not require a bystander to apply lifesaving shocks when necessary. Based on current clinical experience, the WCD is not an alternative to the ICD, but a device that will contribute to better selection of patients for ICD therapy and may be indicated in case of interrupted protection by an already implanted ICD, temporary inability to implant an ICD, or refusal of an indicated ICD.

Subcutaneous Implantable Cardioverter-Defibrillator Technology

Anurag Gupta, Amin Al-Ahmad, and Paul J. Wang

The advent of subcutaneous implantable cardioverter-defibrillator (ICD) systems represents a paradigm shift for the detection and therapy of ventricular tachyarrhythmias. Despite advances in transvenous lead technology, problems remain that notably include requirement for technical expertise; periprocedural complications during implantation and explantation; and long-term lead failure. Although subcutaneous ICD systems may mitigate some of these risks, they provide new shortcomings, such as inability to provide pacing therapy for bradyarrhythmias, ventricular tachyarrhythmias, and cardiac resynchronization. Ongoing clinical evaluation and development are required before the role of subcutaneous ICDs as an adjunctive or primary therapy can be defined. This article examines studies investigating the subcutaneous ICD and discusses its possible advantages and disadvantages as compared with current transvenous ICD systems.

Inappropriate Implantable Cardioverter-Defibrillator Therapy

Sivakumar Ardhanari, Ashok J. Shah, Nitesh Gadeela, and Ranjan K. Thakur

Although improvements in implantable cardioverter-defibrillator (ICD) therapy have taken place, many challenges do remain. Inappropriate delivery of therapy is a big problem that impacts the quality of life of ICD recipients. Although there is now a clear understanding that atrial arrhythmias are the main cause of inappropriate ICD therapies, physicians have not been very successful in preventing them. Additionally, although many tachycardia detection discriminators have been shown to be helpful, it is not clear that there is a particular combination that is ideal for all patients. Until such an algorithm is developed (which may not be possible), a detailed knowledge and use of all available programming options, guided by special characteristics of each unique patient, are the only foreseeable solutions. Finally, one must face the prospect that this problem cannot be vanquished, but only ameliorated.

ICD Lead Design and the Management of Patients with Lead Failure

Gautham Kalahasty and Kenneth A. Ellenbogen

The implantable cardioverter defibrillator (ICD) lead is critical to the function of the ICD system. The mortality reduction associated with ICDs implanted for primary prevention indications has been made possible by the development of effective and reliable transvenous ICD leads. Mortality rates for implantation of transvenous ICD lead systems are currently less than 0.5%. The reliability and functional characteristics of a lead are often not known until it has been in widespread use. An understanding of the mechanism of lead failure is essential for proper patient management. This article describes the design and construction of ICD leads, discusses lead failure, and reviews subsequent management of patients.
Remote Monitoring—The Future of Implantable Cardioverter-Defibrillators Follow-up
Michael L. Bernard, Ernest Matthew Quin, and Michael R. Gold

Remote monitoring has developed out of the need to accommodate the demand of the growing implantable cardioverter-defibrillator (ICD) and cardiac resynchronization therapy (CRT) population. After several years of clinical use, remote device interrogation systems have demonstrated ease of use for both patient and provider, reliability compared with in-office interrogations, and the ability to detect asymptomatic but clinically significant events. The effect of remote monitoring on morbidity and mortality is currently unknown, but several trials are underway to assess these outcomes. Many devices also have the capacity to remotely track physiologic parameters that may improve the management of heart failure. Remote monitoring of ICD-CRT populations is a promising technological advancement that likely will become the standard of care for ICD follow-up.

Ventricular Tachycardia Ablation—For Whom, When, and How?
Conor D. Barrett, Luigi Di Biase, Miguel Vacca, Luis Carlos Saenz, J. David Burkhardt, Jeremy N. Ruskin, and Andrea Natale

This article discusses how ventricular tachycardia ablation should be used, discusses which patients may derive benefit from this treatment, and highlights the best means of implementing it.

Index