

Vectorcardiographic Predictors of Ventricular Arrhythmia Inducibility in Patients with Tetralogy of Fallot

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Abstract: *Vectorcardiographic (VCG) parameters may have predictive value in Tetralogy of Fallot (TOF) patients undergoing electrophysiology studies (EPs) for ventricular arrhythmia (VA) inducibility. Methods: Blinded, retrospective analyses of 35 adult TOF patients undergoing EP studies prior to pulmonary valve replacements were performed (19 female patients, median age 37 years). VA inducibility was evaluated from EPs and resting 12-lead electrocardiograms (ECG's), respectively using heart rate adjusted Q-T interval(QTc), QRS duration, spatial QRS-T angle (peaks), principal T wave and principal QRS-complex (QRSwavev) component vectors (vector component root mean squares). Student t-tests, Mann Whitney U-tests and Analysis of Variance were used to assess differences between those with and without sustained inducible VA and the different VA morphologies. Odds ratios and relative risk were calculated. Results: 15 patients had inducible VA (5 monomorphic, 10 polymorphic VA) and 20 patients were not inducible. Only the QRSwavev showed significant differences between those with and without VA inducibility, $1.04 \pm 0.31mV$ vs. $1.45 \pm 0.48mV$ respectively ($p < 0.003$), with an odds ratio of 37.53 and relative risk of 2.14. Conclusion: VCG evidence of depolarization differences was significant between TOF patients with and without inducible VA. VCG may have a role in risk stratification for arrhythmias in TOF patients.*

Keywords: vectorcardiography, tetralogy of Fallot, ventricular tachycardia

1. Introduction

Tetralogy of fallot (TOF) patients have significant arrhythmia burden post-operatively, reported to be as high as 43.3% [1]. Programmed ventricular stimulation in TOF patients has been showed to have diagnostic and prognostic value in risk stratifying TOF patients [2]. Vectorcardiographic (VCG) principles provide additional clinical information to the 12-lead electrocardiogram (ECG) and have provided further diagnostic [3,4] and prognostic [5-9] uses of the ECG in the traditional 12-lead set-up. We hypothesize that some of these parameters and their vector components may have predictive value in Tetralogy of Fallot (TOF) patients undergoing electrophysiology (EP) studies for ventricular arrhythmia (VA) inducibility.

2. Subject and Methods

A blinded retrospective analysis of 35 adult TOF patients undergoing EP studies prior to pulmonary valve replacements (PVR) was performed (19 female patients, median age 37 years). VA inducibility and vectorcardiography were evaluated from electrophysiology studies and resting 12-lead electrocardiograms, respectively using right ventricular (RV) inducibility studies as described Khairy et al. [2]. Specifically, measurements of Q-T interval adjusted for heart rate (QTc), QRS duration (QRSd), spatial peaks QRS-T angles (SPQRS-T angle), principal T wave and principal QRS-complex component vectors (Twave v and QRSwave v) (root mean square of the T-wave and QRS-complex vector components,

respectively) were used to compare those with inducible VA versus those without inducible VA. QRSwave v, Twave v and SPQRS-T angles were calculated by the visual estimation method (utilizing the Kors' et al regression-related analysis) as described by our group [10]. Figure 1 demonstrates the vectorcardiographic components of a patient with and a patient without VA inducibility. Student t-tests and the Mann-Whitney U test were used as appropriate in comparing those with and those without ventricular inducibility. Analysis of Variance were also used to assess differences between those with and without sustained inducible VA and between the three groups, respectively (non-inducible versus monomorphic versus polymorphic VA patients). An odds ratio (OR) and relative risk (RR) were calculated for inducible VA.

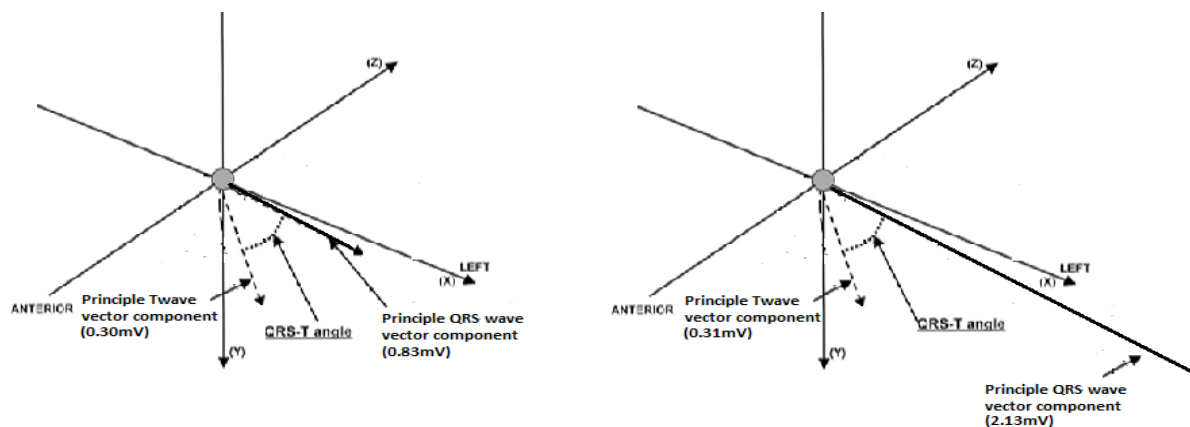


Fig. 1. Example of parameters used in TOF patients with and without ventricular inducibility

3. Results

Of the 35 patients analyzed, 15 had inducible VA (>5 beat ventricular tachycardia) with 5 having monomorphic VA and 10 having polymorphic VA. 20 patients were not inducible. Only the principal QRS-complex vector component showed significant differences between those with and those without VA inducibility, $1.04 \pm 0.31\text{mV}$ vs. $1.45 \pm 0.48\text{mV}$ respectively ($p < 0.003$). Table 1 depicts all other parameters tested with associated p-values. The principle QRS-wave vector component had positive and negative predictive values of 63% and 100% respectively with an odds ratio (OR) of 37.53 (95% confidence interval (CI) 1.98 to 712.97) and relative risk (RR) of 2.14 (95% CI 1.33 to 3.46) at a cut-off of 1 standard deviation above the mean for those with VA inducibility (1.35mV) as noted in table 2. No other parameters including the QTc, QRSd or T wave vector No inter-group variability existed between those with inducible monomorphic VT, as compared to those with inducible polymorphous VT.

Table 1. Parameters used for prediction of ventricular arrhythmia inducibility (VAI)

	QTc[ms]	QRSd[ms]	SPQRS-T angle[°]	QRSwave v[mV]	Twave v[mV]
VAI(n=15)	484.0±39.7	157.5±27.9	103.6±38.4	1.04±0.31	0.46±0.15
No VAI(n=20)	486.0±37.9	162.1±34.9	98.2±45.3	1.45±0.48	0.49±0.22
p-value	0.29	0.72	0.58	0.003	0.90

Table 2. QRS wave vector component (QRS wv) positive and negative predictive values (PPV and NPV), Odds ratio and relative risk with 95% confidence intervals (95% CI).

	PPV	NPV	Odds Ratio	Relative Risk
QRSwv	0.63 (0.41-0.81)	1.00 (0.71-1.00)	37.53(1.98-712.97)	2.14 (1.33-3.46)

4. Discussion

These findings showed the root mean square of the depolarization vector components was more predictive of inducibility than any other parameter tested in our cohort. Surprisingly the QRSd and QTc were not predictive of inducible arrhythmogenicity as suggested by studies including a recent literature review by Bassareo and Mercurio[11]. This study also suggests TOF patients with increased QRSd should undergo electrophysiology studies to assess arrhythmogenicity. And since this has already proven to be predictive of ventricular tachycardia risk [2], one might confer that our small study suggests the QRSwave v should be assessed before EP study performed regardless of QRSd given the inducible average was far less than 180ms as suggested to be predictive of arrhythmogenicity [11]. Furthermore, since increased ventricular stretch and mass to volume ratio may increase arrhythmogenicity as suggested by the above author as well as by Menon et al [12] and Velente et al. [13], respectively, one could rationalize that with this increased stretch and RVH mass, there would also be differences in depolarization sub-component vector orientation. This could cause an overall sum magnitude to be smaller than those with less right ventricular stretch as the increased components in the thickened walls could disperse the magnitude of the overall vector. This fits our cohort as they are all undergoing PVR and thus have RV pressure and volume overload. Also, the association between ventricular arrhythmia inducibility and the root mean square of the QRSwave has been demonstrated in the past by el-Sherif et al [14] as well as others as part of a signal averaged ECG analysis, thus it is not surprising that derived QRSwave v is also predictive. The relative risk cut-off was chosen based on the non-normalization of TOF patient values thus having more noted to have lower values proportionally, thus served as a good cut-off to include most of these patients while not including many of the non-inducible VA patients. Of course limitations of this study include mainly the size of the study. Also, since this was a retrospective study and signal averaged ECG's were not assessed, we were unable to include those values in our risk stratification as have been suggested to be associated with arrhythmogenicity [11].

5. Conclusion

In this retrospective analysis of TOF patients undergoing EP studies, VCG evidence of depolarization differences was present between those TOF patients with and without inducible VA, while the QRS duration as well as all other parameters tested did not. This suggests that VCG, especially the QRSwave v, may have a role in risk stratification for arrhythmias in TOF patients. Larger, prospective studies are needed to validate this method.

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