SUPPLEMENTAL MATERIAL

Supplemental Methods

ECG Analysis

Vectorcardiograms were reconstructed from 12-lead ECGs using the reconstruction matrix developed by Kors et al.[11] The spatial QRS-T angle was calculated based on the difference between the mean QRS- and T-axes.[9] Subsequently, automated Q-, R- and S- amplitude and duration measurements along with diagnostic statement codes from the GE-Marquette 12SL (GE Healthcare, Wauwatosa, WI, USA) analysis program were imported into Microsoft Excel (Redmond, WA, USA). ECG confounder (conduction) types for QRS scoring were classified by automated analysis using slightly different criteria from those used in prior studies[3] as outlined below.

1. Left bundle branch block (LBBB)
    a. Marquette 12SL ECG analysis program statement code for LBBB (# 460)
    b. AND QRS duration ≥140 ms (men) or ≥130 ms women

2. Right bundle branch block and left anterior fascicular block (RBBB+LAFB)
    a. Marquette 12SL ECG analysis program statement code for RBBB (# 440)
    b. AND QRS duration ≥120
    c. AND QRS axis -90º to -45º or QRS axis 181º to 270º

3. Right bundle branch block (RBBB) (without LAFB)
    a. Marquette 12SL ECG analysis program statement code for RBBB (# 440)
    b. AND QRS duration ≥120 ms
    c. AND QRS axis -44º to 180º

4. Left anterior fascicular block (LAFB)
    a. Not meeting prior criteria for LBBB, RBBB+LAFB or RBBB
    b. AND QRS duration ≥100 ms
    c. AND QRS axis-90º to -45º or QRS axis 181º to 270º

5. Left ventricular hypertrophy (LVH)
    a. Not meeting prior criteria for LBBB, RBBB+LAFB, RBBB or LAFB
    b. Meeting criteria for either Sokolow-Lyon or Cornell LVH criteria
        i. Sokolow Lyon criteria
            1. (S in V1) + (R in V5 or V6) ≥2.60 mV
            2. or R in V5 or V6 ≥2.60 mV
        ii. Cornell Criteria
            1. R in aVL + S in V3 ≥2.80 mV (men)
            2. or R in aVL + S in V3 ≥2.00 mV (women)

6. No confounders – Not meeting any of the previous criteria

After classification of conduction/hypertrophy type, QRS scores were calculated using automated algorithms. Notch criteria along with R/R' and S/S' criteria in the QRS score in the presence of left bundle branch block (LBBB) were excluded because they are not captured by standard lead amplitude and duration measurements. Criteria shaded in gray are part of the manual/visual QRS score, but were not implemented in this automated analysis (Figure S1).

Searching the Social Security Death Master File

For this study, we searched the Social Security Death Master File (SSDMF), which contains over 86 million death records created from SSA payment records (www.ssdmf.com). We utilized the custom SSDMF interface created by the CardioVascular Research Grid (CVRG) Project, as outlined on the CVRG wiki (http://wiki.cvrgrid.org). We searched the death records for exact matches by first name, last name and date of birth that died during the study window (October 1, 2009 through December 31, 2010) and cross-matched the last four digits of the social security number for subjects identified to be deceased.

Automated Medical Record Screening at HUP

At HUP, the Penn Data Store was searched to extract age, sex, race and plasma creatinine levels for all subjects meeting ECG inclusion criteria. Data was extracted by querying the database with the medical record number for each ECG patient and matches were verified by confirming name and date of birth. The Penn Data Store is integrated into a central location via nightly Extract, Transform, and Load (ETL) processes built using IBM Data and Quality Stage (IBM Corp., Armonk, NY). The software utilized for mapping the structures of the database for which to load the records is SAP PowerDesigner (SAP America, Inc., Newtown Square, PA), in support with IBM FastTrack for the ETL mapping specifications. The combined effort of all of the software development solutions yields a database environment that cohesively combines the multiple information systems into a single, unified, data structure.

Table S1. Comparison of Mortality Rates at Johns Hopkins Hospital vs. Hospital of the University of Pennsylvania in all Patients with QRS Score ≥5 and QRS-T angle ≥105º

	Univariate Odds Ratio (95% CI*) (n=2,504)	**P**	**Multivariable Model Adjusted Odds Ratio (95% CI) (n=2,504)**	**P**
JHH† (vs. HUP‡)	1.67 (1.30-2.15)	<0.001	1.18 (0.90-1.55)	0.24
Age (per 5-year ↑)	1.15 (1.10-1.20)	<0.001	1.19 (1.13-1.24)	<0.001
Heart rate (per 10-bpm ↑)	1.32 (1.25-1.41)	<0.001	1.38 (1.29-1.47)	<0.001
Chronic renal impairment	2.97 (2.28-3.86)	<0.001	2.44 (1.83-3.25)	<0.001
Female gender	0.98 (0.76-1.27)	0.90	0.72 (0.55-0.95)	0.021

*CI = confidence interval; †HUP = Hospital of the University of Pennsylvania; ‡JHH = Johns Hopkins Hospital.

Table S2. Significant Predictors of Mortality Among Johns Hopkins Hospital Patients with QRS Score ≥5, QRS-T Angle ≥105º and LVEF >35%

	Multivariable Model Adjusted Odds Ratio (95% CI*) (n=1013)	**P**
Chronic renal impairment	3.34 (2.20-5.06)	<0.001
Heart rate (per 10-bpm ↑)	1.43 (1.30-1.58)	<0.001
QRS score (per 3-point ↑)	1.30 (1.07-1.59)	0.007
Age (per 5-year ↑)	1.13 (1.05-1.22)	0.001

*CI = confidence interval

Table S3. Odds Ratios for ECG Variables to Predict One-Year Mortality

	Univariate Odds Ratio (95% CI)	Adjusted Odds Ratio (95% CI)
QRS score <5 and QRS-T angle ≥105º		
JHH	1.18 (0.61-2.26)	0.58 (0.29-1.18)
HUP	2.21 (1.80-2.72)	1.41 (1.13-1.76)
Combined	2.07 (1.70-2.51)	1.29 (1.04-1.59)
QRS score ≥5 and QRS-T angle <105º		
JHH	2.53 (1.45-4.42)	1.61 (0.86-3.00)
HUP	2.31 (1.83-2.90)	1.73 (1.37-2.20)
Combined	2.33 (1.89-2.88)	1.72 (1.38-2.15)
QRS score >5 and QRS-T angle ≥105º		
JHH	2.79 (2.10-3.69)	1.37 (1.00-1.88)
HUP	2.42 (1.95-3.01)	1.47 (1.17-1.85)
Combined	2.59 (2.19-3.06)	1.53 (1.28-1.83)

* These odds ratios correspond to Figure 1 from the manuscript. The reference group is patients with QRS score <5 and QRS-T angle <105º. Multivariable model adjusted for age, sex, chronic renal impairment and heart rate.

QRS Scoring - Grayed Boxes are Criteria Not Implemented in Automated Analysis for this Study

Patient ID _____ QRS duration _____ Amplitude adjust _____
(↑1%/yr age 20-54; ↓1%/yr >55 yrs; ↓ 10% for females)

Age & gender _____ QRS axis _____ Duration adjust _____ RAO(**, ***) Yes/No
(↓ 10% for females)

Lead	RBBB Criteria	Pts	LAFB Criteria	Pts	LAFB + RBBB Criteria	Pts	LVH Criteria	Pts	No Confounders Criteria	Pts	Lead Max Pts
I	Q ≥ 30 ms	1	Q ≥ 30 ms	1	Q ≥ 30 ms	1	Q ≥ 30 ms	1	Q ≥ 30 ms	1	
	R/Q ≤ 1	1	R/Q ≤ 1	1	R/Q ≤ 1	1	R/Q ≤ 1	1	R/Q ≤ 1	1	2
	R ≤ 0.2 mV		R ≤ 0.2 mV		R ≤ 0.2 mV		R ≤ 0.2 mV		R ≤ 0.2 mV		
II	Q ≥ 40 ms	2	Q ≥ 40 ms	2	Q ≥ 40 ms	2	Q ≥ 40 ms	2	Q ≥ 40 ms	2	2
	Q ≥ 30 ms	1	Q ≥ 30 ms	1	Q ≥ 30 ms	1	Q ≥ 30 ms	1	Q ≥ 30 ms	1	
aVL	Q ≥ 30 ms	1	Q ≥ 40 ms	1	Q ≥ 40 ms	1	Q ≥ 40 ms	1	Q ≥ 30 ms	1	2
	R/Q ≤ 1	1	R/Q ≤ 1	1	R/Q ≤ 1	1	R/Q ≤ 1	1	R/Q ≤ 1	1	
aVF	Q ≥ 50 ms	3	Q ≥ 50 ms	3	Q ≥ 50 ms	3	Q ≥ 60 ms	3	Q ≥ 50 ms	3	
	Q ≥ 40 ms	2	Q ≥ 40 ms	2	Q ≥ 40 ms	2	Q ≥ 50 ms	2	Q ≥ 40 ms	2	
	Q ≥ 30 ms	1	Q ≥ 30 ms	1	Q ≥ 30 ms	1	Q ≥ 40 ms	1	Q ≥ 30 ms	1	5
	R/Q ≤ 1	2	R/Q ≤ 1	2	R/Q ≤ 1	2	R/Q ≤ 1	2	R/Q ≤ 1	2	
	R/Q ≤ 2	1	R/Q ≤ 2	1	R/Q ≤ 2	1	R/Q ≤ 2	1	R/Q ≤ 2	1	
V1 Ant.	Q ≥ 50 ms	2			Q ≥ 50 ms	2	any QR	1			(2)
	any Q	1	any QR	1	any Q	1	(or QS if *)		any Q	1	1
	Init R ≤ 20 ms						.04 R or S Notch				
V1 Post.**			R/S ≥ 1	1		1	R/S ≥ 1	1	R/S ≥ 1	1	
	Init R ≥ 60 ms	2	R ≥ 50 ms	2	Init R ≥ 60 ms	2	R ≥ 50 ms	2	R ≥ 50 ms	2	
	Init R ≥ 1.5 mV		R ≥ 1 mV		Init R ≥ 1.5 mV		R ≥ 1 mV		R ≥ 1 mV		4
	Init R ≥ 50 ms	1	R ≥ 40 ms	1	Init R ≥ 50 ms	1	R ≥ 40 ms	1	R ≥ 40 ms	1	
	Init R ≥ 1.0 mV		R ≥ 0.7 mV		Init R ≥ 1.0 mV		R ≥ 0.7 mV		R ≥ 0.7 mV		
			Q&S ≤ 0.2 mV	1			Q&S ≤ 0.2 mV	1	Q&S ≤ 0.2 mV	1	
V2 Ant.	Q ≥ 50 ms	2			Q ≥ 50 ms	2					(2)
	any Q	1	any QR	1	any Q	1	any QR	1	any Q	1	1
	R ≤ 10 ms		R ≤ 10 ms		R ≤ 10 ms		(or QS if *)		R ≤ 10 ms		
	R ≤ 0.1 mV		R ≤ 0.1 mV		R ≤ 0.1 mV		.04 R or S Notch		R ≤ 0.1 mV		
V2 Post.**			R/S ≥ 1.5	1			R/S ≥ 1.5	1	R/S ≥ 1.5	1	
	Init R ≥ 70 ms	2	R ≥ 60 ms	2	Init R ≥ 70 ms	2	R ≥ 60 ms	2	R ≥ 60 ms	2	
	Init R ≥ 2.5 mV		R ≥ 2 mV		Init R ≥ 2.5 mV		R ≥ 2 mV		R ≥ 2 mV		4
	Init R ≥ 50 ms	1	R ≥ 50 ms	1	Init R ≥ 50 ms	1	R ≥ 50 ms	1	R ≥ 50 ms	1	
	Init R ≥ 2.0 mV		R ≥ 1.5 mV		Init R ≥ 2.0 mV		R ≥ 1.5 mV		R ≥ 1.5 mV		
			Q≤0.3 & S≤0.3mV	1			Q≤0.3 &S≤0.3mV	1	Q≤0.3&S≤0.3mV	1	
V3	Q ≥ 30 ms	2	Q ≥ 30 ms	2	Q ≥ 30 ms	2	QR& (Q ≥ 30 ms)	2	Q ≥ 30 ms	2	
	R ≤ 10 ms		R ≤ 10 ms		R ≤ 10 ms		.04 R or S Notch	1	R ≤ 10 ms		2
	Q ≥ 20 ms	1	Q ≥ 20 ms	1	Q ≥ 20 ms	1	any QR		Q ≥ 20 ms	1	
	R ≤ 20 ms		R ≤ 20 ms		R ≤ 20 ms		(or QS if *)		R ≤ 20 ms		
V4	Q ≥ 20 ms	1	Q ≥ 20 ms	1	Q ≥ 20 ms	1	Q ≥ 20 ms	1	Q ≥ 20 ms	1	
	R/Q ≤ 0.5	2	R/Q ≤ 0.5	2	R/Q ≤ 0.5	2	R/Q ≤ 0.5	2	R/Q ≤ 0.5	2	
	R/S ≤ 0.5		R/S ≤ 0.5		R/S ≤ 0.5		R/S ≤ 0.5		R/S ≤ 0.5		
	R/Q ≤ 1	1	R/Q ≤ 1	1	R/Q ≤ 1	1	R/Q ≤ 1	1	R/Q ≤ 1	1	3
	R/S ≤ 1		R/S ≤ 1		R/S ≤ 1		R/S ≤ 1		R/S ≤ 1		
	R ≤ 0.5 mV		R ≤ 0.5 mV		R ≤ 0.5 mV		R ≤ 0.5 mV		R ≤ 0.5 mV		
	.04R Notch		.04R Notch		.04R Notch		.04R Notch		.04R Notch		
V5	Q ≥ 30 ms	1	Q ≥ 30 ms	1	Q ≥ 30 ms	1	Q ≥ 30 ms	1	Q ≥ 30 ms	1	
	R/Q ≤ 1	2	R/Q ≤ 1	2	R/Q ≤ 1	2	R/Q ≤ 1	2	R/Q ≤ 1	2	
	R/S ≤ 1		R/S ≤ 1		R/S ≤ 1		R/S ≤ 1		R/S ≤ 1		
	R/Q ≤ 2	1	R/Q ≤ 2	1	R/Q ≤ 2	1	R/Q ≤ 2	1	R/Q ≤ 2	1	3
	R/S ≤ 2		R/S ≤ 1.5		R/S ≤ 1.5		R/S ≤ 2		R/S ≤ 2		
	R ≤ 0.6 mV		R ≤ 0.6 mV		R ≤ 0.6 mV		R ≤ 0.6 mV		R ≤ 0.6 mV		
	.04R Notch		.04R Notch		.04R Notch		.04R Notch		.04R Notch		
V6	Q ≥ 30 ms	1	Q ≥ 30 ms	1	Q ≥ 30 ms	1	Q ≥ 30 ms	1	Q ≥ 30 ms	1	
	R/Q ≤ 1	2	R/Q ≤ 1	2	R/Q ≤ 1	2	R/Q ≤ 1	2	R/Q ≤ 1	2	
	R/S ≤ 1		R/S ≤ 1		R/S ≤ 1		R/S ≤ 1		R/S ≤ 1		
	R/Q ≤ 3	1	R/Q ≤ 3	1	R/Q ≤ 3	1	R/Q ≤ 3	1	R/Q ≤ 3	1	3
	R/S ≤ 3		R/S ≤ 2		R/S ≤ 2		R/S ≤ 3		R/S ≤ 3		
	R ≤ 0.6 mV		R ≤ 0.6 mV		R ≤ 0.6 mV		R ≤ 0.6 mV		R ≤ 0.6 mV		
	.04R Notch		.04R Notch		.04R Notch		.04R Notch		.04R Notch		
Total	Points		Points		Points		Points		Points		32
	%LV infarct (3 * #pts) ___		% LV infarct (3 * #pts) ___		% LV infarct (3 * #pts) ___		% LV infarct (3 * #pts) ___		% LV infarct (3 * #pts) ___		

Lead	LBBB Critera	Pts	Lead Max Pts
I	any Q	1	
	R/Q ≤ 1	2	
	R/S ≤ 1		3
	R/Q ≤ 1.5	1	
	R/S ≤ 1.5		
II	Q ≥ 40 ms	2	
	Q ≥ 30 ms	1	3
	R/Q ≤ 0.5	1	
	R/S ≤ 0.5		
aVL	Q ≥ 50 ms	2	
	Q ≥ 40 ms	1	
	R/S ≤ 0.5	2	4
	R/Q ≤ 0.5		
	R/S ≤ 1	1	
	R/Q ≤ 1		
aVF	Q ≥ 50 ms	2	
	Q ≥ 40 ms	1	3
	R/Q ≤ 0.5	1	
	R/S ≤ 0.5		
V1 Ant.***	NchInIt40	1	
	R ≥ 0.3 mV	2	
	R ≥ 30 ms		3
	R ≥ 0.2 mV	1	
	R ≥ 20 ms		
V1 Post	S/S' ≥ 2.0	3	
	S/S' ≥ 1.5	2	3
	S/S' ≥ 1.25	1	
V2 Ant.***	NchInIt40	1	
	R ≥ 0.4 mV	2	
	R ≥ 30 ms		3
	R ≥ 0.3 mV	1	
	R ≥ 20 ms		
V2 Post	S/S' ≥ 2.5	3	
	S/S' ≥ 2.0	2	3
	S/S' ≥ 1.5	1	
V5	any Q	1	
	R/R' ≥ 2	2	4
	R/R' ≥ 1	1	
	R/S ≤ 2		
	R ≤ 0.5 mV	1	
V6	Q ≥ 20 ms	1	
	R/R' ≥ 2	2	4
	R/R' ≥ 1	1	
	R/S ≤ 2		
	R ≤ 0.6 mV	1	
Total	Points		33

%LV infarct ___
(3 * #pts)

* (for LVH) if ≥4 other points in leads I, aVL, V4, V5 or V6 then count QS in V1-V3

** (RAO) if P positive amp in V1 ≥0.1 mV or aVF P ≥0.175 mV, then exclude V1-V2 Post criteria

*** (RAO) if P positive amp in V1 ≥0.1 mV or aVF P ≥0.175 mV, then exclude V1-V2 R-criteria points

Figure S1. QRS Scoring Criteria. Abbreviations: LAFB = left anterior fascicular block; LBBB = left bundle branch block; LV = left ventricle; LVH = left ventricular hypertrophy; NchInIt40 = Notch in initial 40 ms; RAO = right atrial overload; RBBB = right bundle branch block. See prior publications (3-5) for detailed definitions.

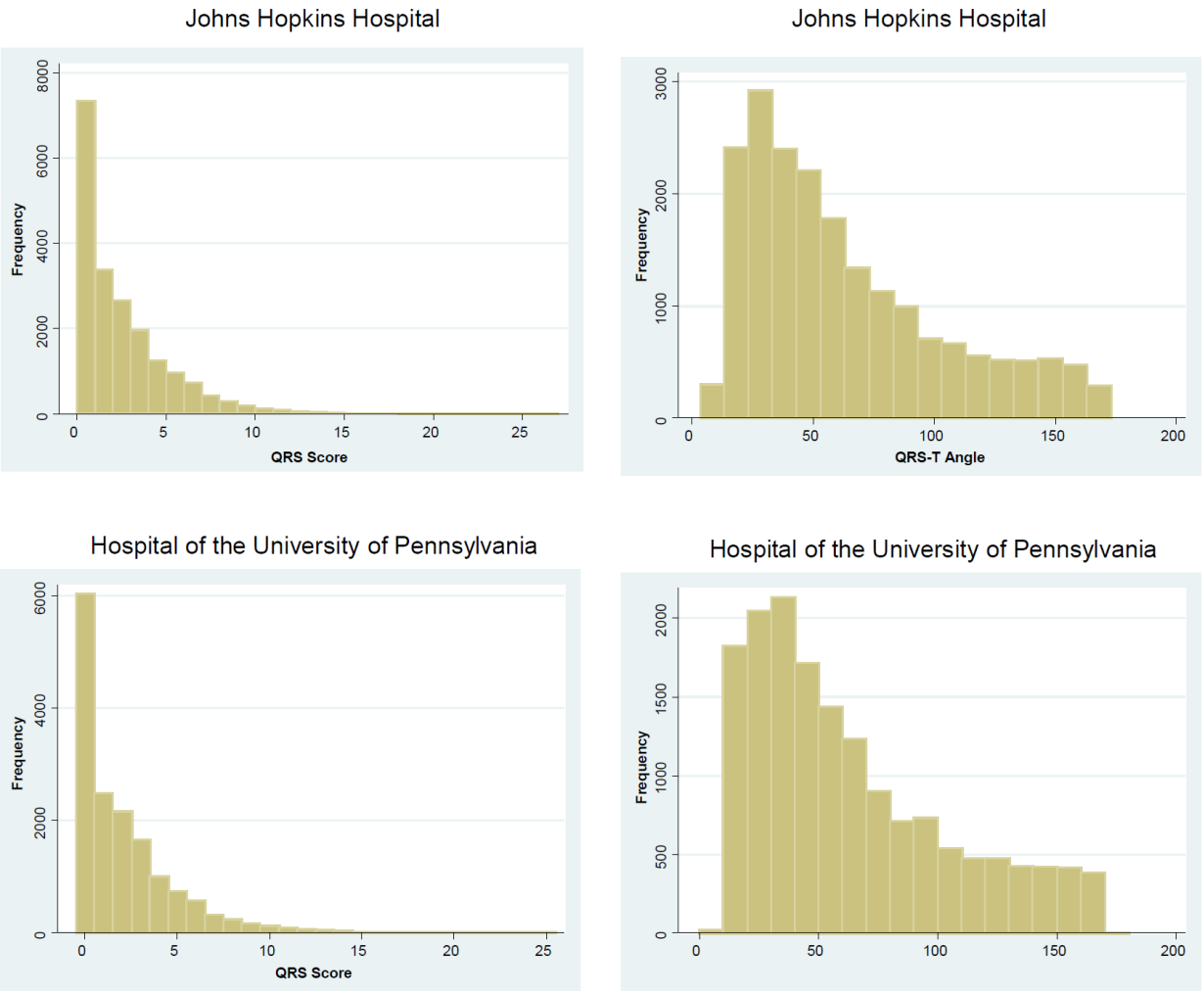

Figure S2. QRS score and QRS-T angle distributions – The median QRS score was 0 [interquartile range 0-3] at both institutions and the median QRS-T angle was 50° at both institutions with interquartile ranges of 30°-85° for Johns Hopkins Hospital and 30°-88° for Hospital of the University of Pennsylvania.