Bundle branch blocks and the risk of mortality in the Atherosclerosis Risk in Communities study

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Aims **The main objective of our study was to evaluate the associations between different categories of bundle branch blocks (BBBs) and mortality and to consider possible impact of QRS prolongation in these associations.**

Methods **This analysis included 15 408 participants (mean age 54 years, 55.2% women, and 26.9% blacks) from the Atherosclerosis Risk in Communities study. We used Cox regression to examine associations between left BBB (LBBB), right BBB (RBBB) and indetermined type of ventricular conduction defect [intraventricular conduction defect (IVCD)] with coronary heart disease (CHD) death and all-cause mortality.**

Results **During a mean 21 years of follow-up, 4767 deaths occurred; of these, 728 were CHD deaths. Compared to No-BBB, LBBB and IVCD were strongly associated with increased CHD death (hazard ratios 4.11 and 3.18, respectively; $P<0.001$ for both). Furthermore, compared to No-BBB with QRS duration less than 100 ms, CHD mortality risk was increased 1.33-fold for the No-BBB group with QRS duration 100–109 ms, and 1.48-fold with QRS duration 110–119 ms, 3.52-fold for pooled LBBB-IVCD group with QRS duration less than 140 ms and 4.96-fold for pooled LBBB-IVCD group with QRS duration at least 140 ms ($P<0.001$). However, mortality risk was not significantly increased for lone RBBB. For all-cause mortality, trends similar to those for CHD death were observed within the BBB groups, although at lower levels of risk.**

Conclusion **Prevalent LBBB and IVCD, but not RBBB, are associated with increased risk of CHD death and all-cause mortality. Mortality risk is further increased as the QRS duration is prolonged above 140 ms.**

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Introduction

The association between bundle branch blocks (BBBs) with increased mortality has been frequently investigated.[1–10] Left BBB (LBBB) has generally been found to be a significant predictor of mortality.[1–5] In reports from the community-based population, the mortality risk for right BBB (RBBB) has been inconsistent.[6–10] The aim of the present study was to compare the associations of different categories of BBB with coronary heart disease (CHD) and all-cause mortality in men and women from community-based populations, and to assess whether a more pronounced QRS prolongation in different categories of BBB increases the risk of death.

Methods

Study population and design

The analysis included participants from the Atherosclerosis Risk in Communities (ARIC) study, which is a population-based multicenter prospective study designed to investigate the natural history and cause of atherosclerotic and cardiovascular disease from four US communities: Forsyth County, North Carolina; Jackson, Mississippi; suburbs of Minneapolis, Minnesota; and Washington County, Maryland ($n = 15\,792$ men and women aged 45–64 years). The eligible participants were interviewed at home and then invited to a baseline clinical examination between 1987 and 1989. They attended three additional clinical examinations at 3-year intervals, and a recent fifth examination completed in 2013 for which data are not included here. Participants were interviewed by phone annually. Details of the ARIC study design, protocol sampling procedures, and selection and exclusion criteria were published elsewhere.[11] The study was approved by each study site's institutional review board. All participants provided written informed consent. For the purpose of this analysis, we excluded 384 participants: 201 with missing ECG or key variables, 136 with inadequate-quality ECG or ECG diagnosis of external pacemaker or Wolff-Parkinson-White pattern, and 47 who were neither African American nor white. After all exclusions, 15 408 participants remained and were included in this analysis.

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Outcome ascertainment

The outcomes considered in the present investigation were CHD death and total mortality that occurred from baseline through 31 December 2010. The follow-up period was up to 24 years (mean 21 years). After baseline, deaths and hospitalization events were ascertained in each clinical center by annual follow-up calls, review of vital records, and community surveillance of hospitalized and fatal events. Detailed definitions of criteria for CHD death classification were published previously.[11,12] Briefly, CHD deaths included sudden death, which is defined as a definite or possible CHD death that occurred within 1 h after the onset of acute symptoms, or had a history of chest pain within 72 h before death, or a history of cardiovascular disease (CVD) at baseline which was classified by the ECG evidence of myocardial infarction (MI) according to the Minnesota Code,[13] or the NOVACODE[14] criteria, or a self-reported history of a clinical diagnosis of MI, angina pectoris, coronary artery bypass surgery, coronary angioplasty, heart failure, or stroke at the time of entering the ARIC study.[11,12]

ECG methods

Identical electrocardiographs (MAC PC, Marquette Electronics Inc., Milwaukee, Wisconsin, USA) were used at all clinic sites, and resting, 10-s standard simultaneous 12-lead ECGs were recorded in all participants using strictly standardized procedures. All ECGs were processed in a central ECG laboratory (initially at Dalhousie University, Halifax, NS, Canada, and later at the EPICARE Center, Wake Forest School of Medicine, Winston-Salem, North Carolina, USA), where all ECGs were visually inspected for technical errors and inadequate quality using an interactive computer graphics terminal. The ECGs were first processed by the Dalhousie ECG program and were reprocessed for the present study using the 2001 version of the GE Marquette 12-SL program (GE, Milwaukee, Wisconsin, USA). BBBs were classified according to the Minnesota Code criteria[13] and categorized as LBBB (Minnesota Code 7.1), RBBB (Minnesota Code 7.2), intraventricular conduction defect (IVCD, Minnesota Code 7.4), and bifascicular BBB {a combination of RBBB and left anterior fascicular block [LAFB, QRS axis between -45 degree and -120° (Minnesota Code 7.8)]; or a combination of RBBB and left posterior fascicular block (LPFB, QRS axis between 91 and 180°)}.[13–15]

Statistical methods

Frequency distributions of ECG measurements were inspected to identify anomalies and outliers. Descriptive statistics were used to determine mean values, SDs and percentile distributions for continuous variables, and frequencies and percentages for categorical variables. Cox proportional-hazards analysis was used to assess the associations of BBB with the risk of mortality in incremental models as follows: model 1, unadjusted; model 2, adjusted for age, sex, and race; and model 3, adjusted for age, sex, race, regional center, BMI, SBP, smoking status, education level, hypertension, diabetes mellitus, history of CVD status, ratio of total cholesterol/high-density lipoprotein (HDL), blood glucose, and serum creatinine at baseline.

The effect of QRS duration on mortality risk in BBBs was estimated using 140 and 150 ms as cut-off points as recommended by the American College of Cardiology Foundation/American Heart Association and Heart Rhythm Society for Cardiac Resynchronization Therapy.[16] Initial analyses indicated that the results were closely similar for both the cut-off points, and 140 ms was retained for all the analyses performed. All analyses were performed with SAS version 9.3 (SAS Institute Inc., Cary, North Carolina, USA).

Results

Study group characteristics

The mean age at baseline was 54 years (SD 5.8), 55.2% were women, and 26.9% were African American. Of the study group, 35.0% had hypertension, 11.9% diabetes, and 9.7% had a history of CVD or ECG evidence of MI. Details of the demographic, clinical, and ECG characteristics of the study population stratified by BBB status are summarized in Table 1. As shown, most of the demographic and clinical characteristics, and the ECG measurements were different between the two groups, with the BBB group having a greater prevalence of CVD risk factors.

Bundle branch blocks and mortality

At baseline, the prevalence of BBBs was 2.8% (429/15 408) [90 LBBB, 181 RBBB, 111 IVCD, and 47 bifascicular blocks (RBBB with left anterior or left posterior fascicular blocks)]. During an average of 21 years of follow-up, there were 728 CHD and 4767 all-cause deaths. Compared to the No-BBB group, LBBB and IVCD were both strong predictors of CHD death and total mortality (Table 2). The risk of CHD death was increased 4.11-fold for LBBB and 3.18-fold for IVCD ($P < 0.001$ for both), and for all-cause mortality, the risk was increased 1.78-fold for LBBB and 1.36-fold for IVCD ($P < 0.001$ for both). RBBB was not significantly associated with CHD death and all-cause mortality.

QRS duration and mortality

The data given in Table 2 showed that the mortality risk levels of LBBB and IVCD were comparable and high for both, and the effect of QRS duration on mortality risk was evaluated for the combined LBBB and ICVD groups with 140 ms as the cut-off point. We used the No-BBB group with QRS duration less than 100 ms as the reference group, evaluating first mortality risk for the No-BBB group with QRS dichotomized at two levels – 100–109 and 110–119 ms. The risk of CHD death for the No-BBB

Table 1 Baseline characteristic and outcomes of study participants

Total $N = 15\,408$ [mean (SD), or %]	No bundle branch block QRS duration <120 ms ($N = 14\,979$)	Bundle branch block QRS duration ≥120 ms ($N = 429$)	P[a]
Age (years)	54 (5.8)	57 (5.4)	<0.001
BMI (kg/m^2)	28 (5.4)	28 (5.1)	0.038
SBP (mmHg)	121 (18.8)	124 (20.7)	0.001
Women (%)	55.8	32.6	<0.001
Race/ethnicity			0.889
White (%)	73.1	73.4	
African American (%)	26.9	26.6	
Education ≤ high school (%)	56.0	61.9	0.001
Current smoker (%)	26.1	28.4	0.013
Hypertension (%)	34.7	42.7	0.001
Diabetes (%)	11.8	15.7	0.015
History of CVD (%)	9.3	26.1	<0.001
Antihypertensives (%)	30.3	44.3	<0.001
Cholesterol-lowering drugs (%)	2.9	3.5	0.435
Ratio of total cholesterol/HDL	4.6 (1.8)	5.1 (1.7)	<0.001
Blood glucose (mg/dl)	109 (40.6)	111 (36.6)	0.263
Serum creatinine (mg/dl)	1.1 (0.4)	1.2 (0.9)	<0.001
Heart rate (/min)	66 (10.3)	64 (10.8)	<0.001
QRS duration (ms)	91 (9.6)	137 (15.8)	<0.001
Outcomes			
CHD death (%)	4.5	14.5	<0.001
All-cause mortality (%)	30.4	51.5	<0.001

BBB, bundle brunch block; CVD, cardiovascular disease; HDL, high-density lipoprotein. [a] P values between the groups of No-BBB and BBB.

group was moderately increased (1.33-fold) with QRS duration 100–109 ms, and the risk was further increased to 1.48-fold with QRS duration 110–119 ms in the multivariable adjusted model (model 3 in Table 3). The CHD mortality risk for the pooled LBBB-IVCD group with QRS duration less than 140 ms was increased 3.52 and 4.96-fold with QRS duration at least 140 ms ($P < 0.001$). The risk of all-cause mortality for the pooled LBBB-IVCD group was increased 1.40-fold ($P < 0.01$) for QRS duration less than 140 ms and 1.89-fold ($P < 0.001$) for QRS duration at least 140 ms.

Similar trends as for CHD death with increased QRS duration were observed for all-cause mortality, although the risk levels were considerably lower. The survival probability curves for CHD and all-cause mortality by BBB category and QRS duration are shown in Figs. 1 and 2. Additional analyses were performed in the No-BBB group to explore the possible reasons for the increased risk observed for QRS duration increase to 100–119 ms. A hierarchical coding of the ECG findings was performed in this subgroup as shown in Table 4. Old MI (ECG-MI) and ECG-LVH together accounted for 48% of all the CHD deaths and for 31% of all-cause mortality. Lone incomplete LBBB (Minnesota Code 7.6, i.e. QRS duration 100–119 ms without other ECG findings coded) accounted for 41% of the CHD deaths and 54% of all-cause mortality. These

Table 2 Hazard ratios for coronary heart disease death and all-cause mortality associated with different bundle branch block categories

	Event rate (n/N)	Events/1000 person-years	Hazard ratio[a] (95% CI)		
			Model 1	Model 2	Model 3
Coronary heart disease death (728/15 408)					
No-BBB	666/14979	2.4	1.00 (reference)	1.00 (reference)	1.00 (reference)
RBBB	14/181	4.7	1.63 (0.96–2.77)	1.31 (0.76–2.27)	0.67 (0.37–1.24)
Bifascicular-BBB	5/47	6.9	2.29 (0.95–5.54)	1.98 (0.82–4.77)	1.54 (0.63–3.74)
IVCD	26/111	15.9	5.90 (3.98–8.73)	4.02 (2.70–5.97)	**3.18 (2.09–4.83)** $P < 0.001$
LBBB	17/90	13.5	4.06 (2.51–6.59)	4.33 (2.67–7.02)	**4.11 (2.52–6.70)** $P < 0.001$
LBBB-IVCD	43/201	14.9	5.01 (3.68–6.83)	4.13 (3.03–5.65)	**3.51 (2.54–4.85)** $P < 0.001$
All-cause mortality (4767/15 408)					
No-BBB	4546/14979	16.0	1.00 (reference)	1.00 (reference)	1.00 (reference)
RBBB	87/181	28.3	1.49 (1.21–1.84)	1.31 (1.05–1.62)	1.03 (0.82–1.28)
Bifascicular-BBB	25/47	32.5	1.68 (1.14–2.50)	1.57 (1.06–2.33)	1.40 (0.94–2.07)
IVCD	57/111	32.2	1.87 (1.44–2.43)	1.44 (1.10–1.88)	**1.36 (1.04–1.79)** $P = 0.026$
LBBB	52/90	40.7	1.87 (1.42–2.46)	1.93 (1.46–2.54)	**1.78 (1.35–2.35)** $P < 0.001$
LBBB-IVCD	109/201	35.7	1.87 (1.55–2.26)	1.64 (1.35–1.99)	**1.54 (1.27–1.87)** $P < 0.001$

BBB, bundle branch block; bifascicular-BBB, RBBB with left anterior fascicular block or left posterior fascicular block; CI, confidence interval; IVCD, intraventricular conduction defect; LBBB, left bundle branch block; LBBB-IVCD, combined LBBB and IVCD group; RBBB, right bundle branch block. [a] Model 1 is an unadjusted model; model 2 is adjusted for age, sex, and race; and model 3 is adjusted for age, sex, race, region of residence, BMI, SBP, smoking status, education level, hypertension, diabetes mellitus, cardiovascular disease status, ratio of total cholesterol/ high-density lipoprotein, blood glucose, and serum creatinine at baseline.

Table 3 Hazard ratios with 95% confidence intervals for coronary heart disease death and all-cause mortality by QRS duration and bundle branch block categories

		Hazard ratio (95% CI)		
	Events/1000 (person-years)	Model 1[a]	Model 2[b]	Model 3[c]
Coronary heart disease death				
No-BBB group				
QRS duration <100 ms	2.0	1.00 (reference)	1.00 (reference)	1.00 (reference)
QRS duration 100–119 ms	4.1	2.04 (1.74–2.40)***	1.64 (1.38–1.94)***	**1.36 (1.14–1.62)** $P = 0.001$
QRS duration 100–109 ms	3.8	1.91 (1.60–2.28)***	1.56 (1.29–1.88)***	**1.33 (1.10–1.60)** $P = 0.004$
QRS duration 110–119 ms	5.1	2.56 (1.94–3.39)***	1.92 (1.48–2.55)***	**1.48 (1.10–1.98)** $P = 0.01$
Right bundle branch block				
QRS duration <140 ms	4.9	2.00 (0.99–4.03)	1.70 (0.84–3.42)	1.20 (0.59–2.43)
QRS duration ≥140 ms	4.6	1.90 (0.86–4.27)	1.32 (0.55–3.19)	0.39 (0.13–1.13)
LBBB-IVCD pooled				
QRS duration <140 ms	15.1	6.49 (4.45–9.46)***	4.80 (3.28–7.02)***	**3.52 (2.36–5.26)** $P < 0.001$
QRS duration ≥140 ms	14.4	5.23 (3.07–8.92)***	5.01 (2.94–8.55)***	**4.96 (2.89–8.53)** $P < 0.001$
All-cause mortality				
No-BBB group				
QRS duration <100 ms	15.4	1.00 (reference)	1.00 (reference)	1.00 (reference)
QRS duration 100–119 ms	18.8	1.23 (1.15–1.32)***	1.07 (1.00–1.15)*	1.03 (0.95–1.11)
QRS duration 100–109 ms	18.4	1.18 (1.09–1.27)***	1.04 (0.96–1.12)	0.99 (0.92–1.08)
QRS duration 110–119 ms	22.4	1.45 (1.27–1.65)***	1.20 (1.05–1.37)**	**1.17 (1.02–1.34)** $P = 0.024$
Right bundle branch block				
QRS duration <140ms	26.7	1.48 (1.11–1.97)*	1.29 (0.97–1.73)	1.01 (0.75–1.35)
QRS duration ≥140ms	30.4	1.66 (1.22–2.27)***	1.38 (1.00–1.91)**	1.07 (0.77–1.50)
LBBB-IVCD-pooled[¶]				
QRS duration <140ms	33.5	1.94 (1.53–2.47)***	1.56 (1.23–1.99)***	**1.40 (1.09–1.79)** $P = 0.001$
QRS duration ≥140ms	40.2	1.98 (1.45–2.69)***	1.88 (1.37–2.56)**	**1.89 (1.38–2.58)** $P < 0.001$

BBB, bundle branch block; CI, confidence interval; IVCD, intraventricular conduction defect; LBBB-IVCD pooled, combined LBBB and IVCD group. [a] Model 1: unadjusted. [b] Model 2: adjusted for age, sex, and race. [c] Model 3: Adjusted for age, sex, race, region of residence, BMI, SBP, smoking status, education level, hypertension, diabetes mellitus, cardiovascular disease status, ratio of total cholesterol/ high-density lipoprotein, blood glucose, and serum creatinine at baseline. * $P < 0.05$. ** $P < 0.01$. *** $P < 0.001$ for P values of hazard ratios.

observations most likely explain the higher mortality risk observed for the No-BBB group with QRS prolonged beyond 100 ms.

A second series of additional analyses was done to compare the consistency of the mortality risk for the long follow-up period compared to the shorter-term follow-up. The risk data for mortality are given in Supplementary Table 1 (http://links.lww.com/JCM/A56). The risk levels for mortality risk evaluated at three different follow-up years are fairly consistent, although some attenuation is observed with increasing follow-up time.

Discussion

The present study evaluated the mortality risk in subgroups stratified by BBB category, QRS duration, and sex. The key findings in the fully adjusted model are as follows: compared to the No-BBB group with QRS duration less than 120 ms, LBBB and IVCD were strong predictors of mortality; using No-BBB with QRS duration below 100 ms as the reference group, CHD mortality risk was increased 3.5-fold for the pooled LBBB-IVCD group with QRS duration less than 140 ms and by 5-fold with QRS duration at least 140 ms; similarly, all-cause mortality risk for the pooled LBBB-IVCD group was increased 1.4 and 1.9-fold for QRS duration levels below 140 ms and at least 140 ms, respectively; mortality risk was not significantly increased for RBBB in the fully adjusted multivariable model.

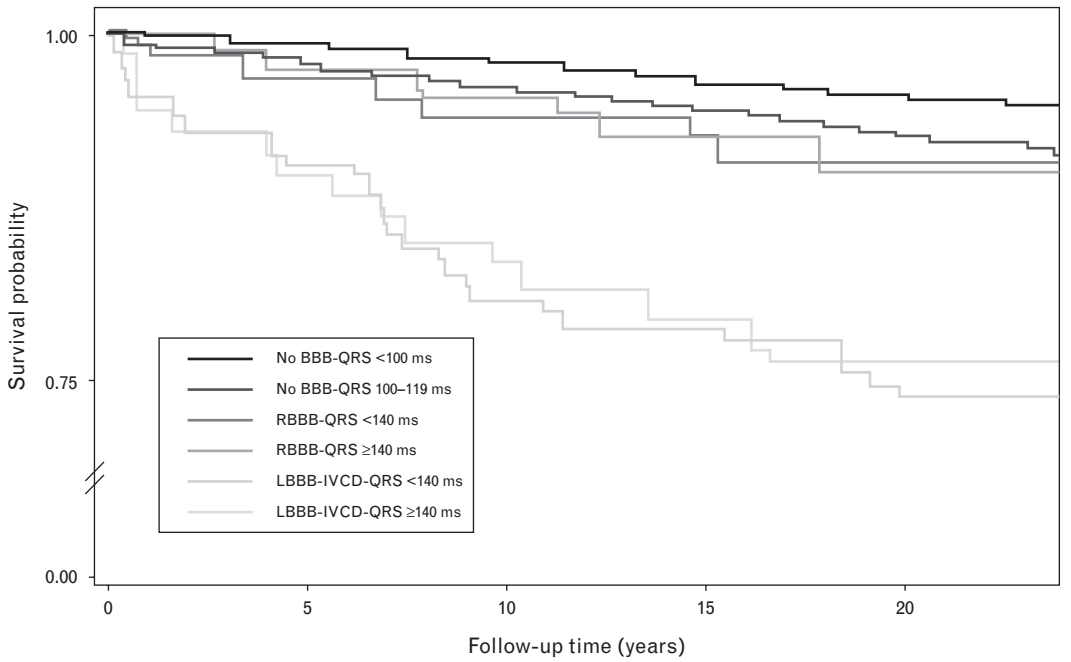
Possible mechanisms for increased mortality risk in bundle branch blocks

The following possible mechanisms for increased mortality risk for LBBB and IVCD are suggested here at least as reasonably rational hypothesis-generating propositions for future research. Prolonged left ventricular excitation particularly in LBBB with a large delay between activation of the ventricular septum and left ventricular free wall produces dyssynchronous and inefficient left ventricular contraction, and thus LBBB is a marker of significant left ventricular systolic dysfunction. Impaired cardiac function with abnormal ventricular conduction patterns reflects a possible cause-and-effect relation between BBB and mortality.[16–18] It can be speculated that the delay and dyssynchrony of left ventricular repolarization and relaxation may also be a contributing factor to increased mortality risk in addition to dyssynchrony of ventricular contraction.

Our results in relation to other investigators

Left bundle branch block has been associated with excess risk of mortality in many studies.[1–5] In contrast to LBBB, reports on the effect of RBBB have been conflicting.[6–10] In a report from the Heart Outcomes Prevention Evaluation (HOPE) trial,[10] baseline LBBB was an independent predictor of heart failure, sudden death, CVD death, and all-cause death, but RBBB was not associated with increased risk for these end-points. Zhang *et al.*[4] evaluated the mortality risk for BBBs during a 14-year follow-up period in 66 450 participants in the Women's

Fig. 1



Number at risk

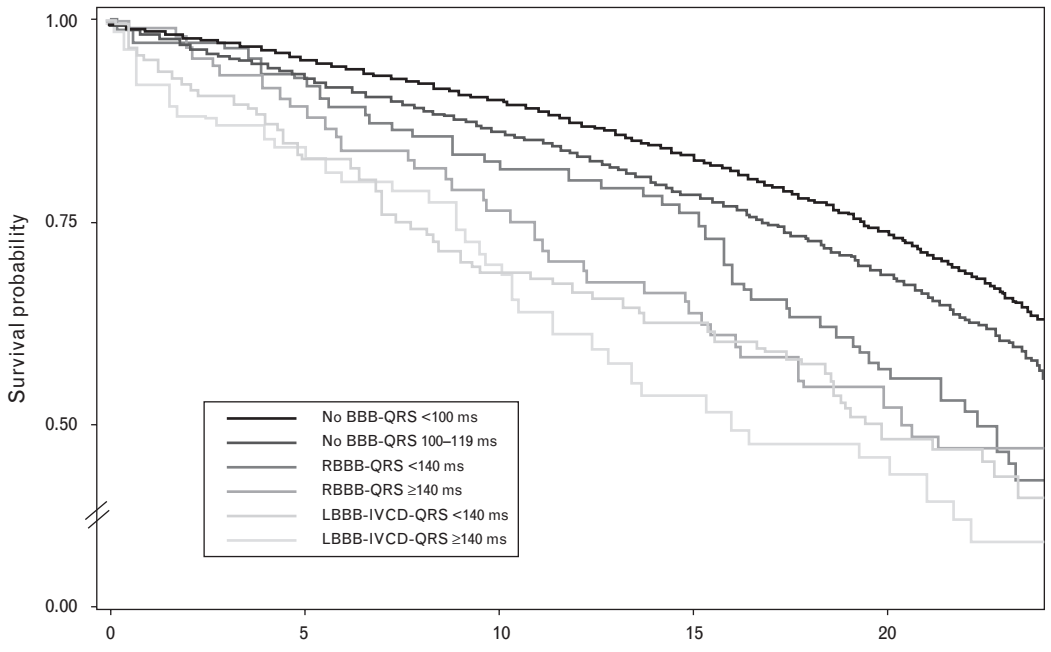
No BBB-QRS <100 ms	11975	11412	10775	9937	8904
No BBB-QRS 100–119 ms	3004	2788	2593	2347	2080
RBBB-QRS <140 ms	101	89	78	70	57
RBBB-QRS ≥140 ms	80	71	61	50	41
LBBB-IVCD-QRS <140 ms	130	104	84	77	66
LBBB-IVCD-QRS ≥140 ms	71	57	46	38	32

Coronary heart disease death survival probability curves by QRS duration and bundle branch block category. LBBB-IVCD, combined left bundle branch block and intraventricular conduction defect (LBBB and IVCD were combined since both were significant predictors, but with too few deaths of coronary heart disease in individual categories); RBBB, right bundle branch block.

Health Initiative study, and found that LBBB, IVCD, and RBBB combined with LAFB were strong predictors of mortality in multivariable adjusted risk models, but lone RBBB was not. Recently, a study by Bussink *et al.*[6] showed that RBBB was associated with increased risk of CVD and all-cause mortality, and adverse cardiovascular outcomes in both sexes.

Wang *et al.*[19] analyzed 2962 patients hospitalized for heart failure in the efficacy of vasopressin antagonism in heart failure outcome study with tolvaptan (EVEREST) study with a median follow-up of 9.9 months. All-cause mortality was 18.7% for patients with normal baseline QRS duration and 28.1% for patients with a prolonged QRS duration, and mortality risk was further increased with more prolonged QRS duration. Aro *et al.*[7] evaluated the relative risk for QRS duration for all-cause and cardiac mortality and sudden arrhythmic death during a 30-year follow-up in a general population of 10 899 Finnish middle-aged men and women, and found that QRS duration at least 110 ms was a strong predictor of cardiac and all-cause death and arrhythmic death. Partial or complete LBBB was significantly associated with arrhythmic death, but not with cardiac or all-cause death, and partial or complete RBBB was not significantly associated with any major end-points. Adesanya *et al.*[20] followed 997 patients with RBBB for a median of 45 months, which showed that increasing QRS duration was an independent predictor of cardiac mortality in patients with RBBB, but it had no influence on all-cause mortality. In our study, the participants with no BBB, but with QRS duration 100–119 ms, had a 36% increase risk of CHD death, but no increased risk of all-cause mortality using QRS below 100 ms as the reference group. Both LBBB and IVCD were significantly associated with increased mortality, and LBBB-IVCD with QRS duration at least 140 ms was the strongest predictor of CHD death and total mortality. However, mortality risk was not significantly increased for RBBB, even for RBBB, with QRS duration at least 150 ms in multivariable-adjusted models.

Fig. 2



Number at risk

No BBB-QRS <100 ms	11975	11412	10775	9937	8904
No BBB-QRS 100–119 ms	3004	2788	2593	2347	2080
RBBB-QRS <140 ms	101	89	78	70	57
RBBB-QRS ≥140 ms	80	71	61	50	41
LBBB-IVCD-QRS <140 ms	130	104	84	77	66
LBBB-IVCD-QRS ≥140 ms	71	57	46	38	32

All-cause mortality survival probability curves by QRS duration and bundle branch block category. LBBB-IVCD, combined left bundle branch block and intraventricular conduction defect (LBBB and IVCD were combined since both were significant predictors for mortality); RBBB, right bundle branch block.

Study limitations

The use of a single ECG from the study baseline, rather than repeated multiple ECGs for risk analysis, may increase the variability and reduce the strength of the observed mortality risk for BBBs. We did not use time-dependent covariates for risk evaluation. However, comparing the trends in mortality risk for three different follow-up periods indicated relatively stable similar trends for short-term and long-term follow-up. Among other limitations of the study was that ejection fraction and other echocardiographic data and information about the use of drugs during the follow-up were not available for this investigation.

Table 4 ECG findings in the group with No-bundle branch block and QRS duration 100–119 ms for coronary heart disease deaths and all-cause deaths

ECG findings	Count [*N* (%)]	CHD death [*N* (%)]	All deaths [*N* (%)]
ECG-MI[a]	231 (7.7)	57 (26.0)	145 (14.1)
Minor Q waves[b]	183 (6.1)	7 (3.2)	67(6.5)
ECG-LVH[c]	369 (12.3)	47 (21.5)	172 (16.7)
LAFB[d]	36 (1.2)	6 (2.7)	21(2.0)
Incomplete RBBB[e]	109 (3.6)	9 (4.1)	45 (4.4)
RR′, R′ < R in V1 or V2	96 (3.2)	3 (1.4)	25 (2.4)
Isolated prolonged QRS[f]	1977 (65.8)	90 (41.1)	557 (54.0)
Total	3004 (100)	219 (100)	1032 (100)

CHD, coronary heart disease; LVH, left ventricular hypertrophy; LAFB, left anterior fascicular block; MI, myocardial infarction; RBBB, right bundle branch block. [a] Minnesota Code (MC) 1.1–1.2, or MC 1.3 with Code 4.1 or 4.2 or 5.1 or 5.2. [b] MC 1.3 without Code 4.1 or 4.2 or 5.1 or 5.2. [c] MC 3.1 or 3.3, or ECG-LVH by Cornell voltage. [d] MC 7.7 (left anterior fascicular block). [e] MC 7.3. [f] QRS duration 100–119 ms (MC 7.6) without other ECG findings.

Conclusion

Prevalent LBBB and IVCD, but not RBBB, are significant predictors of CHD and all-cause mortality, and mortality risk further increased as the QRS duration was prolonged above 140 ms.

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