Review Article

Cardiac Pacing and Defibrillation in Children and Young Adults

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Abstract

The population of children and young adults requiring a cardiac pacing device has been consistently increasing. The current generation of devices are small with a longer battery life, programming capabilities that can cater to the demands of the young patients and ability to treat brady and tachyarrhythmias as well as heart failure. This has increased the scope and clinical indications of using these devices. As patients with congenital heart disease (CHD) comprise majority of these patients requiring devices, the knowledge of indications, pacing leads and devices, anatomical variations and the technical skills required are different than that required in the adult population. In this review we attempt to discuss these specific points in detail to improve the understanding of cardiac pacing in children and young adults.

Introduction

Pediatric pacing has progressed substantially since the first implant in a 14 yr old with myocarditis in 1962 .[1] Current pacemakers have a much smaller size, longer battery life, multiple pacing and sensing modalities, and therapeutic capabilities in the form of detecting and treating tachy-arrhythmias as well improving the contractility of a failing heart. Hence there is an increasing demand for pediatric pacing devices due to increase in clinical indications, technological advances and innovative techniques. However based on the 2010 Health Care Cost and Utilization Project (HCUP) database, only 0.6% of all the implanted cardiac devices have been in the pediatric population. The number of pediatric patients receiving pacemaker implantation has been stable over the past decade; however there has been a 4-fold rise in the number of patients receiving defibrillators and biventricular devices. [2]

Indications

a. Permanent Pacemakers

The most common indications for permanent pacemaker implantation in children, adolescents, and patients with congenital heart disease are:

1) Symptomatic sinus bradycardia related to sinus node dysfunction, associated with poor cardiac output or to prevent episodes of recurrent atrial tachycardias.

2) Advanced second- or third-degree AV block, either congenital or postsurgical, when associated with low cardiac output, ventricular dysfunction, complex ventricular ectopy, syncope or potential of recovery is minimal, especially after cardiac surgery.[3]

Important considerations in children and young adults are 1) an increasing number of young patients are long-term survivors of complex surgical procedures for congenital heart defects that result in palliation rather than correction of circulatory physiology. The residua of impaired ventricular function and abnormal physiology may result in symptoms due to sinus bradycardia or loss of AV synchrony at heart rates that do not produce symptoms in individuals with normal cardiovascular physiology. Hence, the indications for pacemaker implantation in these patients need to be based on the correlation of symptoms with relative bradycardia rather than absolute heart rate criteria. 2) The clinical significance of bradycardia is age dependent; e.g. a heart rate of 45 bpm may be a normal finding in an adolescent, the same rate in a newborn or infant indicates profound bradycardia. 3) Significant technical challenges may complicate device and transvenous lead implantation in very small patients or those with abnormalities of venous or intracardiac anatomy. 4) As there are no randomized clinical trials of cardiac pacing in pediatric or congenital heart disease patients, the level of evidence for most recommendations is consensus based.

b. Implantable Cardioverter-Defibrillators (ICDs)

ICDs are recommended for patients who have survived an episode of cardiac arrest, patients with poor cardiac function with evidence of moderate to severe heart failure, patients with inducible ventricular dysrhythmia in a setting of symptomatic CHD and in patients with genetic cardiomyopathy. Sudden cardiac death (SCD) in childhood and adolescence is associated with congenital heart disease, cardiomyopathies, and genetic arrhythmia syndromes. There is paucity of clinical experience and data regarding ICD implantation for primary prevention of SCD in young patients and therefore recommendations are based on extrapolation of data from adult studies. Unexpected sudden death is reported in 1.2% to 3.0% of patients per decade after surgical treatment of tetralogy of Fallot, with risk factors including ventricular dysfunction, QRS duration, and atrial and ventricular arrhythmias.[4] A significantly greater risk of SCD has been identified for patients with transposition of the great arteries or aortic stenosis, with most cases presumed to be due to a malignant ventricular arrhythmia associated with ischemia, ventricular dysfunction, or a rapid ventricular response to atrial flutter or fibrillation.[5] The lack of prospective and randomized clinical trials precludes exact recommendations regarding risk stratification and indications for ICD implantation for primary prevention of SCD in patients with postoperative congenital heart disease and ventricular dysfunction. ICDs may also be considered as a bridge to orthotopic heart transplantation in pediatric patients, particularly given the longer times to donor procurement in younger patients.[6]

c. Biventricular pacing (Cardiac Resynchronization Therapy, CRT)

There are no randomized multicenter studies regarding use of CRT in pediatrics and young