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Case Report

Analysis of Electrocardiograms of Bidirectional Tachycardia Due to Digitalis Overdose

Nazmi Gultekin[1,*] and Ugur Kocabaş[2]
[1]*Department of Cardiology, Istanbul University Cerrahpasa, Turkey*
[2]*Cardiology Clinic, Atatürk Training and Research Hospital, Turkey*

***Corresponding author:** Nazmi Gultekin, Department of Cardiology, Istanbul University Cerrahpasa, Turkey

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Abstract

A case of congestive heart failure with atrioventricular dissociation, bidirectional tachycardia followed by bigeminy ventricular premature beat due to excessive digoxin administration is presented. The characteristics of ectopic beats in two opposite axis made us think that bidirectional tachycardia originated from two ectopic foci, one ventricular and the other possibly supraventricular.

Introduction

Bidirectional tachycardia, an uncommon type of arrhythmia mostly occurs as a result of digital intoxication. Although it has been reported to occur in other conditions including fulminant myocarditis, covid-19 infection, sarcoidosis, catecholaminergic polymorphic ventricular tachycardia(CPVT), and Andersen-Tawil syndrome, cardiac surgeries, acute ischemia, ischemic cardiomyopathies, coronary allograft vasculopathy, familial hypokalemic periodic paralysis, cardiac tumors, drug overdose (caffeine, aconitine), and cases of familial channelopathies, the use of digitalis in 40% of cases [1,2].

Although atrioventricular dissociation and bigeminy extrasystoles are frequently encountered in digital intoxication (5% and 21%), bidirectional tachycardia is a rare arrhythmia (less than 0.5%) [1,3-6]. The mechanism for bidirectional ventricular tachycardia (BiVT) is not as well known as other forms of ventricular tachycardia but appears to include typical mechanisms including triggered activity from afterdepolarizations, abnormal automaticity, or reentry [1-3]. Evidence from human studies and optical mapping experiments in a genetic CVPT mouse model attribute BiVT to alternating ectopic foci originating from the distal His-Purkinje system in the left and/or right ventricles, respectively.

It was interesting that in our case, besides bidirectional tachycardia, other rhythm disorders due to digital intoxication were detected together.

Case Report

In this article, we present an 18-year-old female patient with rheumatic heart valve disease and congestive heart failure, who developed atrioventricular dissociation, bidirectional tachycardia, and subsequently ventricular premature beats due to digoxin overdose. The characteristics of ectopic beats in opposite directions indicated that bilateral tachycardia originated from two ectopic foci, one ventricular and the other possibly supraventricular. With a daily dose of 1.8 grams of KCl given to the patient, the heart rhythm had completely reached the sinuses on the 6th day.

Electrocardiogram Analysis

On the first electrocardiogram, it is seen that there is atrioventricular dissociation **(Figure 1-3)**. The P-P intervals are 0.56 seconds, and the atrium rate is 107 /minute. The 1st beat in Dı is a nodal beat. The second beat following this is a fusion beat. The 3rd and 4th beats are in opposite directions of each other. When these ectopic beats become the dominant rhythm an attack of tachycardia occurs with a ventricular rate of 150/ minute. Let's call the 3rd beat in Dı as *A-Type* beat.

The 5th,7th,10th,12th,14th,18th, and 21st in this lead are the same type of ectopic beat. These A-type ectopic beats are seen as the 4th,7th,10th, and 15th, beats in Dııı. The frontal plane QRS electrical axis of these ectopic beats is +120º. They show an S1Q3 pattern in the Standard leads. Due to these features, it is understood that *A-Type* ectopic beats show a left posterior division hemiblock pattern. These ectopic beats showed an example of a right bundle branch block in the precordial leads.

The 4th beat in Dı is in the opposite direction of the *type- A* ectopic beat. Let's call this beat as *B-Type* ectopic beat. The 6.9,13,20 beats in Dı are these *B-Type* ectopic beats. The same beats appear to be 6.9,14 beats in Dııı. The frontal plane QRS electrical axis of these beats is -61*. The same beats appear as small q and high R (4 and 8 beats) in aVF, small r, and deep S in aVL (6,8,11,14th beats) . Due to these features, it is understood that ectopic beats show a left anterior division hemiblock pattern. It is noteworthy that in precordial leads they show an example of right bundle branch block-like A–

type ectopic beats, but differ from them in terms of shape. It is seen that the distances between type-A ectopic and Type –B ectopic beats are equal, whereas the distance between A and B is not equal to the distance between B and A **(Scheme 1)**.

In the electrocardiogram taken on the fifth day **(Figure 4,5)**, the basic rhythm is sinus. Bigeminy ventricular ectopic beats are seen in addition to sinus rhythm. These bigeminy extrasystoles show examples of left posterior division hemiblock and right bundle branch block-like to A-Type ectopic beats seen in the electrocardiogram dated on the first day. However, as seen especially in V_1, V_2, V_3, and V_4, the shape of these beats varies alternately. This finding can be explained by the fact that ectopic beats show varying degrees of the block. Let's call one of the ectopic beats A, and the other A', which vary in shape **(Scheme 2a and 2b)**.

Ectopic stimulus (marked with E) originating from a focus in the left ventricular Purkinje network region stimulates the left ventricle through the left anterior division, and from there it passes into the right branch and spreads to the right ventricle **(Scheme 2a)**. The ensuing ectopic stimulus will find the left anterior division momentarily refractory (marked with R in **scheme 2b**), so it will retrogradely reach the right branch and stimulates the right ventricle, and then pass into the left ventricle and activates the left anterior division **(Scheme 2 b)**. Therefore, ectopic beats (A and A') originating the same focus will be seen differently due to different degrees of the block.

In the electrocardiogram taken on the 6th day **(Figure 5)**, it is

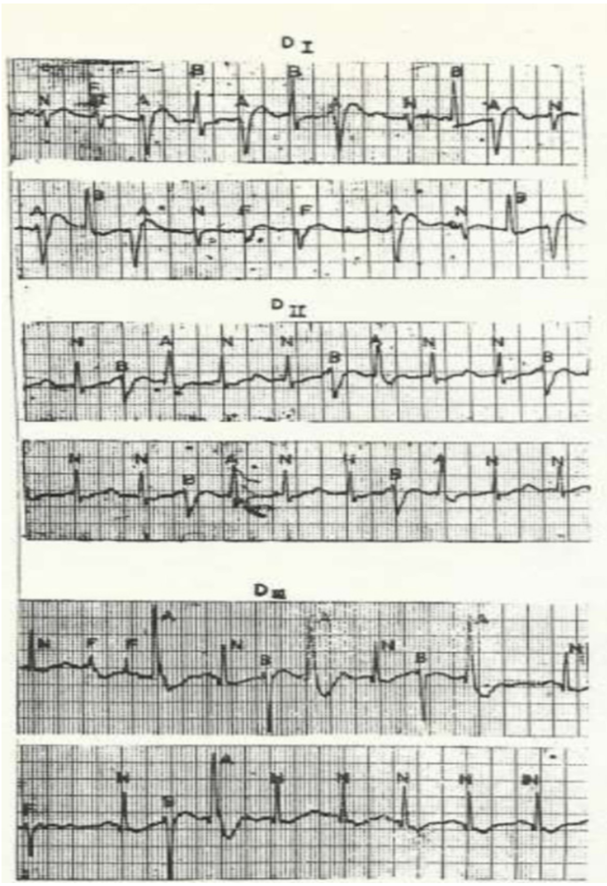


*Figure 1: The first electrocardiogram shows atrioventricular dissociation due to digital intoxication, compound (fusion) beats, and tachycardia consisting of opposing complications in the bipolar extremity leads.*bidirectional tachycardia*Average QRS electric axis is + 120 ⁰* in *type A*, and -61⁰ in *type B complexes.*

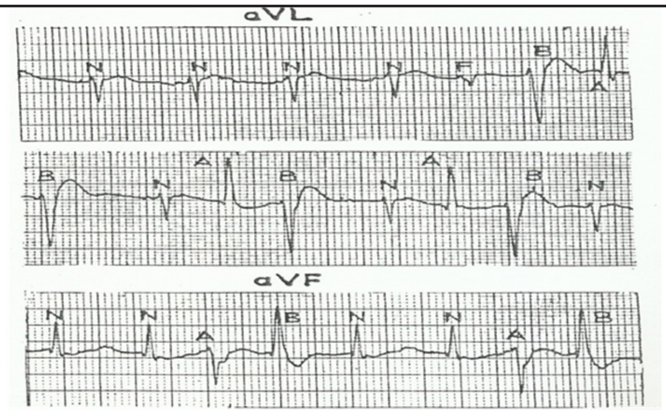


*Figure 2: *Bidirectional ventricular tachycardia* is seen in the unipolar extremity leads in the trace in Figure 1.*

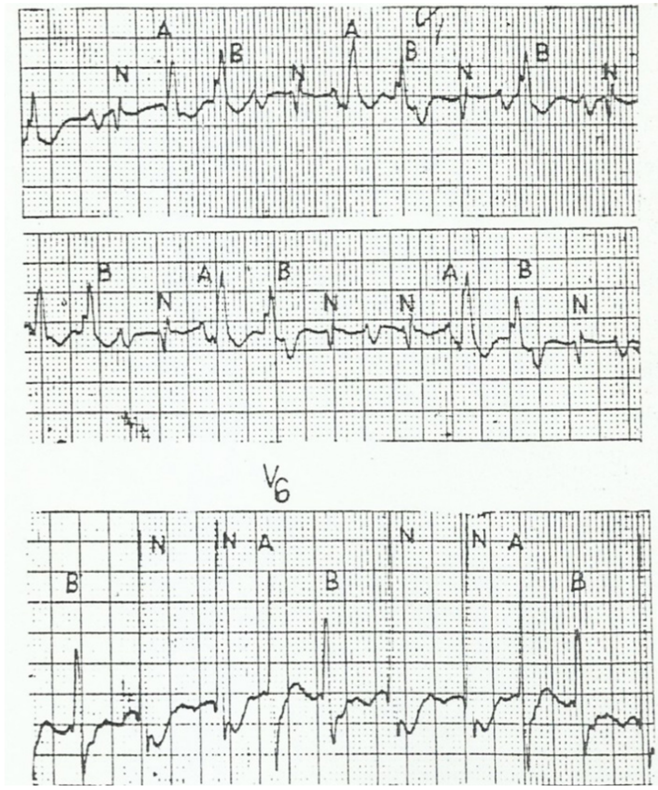
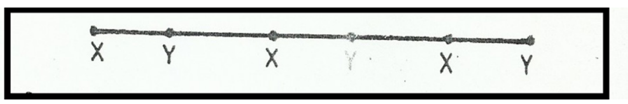


Figure 3: In the precordial leads of the trace in Figure 1., it is seen that both ectopic beats show a right bundle branch block pattern.



Scheme 1: II.Type Bidirectional ventricular tachycardia(xx=x x,yy=yy,xy=xy,xy≠yx (According to Scherf and Kisch.

seen that the digitalis intoxication arrhythmia improved. The rhythm is sinus. The heart rate is 107/minute. The P-R interval is 0.16 seconds. The P character is *P mitral*. There is + 110* right axis deviation. Biventricular hypertrophy is seen.

Discussion

Bidirectional tachycardia has certain criteria. It is a fast regular rhythm, the ventricular rate is 140-180/minute. QRS complexes appear as consecutive complexes of opposite directions. The QRS frontal plane electrical axis is -60^0, -80^0 in one of the opposite complexes, and $+120^0$ in the other [1-6].

In our case, *His Bundle* recordings could not be made, which could clearly explain the origin of bidirectional tachycardia. * A-type* ectopic beats may be beats that come out of the left

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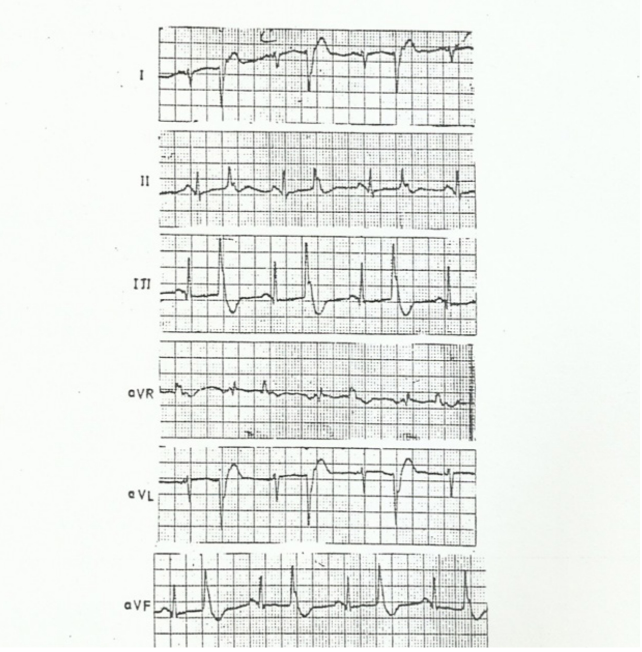


Figure 4: In the electrocardiogram taken on the 3rd day of digital discontinuation, it is seen that bidirectional tachycardia improved, but bigeminy ventricular extrasystoles persisted.

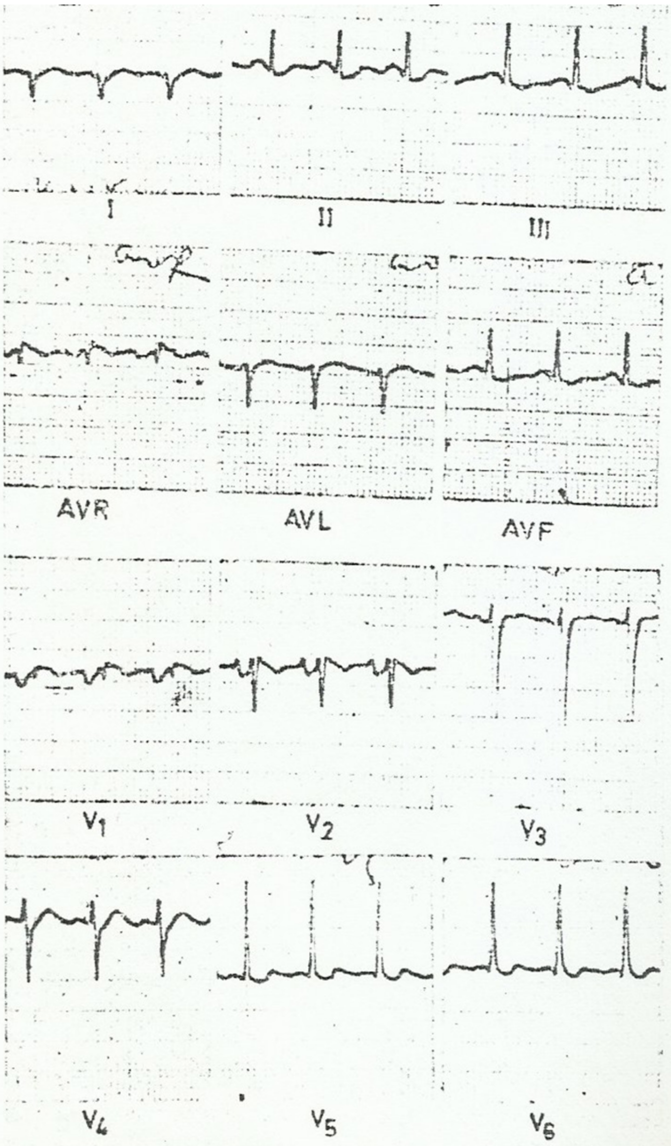
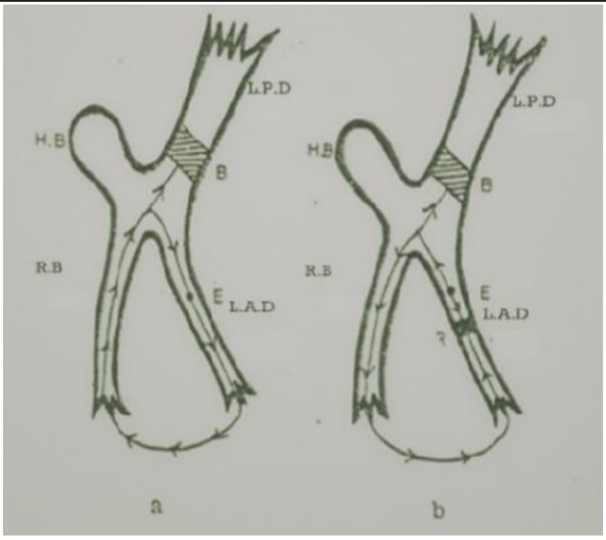


Figure 5: The rhythm is sinus. The heart rate is 107/minute. The P-R interval is 0.16 seconds. The P character is *P mitrale*. There is + 110* right axis deviation. Biventricular hypertrophy is seen.



Scheme 2a-b: Schematic description of bigeminy ventricular extrasystoles showing alternating shape changes, particularly in V_1, V_2, V_3, and V_4, on a detailed electrocardiogram of the first day (see text for explanation).H.B.= His Bundle, L.A.D=Left Anterior Division,L.P.D= Left posterior division, S.D.= Right branch. E = Ectopic focus. B = Blocked area. R=Refractory zone.

ventricle and are transmitted to the left ventricle and then to the right ventricle through the left anterior division, or they are supraventricular beats that are transmitted from the anterior division of the left branch to the left ventricle due to aberrant conduction in the right branch and posterior division of the left branch. Likewise, *B-type* ectopic beats originating from the left ventricle, and they may be transmitted to the left ventricle through the left posterior division and then to the right ventricle, or there may be aberrantly conducted supraventricular beats in the right branch and anterior division of the left branch. As it can be understood from the electrocardiograms of the case, the presence of nodal and ectopic beats as well as compound (fusion) beats are observed. It has been reported that the appearance of fusion beats on the surface electrocardiogram is one of the important findings supporting the ventricular origin of the ectopic focus [6]. Based on this finding alone, we can say that at least one of type A and B ectopic beats is of ventricular origin.

Another important criterion in differentiating between aberrantly conducted supraventricular beats and ventricular beats is the QRS morphology in V1. It has been reported that the QRS pattern showing an initial q wave in V1 and in biphasic form is typical for ventricular ectopic beats, while the beats showing the initial r wave, triphasic form and transmitted to the initial QRS vector in the same direction as the initial QRS vector are supraventricular beats showing phase aberrant ventricular conduction [6]. When we examine the beats in V1 during bidirectional tachycardia in our case from this point of view, it is understood that *A-type ectopic beats are of ventricular origin,* B-type* beats are aberrantly conducted supraventricular beats. As a matter of fact, one of the most important findings that support the ventricular origin of *A-type* ectopic beats is that the bigeminy ventricular extrasystoles seen in the electrocardiogram taken after bidirectional tachycardia disappeared in our case were the same as *A*type* ectopic beats seen during tachycardia. These bigeminy extrasystoles show the character of bigeminal extrasystoles of ventricular origin with all their features.

Some authors, who determined that one of the ectopic beats disappeared by performing sinus carotid massage during bidirectional tachycardia, also suggested the presence of two ectopic foci, one ventricular and the other supraventricular [7].

In the classification of Scherf and Kisch II; It has been reported that acceptance of the presence of two ectopic foci, one supraventricular and the other ventricular, may be the most appropriate explanation in cases of bidirectional ventricular tachycardia [5]. In our case, the relationship between ectopic beats corresponds to type II bidirectional tachycardia in the Scherf and Kisch classification (the AA interval and BB interval are equal, AB interval is not equal to the BA interval) **(Scheme 1)**.

Conclusion

In this case, due to the features discussed above, we concluded that bidirectional tachycardia due to digital intoxication was caused by two ectopic foci, one supraventricular and the other ventricular.

Conflict of interest: None to declare.

Commemorate: The author respectfully commemorates all our colleagues who lost their lives in the Kahramanmaraş/Turkey earthquake as one of Kahramanmaraş's natives.

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