Neonatal and Pediatric Arrhythmias
Clinical and Electrocardiographic Aspects

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KEYWORDS

• Children • Neonates • Arrhythmias • ECG • Bradycardia • Tachycardia • Pediatric arrhythmias

KEY POINTS

- Correct interpretation of an electrocardiogram in children and neonates has different principles from adults; detailed knowledge of these age-dependent changes should be well-known to avoid misinterpretation.
- It is important to know that sinus arrhythmia, ectopic atrial rhythm, "wandering pacemaker," and functional rhythm can be normal characteristics in children.
- Treatment of tachyarrhythmias in children depends on natural history, and height and weight of the patient; in small children, medical treatment can postpone transcatheter ablation.
- Bradyarrhythmias can require pacemaker implantation in children.
- Endocardial or epicardial approach should be chosen depending on the weight and the height of the patient.

INTRODUCTION

Over the last years, arrhythmias have acquired a specific identity also in the field of pediatric cardiology. Pediatric electrophysiologists provide a better diagnostic and therapeutic process, but, for general pediatric cardiologists, it has always been difficult to recognize and treat even simple arrhythmias. This article aims to describe the electrocardiographic aspects of the pediatric electrocardiogram (ECG) and most frequent cardiac arrhythmias.

ELECTROCARDIOGRAPHY IN NEONATES AND CHILDREN: WHAT IS NOT PATHOLOGIC

The basic principles of ECG interpretation in children are identical to those applied in adults. However, progressive ECG changes in anatomy and physiology, taking place between birth and adolescence, result in some features that differ significantly from the normal adult pattern and vary according to the age of the child. Correct interpretation of the ECG is, therefore, potentially difficult, and a detailed knowledge of these age-dependent changes is critically important to avoiding misinterpretation and risky errors.[1]

For example, in pediatric patients, a positive T wave in V2 to V3 can have a "camel hump" aspect, that consists of a second peak starting on the first one-half of the descending part of the T wave. This configuration is due to the particular repolarization pattern in children, which describes a "figure-of-8" pattern rotating in a counterclockwise and then a clockwise direction. The "camel hump" T wave is absent in adults as the repolarization pattern modifies with the growth.

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Sinus arrhythmia, ectopic atrial rhythm, "wandering pacemaker," and junctional rhythm can be normal characteristics in children (15%–25% of healthy children can have these rhythms at the ECG).

Sinus Arrhythmia

According to several reported studies on 24-hour ECG Holter monitoring, all normal children and young adults have evidence of sinus arrhythmia, defined as spontaneous change in adjacent cycle lengths of 100% or more.[2–4] On the ECG, an irregular rhythm can be observed, with gradual variations in PP intervals, a sinus P wave that precedes each QRS, and rates varying with phase of breathing (increase with inspiration and decrease with expiration). During increased vagal tone, sinus pauses of various degree interrupted by escape beats and/or rhythms may be detected (escape beats may be of atrial, junctional, or ventricular origin).[5]

Wandering Pacemaker

This terminology is used when the ECG shows an irregular rhythm with ongoing changes in P wave morphology, with associated changes in PP interval during more than 2 beats, often appearing during period of low heart rates. Wandering atrial pacemaker rhythm is found in 25% of healthy newborn infants, 34% of healthy 10- to 13-year-old boys; 26% of 14- to 16-year-old boys; and 54% of medical students.[1–5] Atrial ectopic rhythm is distinguished from wandering atrial pacemaker rhythm by its unchanging P wave axis/morphology.

Junctional Rhythm

Junctional beats or rhythm can be found during phases of sinus arrhythmia and, for this reason, they are common in the pediatric population. On the ECG, we can observe (1) a regular rhythm with narrow QRS (or QRS resembling the patient's normal QRS), (2) heart rates between 40 and 100 bpm (according to the age), and (3) P waves dissociated from or after each QRS (retrograde conduction). The heart rate, relative to age and activity, is fundamental in deciding whether the junctional rhythm is normal and benign or junctional tachycardia should be considered.

In particular, junctional rhythm occurs in the age group of children with more vagotonia (13% of 10- to 13-year-old boys during sleep,[6] 45% of 7- to 10-year-old children,[1] and 19% of infants).[2] Endurance athletes have a 20% incidence of junctional rhythm, as well.[7]

PEDIATRIC ARRHYTHMIAS

Physiopathology

Cardiac arrhythmias are determined by a disorder in the generation or conduction of the electrical impulse. As for adult patients, also in pediatric patients (neonates, children, and adolescents) tachyarrhythmias are caused by enhanced automaticity, triggered activity or reentry mechanism, whereas bradyarrhythmias derive from missing generation of the impulse, or a slow or blocked conduction through the specific conduction system of the heart.[8–11]

Terminology and Classification

In pediatric patients, a diagnosis of bradycardia depends on the age.[12,13] In general, bradycardia is defined, at rest and awake, as a heart rate of less than 100 bpm in children up to 3 years old, less than 60 bpm in patients 3 to 9 years old, less than 50 bpm in patients 9 to 16 years old, and less than 40 bpm for patients older than 16 years. During sleep, these cutoffs are reduced by 15% to 20%.

A first-degree atrioventricular (AV) block is diagnosed when the PQ interval is longer than the maximum limit for age (140 ms in a child <1 year old, 150 ms in 1- to 5-year-old children, 160 ms in 5- to 10-year-old children, and 200 ms in older children).

Tachycardia is defined as a sequence of 3 or more beats at a rate that is more than 25% of the sinus rate at the onset of the arrhythmia (usually 120 bpm). Tachycardia can be sustained or not sustained (lasting >30 seconds or <30 seconds), paroxysmal (sudden onset and termination), or permanent/incessant (it is present for >20% of the time in 24 hours). A tachycardia is considered supraventricular if it originates from atria and the AV junction, and ventricular if it originates below the His bifurcation.

TACHYARRHYTHMIAS

Premature Supraventricular Beats

Generally, premature supraventricular beats are an idiopathic and clinically silent cardiac arrhythmia. Premature supraventricular beats originate from the atria or the AV junction and are diagnosed occasionally (sometimes during fetal life). Supraventricular extra beats, in neonates, can determine the so-called pseudobradycardia, when conduction to the ventricles is blocked, and usually disappears during the first year of life. This arrhythmia does not need to be treated.