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All-Cause Mortality for Life Insurance Applicants with the Presence of Bundle Branch Block

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Objective.—To determine the all-cause mortality of life insurance applicants who have a bundle branch block.

Background.—Bundle branch block is an electrocardiographic pattern that has variable prognostic implications. Research studies have shown that both left and right bundle branch block are associated with increased mortality among cases that have heart disease. In the general population and life insurance applicant population, the prevalence of bundle branch block is relatively low, and its effects on long-term prognosis are not as well established.

Methodology.—Life insurance applicants with reported bundle branch block were extracted from data covering United States residents between October 2009 and October 2016. Information about these applicants was matched to the Social Security Death Master (SSDMF) file for deaths occurring from 2009 to 2012 and to another commercially available death source file (Other Death Source, ODS) for deaths occurring from 2009 to 2016 to determine vital status. Actual to expected (A/E) mortality ratios were calculated using the Society of Actuaries 2015 Valuation Basic Table (2015VBT), select and ultimate table (age last birthday). All expected bases were not smoker distinct. Confidence bands around these mortality ratios were calculated. The variables of interest were applicant age, gender, location of the bundle branch block, and the presence of cardiac or cardiovascular conditions.

Results.—There were 258,529.85 person-years exposure for applicants with bundle branch block. Of the applicants, 57.2% had right bundle branch block. Of person-years exposure, 11.5% had a cardiac condition along with the bundle branch block, and 4.4% had an underlying cardiovascular condition. Female mortality ratios were higher than those for males, but due to the low number of deaths, this difference was not significant. Left bundle branch block mortality ratios (1.01) were 1.4 times higher than those with right (0.74). Those applicants with a cardiac condition along with their bundle branch block had between 1.6 to 1.8 times the mortality ratio depending on the bundle branch block location, and those with a cardiovascular condition had between 1.5 to 1.7 times the mortality ratio over those applicants with just bundle branch block alone.

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Conclusion.—The presence of bundle branch block in an insurance applicant may be associated with increased all-cause mortality. In this study, life insurance applicants overall had a mortality slightly lower than the expected mortality based on the 2015 VBT. However, applicants with bundle branch block and a cardiac or cardiovascular comorbid condition had a significantly higher mortality ratio.

INTRODUCTION

For many years, electrocardiography has been one of the most important adjuncts to the medical evidence used for the risk stratification of individuals applying for life insurance. In the earliest days of its use, it became clear that a more precise appraisal of the prognostic implications of some of the more common electrocardiographic abnormalities was required.[1] Bundle branch block (BBB), an electrocardiographic (ECG) pattern that has variable prognostic implications, is one of those abnormalities.

The concept of bundle branch block was introduced in 1909 by Eppinger and Rothberger.[2] A large amount of literature related to the prognostic significance of bundle branch block has accumulated since their original paper. Because of the different types of population samples and study designs, these studies have produced different results.[3,4]

In many of the early studies, the subjects were derived from hospital-based populations with heart disease; consequently, the long-term mortality rates were very high. In contrast, in early studies derived from young military populations, bundle branch block was rarely found to be associated with clinically apparent cardiovascular disease and long-term mortality rates were not increased. Hospital-based and military populations are in many ways preselected and not representative of the general population.

In subsequent community-based studies, bundle branch block was generally associated with a greater frequency of underlying heart disease than in the military studies and long-term mortality was increased in individuals with bundle-branch block and concomitant cardiovascular disease. Reports from community-based population studies found no or only marginal risk for right bundle branch block (RBBB).[3,5-8]

The results for left bundle branch block (LBBB) have been conflicting, with some studies reporting a significant increase in mortality,[5,9] while other studies have not found LBBB to be a significant predictor.[10] As a result of these studies, it was recognized that bundle branch block is not a homogeneous clinical disorder and that its prognosis depended on the presence, nature and extent of underlying heart disease.[3,5]

In the general population, the prevalence of bundle branch block is relatively low, and its effects on long-term prognosis were not as well established.[4] Similarly, there had been a paucity of studies that have investigated the long-term prognostic significance of bundle branch block in the life insurance applicant population. Based on clinical studies, the significance of either a right or left bundle branch block in an electrocardiogram of a life insurance applicant with known heart disease was usually clear to company medical directors and lay underwriters. However, when a bundle branch block was discovered by chance in an electrocardiogram taken for purely screening purposes in an applicant with no history of heart disease to account for it, its prognostic significance was often far from clear. Accordingly, in the 1950s and 1960s, studies were mounted by a few life insurance companies to ascertain the mortality significance of bundle branch block to provide risk assessment guidelines on how to handle this purely electrocardiographic abnormality.[1]

An important contribution was made by Singer, who undertook a prospective and retrospective mortality study of 966 life insurance applicants to the New England Mutual Life Insurance Company, whose ECGs were found to show right bundle branch block (complete and incomplete), left bundle branch block and wide QRS complexes of 100 msec or more.[11,12] In another insurance applicant study, Rodstein et al presented follow-up results on 183 applicants from 1929–1948 to the Equitable Life Insurance Company of New York, with ECGs taken at the home office showing right or left BBB or wide QRS.[13] In a third study on policyholders of the Aetna Life Insurance Company, 1950-1962 results were given by age for both RBBB and LBBB combined, without any cardiovascular impairment being specified.[14] More recently, Iacovino published a comparative mortality analysis of an Irish Heart Foundation study reporting the natural history of isolated bundle branch block among 110,000 Irish subjects, who underwent screening for cardiovascular disease.[7,15]

The purpose of the present study was to determine the all-cause mortality of life insurance applicants who had electrocardiographic evidence of a bundle branch block at the time of application. This research is done under the guidance of the Mortality Risk Analysis Committee (MRAC). This Committee is a coordinated multidisciplinary committee of actuaries, medical directors, underwriters and other roles appointed by the senior management of MIB with input from MRAC members. The Committee serves as an advisory group. Its mission is to facilitate and direct research endeavors, focusing on mortality risk relevant to insurance enterprises.[16]

METHODOLOGY

Data Source

The data used for this study was contained in the medical impairment database operated by MIB Group, Inc. MIB is a member cooperative data exchange formed by the North American life insurance industry in 1902. Currently, it is a cooperative of approximately 430 United States and Canadian insurance companies. These member companies represent most of the underwritten life insurance activity in the United States and Canada.[17]

Study Participants

The sample used for this study represented all the MIB member companies' applicants from the United States who applied for life insurance from over 7 years and had a bundle branch block at time of application. It represents approximately 258,530 person-years of exposure and between 1097 and 1226 deaths, depending on the method of death record matching.

Variables

The variables considered for this study were applicant age, gender, the location of the bundle branch block, the presence of cardiac conditions, and the presence of cardiovascular conditions.

The groups for applicant age were: 55-64 and 65-75.

Gender was defined as: Female, Male or Unknown.

Bundle branch block location was: Left, Right, Right with Left Axis Deviation (Right/LAD)

Presence of cardiac conditions was defined (as per MIB coding) as an applicant having:

- Myocardial infarction, no surgery
- Coronary artery disease or myocardial infarction, with surgery
- Cardiomyopathy

Presence of cardiovascular conditions was defined (as per MIB coding) as an applicant having:

- Cerebrovascular disorder, accident or insufficiency
- Peripheral vascular disease or disorder

Data Collection

The life insurance applicant records were first searched against the Social Security

Death Master File (SSDMF). Due to restrictions imposed on the SSDMF, all the deaths that were within 3 years of the date of the search could not be used for this research and were not available for the study.[18] To more accurately confirm all possible deaths, a second death source (Other Death Source, ODS) file was used that had more than 3000 sources of death notifications. This registry was a compilation of obituaries from newspapers or funeral homes, and state vital statistics records. Deaths had to adequately match at least 1 database to be included in the study.

In the Other Data Source, there were many the records that did not have a date of birth, only age at death. From this, the year of birth was calculated using the age at death compared with the applicant year of birth. If the calculated year of birth matched the applicant year of birth, the case was considered a match. These deaths along with the deaths adequately matched on surname, given name and date of birth are labeled in this paper as all deaths. The deaths determined by adequately matching surname, given name and date of birth are called definite deaths.

Table 1. Summary of Life Insurance Applicants with Bundle Branch Block

Condition	Value	Person Years Exposure	Average Deaths
Applicant Age	55 – 64	132,155.06	406.0
	65 – 75	126,374.79	755.5
Gender	Female	17,437.26	43.0
	Male	58,147.56	162.0
	Unknown	182,945.03	956.5
Bundle Branch Block Location	Left	66,101.99	363.0
	Right	147,766.20	580.5
	Right/LAD	44,661.66	218.0
Presence of Cardiac Condition	None	228,724.80	923.0
	Present	29,805.05	238.5
Presence of Cardiovascular	None	247,282.90	1073.0
	Present	11,246.95	88.5
Aggregate		258,529.85	1161.5

Note: Average deaths was the midpoint between All Deaths and Definite Deaths. For bundle branch location Right/LAD represents right bundle branch block with left axis deviation.

Statistical Methods

The Society of Actuaries 2015 Valuation Basic Table (VBT) select and ultimate (age last birthday), male, female and composite was used to form the expected deaths for this study.[19] The average between the mortality ratios based on all deaths or definite deaths using the 2015 VBT as an expected basis is presented in this paper.

Even though actual-to-expected (A/E) mortality ratios were presented in this paper, the conclusions drawn from the analyses were based on comparisons of A/E ratios.

The calculation of exposure was defined as the time in years from the first report of the presence of a bundle branch block to the MIB database until October 18, 2016. If the applicant became an observed death, then the exposure was the number of years between the impairment report date and the date of death, rounded up to the next integer.

Confidence bands at the 95% level are calculated on the mortality ratios, to determine if any condition examined is significantly different than any other. The method used is based on that proposed by Singer in the 5th ed of *Brackenridge's Medical Selection of Life Risks*.[20]

RESULTS

Baseline Characteristics

A summary of the study cohort is presented on Table 1.

There were 258,529.85 person-years of exposure. Note that this study only had applicants 55 to 75 years old at time of application. The younger applicants had so few deaths that making comparisons with this group was insufficient to draw meaningful conclusions. Regarding exposure, 51.1% of

Table 2. Applicant Age by Bundle Branch Block Location

Applicant Age	Bundle Branch Block Location	Person Years Exposure	All Deaths	Definite Deaths	Expected 2015 VBT	Mortality Ratio Qx	Lower Bound	Upper Bound
55 – 64	Left	33,009.33	144	128	118.07	1.15	0.96	1.35
	Right	78,735.24	230	189	286.05	0.73	0.63	0.83
	Right/LAD	20,410.49	65	56	76.53	0.79	0.60	1.02
	Aggregate	132,155.06	439	373	480.65	0.84	0.76	0.93
65 – 75	Left	33,092.66	233	221	239.83	0.95	0.82	1.07
	Right	69,030.96	388	354	499.00	0.74	0.67	0.82
	Right/LAD	24,251.17	166	149	180.40	0.87	0.74	1.01
	Aggregate	126,374.79	787	724	919.23	0.82	0.76	0.88
Total	Left	66,101.99	377	349	357.90	1.01	0.91	1.12
	Right	147,766.20	618	543	785.05	0.74	0.68	0.80
	Right/LAD	44,661.66	231	205	256.93	0.85	0.74	0.96
	Aggregate	258,529.85	1,226	1,097	1,399.88	0.83	0.78	0.88

Note: The confidence limits are at the 95% level. Right/LAD represents right bundle branch block with left axis deviation.

the exposure was found in the 55 to 64 age cohort, but this group only accounted for 35.0% of the deaths. Of the person-years exposure, 6.7% were female, 22.5% were male and 70.8% were of unknown gender.

The majority, with 57.2% of the person-years exposure, had right bundle branch block representing 50.0% of the deaths. In terms of cardiac conditions, 11.5% of the person-years exposure had a cardiac condition, and 4.4% had a cardiovascular condition.

Applicant Age by Bundle Branch Block Location

Applicant age by bundle branch block location is summarized on Table 2.

Overall, the mortality ratios for the left bundle branch block were significantly higher (1.4 times) than for the right. The right bundle branch block with left axis deviation had a slightly higher mortality ratio than right bundle branch block only, but not significantly higher. The mortality ratio is 1.6 times higher for the left than the right in the 55-64 applicant age group.

Gender by Bundle Branch Block Location

Table 3 summarizes gender by bundle branch block location. Even though the female applicants had a higher mortality ratio than the males, it was not that much higher. The left side bundle branch block mortality ratios were higher in both male and female, but the number of deaths were so low that this was not statistically significant.

Bundle Branch Block Location by Presence of Cardiac Conditions

Table 4 shows the bundle branch block location by the presence of cardiac conditions. In all cases, having a cardiac condition had a significantly higher mortality ratio (1.7 times) than not having a condition. The applicants with left bundle branch block and a cardiac condition had 1.6 times the mortality ratio. The increase for the right bundle branch block with a cardiac condition was 1.8 times the mortality ratio and the right bundle branch block with left axis deviation 1.7 times the mortality ratio.

Table 3. Gender by Bundle Branch Block Location

Gender	Bundle Branch Block Location	Person Years Exposure	All Deaths	Definite Deaths	Expected 2015 VBT	Mortality Ratio Qx	Lower Bound	Upper Bound
Female	Left	8,445.69	25	23	27.66	0.87	0.56	1.29
	Right	7,388.38	15	14	23.20	0.63	0.35	1.04
	Right/LAD	1,603.19	5	4	5.80	0.78	0.24	1.90
	Aggregate	17,437.26	45	41	56.66	0.76	0.55	1.02
Male	Left	11,184.80	45	44	50.13	0.89	0.65	1.19
	Right	35,415.76	94	78	155.04	0.55	0.44	0.68
	Right/LAD	11,547.00	34	29	54.24	0.58	0.40	0.82
	Aggregate	58,147.56	173	151	259.41	0.62	0.53	0.72
Unknown	Left	46,471.50	307	282	280.11	1.05	0.93	1.17
	Right	104,962.06	509	451	606.81	0.79	0.72	0.86
	Right/LAD	31,511.47	192	172	196.89	0.92	0.79	1.06
	Aggregate	182,945.03	1,008	905	1,083.81	0.88	0.83	0.94
Total	Left	66,101.99	377	349	357.90	1.01	0.91	1.12
	Right	147,766.20	618	543	785.05	0.74	0.68	0.80
	Right/LAD	44,661.66	231	205	256.93	0.85	0.74	0.96
	Aggregate	258,529.85	1,226	1,097	1,399.88	0.83	0.78	0.88

Note: Right/LAD represents right bundle branch block with left axis deviation.

Table 4. Bundle Branch Block Location by Presence of Cardiac Conditions

Bundle Branch Block Location	Presence of Cardiac Conditions	Person Years Exposure	All Deaths	Definite Deaths	Expected 2015 VBT	Mortality Ratio Qx	Lower Bound	Upper Bound
Left	None	55,491.34	284	259	295.48	0.92	0.81	1.03
	Present	10,610.65	93	90	62.42	1.47	1.18	1.80
	Aggregate	66,101.99	377	349	357.90	1.01	0.91	1.12
Right	None	133,681.32	511	442	698.76	0.68	0.62	0.74
	Present	14,084.88	107	101	86.30	1.21	0.97	1.44
	Aggregate	147,766.20	618	543	785.06	0.74	0.68	0.80
Right/LAD	None	39,552.14	186	164	224.44	0.78	0.66	0.90
	Present	5,109.52	45	41	32.48	1.32	0.96	1.79
	Aggregate	44,661.66	231	205	256.92	0.85	0.74	0.96
Total	None	228,724.80	981	865	1,218.68	0.76	0.71	0.81
	Present	29,805.05	245	232	181.20	1.32	1.15	1.48
	Aggregate	258,529.85	1,226	1,097	1,399.88	0.83	0.78	0.88

Note: The cardiac conditions can be one or more of the following: Myocardial Infarction, no surgery, Coronary Artery Disease or Myocardial Infarction, with surgery, Cardiomyopathy. Right/LAD represents right bundle branch block with left axis deviation.

Table 5. Bundle Branch Block Location by Presence of Cardiovascular Conditions

Bundle Branch Block Location	Presence of Cardiovascular Conditions	Person Years Exposure	All Deaths	Definite Deaths	Expected 2015 VBT	Mortality Ratio Qx	Lower Bound	Upper Bound
Left	None	63,202.47	348	324	339.29	0.99	0.88	1.10
	Present	2,899.52	29	25	18.61	1.45	0.96	2.11
	Aggregate	66,101.99	377	349	357.90	1.01	0.91	1.12
Right	None	141,640.45	571	498	747.03	0.72	0.65	0.78
	Present	6,125.75	47	45	38.02	1.21	0.89	1.61
	Aggregate	147,766.20	618	543	785.05	0.74	0.68	0.80
Right/LAD	None	42,439.98	215	190	242.12	0.84	0.72	0.95
	Present	2,221.68	16	15	14.81	1.05	0.59	1.72
	Aggregate	44,661.66	231	205	256.93	0.85	0.74	0.96
Total	None	247,282.90	1,134	1,012	1,328.44	0.81	0.76	0.86
	Present	11,246.95	92	85	71.44	1.24	1.00	1.53
	Aggregate	258,529.85	1,226	1,097	1,399.88	0.83	0.78	0.88

Note: The cardiovascular conditions can be one or more of the following: Cerebrovascular disorder, accident or insufficiency. Peripheral vascular disease or disorder. Right/LAD represents right bundle branch block with left axis deviation.

Bundle Branch Block Location by Presence of Cardiovascular Conditions

Cardiovascular applicants by bundle branch block location is summarized on Table 5.

Those cardiovascular applicants overall had 1.5 times the mortality ratio than those that did not have a cardiovascular condition. Those right bundle branch block with cardiovascular conditions had a significantly higher mortality ratio than those without the condition. Their mortality ratio is 1.7 times that of those applicants without a cardiovascular condition. Even though the left bundle branch block applicants along with the right/left bundle branch block with a cardiovascular condition had a higher mortality ratio, the number of deaths was so small that this difference could not be proved to be statistically significant.

DISCUSSION

This life insurance-based population study focuses on all-cause mortality for insurance applicants who had electrocardiographic evidence of a bundle branch block at the time of application. The main results of the study indicate that even though there were conditions where mortality ratios were different, the overall mortality of applicants with a bundle branch block was slightly lower than the expected mortality based on the Society of Actuaries 2015 Valuation Basic Table.

There were 258,529.85 person-years of exposure resulting in average total deaths of 1161.5 (based on the average of 1226 all deaths and 1097 definite deaths as defined in the data collection and statistical methods section). Because younger applicants had so few deaths, this study included only applicants aged 55 to 75 years at time of application. Of the exposure, 51.1% was found in the 55 to 64 age cohort, but this group only accounted for 35.0% of the deaths. Female mortality ratios were consistently higher than those of males, but the differences were not statistically significant.

The majority of applicants with 57.2% of the person-years exposure had a right bundle branch block (RBBB), representing 50.0% of the deaths. Applicants with a left bundle branch block (LBBB) experienced 25.6% of the person-years exposure, representing 31.2% of the deaths. Applicants with the combination of RBBB and left axis deviation (LAD) experienced 17.3% of the person-years exposure, representing 18.8% of the deaths.

Applicants with LBBB had 1.4 times the mortality as applicants with RBBB. Applicants with the combination of a RBBB and LAD had a slightly higher mortality ratio than RBBB alone, but not significantly higher.

In terms of concomitant cardiovascular disease, 11.5% of the person-years exposure had a cardiac condition and 4.4% had a cardiovascular condition (as defined by MIB coding). Applicants with cardiac conditions and a bundle branch block, had a significantly higher mortality ratio (overall 1.7) than those not having a cardiac condition, but this added risk factor was infrequent in the study population (11.5% of all the person-years exposure). Applicants with LBBB and a cardiac condition had 1.6 times the mortality ratio. The increase for applicants with a RBBB with a cardiac condition was 1.8 times the mortality ratio and for RBBB with LAD, 1.7 times the mortality ratio.

Similarly, applicants with cardiovascular conditions had a significantly higher mortality ratio (overall 1.5) than those not having a cardiovascular condition but again, the prevalence of this additional risk factor was low (4.4% of all person-years exposure). Those applicants with a RBBB and a cardiovascular condition had a significantly higher mortality ratio than those without the condition. Their mortality ratio was 1.7 times that of those applicants without a cardiovascular condition. Even though applicants with a LBBB, and those with the combination of a RBBB and LAD along with a cardiovascular condition also had higher mortality ratios, the number of deaths was so small that this difference could not be proved to be statistically significant.

The prevalence of bundle branch block in the present study is like that found in comparable populations. The increased prevalence of bundle branch block with age has also been described previously.[4] In a life insurance applicant population prevalence survey reported by Ferrer, of 19,734 electrocardiograms from Metropolitan Life insurance applicants obtained over a 5-year period, the prevalence of bundle branch block were 0.87% (Right), 0.26% (Left), and 0.16% (Right/LAD).[21]

Similarly, in most population studies, BBB was more common among men than women, and RBBB was more frequent than LBBB. For example, in the Irish Heart Foundation study mentioned in the introduction, a population of 110,000 subjects was screened from 1968 to 1993 for the presence of cardiovascular disease and its risk factors.[7] The prevalence of BBB without heart disease was 0.28%, and isolated RBBB was significantly more prevalent than isolated LBBB (0.18% vs 0.l0%). The prevalence of each location significantly increased with age. Males accounted for 73% and 86% of cases of LBBB and RBBB, respectively. In the absence of clinically overt cardiac disease, the presence of LBBB or RBBB was not associated with increased overall mortality. After a mean follow-up of 9.5 years, isolated LBBB was associated with an increased risk of developing overt cardiovascular disease and increased cardiac mortality.

Looking at RBBB specifically, previous studies have indicated that the prognosis is related largely to the presence, type, and severity of underlying heart disease. In patients with known or suspected cardiovascular disease, several large cohort studies have shown that RBBB is an independent predictor of all-cause mortality.[22-26] Among 12,346 women with cardiovascular disease (excluding those with LBBB) who participated in the Women's Health Initiative trial, there was a significantly greater risk of death from coronary heart disease but not overall mortality among women with RBBB compared with no BBB.[22] In a large cohort of patients without heart failure referred for symptom-limited exercise nuclear testing at a tertiary care center, those with RBBB were associated with increased mortality during 6 years follow-up and after adjustment for potential confounders.[23] In patients with chronic coronary artery disease who underwent coronary and left ventricular angiography as part of the Coronary Artery Surgery Study, those with RBBB had a mortality rate twice that of patients without BBB during a follow-up period of 4.9 years.[24] In contrast, the prognostic significance of left and right bundle branch block in patients with chronic stable cardiovascular disease was evaluated in the Heart Outcomes Prevention Evaluation (HOPE) study cohort. Baseline RBBB was not associated with increased cardiovascular or all-cause mortality risk.[25]

Long-term outcomes are generally excellent in patients with RBBB and without apparent heart disease, although some reports have suggested an increase in all-cause and cardiac mortality. In a primary prevention study from Sweden in which 7392 middle-aged men were followed for 28 years, men with RBBB had no increased all-cause mortality compared with men without bundle branch block.[5] Similarly, among 53,197 women free of cardiovascular disease (excluding those with LBBB) upon entry into the Women's Health Initiative trial, there was no significant increase in either death from coronary heart disease or death from any cause.[22] In contrast, among 18,441 participants in the Copenhagen City Heart Study without a prior MI, heart failure, or LBBB who were followed for over 20 years, persons with RBBB had significantly greater all-cause and cardiovascular mortality compared with those without RBBB.[27] In a 2015 systematic review and meta-analysis, which included six cohorts free of known cardiovascular disease (1019 patients with RBBB and 95,079 without RBBB), RBBB with associated with greater all-cause mortality.[28]

The prognosis in individuals with LBBB had also been shown to be related to the presence, type and severity of any concurrent underlying heart disease. LBBB is an independent predictor of all-cause mortality in patients with known or suspected coronary heart disease (CHD).[29] Among 12,354 women with cardiovascular disease (excluding those with RBBB) who participated in the Women's Health Initiative trial, there was a significantly greater risk of death from coronary heart disease and death from any cause among women with LBBB compared with no BBB.[22] In a review of 7073 adults referred for nuclear exercise testing, 2% of the subjects had LBBB. After a mean follow-up of nearly 7 years, those with LBBB had a greater mortality than those without LBBB.[23] In a post-hoc analysis of the 15,609 subjects with known CHD enrolled in the Coronary Artery Surgery Study (CASS), the presence of LBBB was associated with a more than fivefold increase in mortality after two years of follow-up.[24] In the Heart Outcomes Prevention Evaluation (HOPE) cohort of 9541 patients with cardiovascular disease or diabetes in the absence of heart failure, the presence of LBBB was associated with a significantly higher risk for all-cause mortality.[25]

LBBB appears to have a minimal effect on outcomes in younger, apparently healthy subjects, while LBBB in older individuals has been associated with an increase in mortality.[29] Two large cohorts of younger asymptomatic persons have reported no increase in mortality in subjects with LBBB.[30,31] In contrast, in the Swedish primary prevention study mentioned above, a higher mortality rate was demonstrated among the men with LBBB. Compared to men without bundle branch block, those with LBBB had significant increases in all-cause mortality that was primarily due to out-of-hospital sudden death.[5] Similarly, among 53,377 women without cardiovascular disease at baseline (excluding those with RBBB) who participated in the Women's Health Initiative trial, there was a significantly greater risk of death from coronary heart disease and a trending toward higher death from any cause among women with LBBB compared to those with no BBB.[22]

Previous studies have found varying prognoses in individuals with the combination of RBBB and LAD depending on the population from which the individuals were drawn.[32] Prevalences have ranged from less than 0.01% in generally healthy young military personnel,[30] 0.35% in a survey of Belgian citizens 35 years or older, [33] and about 1% in older hospitalized patients.[34,35] In generally healthy adults, RBBB and LAD may have a benign prognosis, but in patients with coexisting cardiovascular disease, its prognosis is usually more ominous.[32]

A subanalysis of the Manitoba study showed that in apparently healthy men with RBBB, right and left axis deviation occur more commonly than in those without this conduction disturbance but no adverse long-term prognosis was demonstrated.[36] In a prospective study in which 554 patients with chronic bifascicular and trifascicular conduction abnormalities were followed for an average of 42.4 +/− 8.5 months, the actuarial 5-year mortality from an event that could conceivably have been a bradyarrhythmia was 6%.[37] A 12-year follow-up of patients with right bundle branch and left anterior fascicular block revealed excess mortality and morbidity that was independent of recognized coexistent cardiac disease compared with an age- and sex-matched group of patients with intact intraventricular conduction.[32]

Returning to the insurance applicant studies mentioned in the introduction, Singer undertook a prospective and retrospective mortality study of 966 life insurance applicants to the New England Mutual Life Insurance Company whose ECGs were found to show right bundle branch block (complete and incomplete), left bundle branch block and wide QRS complexes of 100 msec or more. Cases with an ECG abnormality were divided into those without a significant cardiovascular abnormality and those showing a major cardiovascular abnormality, including hypertension and a history of coronary artery disease.

The general conclusions reached from the New England Life study were summarized by Singer as follows: excess mortality in all types of bundle branch block and wide QRS correlated well with the associated major cardiovascular disorder, being largest in coronary heart disease and moderate in arterial hypertension, borderline blood pressure elevation and other rateable cardiovascular impairments. Where there was no rateable cardiovascular impairment, excess mortality was minimal for applicants with complete right or left bundle branch block, and the mortality ratio for incomplete right bundle branch block was below the standard intercompany level.[11,12]

In another insurance applicant study, Rodstein et al presented follow-up results on 183 applicants from 1929-1948 to the Equitable Life Insurance Company of New York, with ECGs taken at the home office showing right or left BBB or wide QRS. Many of these applicants had associated CV impairments, some severe enough to result in declination, others in the issue of rated insurance. Numbers of observed deaths ranged from 6 to 15, with exposure between 184 and 616 person-years. Excess mortality was modest when the CV impairment was insurable, with a mortality ratio of only 111% in RBBB and 146% in LBBB. When the CV impairment was declinable, the mortality ratio was still only 186% in RBBB and 260% in LBBB.[13]

In the third study on policyholders of the Aetna Life Insurance Company, 1950-1962 results were given by age for both RBBB and LBBB combined, without any CV impairment being specified. An overall mortality ratio of 215% was found, based on 14 death claims in 2063 policy-years of exposure.[14]

STRENGTHS AND LIMITATIONS

The strength of this study lies in the fact that it is an insurance industry population-based study and that the bundle branch block applicants were collected from a nationwide life insurance database. Several limitations of this study should be acknowledged. The definition of a bundle branch block applicant in our study was based on the coding requirements for the MIB database.

The individuals in the MIB database are a unique cohort of life insurance applicants. Life insurance applicants are generally held to be in a higher socio-economic class with access to better health care and living conditions and generally make healthier lifestyle choices. Similarly, they are believed to invest more in prevention, resulting in their experiencing lower mortality rates than those of the general population for the same age and gender groups. In addition, life insurance companies' underwriting process (detailed health questions plus medical exam and/or fluid collection) tends to select risks that are generally in much better health than the average individual in the US population.

Most of the literature presents relative risk statistics with a basis population that does not have a bundle branch block. This study does not have that type of comparison. The comparisons made were the difference of those having cardiac or cardiovascular conditions vs those that do not.

Due to the ambiguity in some of the information used to match the death records, the mortality ratios have been presented using the average value from all deaths and definite deaths. The actual-to-expected (A/E) mortality ratios presented in this paper were an underestimate of the true A/E mortality ratios. This was due to the most recent 3 years of SSDMF deaths being excluded. We were unable to estimate the effect that missing the most recent SSDMF deaths had on this cohort. However, comparison of A/E ratios between the factor levels of the variables under study (eg, age at application vs gender) provided meaningful insights. These ratio comparisons were consistent, regardless of the actual A/E mortality ratio. Previous researchers pointed out this phenomenon and referred to the different conditions as mortality gradients.[38]

CONCLUSION

Bundle branch block in an insurance applicant may be associated with increased all-cause mortality. Overall in this study, life insurance applicants had a mortality slightly lower than the expected mortality based on the 2015 VBT. However, applicants with a bundle branch block and a cardiac or cardiovascular comorbid condition had a significantly higher mortality ratio.

REFERENCES

1. Brackenridge RDC. Electrocardiography. In: *Medical Selection of Life Risks*. 2nd ed. New York, NY: The Nature Press; 1985.
2. Eppinger H, Rothberger CJ. Zur Analyse des Elektrokardiogramms. *Wien Klin Wochenschr*. 1909;22:1091-1098.
3. Fleg JL, Das DN, Lakatta EG. Right bundle branch block: long-term prognosis in apparently healthy men. *J Am Coll Cardiol*. 1983;1:887-892.
4. Behar S. Are Right and Left Bundle Branch Block Similarly Associated with Increased Risk of Mortality? *Am J Med*. 2001;110:318-319.
5. Eriksson P, Wilhelmsen L, Rosengren A. Bundle-branch block in middle-aged men: risk of complications and death over 28 years. *Eur Heart J*. 2005;26:2300-2306.
6. Trainsdottir IS, Hadarson T, Thorggeirsson G, et al. The epidemiology of right bundle branch block and its association with cardiovascular morbidity—the Reykjavik Study. *Eur Heart J*. 1993;14:1590-1596.
7. Fahy GJ, Pinski SL, Miller DP, et al. Natural history of isolated bundle branch block. *Am J Cardiol*. 1996;77:1185-1190.
8. Miller WL, Hodge DO, Hammill SC. Association of uncomplicated electrocardiographic conduction blocks with subsequent cardiac morbidity in a community-based population (Olmsted County, Minnesota). *Am J Cardiol*. 2008;101:102-106.
9. Rotman M, Triebwasser JH. A clinical and follow-up study of right and left bundle branch block. *Circulation*. 1975;51:477-484.
10. Eriksson P, Hanson PO, Eriksson H, et al. Bundle-branch block in a general male population: the study of men born 1913. *Circulation*. 1998;98: 2494-2500.
11. Singer RB. Mortality in 966 life insurance applicants with bundle branch block or wide QRS. *Trans Assoc Life Insur Med Dir Am*. 1969;52: 94.

12. Singer RB. Mortality in insureds with complete right or left bundle branch block. *J Insur Med.* 2007;39:8-16.
13. Rodstein M, Mills JP, Lovell JF, et al. A mortality study of bundle branch block. *Arch Int Med*. 1951;87:663-668.
14. Agee F Jr. Data given in discussion of the preceding paper presented at: American Life Convention, 50th Meeting, *Proceedings of the American Council of Life Insurance Medical Section Medical Section*. 1962:138-144.
15. Iacovino JR. Mortality Analysis of complete right and left bundle branch block in a selected community population. *J Insur Med*. 1997;29:91-100.
16. Available at: www.mibgroup.com/riskanalytics/industrystudies.html
17. Available at: www.mib.com
18. Federal Register. 2014;79:78314-78324. Available at: http://www.gpo.gov/fdsys/pkg/FR-2014-12-30/html/2014-30199.htm.
19. 2015 Composite Mortality Table based on the Society of Actuaries 2015 Valuation Basic Table for Male and Female Non Smokers and Smokers, Age Last Birthday.
20. Singer RB. The application of life table methodology to risk appraisal. In: Brackenridge RDC, Croxson RS, and MacKenzie R, eds. *Brackenridge's Medical Selection of Life Risks*. 5th ed. New York, NY: Palgrave Macmillan; 2006:66-67.
21. Ferrer MI. A survey of 19,734 electrocardiograms obtained in insurance applicants. *J Insur Med*. 1985;16:6-13.
22. Zhang ZM, Rautaharju PM, Soliman EZ, et al. Mortality risk associated with bundle branch blocks and related repolarization abnormalities (from the Women's Health Initiative [WHI]). *Am J Cardiol*. 2012;110:1489-1495.
23. Hesse B, Diaz LA, Snader CE, et al. Complete bundle branch block as an independent predictor of all-cause mortality: report of 7,073 patients referred for nuclear exercise testing. *Am J Med*. 2001;110: 253-259.
24. Freedman RA, Alderman EL, Sheffield LT, Saporito M, Fisher LD. Bundle- branch block in patients with chronic coronary artery disease: angio- graphic correlates and prognostic significance. Coronary Artery Surgery Study (CASS). *J Am Coll Cardiol*. 1987;10:73-80.
25. Sumner G, Salehian O, Yi Q, et al. The prognostic significance of bundle branch block in high-risk chronic stable vascular disease patients: a report from the HOPE trial. *J Cardiovasc Electrophysiol*. 2009;20:781-787.
26. Sauer WH. Right Bundle Branch Block. Post TW, ed. *UpToDate*. Waltham, MA: UpToDate Inc. Accessed at http://www.uptodate.com on June 02, 2018.
27. Bussink BE, Holst AG, Jespersen L, et al. Right bundle branch block: prevalence, risk factors, and outcome in the general population: results from the Copenhagen City Heart Study. *Eur Heart J*. 2013;34:138-146.
28. Xiong Y, Wang L, Liu W, et al. The Prognostic Significance of Right Bundle Branch Block: A Meta-analysis of Prospective Cohort Studies. *Clin Cardiol*. 2015;38:604-613.
29. Sauer WH. Left Bundle Branch Block. Post TW, ed. *UpToDate*. Waltham, MA: UpToDate Inc. Available at http://www.uptodate.com. Accessed June 2, 2018.
30. Rotman M, Triebwasser JH. A clinical and follow-up study of right and left bundle branch block. *Circulation*. 1975;51:477-484.
31. Rabkin SW, Mathewson FA, Tate RB. Natural history of left bundle-branch block. *Br Heart J*. 1980;43:164-169.
32. Pine MB, Oren M, Ciafone R, et al. Excess Mortality and Morbidity Associated with Right Bundle Branch and Left Anterior Fascicular Block. *J Am Coll Cardiol*. 1983;1:1207-1212.
33. Kulbertus HE. Re-evaluation of the prognosis of patients with LAD-RBBB. *Am Heart J*. 1976;92:665-667.
34. Dhingra RC, Wyndham C, Bauernfeind R, et al. Significance of chronic bifascicular block without apparent organic heart disease. *Circulation*. 1979;60:33-39.
35. Dhingra RC, Wyndham C, Deedwania PC, et al. Effect of age on atrioventricular conduction in patients with chronic bifascicular block. *Am J Cardiol*. 1980;45:749-56.
36. Rabkin SW, Mathewson FA, Tate RB. The natural history of right bundle branch block and frontal plane QRS axis in apparently healthy men. *Chest*. 1981;80:191-196.
37. McAnulty JH, Rahimtoola SH, Murphy E, et al. Natural history of "high-risk" bundle-branch block: final report of a prospective study. *N Engl J Med*. 1982;307:137-143.
38. Warren, JR, Milesi C, Humphries M, Grodsky E. Do inferences about mortality rates and gradients vary by source of mortality information? Paper presented at: Population Association of America; May 2015; San Diego, CA.