Despite Machine Learning Models, QRS Duration Remains the Superior ECG Criterion for Predicting Left Ventricular Dilation in Patients with Left Bundle Branch Block

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Background

- The utility of ECG to diagnose left ventricular (LV) dilation in patients with left bundle branch block (LBBB) is not known.[1]
- We previously showed QRS duration is a modest classifier for LV dilation in presence of LBBB.[2]
- Machine learning methods have the potential to improve classification of LV dilation by ECG.

Research Questions

- We sought to compare the diagnostic yield of ECG using (i) QRS duration, (ii) published LV hypertrophy (LVH) criteria, and (iii) machine learning (ML) models to detect increased left ventricular end diastolic volume indexed (LVEDVi) in the setting of LBBB.

Methods and Materials

- 12-lead ECGs were processed to reconstruct orthogonal X, Y, Z leads using Kors's matrix and obtain root-mean-squared (3D) ECG.
- R wave, S wave and overall amplitudes, voltage-time-integrals (VTIs), and other ECG features were extracted from all ECG leads.
- ML algorithms [logistic regression (LR), support vector classifier (SVC), decision trees (DT), random forest (RF), gradient boosted machine (GBM) and boosted trees (BT)] were trained to predict increased LVEDVi (women >61 mL/m^2, men >74 mL/m^2) from ECG features on a training set of 2668 ECGs with typical LBBB and echocardiogram within 45 days before or after ECG.
- LVEDV was measured using ASE biplane method of discs.
- We obtained ROC AUCs for prediction of increased LVEDVi by (i) QRS duration, (ii) published LVH criteria, and (iii) ML models in a **separate validation set** of adults with typical LBBB.

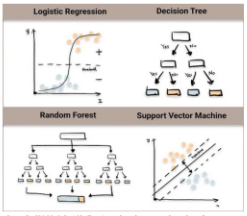

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Table 1. Validation set population characteristics

Variable	Women (N=219) Median (IQR)	Men (N=194) Median (IQR)
Age, years	74 (65-83)	72.5 (66-80)
BSA, m^2	1.9 (1.7-2.1)	2.1 (2.0-2.3)
LV Mass, g	164 (133-197)	227 (187-275)
LVEDV, ml	101 (76-138)	147 (113-199)
LVESV, ml	45 (31-71)	68 (48-105)
LVEF, %	54 (45-63)	53 (38-63)
QRS duration, ms	149 (140-158)	157 (150-168)
Amplitude$_{QRS-3D}$, mV	1.4 (1.2-1.7)	1.7 (1.3-1.9)
VTI$_{QRS-3D}$, μVs	102 (85-123)	124 (99-150)

Table 2. Area under receiver operating characteristic curve (AUC), sensitivity, and specificity for prediction of increased LVEDVi (women >61 mL/m2, men >74 mL/m2) in validation set (N=413).

ECG criteria	AUC	Sensitivity	Specificity
QRS duration			
Men ≥160 ms	0.699	0.607	0.691
Women ≥150 ms	0.668	0.687	0.618
Klein (S_{V2} + R_{aVR})	0.546	0.078	0.951
Peguero-Lo Presti (max S + S_{V4})			
Men ≥2.8 mV	0.578	0.786	0.309
Women ≥2.3 mV	0.529	0.771	0.265
Cornell voltage (R_{aVL} + S_{V3})			
Men ≥2.8 mV	0.596	0.5	0.6
Women ≥2.0 mV	0.517	0.602	0.39
Cornell VDP ((R_{aVL}+S_{V3}) *QRS duration)	0.58	0.832	0.228
S_{V3} + S_{V3} (>6.0 mV)	0.56	0.174	0.907
R aVL (≥1.1 mV)	0.509	0.06	0.898
R aVL VDP (>103 mV * msec)	0.524	0.437	0.634
Sokolow-Lyon (S_{V1} + max R (V5 or V6)), ≥3.5 mV	0.528	0.06	0.963
Sokolow-Lyon VDP			
Men >367.4 mV* msec	0.577	0.512	0.573
Women >322.4 mV*msec	0.543	0.446	0.618
Gubner-Ungerleider (R_I + S_{III}), >2.5 mV	0.519	0.03	0.927
Max R + max S in V1-V6 (>4.5 mV)	0.549	0.138	0.939
RI + SII (≥2.6 mV)	0.512	0	1
Machine Learning Model	**AUC**	**Sensitivity**	**Specificity**
Logistic regression			
Men	0.657	0.214	0.927
Women	0.669	0.169	0.897
Support vector classifier			
Men	0.638	0.524	0.627
Women	0.571	0.53	0.581
Decision trees			
Men	0.601	0.536	0.664
Women	0.555	0.313	0.728
Random forest			
Men	0.675	0.345	0.873
Women	0.692	0.446	0.779
Gradient boosted machine			
Men	0.65	0.357	0.864
Women	0.666	0.325	0.846
Boosted trees			
Men	0.609	0.345	0.781
Women	0.608	0.386	0.787

Results

- Among the validation set of **413** adults (53% women, age 73±12 yr) with LBBB, **QRS duration** alone had a higher AUC (women 0.67, men 0.70) for diagnosing increased LVEDVi compared to standard LVH criteria (Table 2).
- The **best ML model** (RF; women 0.69, men 0.68) did not outperform QRS duration alone.

Conclusion

- In patients with LBBB, QRS duration ≥150 ms in women and ≥160 ms in men is a superior predictor of LV dilation than traditional ECG-based LVH criteria.
- ML methods performed similarly to QRS duration and did not provide any additional benefit for predicting LV dilation.

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Conflicts of Interest - None

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