Original Article

Evaluation of Morphology of Premature Ventricular Contraction on 12-Lead Electrocardiogram

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Abstract:

Background-Evaluation of different morphology of premature ventricular contraction (PVC) in 12-lead ECG might reflect the presence or absence of myocardial diseases and determine PVC foci. It is important for ablation procedure and it can help in pre-procedural planning and potentially may improve ablation outcome.

Methods and Results-In this study, 12-lead Electrocardiogram (ECG) of 50 patients with or without structural cardiac diseases, who had experienced PVC, were obtained. PVC QRS duration, contour, pattern, unifocal or multifocaland different morphology in various lead were evaluated. PVC-QRS morphology of 50 ECGs showed QRSd d" 140ms was 60%, >140ms was 24%, >160ms was 16%. QRS notching <40ms was 42%, >40ms was 16%, smooth contour was 42%. The morphology of PVCs in lead V1, RBBB morphology was 36%, LBBB morphology was 64%; in lead V1 & V2, high r 8%, low r 4%. QRS wave polarity in lead I negative (QS, Qr, or rS wave pattern) 28%, positive (R-wave pattern) 52%; in lead II, III, avF, positive 76%. Of these RR' or Rr' pattern 20%, R pattern 56%. Negative 24%. QRS transition in chest lead, 16% transition occur at V4 –V5, 48% at V3-V4, 4% at V2-V3, 36% at V1-V2 level. The pattern of PVCs were bigeminy 24%, trigeminy 6%, couplet 4%, salvos 12%, R on T 2%, VT 6%. Of the 32 PVCs originating from the RVOT, 8 were classified as of free-wall origin, 24 of septal, 14 of left, 26 of right, 4 of proximal, and 2 of distal origin. Of the 6 PVCs originating from the LVOT, 4 were originated from the LVOT close to the left coronary cusp and 2 were originated from the LVOT close to the right coronary cusp. Of the 12 PVCs originated from LV fascicle, 12 of posterior fascicle origin and none from anterior fascicle origin.

Conclusion-12-lead ECG is a simple, inexpensive and noninvasive tool to detect PVCs and facilitate their localization. By evaluating morphology of PVC, we can also predict the structural and functional state of heart.

Keywords: Electrocardiogram, Cardiac Arrhythmia, Premature Ventricular Beats,

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Introduction:

Premature ventricular contraction (PVC) is the most common cardiac arrhythmia in patients with or without any kind of diagnosed cardiac diseases[1]. PVC is an extra heart beat originates from the ventricles and comes before the normal heart beat. Although in general, this arrhythmia may occur in a healthy person, but it is more prevalent with increasing age and occur in association with a variety of cardiac and non-cardiac diseases such as hypertension, myocardial infarction, and so on[2].

The mechanisms by which PVCs are generated include enhanced normal or abnormal automaticity, triggered activity resulting in afterdepolarizations and reentry. Several pattern of PVCs are described, like-bigeminy, trigeminy, quadrigeminy, couplet, salvos, unifocal, multifocal PVCs, R on T phenomenon, VT[3]. Today, the electrocardiogram (ECG) remains the simplest and cost

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effective non-invasive diagnostic method for determining arrhythmias. The morphological features of the premature ventricular complex (PVC) have been citedas a clue to the presence or absence of underlying cardiac disease[4]. Scherf and Schott[5] recognized that PVCs with exceptionally wide QRS complexes frequently occurred in diseased hearts.Soloff[4] found that PVCs with a bizarre and distorted configuration were highly suggestive of underlying myocardial disease in contrast to those with the "classic" smooth pattern. Morphology is also useful to localize the site of origin of PVCs before ablation procedure where indicated. This helps not only in pre-procedural planning, but also can potentially improve ablation outcomes[6].

PVCs may originate from various foci. If PVC focus is in right ventricle, it would appear as Left Bundle Branch Block (LBBB) and if it is in left ventricle, it would appear as Right Bundle Branch Block (RBBB) because in this state left ventricle would depolarize earlier. In general there are three common regions are defined for PVC foci: Right Ventricular Outflow Tract (RVOT), Left Ventricular Outflow Tract (LVOT)[7] and Aortic Cusp (AC). Many researches for determining various divisions of idiopathic VT or PVC foci have been developed so far, including idiopathic ventricular tachycardia (IVT) consist of RVOT VT/PVC, Idiopathic Left Ventricular Tachycardia (ILVT), Idiopathic Propranolol sensitive VT (IPVT), LVOT VT/PVC[8] and AC[6]. It has been reported that 60-80% of the idiopathic tachycardia in normal hearts arise from the RVOT and 10% of them arise from LVOT[9]. RVOT VT/PVC is more common in females at age 30 to 50 years old[10] shows wide QRS complex and LBBB pattern with inferior axis[11], whereas LVOT VT/PVC usually shows RBBB morphology in lead V1 with wide monophasic R-wave in precordial leads. Morphologic explanations of ECG characteristics are useful for differentiating of VT/PVC arising from the AC region. VT/PVC originated from the left coronary cusp produces multiphasic QRS morphology with an M or W configuration in lead V1 with a precordial transition no later than V2. A left bundle pattern with a wide small R wave in lead V2 and a precordial transition usually at V3 is revealed in PVCs with a right coronary cusp origin[6].

Kamakura et al.[12] proposed the method to estimate the origin of VT/PVC from the RVOT and LVOT by using indexes obtained from 12-lead ECG. They classified PVC/VT from the RVOT into 8 subdivisions by using 3-dimensional anatomic relation: anteriorposterior, right-left, and superior-inferior. The features they used for estimating the origin of PVC/VT consisted of morphology, amplitude, duration and polarity of QRS complex. To distinguish LVOT from RVOT region, they showed that R/S amplitude ratio in lead V_3 is a helpful index. If the ratio of R/S amplitude in V_3 is equal or higher than 1, the PVC/VT stems from LVOT zone, otherwise arises from RVOT.

The purpose of this study is to find out the various morphology and foci of PVCs using 12-lead ECG.

Materials and methods:

Data collection

12 lead ECGs of the 50 patients with or without structural cardiac disease, who had experienced PVC, were obtained. The data was collected from National Institute of Cardiovascular Diseases (NICVD) arrhythmia clinic.

PVC detection

First of all, PVCs were recognized and distinguished from the normal beats. Because of their greatness in height, depth and length, PVCs could easily be detected. They were characterized by-

- Duration of more than 120 msec
- .Bizarre morphology that does not resemble usual aberration (i.e. a typical right or left bundle branch block).
- T wave in the opposite direction from the main QRS vector.
- A fully compensatory pause.

QRS duration and morphology

In this study we detected the duration, contour, pattern (bigemini, trigemini, quadrigeminy, couplet, triplet, salvoes), unifocal or multifocal and various morphology of PVCs in different leads like lead I,II,III,avF,V1 and QRS transition in chest lead.

Presence or absence of notching in PVC was also detected. Notching in QRS complex was determined as a tri-phasic R or Q wave with an interval greater than 40 msec between the first and second peak of the QRS complex. Existence of notching is considered when notching is observed in more than three of the six limb leads. When notching occurred near the summit, the non-dominant peak was measured.

Classification of anatomical site of PVCs by 12-lead ECGs

According to the morphology of different lead of 12-lead ECG PVCs were originated from the LVOT, RVOT (free wall, septal origin, right, left side, proximal, distal origin), basal RV, LV fascicles and aortic cusp (Right and Left coronary cusp). Figure 1 shows a sample of 12-lead ECG of patients with PVC originating from RVOT septum.

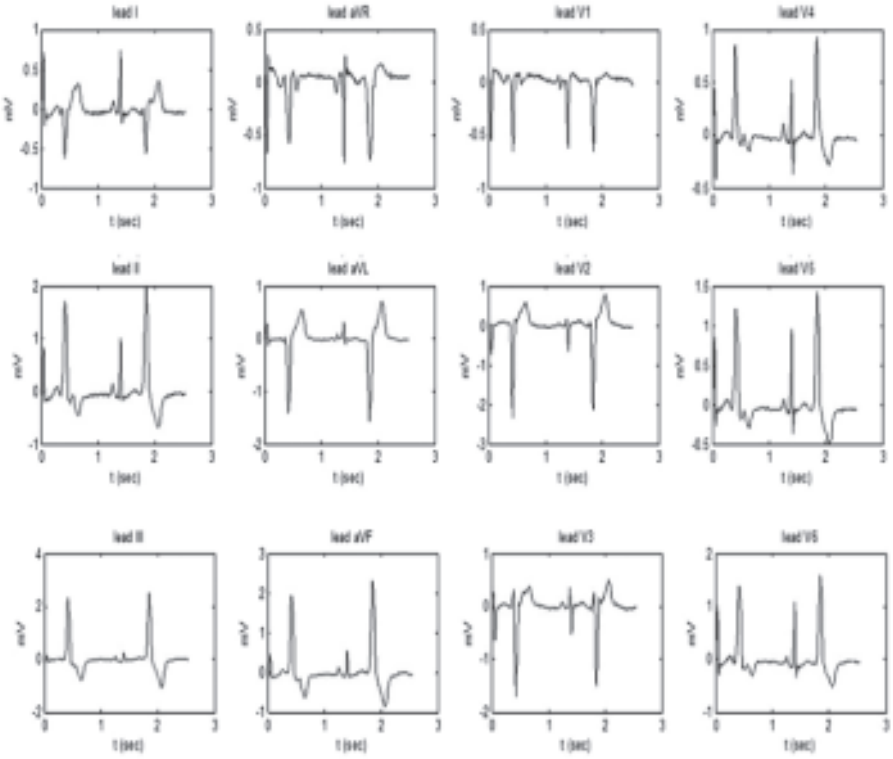

Fig.-1

Results:

The electrocardiographic characteristics of PVC-QRS morphology of 50 ECGs are shown in Table 1. QRSd d" 140ms was 60%, >140ms was 24%, >160ms was 16%. QRS notching <40ms was 42%,>40ms was 16%, smooth contour was 42%.Table II. Showed the morphology of PVCs in lead V1, V2 and lead 1 (n=50). In lead V1,RBBB morphology was 36%, LBBB morphology was 64%; in lead V1 & V2, high r 8%, low r 4%. QRS wave polarity in lead I negative (QS, Qr, or rS wave pattern) 28%, positive (R-wave pattern) 52%. Table III. Showed the morphology of PVCs in lead II, III, avF (n=50). Positive 76%. Of these RR' or Rr' pattern 20%, R pattern 56%. Negative24%.Table IV. Showed QRS transition in chest lead (n=50). 16% transition occur at V4 –V5, 48% at V3-V4, 4% at V2-V3, 36% at V1-V2 level.Table V. showed the pattern of PVCs (n=50). Bigeminy 24%, Trigeminy 6%, Couplet 4%, Salvos 12%, R on T 2% , VT 6%. The sites of origin of all 50 PVCs are shown in Table VI. Of the 32 PVCs originating from the RVOT, 8 were classified as of free-wall origin, 24 of septal, 14 of left, 26 of right, 4 of proximal, and 2 of distal origin. Of the 6 PVCsoriginating from the LVOT, 4 were originated from the LVOT close to the left coronary cusp and 2 were originated from the LVOT close to the right coronary cusp. Of the 12 PVCs originated from LV fascicle, 12 of posterior fascicle origin and none from anterior fascicle origin.

Table-I

Electrocardiographic Characteristics of PVC-QRS morphology (n=50).

Characteristics	Number	Percentage (%)
QRS duration (ms)		
≤ 140	30	60%
> 140	12	24%
> 160	8	16%
QRS notching (ms)		
< 40	21	42%
> 40	8	16%
Smooth contour	21	42%

PVC, premature ventricular complex; ECG, electrocardiogram; < 40ms =narrow notching; > 40ms = broad notching.

Table-II

Morphology of PVCs in lead V1 and lead 1 (n=50).

Morphology in V1 & V2	Number	Percent (%)
RBBB	18	36
LBBB	32	64
High r	4	8
Low r	2	4
Morphology in 1		
Negative	14	28
Positive	26	52

LBBB, Left bundle branch; RBBB, Right bundle branch; High r means initial r-wave amplitude 0.2 mV in both lead; Low r means r-wave amplitude, 0.2 mV in 1 or both leads.

Table-III

Morphology of PVCs in lead II,III,avF (n=50).

Morphology in II, III, avF	Number	Percent (%)
Positive	38	76
RR' or Rr' pattern	10	20
R pattern	28	56
Negative	12	24

Table-IV

QRS transition in chest lead (n=50).

QRS transition	Number	Percent (%)
V4 –V5	8	16
V3 –V4	24	48
V2 –V3	2	4
V1 –V2	18	36

Table-V

Pattern of PVCs (n=50).

Pattern	Number	Percent (%)
Bigeminy	12	24
Trigeminy	3	6
Couplet	2	4
Salvos	6	12
R on T	1	2
VT 3	6	

Table-VI

Number of PVC origins. (n=50).

Site of origin	Number	Percent (%)
RV outflow tract	32	64.0
Free wall side	8	16.0
Septum side	24	48.0
Left side	14	28.0
Right side	26	52.0
Proximal side below PV	4	8.0
Distal side below PV	2	4.0
LV outflow tract	6	12.0
Left coronary cusp	4	8.0
Right coronary cusp	2	4.0
Fascicular PVC	12	24.0
Posterior fascicle	12	24.0
Anterior fascicle	0	0.0

RV, right ventricle; LV, left ventricle; PV, pulmonary valve.

Discussion:

This study shows a method to identify PVCs and determine their duration, pattern, and morphology of PVCs in different lead of 12-lead ECG. Through which foci of PVCs can also be determined.

In our study, total 50 ECGs were evaluated. Among them QRSd d" 140ms was 60%, >140ms was 24%, >160ms was 16%. QRS notching <40ms was 42%, >40ms was 16%, smooth contour was 42%. Broad notches or shelves coupled with QRS duration >160 msec is a useful discriminator between the presence and absence of heart disease, as suggestedby other studies [4, 5].These PVCs might serve as a reliable marker for a particular structural and functional state of a nonspecifically diseased myocardium: dilated and globally hypokinetic. On the other hand, PVCs (with smooth contour or narrow notches as well as QRS duration < 160 msec is more likely to identify patients with normal-size hearts with normal or near-normal left ventricular function despite the presence of underlying cardiac disease[13].

We also evaluated morphology of PVCs in different leads of 12-lead ECG, like lead I, II, III, avF, V1 and QRS transition in precordial leads. Through which location of PVCs origins can be determined.

In our study, 32 PVCs (64%) were originated from RVOT, which is consistent with previous study[9]. RVOT PVC is associated with a characteristic ECG morphology of LBBB in lead V1 with inferior axis[11]. The QRS duration and the QRS wave morphology in leads II and III is informative. If the QRS duration is >140 ms, the origin is likely to be on the free-wall side. If it is d"140 ms, the origin is likely to be on the septal side (diagnostic accuracy: 80%).If the RR' or Rr' wave pattern is observed in leads II and III, the origin is on the free-wall side. If the R-wave pattern was seen in leads II and III, the origin was likely to be on the septal side (diagnostic accuracy: 86%). QRS transition at V4-V5, origin

is free-wall RVOT and transition at V3-V4, origin is septal RVOT. The QRS wave polarity of lead I is another useful index. If lead I showed negative polarity (QS, Qr, or rS wave pattern), the origin is likely to be on the left side. If lead I showed positive polarity (R-wave pattern), the origin is likely to be on the right side (diagnostic accuracy: 83%).If the initial r-wave amplitude in leads V1 and V2 is high (e"0.2 mV in both leads), the origin is likely to be on the proximal side. If the initial r-wave amplitude in V1 and V2 is low (<0.2 mV in one or both leads), the origin is likely to be on the distal side (diagnostic accuracy: 66%)[12].

LVOT PVC is suggested by RBBB morphology in lead V1 with inferior axis or LBBB morphology with inferior axis with small R-waves in V1 and early precordial transition (R/S = 1 by V2 or V3) [11].In our study, 6 PVCs (12%) were originated from LVOT,which is also consistent with previous study [9]. Among them 4 were originated from the LVOT close to the left coronary cusp and 2 were originated from the LVOT close to the right coronary cusp. Aortic sinus cusp origin is sometimes difficult to differentiate from RVOT PVC because both are so close to each other. VT/PVC originated from the left coronary cusp produces multiphasic QRS morphology with an M or W configuration in lead V1 with a precordial transition no later than V2. A left bundle pattern with a wide small R wave in lead V2 and a precordial transition usually at V3 is revealed in PVCs with a right coronary cusp origin[6]. The RBBB QRS configuration with a left superior axis, suggesting an exit site from the posterior fascicle and RBBB/right inferior axis, suggesting an exit site from anterior fascicle. In our study, we found of the 12 PVCs originated from LV fascicle, 12 from posterior fascicle origin and none from anterior fascicle origin.

We also found several pattern of PVCs like bigeminy, trigeminy, couplet, salvos, R on T, VT in our study.

The clinical value of studying morphology of PVCs in 12-lead ECG is a cost effective and noninvasive means of risk stratifying patients early during the initial evaluation period when used in conjunction with the history and physical examination. It can also serve to prompt additional caution when contemplating the use of drugs that significantly impair ventricular function, including certain antiarrhythmic agents. Studying morphology of PVCs in different lead of 12-lead ECG also helps determining their foci and can be important for ablation procedure and may help to improve ablation outcome.

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