ORIGINAL ARTICLE

Prevalence of Intraventricular Conduction Disturbances in a Large French Population

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Background: Recommendations for the interpretation of electrocardiogram have been published in 2009. The aim of this study was to define the prevalence of intraventricular conduction disturbances (ICoDs) in a large population, using these recommendations.

Methods: From 01/31/1996 to 09/22/2010, an electrocardiogram was performed at each visit for all aircrew members examined for fitness assessment in an aeromedical center. The prevalence of left bundle branch block (LBBB), right bundle branch block (RBBB), incomplete LBBB, incomplete RBBB, nonspecific intraventricular disturbance (NIVCD), left anterior fascicular block (LAFB), and left posterior fascicular block (LPFB) was measured and compared by age and gender.

Results: The global prevalence of ICoD was 3.09% in our population of 69,186 patients. The most frequent types of ventricular blocks were IRBBB (1.25%) and LAFB (1.10%), whereas RBBB (0.46%), LBBB (0.08%), ILBBB (0.03%), NIVCD (0.05%), and LPFB (0.13%) were rare findings. ICoDs are more frequent for males and older age groups ($P < 0.001$).

Discussion: Our results are comparable to studies concerning low cardiovascular risks populations. The association between ICoD and cardiovascular diseases needs to be studied in this population.

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electrocardiogram; intraventricular conduction disturbance; prevalence

Most of the studies about intraventricular conduction disturbances (ICoDs) have been performed on subjects with several cardiovascular risk factors, or focused on bundle branch blocks only.^{1–4}

In 2009, The American Heart Association, in association with the American College of Cardiology and the Heart Rhythm Society, published new recommendations for the interpretation of electrocardiogram (ECG).⁵ The aim of this study was to define the prevalence of ICoD in a large population using these recommendations.

Indeed, as far as we are concerned about our aeromedical center, finding a cardiac disease

before its first manifestation in aircrew members is very important for the flight safety.

METHODS

Study Population

The study population was composed of all aircrew members (military and civilian, jet, and transport crew) examined for fitness assessment at the Aeromedical Expertise Centre of Clamart from 01/31/1996 to 09/22/2010. A 12-lead ECG was performed on each visit for all patients.

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This population is usually considered as a selected population with a low cardiovascular risk.⁶ Indeed, it is composed of people estimated as healthy enough to become aircrew members, based on civilian or military fitness criteria. They are usually young, with a mean age (ma) under 40 years old (yo), and a high socioprofessional level. In addition, aircrew members are examined every year (pilots) or every 2 years (other aircrew members) for fitness assessment. The importance of a regular physical activity and adequate dietetic rules are discussed during these examinations. However, in this study, we did not collect data about the cardiovascular risk factors or diseases of our patients.

Electrocardiography

ICoDs included in the study were complete right bundle branch block (RBBB), incomplete right bundle branch block (IRBBB), complete left bundle branch block (LBBB), incomplete left bundle branch block (ILBBB), nonspecific intraventricular conduction disturbance (NIVCD), left anterior fascicular block (LAFB), and left posterior fascicular block (LPFB). For IRBBB and RBBB, the frontal plane axis was also studied in order to divide these ICoD in three groups: normal axis, left axis if $< -45^\circ$, right axis when $> 90^\circ$. ECG with Brugada pattern and those with ventricular preexcitation of Wolff-Parkinson-White type were excluded.

RBBB was defined by a QRS greater than or equal to 120 ms, a rsr' , rsR' , or rSR' in leads V_1 or V_2 (the R' or r' deflection is usually wider than the initial R wave), and an S wave of greater duration than R wave or greater than 40 ms in leads I and V_6 . When a pure dominant R wave is present in V_1 , R peak time (time from QRS onset to R wave peak) must be greater than 50 ms but normal in leads V_5 and V_6 .

IRBBB was defined by QRS duration between 110 and 119 ms in adults. Other criteria are the same as for RBBB.

LBBB was defined by a QRS greater than or equal to 120 ms, a broad notched or slurred R wave in leads I, aVL, V_5 , and V_6 (an occasional RS pattern in V_5 and V_6 attributed to displaced transition of QRS complex), absent q waves in leads I, V_5 , and V_6 (a narrow q wave may be present in lead aVL), and an R peak time greater than 60 ms in leads V_5 and V_6 but normal in leads V_1 , V_2 , and V_3 , when small

initial r waves can be discerned in the above leads. The QRS axis in frontal plane, the ST segment, and the T wave may be changed.

ILBBB was defined by a QRS duration between 110 and 119 ms, the presence of left ventricular hypertrophy pattern, an R peak time greater than 60 ms in leads V_4 , V_5 , and V_6 , and the absence of q wave in leads I, V_5 , and V_6 .

NIVCD was defined by a QRS duration greater than 110 ms without criteria for RBBB or LBBB.

LAFB was defined by a frontal plane axis between -45° and -90° , a qR pattern in lead aVL, a R-peak time in lead aVL of 45 ms or more, and a QRS duration less than 120 ms.

LPFB was defined by a frontal plane axis between 90° and 180° , a rS pattern in leads I and aVL, a qR pattern in leads III and aVF, and a QRS duration less than 120 ms.

All these criteria are based on the recommendations for the interpretation of ECG published in 2009.⁵

All ECGs were performed on the same machine model (HP M1700A, PageWriter version A.03; Hewlett-Packard®, Palo Alto, CA, USA).

Every ECG was read by an experienced physician, and stored with the TraceMasterECGVue® system.

For our study, all ECGs from 01/31/1996 to 09/22/2010 were analyzed by the TraceMasterECGVue using the criteria set by the American Heart Association in 2009. Those with a diagnosis of ICoD were reviewed independently and blindly by a junior and a senior physician (they did not know the diagnosis proposed by the machine or by the other physician, and they had no information about patient identity). In case of a disagreement, another senior physician analyzed ECG to confirm the diagnosis.

A sample of ECG considered as normal by the TraceMasterECGVue, paired by age and gender with those with a diagnosis of ICoD, was tested by randomization and analyzed by a physician, in order to validate the computerized screening (the group of ECGs with the diagnosis of ICoD and the sample of ECG considered as normal had the same size). All these ECGs were also considered as normal by the physician.

For each subject, when several ECGs were performed during this 14-year follow-up, we only kept one ECG to calculate the prevalence. For patients with ICoDs, we kept the first ECG with a diagnosis of ICoD. For the other patients, the ECG was chosen randomly.

Finally, all data were exported to a database using Microsoft Access.

In this study, patient information was deidentified, and the database was composed of electrocardiographic data, age, and gender.

Statistical Analysis

Results are described in terms of percentages. Ages are shown as mean $\pm$ standard deviation.

Three age groups were defined (30 –, 30–44, 45 +), and population was also separated in males/females. Prevalence in each group was compared with a logistic regression to adjust for age or sex, using RStudio software V 0.98.051.

RESULTS

In our study, 221,250 ECGs were performed in a population of 69,186 aircrew members: 49,660 males (71.8%) and 19,526 females (28.2%). For males, mean age was 32.6 ± 11.3 yo, with a range of 16–85 yo. For females, mean age was 28 ± 8.3 yo, with a range of 16–85 yo.

The prevalence of ICoD for our age groups and their sex distribution is shown in Table 1.

The prevalence of all ICoD was 3.09%.

The analysis revealed 863 IRBBB (1.25%, ma: $33.7 \text{ yo} \pm 11.4$, 95.5% male [1.66%], 4.5% female [0.20%]); 316 RBBB (0.46%, ma: $42.7 \text{ yo} \pm 16$, 94.1% male [0.60%], 5.9% female [0.10%]); 760 LAFB (1.10%, ma: $40.4 \text{ yo} \pm 13.5$, 88.0% male [1.35%], 12.0% female [0.47%]); 88 LPFB (0.13%, ma: $31.4 \text{ yo} \pm 10$, 78.4% male [0.14%], 21.6% female [0.10%]); 56 LBBB (0.08%, ma: $50 \text{ yo} \pm 11.7$, 75.0% male [0.08%], 25.0% female [0.07%]); 37 NIVCD (0.05%, ma: $41.9 \text{ yo} \pm 14$, 94.6% male [0.07%], 5.4% female [0.01%]); and 21 ILBBB (0.03%, ma: $50 \text{ yo} \pm 16.6$, 81.0% male [0.03%], 19.0% female [0.02%]).

The prevalence of RBBB and IRBBB depending on the frontal plane axis is shown in Table 2.

Concerning RBBB, 203 had a normal axis (0.29%, ma: $41.1 \text{ yo} \pm 14.7$, 94.1% males [0.38%], 5.9% females [0.06%]), 59 had a left axis (0.09%, ma: $49.3 \text{ yo} \pm 18$, 94.9% males [0.11%], 5.1% females [0.02%]), and 54 had a right axis (0.08%, ma: $41.8 \text{ yo} \pm 16.9$, 92.6% males [0.10%], 7.4% females [0.02%]).

Concerning IRBBB, 792 had a normal axis (1.14%, ma: $32.9 \text{ yo} \pm 10.9$, 95.3% males [1.52%], 4.7% females [0.19%]), 63 had a left axis (0.09%,

ma: $42 \text{ yo} \pm 13.2$, 98.4% males [0.12%], 1.6% females [0.01%]), and 8 had a right axis (0.01%, ma: $45 \text{ yo} \pm 13.7$, 87.5% males [0.01%], 7.4% females [0.01%]).

The most frequent types of ventricular blocks were IRBBB (1.25%) and LAFB (1.10%), whereas LBBB (0.08%), NIVCD (0.05%), ILBBB (0.03%), and LPFB (0.13%) were rare findings.

The prevalence of conduction defects was higher in the oldest age group (>45 years) for all ICoD except for LPFB. Nevertheless, the distribution of LPFB is different in the three age groups when adjusted to sex ($P = 0.03$).

For females, prevalence of all ICoD remains between 0.59% and 1.10% until 45 yo, and then increases to 2.15% when aged 45–50, 5.15% at 50–55, and 8.13% after 55 yo (Fig. 1).

For males, this prevalence generally increases with age: from 2.79% under 20 yo to 6.85% after 55 yo (Fig. 1).

Males had more RBBB (0.60% vs 0.10%), LAFB (1.35% vs 0.47%), IRBBB (1.66% vs 0.20%), and NIVCD (0.07% vs 0.01%) than females. The prevalence is the same in male/female for LBBB, LPFB, and ILBBB when adjusted to age.

For females, 48.4% of ICoDs were LAFB and 20.7% were IRBBB. In addition, we found 10.1% of LPFB, 10.1% of RBBB, 7.4% of LBBB, 2.1% of ILBBB, and 1.1% of NIVCD (Fig. 2).

For males, the most frequent types of ICoDs were IRBBB (42.2%) and LAFB (34.2%). We also found 15.2% of RBBB, 3.5% of LPFB, 2.2% of LBBB, 1.8% of NIVCD, and 0.9% of ILBBB.

In the study of prevalence of RBBB and IRBBB depending on frontal plane axis, we can notice that the distribution is different in the age and sex groups, except for IRBBB with a right axis.

DISCUSSION

Strength of This Study

The population of our study is the largest in Europe concerning prevalence of ICoD in the general population, and one of the first concerning a selected population with a low cardiovascular risk, associated with the study of Pelliccia et al. among Italian sportive people.⁷ This is also one of the only studies showing the prevalence of rare ICoDs such as LPFB and ILBBB, and the repartition of prevalence of RBBB and IRBBB according to frontal plane axis.

Table 1. Distribution of Intraventricular Conduction Disturbances in Males/Females and in Three Age Groups

ICoD	Total n = 69,186		Males n = 49,660		Females n = 19,526		Adjusted P Value	30 – n = 37,772		30 – 44 n = 21,774		45 + n = 9 640		Adjusted P Value
	n	%	n	%	n	%		n	%	n	%	n	%	
LBBB	56	0.08	42	0.08	14	0.07	0.25	2	0.01	14	0.06	40	0.41	<0.001
RBBB	316	0.46	297	0.60	19	0.10	<0.001	83	0.22	86	0.40	147	1.52	<0.001
LAFB	760	1.10	669	1.35	91	0.47	<0.001	200	0.53	264	1.21	296	3.07	<0.001
LPFB	88	0.13	69	0.14	19	0.10	0.08	47	0.12	30	0.14	11	0.11	0.03
ILBBB	21	0.03	17	0.03	4	0.02	0.91	2	0.01	7	0.03	12	0.12	<0.001
IRBBB	863	1.25	824	1.66	39	0.20	<0.001	384	1.02	323	1.49	156	1.62	<0.001
NIVCD	37	0.05	35	0.07	2	0.01	0.03	10	0.03	13	0.06	14	0.15	<0.001
total	2141	3.09	1953	3.93	188	0.96	<0.001	728	1.92	737	3.38	676	7.01	<0.001

ICoD = intraventricular conduction disturbance; ILBBB = incomplete left bundle branch block; IRBBB = incomplete right bundle branch block; LAFB = left anterior fascicular block; LBBB = complete left bundle branch block; LPFB = left posterior fascicular block; NIVCD = nonspecific intraventricular conduction disturbance; RBBB = complete right bundle branch block.

Table 2. Distribution of RBBB and IRBBB Depending on the Frontal Plane Axis

ICoD	Total n = 69,186		Males n = 49,660		Females n = 19,526		Adjusted P Value	30 – n = 37,772		30 – 44 n = 21,774		45 + n = 9640		Adjusted P Value
	n	%	n	%	n	%		n	%	n	%	n	%	
RBBB														
Total	316	0.46	297	0.60	19	0.10	<0.001	83	0.22	86	0.40	147	1.52	<0.001
Normal axis	203	0.29	191	0.38	12	0.06	<0.001	56	0.15	58	0.27	89	0.92	<0.001
Left axis	59	0.09	56	0.11	3	0.02	0.01	11	0.03	11	0.05	37	0.38	<0.001
Right axis	54	0.08	50	0.10	4	0.02	0.007	16	0.04	17	0.08	21	0.22	<0.001
IRBBB														
Total	863	1.25	824	1.66	39	0.20	<0.001	384	1.02	323	1.49	156	1.62	<0.001
Normal axis	792	1.14	755	1.52	37	0.19	<0.001	369	0.98	300	1.37	123	1.28	<0.001
Left axis	63	0.09	62	0.12	1	0.01	0.002	14	0.04	20	0.09	29	0.30	<0.001
Right axis	8	0.01	7	0.01	1	0.01	0.51	1	0.003	3	0.01	4	0.04	0.054

ICoD = intraventricular conduction disturbance; IRBBB = incomplete right bundle branch block; RBBB = complete right bundle branch block.

Analysis of the Results

We can notice that prevalence of ICoD is different between males and females, and also different according to age. Exceptions are LBBB and ILBBB for sex, and IRBBB with right axis for both sex and age. These differences are not significant because of a too small sample, especially for the females group (less than 5 for ILBBB and IRBBB with a right axis).

For females, we principally find ICoD after 50 yo, and the distribution depending on the age is very different from males (Fig. 1). That is why these results have to be shown separately.

If LAFB and IRBBB are the dominant ICoDs as expected, it is unusual to find so much LPFBs. LPFB is an extremely rare finding in the general population, because the posterior division of the

left bundle branch is the least vulnerable segment of the intraventricular conduction system. In our study, LPFBs are more frequent than LBBBs for both males and females, and even the same as RBBBs for females (Fig. 2). The explanation could be that the definition of LPFB given by the American Heart Association only includes electric criteria, without any information concerning an organic lesion. The consequence is that any ECG with a right axis and a pattern similar to the definition is considered as an LPFB. Thus, we can suppose that they are overestimated in our study.

Comparison to Other Studies

The global prevalence of ventricular conduction blocks in this study is comparable to other

Figure 1. Distribution of ICoD depending on the age and sex.

important studies. It is more than the population of Framingham (1948–1973) studied by Kreger et al.¹ with a prevalence of 2.6% (vs 3.93%) for males and 1.2% (vs 0.96%) for females, but less than Haataja et al.⁸ on the Health 2000 survey concerning general population in Finland with a global prevalence estimated at 5.1% (vs 3.09%). Prevalence is also more important than found in Ostrander study⁹ (3.09% vs 2%), but this study did not count LAFB, which is the most frequent ICoD in our study.

As our population was young and healthy, we can notice that we found less RBBB than Kreger et al.,¹ Haataja et al.,⁸ or Pelliccia et al.⁷ (2.4%, 1.1%, and 1%, respectively, vs 0.46%). However, most of the studies with a mean age inferior to 45 yo, such as Fahy et al.¹⁰ (general population, ma = 44 yo), Rotman and Triebwasser¹¹ (U.S. Air Force, ma = 33 yo), Carlioz et al.¹² (French aircrew members, ma = 36 yo), or Ostrander et al. (Tecumseh population, ma = 40 yo),⁹ find a smaller

prevalence of RBBB (0.18%, 0.17%, 0.17%, and 0.35%, respectively, vs 0.46%). We found no other population-based studies concerning the frontal axis of RBBB in our literature search.

Concerning LBBB, it can be compared to a low cardiovascular risk population such as Pelliccia et al.⁷ or Rotman and Triebwasser¹¹ (respectively, 0.1% and 0.05% vs 0.08%).

For the LAFB, we found a similar prevalence as that of the Health 2000 survey⁸ (1.1% vs 1%) but more than Pelliccia et al.⁷ (1.1% vs 0.5%).

Concerning IRBBB, prevalence is less than studies of Canaveris¹³ among aircrew members, Ostrander et al.,⁹ and Durakovic and Mimica¹⁴ in general population (respectively, 3.4%, 1.38%, and 1.64% vs 1.14%), but quite the same as the Health 2000 survey⁸ (1% vs 1.14%).

Finally, we found less ILBBB and NIVCD than the Health 2000 survey⁸ (respectively, 1% vs 0.03% and 0.6% vs 0.05%), but the same prevalence of LPFB (0.1% vs 0.13%).

Figure 2. Distribution of ICoD depending on sex. ICoD = intraventricular conduction disturbance; ILBBB = incomplete left bundle branch block; IRBBB = incomplete right bundle branch block; LAFB = left anterior fascicular block; LBBB = complete left bundle branch block; LPFB = left posterior fascicular block; NIVCD = nonspecific intraventricular conduction disturbance; RBBB = complete right bundle branch block.

LIMITATIONS

We can notice a few limitations in this study. First, the study population is young and healthy, examined for a fitness assessment in an aeromedical expertise center, and it cannot strictly be representative of the general population.

In addition, males were more represented than females (sex ratio 2.5). Finally, we did not study the association between ICoD and cardiovascular diseases, which could be the subject of another study.

CONCLUSION

This is the first study with a large population, using the new standard of interpretation to define the ICoD prevalence. The prevalence of all ICoD in this population is 3.09%. ICoDs differ in prevalence between sex and age groups, they are more frequent for males and older age groups. The association between ICoD and cardiovascular diseases needs to be studied in our population.

The realization of a systematic ECG at each visit in our aeromedical center is very important. Indeed, if the appearance of an abnormality on the ECG leads to the discovery of a cardiomyopathy in aircrew members, this may have an impact on flight safety.

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