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Commentary

New Developments in Cardiac Arrhythmias Diagnosis

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DESCRIPTION

Cardiac arrhythmias are the world's leading cause of death and inflict a significant pressure on the healthcare system. About 20% of all deaths each year are reportedly caused by sudden cardiac death, which is an extremely high number and represents the earliest sign of cardiac arrhythmias. Furthermore, concomitant conditions like hypertension, ischemic heart disease, valvular cardiomyopathy, and an elevated risk of stroke are frequently present in people who are prone to atrial tachy-arrhythmias such atrial flutter and fibrillation. Medical devices like pacemakers and implantable defibrillators, which try to restore normal heart rhythm, have become increasingly common as a result of technological advancements in electrical stimulation and sensing modalities.

However, forecasting the development of arrhythmias and preventing the change from steady state to unstable rhythms has proven to be a very difficult endeavour due to the complicated spatiotemporal dynamics and non-linearity of the human heart. Although implantable cardioverter defibrillators continue to be the principal clinical intervention for deadly ventricular arrhythmias, patients frequently experience inappropriate shocks as a result of false positives and a decreased quality of life. Here, we set out to provide a thorough analysis of recent developments in cardiac arrhythmia prediction, prevention, and control tactics. In addition to outlining intriguing possible pacing approaches for efficiently anticipating the beginning of aberrant rhythms and managing cardiac arrhythmias, we also present an overview of conventional clinical arrhythmia care techniques.

One of the main causes of death globally, Sudden Cardiac Death (SCD) brought on by cardiac arrhythmias results in around 300,000 deaths per year in the United States alone. Although not fatal, atrial tachyarrhythmias (abnormally faster atrial activation rates) like atrial flutter and Atrial Fibrillation (AF) are linked to serious complications. The most common of these complications is thromboembolic (cerebral, extremities, or visceral), which increases the risk of strokes, limb ischemia, organ infarctions, and consequently, hospitalizations. Bradyarrhythmias, or unusually slow heart rhythms, that result from problems with the atrial conduction pathways may cause morbidity or advance to SCD by causing VT or asystole. On the other hand, the main cause of SCD, Ventricular Tachyarrhythmias (VT/VF), can be fatal and call for prompt therapeutic care.

Arrhythmias, either atrial or ventricular, currently affect 1.5-5% of the general population. With new pacing strategies being developed to apply electrical stimulations for the prevention and suppression of arrhythmias, the past ten years have witnessed an abundance of medical devices seeking to restore normal heart rhythm. Numerous electrical stimulation approaches have been developed and put into practice for the management of arrhythmias, ranging from cardiac resynchronization therapy and implantable defibrillators to anti-tachycardia pacing and innovative pacemaker algorithms. Traditional non-physiological pacing from the right ventricular apex has shown effective in treating bradyarrhythmias, but it has deleterious hemodynamic effects due to dyssynchronous ventricular contraction that put patients at risk for developing AF, cardiomyopathy, Heart Failure (HF), or even dying.

Technical difficulties prevent the widespread use of physiological cardiac pacing, an alternative strategy that transmits electrical impulses through the normal conduction pathway and has demonstrated a relative risk reduction of 27% for newly developing chronic AF when compared to ventricular pacing. The sino-atrial node's inability to raise the heart rate to accommodate shifting metabolic needs is known as chronotropic incompetence. Technological advancements in pacing have made rate responsive or adaptive pacing possible. The majority of contemporary adaptive pacing devices incorporate sensors to identify physiological or physical activity indicators and mimic a typical sino-atrial nodal response.

The spatiotemporal and anatomical complexity of the human heart makes it difficult to create algorithms that can successfully control heart rate and avoid deadly arrhythmias, despite advancements in cardiac arrhythmia therapy techniques. Additionally, although Implantable Cardioverter Defibrillator (ICD) shocks and anti-tachycardia pacing techniques can shield people from fatal arrhythmias, excessive and inappropriate pacing or shocks have negative effects, including impaired myocardial contraction that causes systolic dysfunction, progressive HF, futile drug therapy, pro-arrhythmogenicity, decreased quality of life, and psychological effects on the patient.

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