The QRSVm ECG Parameter as a Predictor of Arrhythmia in Tetralogy of Fallot: A Pilot Study

Elliott Sexton*, Medical Student, Newcastle University – e.sexton@ncl.ac.uk
Dr Louise Coats MBBS MRCP PhD, Institute of Cardiovascular Research, Newcastle University.

Background

Tetralogy of Fallot (ToF)

- Congenital heart condition present in 3 in every 10,000 births, characterised by a combination of 4 specific heart abnormalities (**Fig. 1**).
- Untreated, survival is <1 year for 2 out of 3 patients.
- Invasive reparative surgery undertaken in infancy has allowed ToF patients to lead mostly normal lives, improving 30 year survival to over 85%.

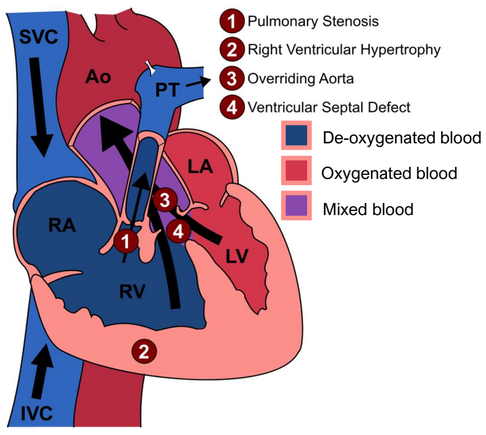


Figure 1: ToF anatomy

Complications

Increasing survival means more ToF patients are suffering chronic complications (**Fig. 2**).

Chronic altered heart anatomy/function + scarring from surgical incisions

Altered electrical conduction in heart muscle

Abnormal heart rhythms (arrhythmias)

Sudden Cardiac Death (SCD) (1.8%)

Progression

Figure 2: Chronic ToF complications

QRS Vector magnitude (QRSVm)

- Recent research has suggested risk factors for arrhythmia in ToF patients, most promisingly a reduction in the QRS Vector magnitude (QRSVm) ECG parameter.
- If proven reliable and effective, QRSVm could provide a cheap, easy, non-invasive screening method for arrythmia risk stratification in patients with ToF.

Research Objectives

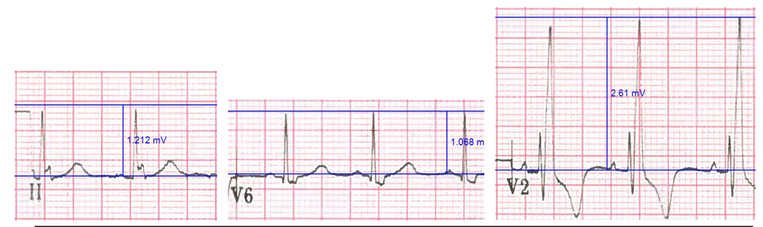
1) **To test whether results suggesting QRSVm reduction is predictive of subsequent arrythmia are reproducible in a local patient population.**
2) **To measure QRSVm values over serial ECGs and qualify if any patterns of change over time are present.**
3) **To determine how susceptible the QRSVm parameter is to measurement errors and whether these influence accuracy.**

Methods

Study Design

We conducted a retrospective pilot cohort study using 13 patients enrolled into the Freeman Hospital's Adult Congenital Heart Disease Database who had also undergone a Pulmonary Valve Replacement (PVR)

- Relevant medical history and demographics obtained from patient notes.
- ECGs <6 months before PVR measured using electronic callipers and QRSVm calculated (**Fig. 3**).
- QRSVm variation over time measured using serial ECGs.
- Intra-observer variation (IOV) calculated to test accuracy and reliability.



$$\sqrt{\left\{(QRS maximum\ lead\ II)^2 + (QRS maximum\ lead\ V6)^2 + (-0.5 \cdot QRS maximum\ lead\ V2)^2\right\}}$$

Figure 3: Measurement and calculation of QRSVm

Results

1) QRSVm <6 months after PVR

- Presented as individual data points, low sample sizes (**Fig. 4**).
- Trend suggests slight reduction in QRSVm in patients with AT vs. controls (T-test, p=0.191).
- Only 1 data point lower than all controls in arrythmia group – low sensitivity.
- Same data point was the only value less than proposed threshold for intervention (1.24mV).
- PVR itself did not significantly alter QRSVm (T-test, p=0.575).

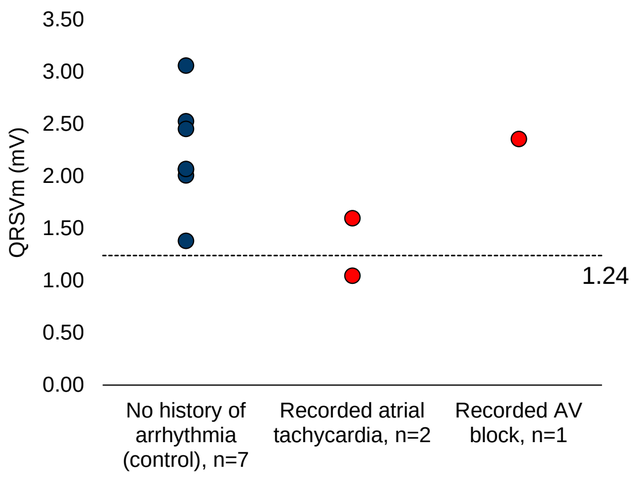


Figure 4: QRSVm <6 months prior to PVR against arrythmia history.

2) QRSVm over serial ECGs

- Large fluctuations seen in serial QRSVm measurements in some patients, whilst smoother pattern of reduction/gain in others.
- Casts some doubt over usefulness of measure for risk stratification if it is highly dynamic.
- Only 1 patient (of 3) with an arrhythmia remained consistently below proposed intervention threshold.

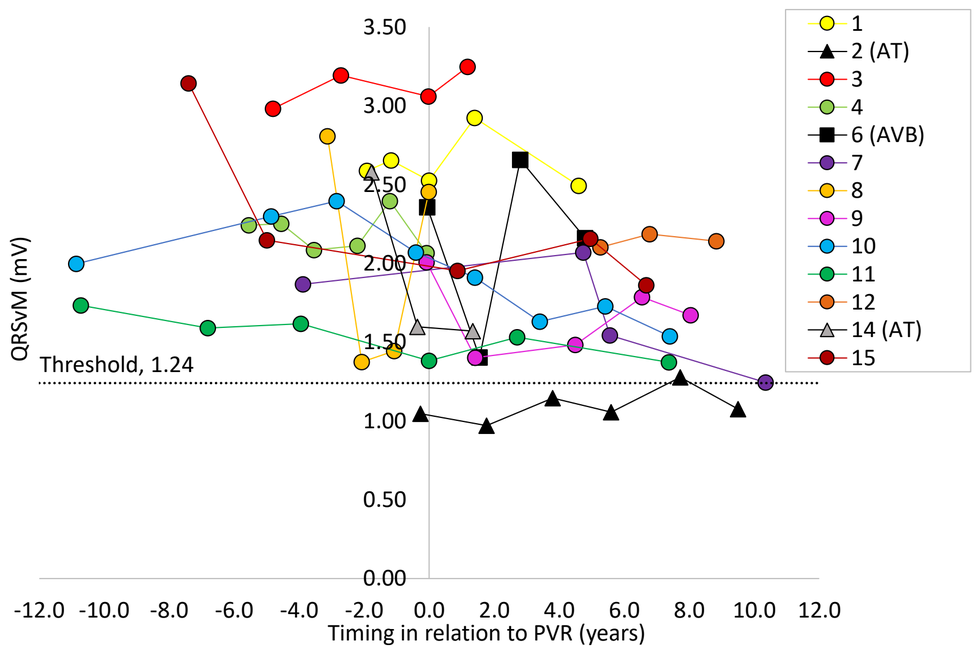


Figure 5: QRSVm recorded over serial ECG measurements. Colour coded to show individual patient progression. AT = Atrial tachycardia, AVB = Atrioventricular block.

3) Tests for measurement error and IOV

- Bland-Altman plots suggest highly consistent measurements with low error rate and 1 outlier.*
- Difference between IOV in controls vs. arrhythmias approached significance (T-test, p=0.09).

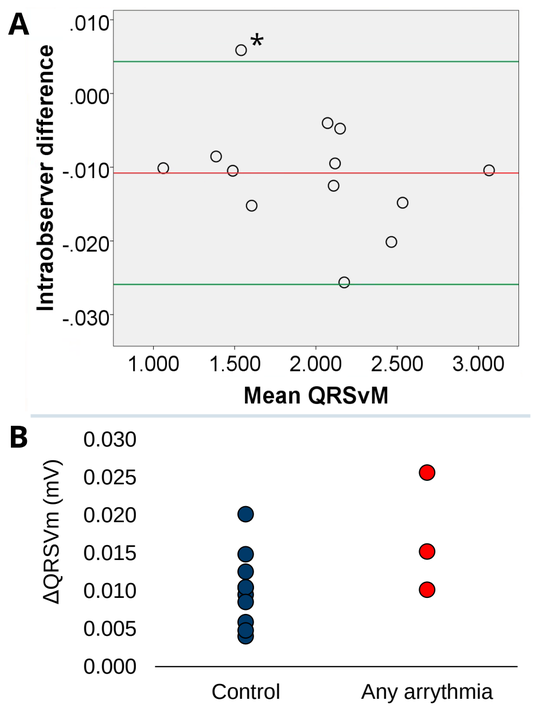


Figure 6: A) Bland-Altman analysis for measurement error. **B)** Intra-observer variation for QRSVm against arrythmia.

Conclusions

1) QRSVm <6 months after PVR

- **The pilot successfully reproduced the measurement methods and expected values of QRSVm.**
- **Whilst there was a general reduction in QRSVm in the arrhythmia group, this had no statistical significance**.
- Power calculations have been conducted to inform future sample size (**Table 1**) .

2) QRSVm over serial ECGs

- **There were no significant associations between QRSVm over serial ECGs and development of arrhythmia**.
- **This casts doubt over the clinical usefulness of this parameter as a risk stratification tool**.
- Further analysis into clinical events that surround peaks/troughs in QRSVm would be beneficial.

3) IOV and measurement error

- **IOV was found to be low and QRSVm appears to be a robust and accurate method**. Further calculation of inter-observer variation is necessary.

Table 1: Power calculation outputs

	Power (%)	Sample size (n)
QRSVm <6m prior to PVR	95	36
QRSVm IOV	95	24

References

1. Shinebourne, E. A. et al. (2006). Tetralogy of Fallot: from foetus to adult. Heart, 92(9), 1353–1359. 2. Cortez, D. et al. (2016). Noninvasive Predictors of Ventricular Arrhythmias in Patients With Tetralogy of Fallot Undergoing Pulmonary Valve Replacement. JACC Clin Electrophysiol. 2017 Feb;3(2):162-170. 3. Hunter, R. M. et al. (2013). Lifetime Costs and Outcomes of Repair of Tetralogy of Fallot Compared to Natural Progression of the Disease: Great Ormond Street Hospital Cohort. PLoS ONE, 8(3), e59734.

Acknowlegements

Dr Louise Coats (Project Supervisor) Newcastle University.
Dr Bill Chaudry (Director, Cardiovascular Research Institute).
Dr Stephen Murray, Consultant Cardiologist (EP).
Ms Caroline Elliott, Specialist Medical Secretary, Freeman Hospital.