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Right bundle branch block: prevalence, risk factors, and outcome in the general population: results from the Copenhagen City Heart Study

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Aims To determine the prevalence, predictors of newly acquired, and the prognostic value of right bundle branch block (RBBB) and incomplete RBBB (IRBBB) on a resting 12-lead electrocardiogram in men and women from the general population.

Methods and results We followed 18 441 participants included in the Copenhagen City Heart Study examined in 1976–2003 free from previous myocardial infarction (MI), chronic heart failure, and left bundle branch block through registry linkage until 2009 for all-cause mortality and cardiovascular outcomes. The prevalence of RBBB/IRBBB was higher in men (1.4%/4.7% in men vs. 0.5%/2.3% in women, $P < 0.001$). Significant predictors of newly acquired RBBB were male gender, increasing age, high systolic blood pressure, and presence of IRBBB, whereas predictors of newly acquired IRBBB were male gender, increasing age, and low BMI. Right bundle branch block was associated with significantly increased all-cause and cardiovascular mortality in both genders with age-adjusted hazard ratios (HR) of 1.31 [95% confidence interval (CI), 1.11–1.54] and 1.87 (95% CI, 1.48–2.36) in the gender pooled analysis with little attenuation after multiple adjustment. Right bundle branch block was associated with increased risk of MI with an HR of 1.67 (95% CI, 1.16–2.42) and pacemaker insertion with an HR of 2.17 (95% CI, 1.22–3.86), but not with chronic heart failure (HR 1.37; 95% CI, 0.96–1.94), atrial fibrillation (HR 1.10; 95% CI, 0.73–1.67), or chronic obstructive pulmonary disease (HR 0.99; 95% CI, 0.60–1.62). The presence of IRBBB was not associated with any adverse outcome.

Conclusion In this cohort study, RBBB and IRBBB were two to three times more common among men than women. Right bundle branch block was associated with increased cardiovascular risk and all-cause mortality, whereas IRBBB was not. Contrary to common perception, RBBB in asymptomatic individuals should alert clinicians to cardiovascular risk.

Keywords Epidemiology • Mortality • Prognosis • Electrocardiography • Bundle branch block

Introduction

Right bundle branch block (RBBB) is generally considered a benign finding that does not imply increased risk when found in asymptomatic healthy individuals.[1–3] The prevalence of RBBB is known to increase with age, to be higher in men, diabetics, and in patients with hypertension.[2,4–6] Right bundle branch block may also indicate affection of the right side of the heart through cor pulmonale, myocardial ischaemia/infarction, pulmonary embolism, myocarditis, or congenital heart disease. Among patients with heart failure, the presence of RBBB has been associated with an adverse prognosis.[7,8]

Most of the conventional knowledge on RBBB in asymptomatic individuals is based on relatively few, relatively small, and older

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studies. Several of these studies are case–control studies based on hospitalized individuals, do not include women, are restricted to specific age groups, or use different definitions of RBBB.[2,3,7–11] Right bundle branch block is associated with lung disease and with disease severity in patients with chronic obstructive pulmonary disease (COPD)[12]; yet, no previous study of asymptomatic individuals has taken lung function into account.

Whereas RBBB patterns are relatively rare in electrocardiograms (ECG's) in the general population, incomplete RBBB (IRBBB), with a normal duration of the QRS complex, is a common finding. Most persons with IRBBB have no clinical evidence of structural heart disease and IRBBB is seen relatively frequently in healthy young athletes.[13] Incomplete RBBB is thus regarded as a benign condition but—to our knowledge—this is based on only one study of 134 asymptomatic middle-aged men which reported no increased risk of death due to coronary heart disease (CHD) or cardiovascular diseases (CVDs) in 20 years of follow-up.[14]

Evidently, the prognostic value of incidentally discovered RBBB has important implications for cardiovascular risk assessment. The aim of the present study was therefore to describe the prevalence of RBBB and IRBBB in the general population, to determine risk factors and to establish the prognostic implication of incidentally found RBBB and IRBBB.

Methods

Population and design

Data were derived from the Copenhagen City Heart Study, a prospective cardiovascular study including a total of 18 974 individuals aged ≥20 years, randomly sampled from the ~90 000 residents from a specified area of Copenhagen, Denmark. In 1976–78, 14 223 participants were included, and in each of the three following surveys, all sampled persons were re-invited and supplemented by subjects in younger birth cohorts; in 1981–83 (1563 new participants), from 1991 to 1993 (2360 new participants), and in 2001–03 (828 new participants).[15,16]

This study included participants from the baseline examination in 1976 as well as new participants from the following examinations. Participants with previous myocardial infarction (MI), chronic heart failure, left bundle branch block (LBBB), or missing values of RBBB or IRBBB were excluded from this study (refer to *Figure 1* for flow chart). Analyses of newly acquired RBBB and IRBBB were based on the participants who attended both the first and the second examination and were also free from RBBB at the baseline.

Variables of interest

Each assessment consisted of a self-administered questionnaire, a non-fasting venous blood sample, a physical examination including spirometry, and a 12-lead resting ECG. Electrocardiograms were stored in digital and/or paper format and classified by the Minnesota Code Classification System for Electrocardiographic Findings. Two independent investigators evaluated the ECG's. A third investigator would make the final decision in the case of disagreement.[15] Right bundle branch block was defined according to the Minnesota Code criteria (7-2-1) by a QRS duration of ≥120 ms in a majority of beats in any of leads I, II, III, aVL, aVF, *plus* R′ > R in lead V_1 or V_2, or; QRS mainly upright, with an R-peak duration of ≥60 ms in lead V_1 or V_2 or; S duration > R duration in all beats in lead I or II. Incomplete RBBB was defined according to the Minnesota Code criteria (7-3) by a QRS duration of <120 ms in each of leads I, II, III, aVL, aVF, in combination with R′ > R in lead V_1 or V_2.[17]

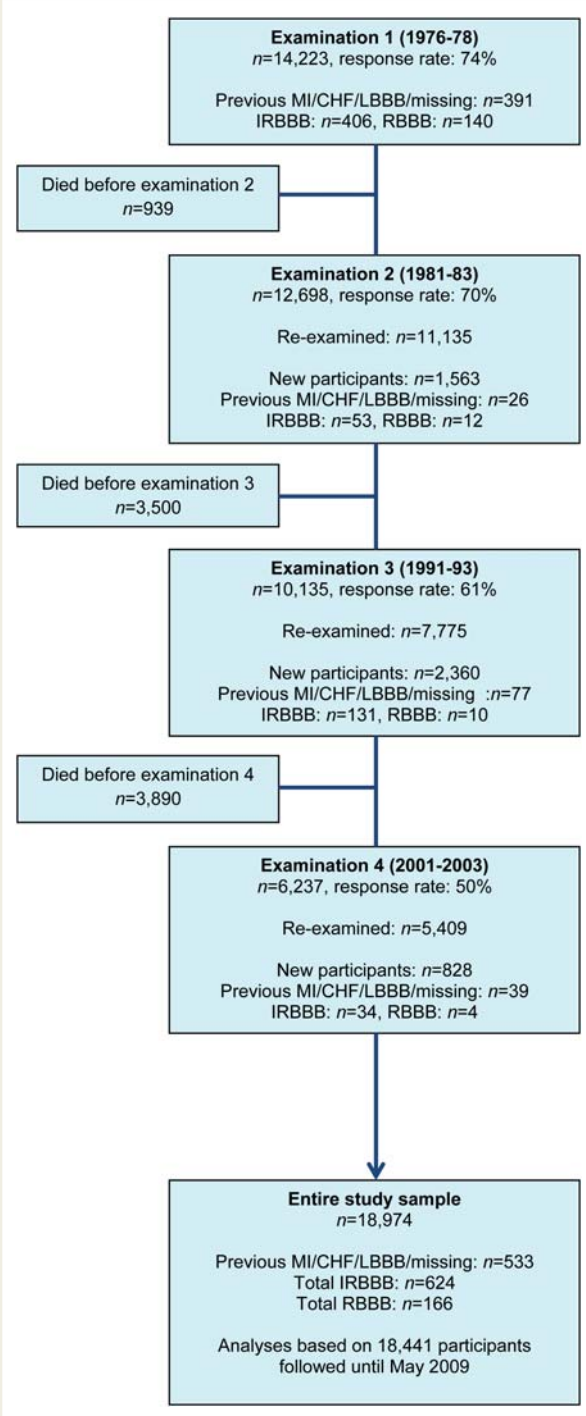


Figure 1 Flow chart of the study population of the Copenhagen City Heart Study.

Diabetes was defined as self-reported diabetes mellitus or non-fasting glucose levels of ≥11.1 mmol/L (200 mg/dL). *Body mass index* (BMI) was defined as weight in kilograms divided by height in meters squared. *Physical activity* in leisure time was divided into two categories:

sedentary/moderate activity for <4 h per week and high/intense activity for >4 h per week. *Tobacco smoking* was divided into three categories: never smokers, ex-smokers, and current smokers. *Total cholesterol and triglycerides* were non-fasting. *Heart rate* was determined from the 12-lead electrocardiograms. *Blood pressure* was measured in a sitting upright position after 5 min of rest. *Medical treatment of blood pressure* was self-reported. *Family history* was positive if one or both of the parents had had an MI. *Educational level* was divided into three categories: <8 years (low), 8–11 (intermediate), and >11 (high) years of schooling. *Lung function* was assessed by spirometry. Chronic obstructive pulmonary disease was defined as forced expiratory volume in 1 s (FEV_1) divided by forced vital capacity (FVC) below 0.7 in combination with FEV_1 below 70% of predicted. Forced expiratory volume in 1 s predicted was computed using the following formula in women: $1.597 + 0.5552 \times \text{height}^3 - 0.01574 \times \text{age}$ and in men: $2.081 + 0.5846 \times \text{height}^3 - 0.01599 \times \text{age}$.[18]

Endpoints

The endpoints studied were all-cause mortality, cardiovascular mortality (ICD-8: 390–459; ICD-10: I00–99), non-cardiovascular mortality, MI (ICD-8: 41 009, 41 099; ICD-10: I21), pacemaker (PM) insertion (ICD-8: 32 120–32 131, 32 199, 32 600–32 680; ICD-10: BFC, BFF, ZZ4050), atrial fibrillation (ICD-8: 42 793–42 794; ICD-10: I489), chronic heart failure (ICD-8: 42 709, 42 710; ICD-10: I50), and COPD (ICD-8: 491–492; ICD-10: DJ44). Data regarding prior morbidity, outcomes, and mortality were obtained from the National Patient Registry and the National Danish Causes of Death Register. Since 1977 all admissions to Danish hospitals and since 1994 all in-hospital and out-patient contacts have been registered in the National Patient Registry with one or more appropriate discharge diagnoses according to the International Classification of Diseases, i.e. the 8th edition from 1977 to 1994 and the 10th edition from 1994 onwards. Validation data on hospital admission for MI, heart failure, and COPD were available, but not for the remaining diagnoses or for outpatient contact. The National Patient Registry has been validated and found well suited for use in epidemiological research.[19] Specifically, the registry diagnosis of MI morbidity and mortality have a positive predictive value of 92–94%,[20] hospital admission for Heart Failure an estimated specificity of 99%, albeit with sensitivity below 30,[21] and hospital admission for COPD a positive predictive value of 92%.[22] Follow-up was from the date of inclusion till first diagnosis of MI, chronic heart failure, atrial fibrillation, PM insertion, COPD, death, emigration, or end of follow-up. All participants were followed from the date of their baseline examination until May 2009. Follow-up was almost complete because of national coverage with only loss to follow up due to emigration (<0.5%).

The Ethics Committee for the Copenhagen area approved the study (KF 100.2039/91).

Statistical analysis

The primary variables of interest were the presence of RBBB/IRBBB. For age-adjusted comparison between groups, we used linear and logistic regression, as appropriate, with adjustment for age and age squared for improved model fit. The prevalence of RBBB/IRBBB was based on ECG findings at study entry, i.e. based on the 624 subjects with IRBBB and 166 subjects with RBBB out of 18 441 subjects under study (*Figure 1*). The prognostic value of RBBB/IRBBB was, similarly, based on these baseline ECG recordings in the entire sample ($n = 18\,441$) followed until May 2009. Incident RBBB/IRBBB was newly developed and defined as RBBB/IRBBB at re-examination in participants who had been free of RBBB/IRBBB at the baseline. Predictors of newly developed RBBB/IRBBB were analyzed by means of logistic regression. Due to differences in time to follow-up in the three re-examinations, the analyses was not performed on the pooled data but primarily as 5-year follow-up of the first examination and repeated for newly developed RBBB/IRBBB between surveys 2 and 3 and surveys 3 and 4, respectively.

Gender-specific survivor functions were estimated for individuals with RBBB, IRBBB, and no BBB, respectively, with the Kaplan–Meier method. Survival analyses were performed by the Cox proportional hazards model with age as the underlying time scale, thus ensuring optimal age adjustment. Subjects entered the analysis at their first examination in the study and were followed until outcome, death, or end of follow-up. All initial models were gender-specific. Only after assessing whether the prognostic value of the ECG findings was similar in both genders, the analyses were repeated on pooled data. Covariates were regarded as confounders of the association between RBBB/IRBBB and outcome based on a priori assumptions regarding causal web and if the covariate was associated with RBBB/IRBBB after age adjustment with a cut-off for *P*-value below 0.15. Covariates in multivariable regression models were treated as categories according to the descriptions above. Variables measured on a continuous scale were categorized into quintiles and analysed as such to avoid assumptions regarding linearity. Assumptions of proportional hazards was tested formally by Schoenfeld residuals and found valid for all models.

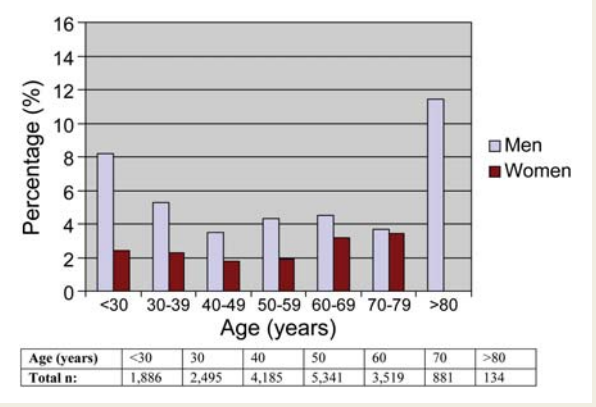
Statistical analysis was performed using Stata 11.1 (StataCorp LP, College Station, TX, USA).

Results

Prevalence of IRBBB and RBBB

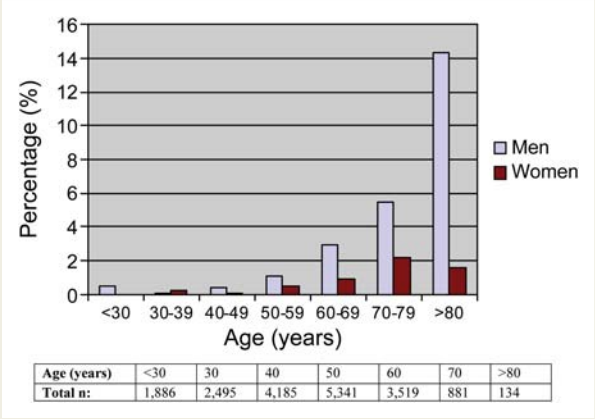
After excluding participants with previous MI or chronic heart failure ($n = 341$), with missing ECG's ($n = 75$), or LBBB ($n = 117$), 18 441 participants were available for the analyses and were followed with a median follow-up of 20.5 years (inter-quartile range 13.9–30.3).

The prevalence of IRBBB and RBBB was significantly higher in men compared with women ($P < 0.001$): 398 (4.7%) men and 226 (2.3%) women had IRBBB, while 119 (1.4%) men and 47 (0.5%) women had RBBB. *Figures 2* and *3* show the prevalence of IRBBB and RBBB, respectively, by gender and age. Right bundle branch



Age (years)	<30	30	40	50	60	70	>80
Total n:	1,886	2,495	4,185	5,341	3,519	881	134

Figure 2 Prevalence of incomplete right bundle branch block among the 18 441 participants at baseline examinations.



Age (years)	<30	30	40	50	60	70	>80
Total n:	1,886	2,495	4,185	5,341	3,519	881	134

Figure 3 Prevalence of right bundle branch block among the 18 441 participants at baseline examinations.

block increased with age in both genders, whereas IRBBB displayed a more U-shaped association with age. However, for age above 80, prevalence was based on a limited number of cases.

Baseline characteristics of prevalent IRBBB, RBBB, and no BBB are shown in *Table 1*. Participants with RBBB were on average 13 years older than subjects without RBBB. After age adjustment, there were few differences: men with RBBB had a significantly higher systolic blood pressure and women with RBBB had higher cholesterol levels. Incomplete RBBB was associated with a significantly lower BMI in both genders. Men with IRBBB were younger and had slightly lower blood pressure.

Clinical characteristics of newly developed incomplete right bundle branch block and right bundle branch block

Among the 10 327 participants free of IRBBB and RBBB at the first examination who attended the second examination after 5 years, 249 (133 men and 116 women) developed IRBBB. After multivariable adjustment, male gender, increasing age, and low BMI predicted newly acquired IRBBB (*Table 2*). Among the 10 629 participants free from RBBB at the first examination, 51 (33 men and 18 women) developed RBBB. Male gender, increasing age, higher systolic blood pressure, and IRBBB at the baseline were significant predictors of newly acquired RBBB after multivariable adjustment. Similar results were found when analysing predictors of newly developed IRBBB/RBBB between second and third surveys and third and fourth surveys (results not shown).

Cardiovascular disease outcomes

Among the 166 participants with RBBB, 107 men and 38 women died during follow-up. *Figures 4* and *5* show the Kaplan–Meier survival curves regarding all-cause and cardiovascular mortality comparing participants with IRBBB and RBBB and no BBB. Results from survival analyses of the different outcomes for men, women, and pooled data are shown in *Table 3*. With the exception of MI, hazard ratios (HR) were comparable in both genders. Overall, RBBB was associated with an increased all-cause mortality risk with an HR of 1.31 [95% confidence interval (CI), 1.11–1.54]. The increased mortality risk was caused by increased cardiovascular mortality (HR 1.87; 95% CI, 1.48–2.36), whereas non-cardiovascular mortality was not increased (HR 1.00; 95% CI, 0.79–1.26). After multivariable adjustment, HR attenuated somewhat but remained statistically significant.

A significant association between RBBB and MI was seen in women (HR 2.79, 95% CI 1.50–5.22), but not in men (HR 1.37; 95% CI, 0.87–2.16). This gender difference was statistically significant (*P*-value for interaction 0.01) but, since multiple comparisons were performed, this may be a chance finding. In the pooled data, including both sexes, HR was 1.67 (95% CI, 1.16–2.42). The risk of chronic heart failure was also increased (HR 1.37; 95% CI, 0.96–1.94), but this association did not reach statistical significance. Right bundle branch block was not associated with increased risk of atrial fibrillation or COPD, but as expected was significantly related to risk of PM insertion with age-adjusted HR of 2.17 (95% CI, 1.22–3.86). However, only 12 (7%) of the 166 participants with RBBB had a PM implanted during the 20.5-year median follow-up. Incomplete RBBB was not associated with increased mortality or any other outcome under study.

When repeating analyses using only 13 832 individuals examined in 1976, results were similar (data not shown). Analyses were also repeated including only in-hospital admissions for relevant outcomes, i.e. chronic heart failure, atrial fibrillation, and COPD. Since <1% had only outpatient contacts, all results remained unaffected. Further, to explore whether the prognostic implications of RBBB may differ by the age of development, analyses was stratified by age at study entry. Using a cut-off of 60 years, there was a tendency of higher HR's among participants below age 60 for all outcomes except MI and PM insertion. However, none of the differences reached statistical significance (*P*-value for interaction all >0.05). For cardiovascular mortality, age-adjusted HR for RBBB discovered below age 60 was 2.16 (1.30–3.60) and for age 60 or above was 1.57 (1.21–2.04).

Discussion

The main finding of this study was that in individuals free from CVD, incidentally discovered RBBB was associated with ~30% increased mortality risk mainly due to CVD. As expected, participants with RBBB were older and had a somewhat more unfavourable risk factor profile: however, this only partially explained the excess risk. In contrast, IRBBB was not associated with cardiovascular risk factors or adverse outcomes during 33 years of follow-up.

Prevalence and predictors of right bundle branch block

The prevalence of RBBB was approximately twice as high in men as in women and was highly age-dependent ranging from 0.6% in women below the age of 40 to 14.3% in men above the age of 80. Previous studies have shown varying results, most likely due to differences in age distribution and population characteristics, including lack of exclusion of participants with existing heart disease.

Table 1 Distribution of risk factors by presence of right bundle branch block and incomplete right bundle branch block in 18 441 participants in the Copenhagen City Heart Study

	No BBB	IRBBB	RBBB	*P*-value[a]	
				IRBBB vs. no BBB	RBBB vs. no BBB
Men	7960	398	119		
Age (years)	50.1 (13.4)	48.2 (15.5)	64.0 (12.3)	0.01	<0.0001
Diabetes (%)	273 (3.5)	9 (2.3)	10 (8.6)	0.28	0.22
BMI, mean (SD) (kg/m^2)	25.6 (3.7)	24.6 (3.9)	26.2 (3.6)	<0.0001	0.32
High physical activity, leisure time (%)	1660 (20.9)	102 (25.7)	29 (32.7)	0.21	0.14
Current smoker (%)	4271 (53.7)	218 (55.1)	73 (61.3)	0.15	0.14
Cholesterol, mean (SD) (mmol/L)	5.8 (1.1)	5.6 (1.2)	6.0 (1.2)	0.29	0.16
Triglycerides, mean (SD) (mmol/L)[b]	2.0 (1.3)	1.9 (1.2)	2.1 (1.3)	0.26	0.25
Heart rate, mean (SD) (b.p.m.)	73.1 (13.2)	73.2 (12.9)	76.5 (14.3)	0.40	0.13
Systolic BP, mean (SD) (mmHg)	137.7 (19.1)	134.5 (18.0)	150.8 (21.6)	0.01	0.02
Treated hypertension (%)	323 (4.1)	15 (3.8)	12 (10.1)	0.99	0.33
Family history of MI (%)	1825 (24.0)	79 (20.4)	30 (28.3)	0.37	0.25
High education level (%)	4332 (54.6)	236 (59.6)	47 (39.8)	0.65	0.35
COPD (%)	651 (8.2)	37 (9.3)	21 (17.7)	0.23	0.45
Women	9691	226	47		
Age, mean (SD) (years)	50.0 (13.3)	50.9 (13.8)	61.5 (10.2)	0.33	<0.0001
Diabetes (%)	162 (1.7)	3 (1.3)	0 (0.0)	0.62	—
BMI, mean (SD) (kg/m^2)	24.5 (4.4)	23.4 (4.4)	25.7 (5.1)	<0.0001	0.60
High physical activity, leisure time (%)	1228 (12.7)	24 (10.6)	4 (8.7)	0.35	0.84
Current smoker (%)	4335 (44.8)	101 (44.7)	21 (45.7)	0.89	0.61
Cholesterol, mean (SD) (mmol/L)	6.0 (1.2)	6.1 (1.4)	6.3 (1.1)	0.47	0.03
Triglycerides, mean (SD) (mmol/L)[b]	1.5 (0.9)	1.4 (1.0)	1.8 (1.8)	0.79	0.12
Heart rate, mean (SD) (b.p.m.)	80.0 (11.8)	79.9 (11.7)	85.4 (12.2)	0.57	0.14
Systolic BP, mean (SD) (mmHg)	31.5 (20.9)	129.9 (20.6)	141.3 (21.5)	0.06	0.95
Treated hypertension (%)	486 (5.0)	16 (7.1)	4 (8.7)	0.30	0.84
Family history of MI (%)	2639 (28.1)	62 (27.9)	16 (36.4)	0.95	0.44
High education level (%)	5298 (54.8)	117 (51.8)	21 (45.7)	0.45	0.61
COPD (%)	381 (3.9)	12 (5.3)	4 (8.5)	0.36	0.40

BP, blood pressure; MI, myocardial infarction.
[a]*P*-values derived from logistic or linear regression, as appropriate, with age adjustment.
[b]Triglycerides were not measured at the second examination in 1981–83.

A Swedish study of 855 men from the general population reported a comparable cumulative incidence ranging from 1% at age 50 to 13% at age 80.[2] In the Reykjavik study, which included 18 762 individuals, the prevalence of RBBB was somewhat lower increasing from 0% at the age of 30 to 4.1% in men and 1.6% in women between 75 and 79 years of age.[23] Other studies have also reported a prevalence that was twice as high in men compared with women.[1,23,24]

In addition to increasing age and male gender, prevalent and incident RBBBs were associated with higher blood pressure but not consistently with other cardiovascular risk factors. Similar results have been reported in other studies.[2,5,6,11,23] This may indicate that RBBB when seen in patients free from CVDs should not be regarded as a marker of the cumulative effect of traditional cardiovascular risk factors causing CHD but as a marker of progressive degenerative disease, as indicated through the associations with increasing age and hypertension. The higher prevalence of RBBB in men compared with women was not caused by differences in risk factor distribution and remains largely unexplained.

Right bundle branch block and outcomes

We report a significantly higher mortality in individuals with RBBB even after multiple adjustment for cardiovascular risk factors. The increased mortality is caused by increased risk of cardiovascular outcomes, as demonstrated by higher risk of hospital admission and outpatient contact and from cardiovascular mortality rates. In contrast and somewhat surprising, hospital admission for COPD was not increased. Most studies on the prognostic significance of RBBB in populations free from overt cardiac disease have reported lower risk in subjects with RBBB. For example, a study following 394 subjects with RBBB identified through USAF Electrocardiographic Library found no increased mortality,[10]

Table 2 Factors predicting development of newly acquired incomplete right bundle branch block and right bundle branch block after 5 years of follow-up among participants free of incomplete right bundle branch block/right bundle branch block in 1976–78

	Age-adjusted OR (95% CI)		Multivariable-adjusted OR (95% CI)
	Men	Women	Pooled data
Newly developed IRBBB, *n* (%)	133 (3.0)	116 (1.9)	249 (2.4)
Male gender	—	—	1.78 (1.37–2.31)***
Age (years)	1.01 (0.99–1.02)	1.01 (1.00–1.03)	1.02 (1.01–1.03)**
BMI (per unit)	0.94 (0.90–0.99)*	0.91 (0.86–0.96)***	0.93 (0.90–0.97)***
Systolic BP (mmHg)	1.00 (0.99–1.01)	0.99 (0.97–1.00)*	1.00 (0.99–1.00)
Newly developed RBBB, *n* (%)	33 (0.72)	18 (0.30)	51 (0.48)
Male gender	—	—	2.06 (1.13–3.77)*
Age (years)	1.04 (1.01–1.07)*	1.08 (1.03–1.13)*	1.03 (1.00–1.06)*
Diabetes	0.68 (0.09–5.04)	6.47 (1.45–28.96)*	1.33 (0.39–4.51)
Systolic BP (mmHg)	1.01 (1.00–1.03)	1.03 (1.00–1.05)*	1.02 (1.01–1.04)**
COPD	1.25 (0.47–3.24)	0.70 (0.09–5.32)	0.88 (0.36–2.14)
IRBBB	11.37 (5.42–23.85)*	13.06 (4.20–40.63)*	11.21 (5.87–21.38)***

*$P \leq 0.05$.
**$P < 0.01$.
***$P < 0.001$.

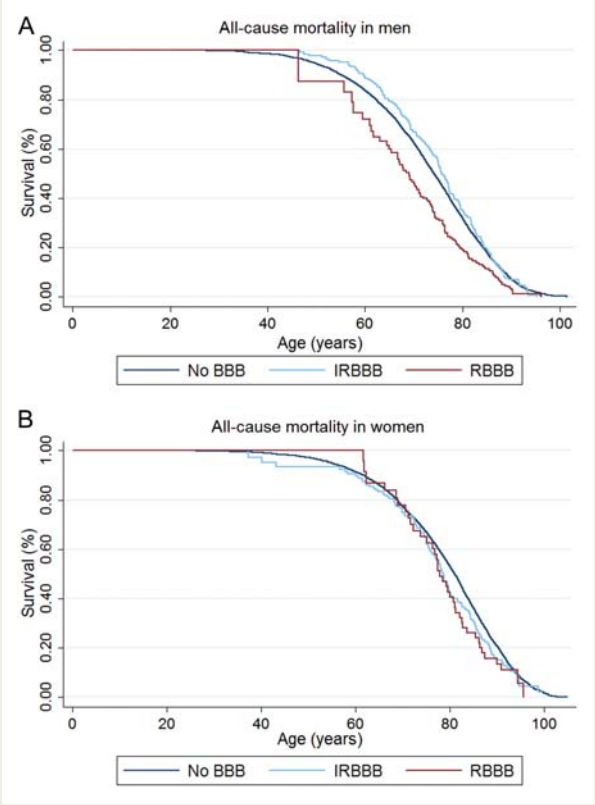


Figure 4 The Kaplan–Meier survival curves regarding all-cause mortality in men (*A*) and women (*B*) by right bundle branch block at the baseline.

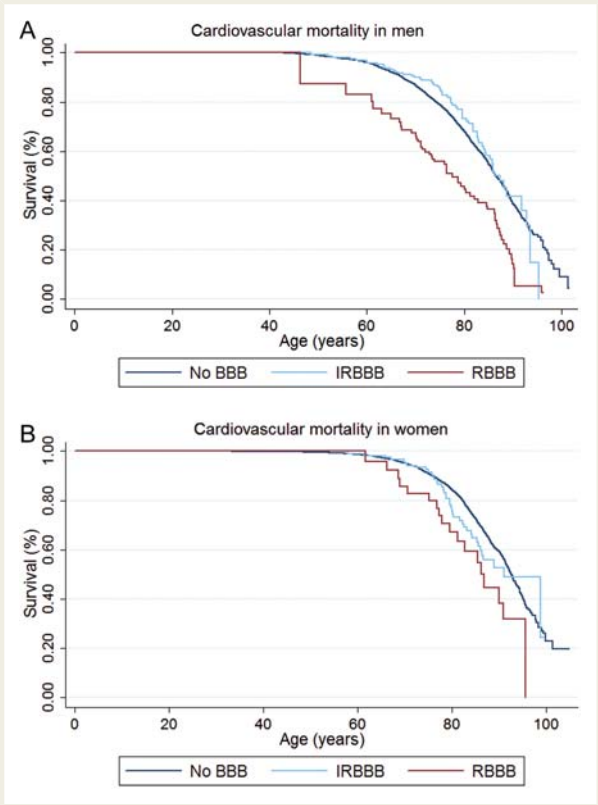


Figure 5 The Kaplan–Meier survival curves regarding cardiovascular mortality in men (*A*) and women (*B*) by right bundle branch block at the baseline.

Table 3 Hazard ratios for mortality and hospital admission by presence of incomplete right bundle branch block or right bundle branch block at baseline examination among 18 441 men and women in the Copenhagen City Heart Study

	Number of cases in men/women	Men	Women	Pooled	
		Age-adjusted HR (95% CI)	Age-adjusted HR (95% CI)	Age-adjusted HR (95% CI)	Multiple-adjusted[a] HR (95% CI)
All-cause mortality					
No BBB	4857/5017	Reference	Reference	Reference	Reference
IRBBB	207/120	0.96 (0.84–1.11)	1.13 (0.94–1.35)	1.02 (0.91–1.14)	1.04 (0.93–1.17)
RBBB	107/38	1.29 (1.07–1.56)**	1.34 (0.97–1.84)	1.31 (1.11–1.54)**	1.24 (1.05–1.47)*
Cardiovascular mortality					
No BBB	1680/1568	Reference	Reference	Reference	Reference
IRBBB	65/40	0.88 (0.69–1.13)	1.19 (0.87–1.64)	0.98 (0.81–1.19)	1.03 (0.84–1.26)
RBBB	55/18	1.85 (1.41–2.42)***	1.93 (1.21–3.07)**	1.87 (1.48–2.36)***	1.56 (1.23–1.99)***
Non-cardiovascular mortality					
No BBB	3177/3449	Reference	Reference	Reference	Reference
IRBBB	142/80	1.00 (0.85–1.19)	1.10 (0.88–1.37)	1.04 (0.91–1.19)	1.05 (0.91–1.20)
RBBB	52/20	0.98 (0.74–1.29)	1.05 (0.68–1.63)	1.00 (0.79–1.26)	1.03 (0.81–1.29)
Myocardial infarction					
No BBB	1015/705	Reference	Reference	Reference	Reference
IRBBB	46/21	1.06 (0.79–1.42)	1.45 (0.94–2.24)	1.16 (0.91–1.48)	1.23 (0.96–1.57)
RBBB	19/10	1.37 (0.87–2.16)	2.79 (1.50–5.22)**	1.67 (1.16–2.42)**	1.48 (1.01–2.17)*
Chronic heart failure					
No BBB	974/1037	Reference	Reference	Reference	Reference
IRBBB	39/21	0.91 (0.66–1.25)	0.98 (0.64–1.51)	0.93 (0.72–1.21)	0.99 (0.77–1.29)
RBBB	24/8	1.41 (0.94–2.12)	1.25 (0.62–2.51)	1.37 (0.96–1.94)	1.26 (0.88–1.82)
Atrial fibrillation					
No BBB	870/972	Reference	Reference	Reference	Reference
IRBBB	30/17	0.77 (0.53–1.11)	0.81 (0.50–1.1)	0.78 (0.59–1.05)	0.83 (0.62–1.11)
RBBB	17/6	1.14 (0.70–1.84)	1.02 (0.46–2.28)	1.10 (0.73–1.67)	1.11 (0.73–1.67)
Pacemaker insertion					
No BBB	241/202	Reference	Reference	Reference	Reference
IRBBB	15/4	1.41 (0.83–2.37)	0.93 (0.35–2.51)	1.27 (0.80–2.01)	1.24 (0.77–1.99)
RBBB	10/2	2.30 (1.22–4.34)**	1.73 (0.43–6.96)	2.17 (1.22–3.86)**	2.42 (1.36–4.31)**
COPD					
No BBB	800/893	Reference	Reference	Reference	Reference
IRBBB	38/26	1.10 (0.79–1.52)	1.38 (0.94–2.04)	1.20 (0.93–1.54)	1.18 (0.92–1.51)
RBBB	12/4	1.02 (0.57–1.80)	0.92 (0.34–2.45)	0.99 (0.60–1.62)	1.05 (0.64–1.72)

[a]Adjustment for age, BMI, and systolic blood pressure.
*$P \leq 0.05$.
**$P < 0.01$.
***$P < 0.001$.

while an Irish study of 198 subjects with RBBB from 110 000 screened individuals found that neither LBBB nor RBBB was associated with increased mortality in the absence of overt cardiac disease.[1] The prevalence of RBBB in this study however was low at <1% above the age of 64 years. A recent Finnish study based on 10 899 middle-aged subjects from the general population also found no association between RBBB and cardiovascular or all-cause mortality. However, in this study, risk may have been underestimated since a QRS duration cut-off point of 110 ms was used with no distinction between IRBBB (QRS < 120 ms) and RBBB (QRS > 120 ms).[11] A Swedish study of 7392 middle-aged men from the general population identified 70 individuals with RBBB.[9] During almost 30 years of follow-up, neither all-cause nor cardiovascular mortality was increased, although statistical power was limited. In both studies, RBBB was a rare finding with an overall prevalence of only 0.2–0.4%. In the Reykjavik

study, 193 participants with RBBB identified from a population study of 18 762 did have increased mortality, but this was no longer the case after adjustment for existing heart disease and cardiovascular risk factors was made.[23] In contrast, a US study comprising 300 individuals with RBBB from a community-based patient population found similar mortality risk in LBBB and RBBB.[5] In the Framingham study, 70 individuals with newly acquired RBBB had an almost three times higher cardiovascular mortality risk than age-matched controls.[24] Finally, in a Belgian study of almost 10 000 subjects free from CHD, RBBB was associated with a multivariable adjusted HR of 2.36 (1.21–4.62) for CVD mortality.[25]

Our prior assumption that might contribute to explain discrepancies in the literature was that RBBB among younger individuals might indicate a more innocent congenital aberration of the conduction system, whereas RBBB in the elderly may reflect degenerative disease not isolated to the conduction system and thus carry a higher risk. However, age-specific analysis did not support this. Although statistical power in subgroup analyses was limited and firm conclusions should be drawn with caution, RBBB may even be more strongly associated with risk in younger than in older subjects.

Incomplete right bundle branch block

Incomplete RBBB was a common finding at all ages with twice the prevalence in men compared with women. The presence of IRBBB was not related to CVD risk factors after adjustment for confounders but was more prevalent in participants with lower BMI. This may be caused by systematically difference in placement of precordial leads and cardiac location related to BMI. A main finding of this study was that IRBBB was not associated with any of the adverse outcomes studied. This is in line with a previous smaller study, which prospectively followed 34 middle-aged men with IRBBB for 20 years and found no association with cardiovascular mortality.[13] In that study, participants with IRBBB also had a considerably higher likelihood of developing RBBB at follow-up.[13] The number of participants later developing RBBB in the present study was small and did not allow for subgroup analysis regarding prognosis.

Strengths and limitations of the study

This study is the hitherto largest study of prevalence and prognostic value of RBBB in the general population. Strengths include the large number of outcomes, long and complete follow-up, the wide range of ages, and the inclusion of both men and women, unlike many existing studies.[2,9,11,14] Definition of RBBB and IRBBB in the present study follows the Minnesota coding standard. A previous validation study indicated that among ECG's classified as no BBB, 1.7% were incorrectly not coded as IRBBB and 0.08% as RBBB.[17] Thus, the prevalence of IRBBB is likely to be underestimated, whereas RBBB is correctly classified. Although our study is relatively large, the number of participants with RBBB is limited and study limitations include a lack of statistical power with regard to some outcomes as indicated by the large confidence intervals, especially in women. Furthermore, we do not have detailed clinical information such as for instance echocardiographic assessment. For screening purposes, however, such information will rarely be available and thus the study mimics the setting in which screening would normally take place.

Conclusion

This community-based study shows that the prevalence of IRBBB and RBBB is two to three times higher in men than in women. Right bundle branch block is associated with increased risk of all-cause mortality and adverse cardiovascular outcomes with similar associations in both genders. Reassuringly, although IRBBB has some tendency to progress to RBBB, IRBBB by itself is not associated with any clinically relevant adverse outcome. Our results indicate that the finding of an RBBB—unlike IRBBB—in the ECG of a person without known cardiac disease should alert physicians to more careful patient evaluation and follow-up.

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