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# Essential ECG clues in patients with congenital heart disease and arrhythmias

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**Abstract** The prevalence of adults with congenital heart disease has dramatically increased during the last decades due to significant advances in the surgical correction of these conditions. As a result, patient's survival has been prolonged and arrhythmias have become one of the principal causes of morbidity and mortality for these patients. The surface 12-lead ECG may play a critical role in the identification of the underlying heart disease of the patient, the recognition of the arrhythmia mechanism and may also help in the planification of the ablation procedure in this setting. Finally, important prognostic information can be also obtained from the ECG in these patients. The present review will offer an overview of the principal utilities of the surface ECG in the diagnosis and management of patients with CHD and arrhythmias.

*Keywords:* Congenital heart disease; Arrhythmia; Catheter ablation

## Introduction

The surface 12-lead ECG remains as an invaluable tool for the diagnosis of patients with congenital heart disease (CHD) and arrhythmias [1,2]. During the last decades, significant medical advances have dramatically increased the survival rates of patients with CHD thus making possible that up to 90% of infants born with a congenital defect arrive to adulthood [3–6]. As a consequence of an extended survival, the incidence of arrhythmias in this population has been also significantly increased. The arrhythmia management of these patients is complex often involving an invasive approach with catheter ablation. In this context, the surface 12-lead ECG provides significant information that may help us in the management of these patients. Firstly, the basal ECG during sinus rhythm can give us important clues regarding the underlying heart disease of the patient. We can also obtain important information about the arrhythmia mechanism from the 12-lead ECG during the clinical tachycardia. On the other hand, when the arrhythmia management requires an invasive approach, the 12-lead ECG findings combined with relevant clinical information may serve us in the planification of the ablation procedure. Finally, the 12-lead ECG can also give us significant information that may have prognostic implications for these patients. The present review will offer an overview of the principal utilities of the surface ECG in the diagnosis and management of patients with CHD and arrhythmias, and will be supported by surface 12-lead ECG-based real cases.

### *Underlying heart disease*

The different subtypes of CHD are associated with particular ECG findings that have been widely described in the literature [1,2]. In general, most part of these findings are usually unspecific. However, some subtypes of CHD are associated with specific ECG findings that may allow us to identificate the underlying heart disease of the patient just by taking a look to the basal 12-lead ECG during sinus rhythm. This is the case of the laterality defects in which the evaluation of the morphology and axis of the P wave and the QRS as well as a close inspection of the R wave progression pattern in the precordial leads can give us the clue to precisely identify the underlying heart defect. For example, patients with dextrocardia typically exhibit a reverse R wave progression pattern in the precordial leads that can be easily identified in the basal surface 12-lead ECG (Fig. 1A). On the other hand, the P wave morphology and axis in this setting can give us the clue for identifying the sinus node location and thus the situs visceralis of the patient. In patients with situs solitus, the P wave is positive in leads I and aVL and negative in aVR. However, in patients with situs inversus,

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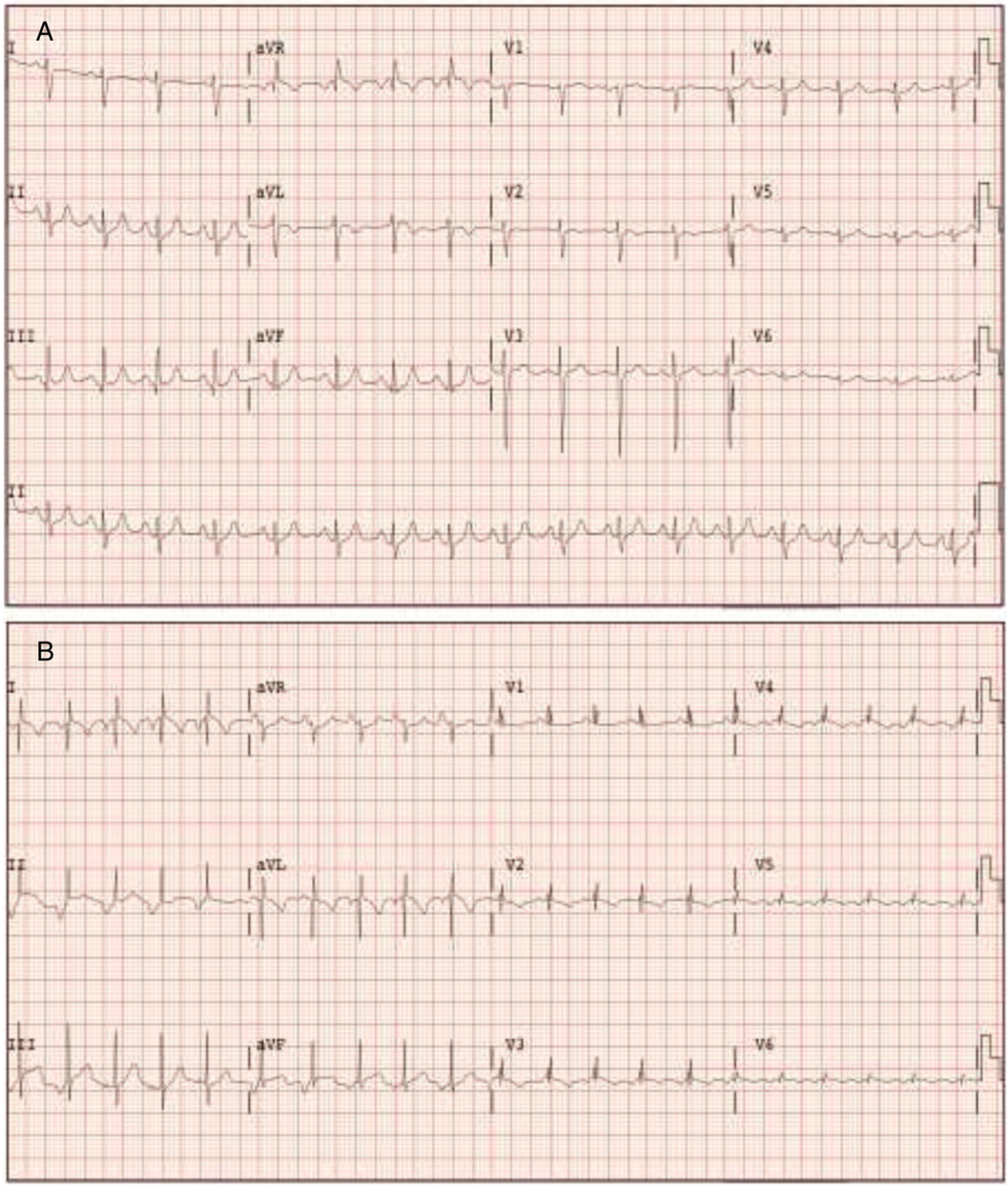


Fig. 1. Panel A: 12-lead ECG of a patient with dextrocardia and situs solitus showing the typical reverse R wave progression pattern in the precordial leads. As the sinus node is in the usual location, the morphology and axis of the P wave are normal. Panel B: 12-lead ECG of a 2-year-old patient with dextrocardia and situs inversus. Note the reverse R wave progression pattern in the precordial leads. Importantly, as the right atrium is located in the left side of the patient, the sinus P wave is negative in leads I and aVL, and positive in aVR.

the right atrium and thus the sinus node are located in the left side of the heart resulting in negative P waves in I and aVL and positive in aVR (Fig. 1B).

Patients with heterotaxy syndromes also exhibit specific ECG findings. Right atrial isomerism is associated with the presence of two right atria positioned in a mirror image and subsequently two sinus nodes and two AV nodes [7]. As a result, it is possible to identify two different P wave morphologies and two different QRS axis and morphologies depending on the origin of the atrial activation and the AV node implicated in the conduction of the electrical activity to the ventricles. Patients with right atrial isomerism may develop supraventricular tachycardias with a re-entrant mechanism implicating a circuit between the two AV nodes. These so called “twin” AV nodes tachycardias can be successfully treated by radiofrequency ablation of one of