The ECG role in identifying the etiology of tachycardia-induced cardiomyopathy (TIC)

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Tachycardia-induced cardiomyopathy (TIC) is a well recognized entity of heart failure (HF) and various mechanisms due to tachyarrhythmias have been postulated to be responsible for impaired cardiac contractility. Previously reported cases showed reversibility of such disorders whenever stable cardiac rhythm is maintained adequately and we report on a 16-year-old boy who has been diagnosed to have TIC, which was misinterpreted initially as sinus tachycardia secondary to dilated cardiomyopathy and heart failure. A complete recovery of his left ventricular function was achieved by radiofrequency catheter ablation and highlights the importance of a 12-lead electrocardiogram (ECG) assessment in such patients.

Keywords: ECG, Atrial tachycardia, Cardiomyopathy, Ablation

Case

A 16-year-old boy, with a six-month history of congestive heart failure, was referred from another hospital for medical management and possible device implantation. On presentation to our hospital he was quite symptomatic and had a significant history of shortness of breath (SOB) at rest, orthopnea and paroxysmal nocturnal dyspnea (PND). He had no evident history of any preceding viral infection, drugs or alcohol addiction that could be elicited. An electrocardiogram (ECG) showed non-sinus tachycardia, with a rate of 160 beats/min, and an inverted P-wave was noted at lead I, aVL, and upright P-waves at the inferior leads, suggestive of left atrial automatic focus (Fig. 1).

Despite optimal medical therapy for heart failure at the time of admission, his echocardiography revealed a severely dilated left ventricle with ejection fraction of 15% and severe functional mitral regurgitation.

Based on our ECG findings which are consistent with ectopic atrial arrhythmia and amenable for radiofrequency catheter ablation (RFCA), he underwent an electrophysiological study (EPS). An incessant form of left atrial tachycardia was detected during the study and a non-contact mapping system (NAV-X-Endocardial Solutions, Inc. (ESI), St. Paul, Minnesota) was used to identify the focus. A left atrial geometry was created, and thorough mapping was carried out using both local activation and voltage mapping in...
reference to the coronary sinus (CS) catheter (Fig. 2). The area of interest was preceding CS catheter by 58 msec, adjacent to the left superior pulmonary vein, and a total of 10 min and 35 s of...
radiofrequency energy was applied (50 W, temperature of 60 °C).

A complete recovery of sinus rhythm was achieved afterward and his heart rate immediately reduced to 120 beats per minute (Fig. 3). A significant functional capacity and general well being improvement were documented during follow up and, with the help of anti-failure medications, cardiac function recovery was demonstrated by serial echocardiograms within six months of follow up.

Discussion

Tachycardia-induced cardiomyopathy is a well described disorder that is related to various types of arrhythmias [1–3]. Although atrial fibrillation is the most frequent cause of ventricular dysfunction in the adult age group, it may also be a consequence rather than a cause of heart failure [4,5]. Unexplained systolic dysfunction is associated with any form of tachyarrhythmias, especially in a normally structural heart, and should be evaluated carefully. Many mechanisms have been demonstrated in experimental animal models to elucidate the pathophysiology of TIC at the level of myocytes. Unmatched myocardial demand as well as stiffened coronaries secondary to increased sympathetic tone could result in stunning phenomena [6–8]. Down regulation of beta-1-receptors [7–14], secondary to myocardial remodeling and depletion of energy stores [12] with consequent mishandling of calcium metabolism can impact the myocardial contractility [8,9,15]. Oxidative stress with an imbalance between pro-oxidant and antioxidant pathways was also found to be another co-factor in the same process of TIC [10–16]. Various changes as a consequence of the afore-mentioned mechanisms described histologically are such as myocyte hyperplasia and lengthening, myocardial fibrosis, impaired coronary reserve and apoptosis [11].

The diagnosis of tachycardia-induced cardiomyopathy requires a high index of suspicion, as the underlying arrhythmia may not always be apparent. The paroxysmal nature of the events may obscure immediate diagnosis of abnormal arrhythmias as a cause of dilated heart. Similarly, a right-sided atrial ectopic tachycardia in a young patient is commonly misinterpreted as sinus tachycardia. The tendency for ectopic foci in young patients to cluster near atrial appendages or pulmonary veins and crista terminals may render such rhythm indistinguishable from normal sinus rhythm [17]. In addition, P-wave morphology can distort the preceding QRS complex or T wave. Several studies have been published and focused on 12-lead analysis of P-wave morphology to determine the origin of the tachycardia. Leads aVL and V1 are the most useful to distinguish between right and left origin [18]. Right appendage foci produces a normal frontal plane P-wave axis, but the vector of atrial depolarization in the horizontal plane is directed from anterior to posterior.

Figure 3. Post ablation twelve leads electrocardiogram showed sinus tachycardia rate of 120 beat/min. Note the normalization of the P-wave axis.
such that the P-wave in the right chest leads is predominantly negative. Left-sided foci in the appendage and the left pulmonary vein are usually quite obvious from the frontal plane, where the P-wave axis can be typically in the range of +90 to +180 degree. When it originates around the crista terminals or right pulmonary veins, the P-wave can be hard to distinguish from sinus tachycardia and other features of the ECG must be examined with great care [17,18].

In our patient a firm diagnosis of left atrial tachycardia was made on the basis of a standard 12-lead ECG finding, which reveals a single abnormal P-wave axis and inappropriate heart rate for the patient’s age, which was out of proportion to compensatory heart failure mechanism.

Conclusion

Recent advances in mapping and ablation of focal tachycardia provide a safe and successful curative therapy. However, recognition of such tachycardia is the key factor for successful management. A standard 12-lead surface ECG provides a simple and non-invasive method that can help in determining the origin of tachycardia.

Conflict of interest

The authors have no conflicts of interest to declare.

References