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P-wave characteristics as electrocardiographic markers of atrial myopathy in prediction of incident atrial fibrillation – The Malmö Preventive Project.

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Abstract:	Background P-wave indices reflect atrial abnormalities contributing to atrial fibrillation (AF). We aimed to assess a comprehensive set of P-wave characteristics for prediction of incident AF in a population-based setting. Methods Malmö Preventative Project (MPP) participants were reexamined in 2002-2006 with electrocardiographic (ECG) and echocardiographic examinations and followed for 5 years. AF-free subjects (n=983, age 70±5 years, 38% females) with sinus rhythm ECGs were included in the study. ECGs were digitally processed using the Glasgow algorithm. P-wave duration, axis, dispersion, P-terminal force in lead V1 and interatrial block (IAB) were evaluated. ECG risk score combining the morphology, voltage and length of P-wave (MVP score) was calculated. New-onset diagnoses of AF were obtained from nation-wide registers. Results During follow up, 66 patients (7%) developed AF. After adjustment for age and gender, the independent predictors of AF were abnormal P-wave axis > 75° (HR 1.63 CI95% 1.95-11.03) and MVP score 4 (HR 6.17 CI 95% 1.76-21.64), both correlated with LA area: Person r -0.146, p<0.001 and 0.192, p<0.001 respectively. Advanced IAB (aIAB) with biphasic P-wave morphology in leads III and aVF was the most prevalent variant of aIAB and predicted AF in a univariate model (HR 2.59 CI 95% 1.02-6.58). Conclusion P-wave frontal axis and MVP score are ECG-based AF predictors in the population-based cohort. Our study provides estimates for prevalence and prognostic importance of different variants of aIAB, providing a support to use biphasic P-wave morphology in lead aVF as the basis for aIAB definition.
Suggested Reviewers:	

8/17/2023

Editor-in-Chief
Europace Journal

Department of Cardiology
Pyotr Platonov, MD, PhD, FESC, FHRS
Professor

Dear Professor Adrian Baranchuk,

On behalf of the co-authors, we would like to ask you to consider the manuscript "**P-wave characteristics as electrocardiographic markers of atrial myopathy in prediction of incident atrial fibrillation – The Malmö Preventive Project**" for publication in the Journal of Electrocardiology.

The manuscript presents the results of the original study based on the data from the Malmö Preventive Project with focus on P wave indices in prediction of incident atrial fibrillation. We performed a comprehensive assessment of P wave indices incorporating duration, morphology, amplitude and electrical axis including the recently proposed ECG risk score combining morphology, voltage in lead I and duration in prediction of incident atrial fibrillation in epidemiologic cohort. Also, we provided a detailed account of the prevalence and prognostic importance of the different electrocardiographic patterns of advanced interatrial block based on the presence of biphasic/negative P waves in inferior leads affecting one, two or all three leads.

We confirm that none of the authors has conflicts of interests in regard to this study and that the manuscript has not been published and is not under consideration for publication elsewhere.

Sincerely, on behalf of co-authors,

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Highlights

- The detailed account of different variants of interatrial block (IAB) is provided
- Morphology-voltage-P-wave duration (MVP) score is validated in epidemiologic cohort
- Advanced IAB (aIAB) appears to be associated with left atrial enlargement
- The most prevalent aIAB type is aIAB with biphasic morphology in leads aVF and III
- High MVP score, but not aIAB, independently predicts incident atrial fibrillation

P-wave characteristics as electrocardiographic markers of atrial myopathy in prediction of incident atrial fibrillation – The Malmö Preventive Project.

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Abstract

Background: P-wave indices reflect atrial abnormalities contributing to atrial fibrillation (AF). We aimed to assess a comprehensive set of P-wave characteristics for prediction of incident AF in a population-based setting.

Methods: Malmö Preventative Project (MPP) participants were reexamined in 2002-2006 with electrocardiographic (ECG) and echocardiographic examinations and followed for 5 years. AF-free subjects (n=983, age 70±5 years, 38% females) with sinus rhythm ECGs were included in the study. ECGs were digitally processed using the Glasgow algorithm. P-wave duration, axis, dispersion, P-terminal force in lead V1 and interatrial block (IAB) were evaluated. ECG risk score combining the morphology, voltage and length of P-wave (MVP score) was calculated. New-onset diagnoses of AF were obtained from nation-wide registers.

Results: During follow up, 66 patients (7%) developed AF. After adjustment for age and gender, the independent predictors of AF were abnormal P-wave axis > 75° (HR 1.63 CI95% 1.95-11.03) and MVP score 4 (HR 6.17 CI 95% 1.76-21.64), both correlated with LA area: Person r -0.146, p<0.001 and 0.192, p<0.001 respectively. Advanced IAB (aIAB) with biphasic P-wave morphology in leads III and aVF was the most prevalent variant of aIAB and predicted AF in a univariate model (HR 2.59 CI 95% 1.02-6.58).

Conclusion: P-wave frontal axis and MVP score are ECG-based AF predictors in the population-based cohort. Our study provides estimates for prevalence and prognostic importance of different variants of aIAB, providing a support to use biphasic P-wave morphology in lead aVF as the basis for aIAB definition.

Key words: interatrial block, atrial fibrillation, MVP score, P-wave.

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Author contribution

MAB: Coceptualization, Methodology, Formal analysis, Writing – Orriginal Draft GC: Investigation JC: Software, Data Curation, LSBJ and JGS: Writing – Review and Editing, PGP: Coceptualization, Writing – Review and Editing, Supervision.

Introduction

P-wave indices reflect electrophysiological and structural abnormalities in the atria (1, 2) consistent with atrial cardiomyopathy – a newly defined entity. (3) One of the clinical manifestations of atrial cardiomyopathy is supraventricular arrhythmias including atrial fibrillation (AF). (4) The association of P-waves indices with AF has been evaluated in different studies.(5, 6) In the Framingham Heart Study (FHS) and the Atherosclerosis Risk in Communities (ARIC) study prolonged P-wave duration is associated with increased risk of AF. (7) A strong association has been found between P-terminal force in lead V_1 (PTF-V_1) and AF in the ARIC cohort, but not in FHS. P-wave axis has been found to predict AF in the Cardiovascular Health Study (CHS). (8) P-wave dispersion has been demonstrated to be associated with incident AF in ischemic stroke survivors. (9)

One of the most studied indices is interatrial block (IAB), an electrocardiographic (ECG) phenomenon reflecting delayed conduction between the right and left atria through Bachmann's bundle. (10) IAB reflects atrial abnormalities such as left atrial (LA) enlargement (11) and conduction delay (12) – an anatomical and electrical substrate for development of atrial arrhythmias. Advanced IAB is characterized by retrograde propagation of depolarization in the LA and reflected on the ECG as the presence of biphasic P-waves with terminal negative component in inferior leads II and/or aVF. Variability of biphasic/negative P-waves in inferior leads affecting one, two or all three leads have been reported in regard to incident AF in general population. (13)

Furthermore, it had been shown that P-wave voltage in lead I reflects cardiac conductive properties and the extent of atrial fibrosis. (14). Recently a new predictive tool has been proposed for identification of patients at AF risk – the ECG risk score combining the morphology (e.g. IAB), voltage and length of P-wave (MVP score). (15) The predictive value

of MVP score has been confirmed in a few studies performed in different patient populations. (16, 17) However, it has not been evaluated in epidemiologic cohorts.

The aim of the study was to assess the association of earlier proposed P-wave indices with structural LA abnormalities and incident AF in a population-based setting.

Method

Study population, baseline assessment and ECG processing.

The cohort comprised 1117 subjects enrolled in the Malmö Preventive Project (MPP). (18, 19) Full birth cohorts between 1921-1949 were invited and underwent screening between 1974 to 1992. Between 2002-2006, surviving participants were invited to a re-examination. As part of the re-examination, a random subsample of participants selected as described previously (19) underwent a physical examination, from which the baseline data for this study was collected.

A resting 10-second 12-lead electrocardiography (MAC, MAC5K or MAC8 devices from GE Healthcare, Milwaukee, WI, USA), transthoracic echocardiography, and clinical information were collected.(19, 20) Digital ECGs were retrieved from an electronic database (MUSE, GE Healthcare, Milwaukee, WI, USA) and processed offline using the Glasgow algorithm.(21) After ECG processing, subjects with PQ-times greater than 320 or smaller than 80 ms, AF or flutter, AV-block type 1 and 2 or pacemaker dependent heart rhythms, and missing data were excluded from the study (n=134), resulting in 983 subjects with P-waves of suitable for analysis quality which comprised the sample for this study.

The study was approved by The Regional Ethical Review board at Lund University, Sweden and complied with the Helsinki Declaration. (20)

P-wave indices and definition of IAB

Conventional P-wave indices were calculated using the Glasgow algorithm.(21) PTF-V_1 was defined as duration in ms of the terminal negative component of the P-wave multiplied by its depth in millimeters (mm*ms), and a measurement > 40 mm*ms was considered abnormal. (22) A P-wave axis less than 0 ° and greater than 75 ° was considered abnormal. P-wave morphology was automatically processed and coded as positive, negative or biphasic.

IAB was defined as a P-wave ≥120 ms (12) and classified in regard to the number of affected inferior leads (Figure 1). Partial IAB was defined in case of positive P-wave in all three inferior leads (pIAB-0) and of biphasic or negative P-wave in one inferior lead III (pIAB-1), advanced IAB – in case of biphasic or negative P-wave in two inferior leads III and aVF (aIAB-2) and in all three inferior leads (aIAB-3 or typical aIAB as originally defined (23)). If the combination of P-wave polarities did not match any of the prespecified morphological IAB classes it was considered an unclassified IAB.

MVP score was calculated as described previously, Table 1. (15)

P-wave dispersion was measured by P-wave duration/P-wave vector magnitude calculated automatically as previously described and expressed in ms/mV. (9)

New onset AF

AF incidence was ascertained at the end of follow-up dated June 30, 2009 within a median of 4.2 (IQR 3.7-4.8) years from baseline re-examination. New-onset diagnoses of AF were obtained from the Swedish National Patient Registers, (24) in which AF diagnosis is identified with high specificity and modest sensitivity. (24, 25) Diagnosis codes of 427.92 (ICD-8), 427D (ICD-9) or I48 (ICD-10) were used to identify incident AF.

Statistical analyses

All statistical analyses were performed using the SPSS statistics software, version 27 for Mac. For descriptive statistics, we computed means and standard deviation for continuous variables with normal distribution. Count and percentage was calculated for categorical variables.

Pearson correlation statistics for normally distributed continuous variables were used to estimate the correlation of P-wave indices with LA size. Patients with LA enlargement defined as LA area >20 sm^2 (26) were compared to patients with normal LA size using $\chi 2$ test in regard to the prevalence of P-wave indices expressed as categorical variables. Relative risks for LA enlargement were calculated using logistic regression.

For assessment of AF predictors, hazard ratios (HR) with corresponding 95% confidence intervals (CI) were computed using Cox regression models, and presented unadjusted, adjusted for age and gender, and adjusted for age, gender and LA enlargement. The proportional hazards assumption was checked using Kaplan-Meier curves.

Results

Baseline assessment

Baseline subject characteristics are presented in the Table 2. The mean age of the study participants was 70 years and the majority of them were men.

Abnormal PTF-V_1 was found in 26 % of study subjects, abnormal P wave axis – in 10%. We observed pIAB in 35 %, of whom 20% had pIAB-0 and 15% - pIAB-1. The prevalence of aIAB was 6.5%, of whom 5% had aIAB-2 and 1.5% aIAB-3. The mean MVP score was 1. None of the participants had MVP score greater than 4.

Measurements of LA size were available for 927 subjects (94%). LA enlargement was found in 353 of them (38%). Those with LA enlargement more often had pIAB-1, aIAB-2, and MVP score >3. (Table 3). The relative risk of LA enlargement was 1.97 (95% CI 1.08-3.56) for aIAB-2, 1.72 (95% CI 1.26-2.34) for pIAB-1 and 1.48 (95% CI 1.20-1.82) for MVP score > 3. All P-wave indices had low sensitivity and high specificity for LA enlargement (Table 4).

The correlation was found between LA area and MVP score (r 0.192, p<0.001), P-wave duration (r 0.085, p=010), P- wave duration over P-wave vector magnitude (r 0.200, p<0.001) and P-wave axis (r -0.146, p<0.001).

Predictors of incident AF

During follow-up, new onset AF was registered in 66 participants (7 %). At baseline, subjects with incident AF were older, had a larger LA area and lower left ventricular ejection fraction, more often had P-wave duration ≥120 ms, pIAB, abnormal P-wave axis, greater MVP score and lower P positive amplitude in lead I than AF-free subjects (Table 2).

There was an association between aIAB-2 and incident AF (Figure 2, univariate HR 2.59 95% CI 1.02-6.58). None of the 15 subjects with aIAB-3 had documented AF during follow-up.

ECG predictors of new onset AF are detailed in Supplemental Table 1. In the univariate Cox regression analysis, aIAB-2 (HR 2.59 95% CI 1.02-6.58), abnormal P-wave axis > 75° (HR 4.46 95% CI 1.88-10.60), reduced P-wave amplitude in lead I (HR 0.97 95% CI 0.97-1.00) and MVP score 4 (Figure 3, univariate HR 5.45 95% CI 1.61-18.43) were associated with increased risk of AF. These markers had low sensitivity and high specificity for incident AF (Table 4). The association remained significant for abnormal P-wave axis > 75° (HR 6.47 95% CI 2.41-17.35) and MVP score 4 (HR 6.17 95% CI 1.76-21.64) in a multivariate model after adjustment.

Discussion

We performed a comprehensive evaluation of P wave indices as markers of atrial myopathy for prediction of incident AF in an elderly epidemiologic cohort. Neither P-wave duration, nor PR-interval or PTF-V_1 were associated with incident AF, suggesting their limited value as risk indicators. Contrary, P-wave morphology, measured by frontal plane P-wave axis and the MVP risk score combining P-wave morphology, voltage, and duration, appeared to be useful in AF prediction, independently of LA structural abnormalities.

Notably, the risk of AF development was similar for subjects with normal P-wave duration and pIAB, including those with isolated biphasic P wave in lead III and unaffected leads aVF and II. The prevalence of the typical aIAB was low (1.5%) and had limited value for AF prediction. However, we found an association with AF for the most prevalent (5%) variant of aIAB, with affected leads III and aVF.

Interatrial block

IAB is the most well-recognized of the P wave indices. It occurs due to a conduction delay between the right and left atria and reflects atrial remodeling. In agreement with previous studies (27) we have observed an association between advanced IAB and LA enlargement supporting the notion of IAB being an ECG marker of LA abnormality. The association of aIAB and supraventricular arrhythmias, and AF in particular, is well established and named Bayes syndrome in recognition of Antonio Bayes de Luna who first described this association. (28) Impaired atrial conduction forms the substrate for development of re-entry arrhythmias including AF. (29) In ARIC study 3-fold risk increase of AF was shown for patients with aIAB.(30) We have observed a 2.5-fold, but statistically insignificant, increase in incident AF risk among those with aIAB-2.

Very few subjects had advanced IAB defined using the strict definition that requires the presence of a biphasic +/- P-waves in all three inferior leads; this limits its usefulness as a prognostic marker. In real life, patients may present with a continuum of abnormalities in inferior leads that reflect more or less altered sequence of LA depolarization in the caudocranial direction. It has been shown that the extent of P-wave abnormalities in inferior leads, expressed as the number of affected inferior leads, is related to incident AF and LA enlargement. (13) In our material, isolated biphasic P-wave in lead III was the most common P-wave pattern (15% of the entire cohort), followed by the presence of biphasic P waves in leads III and aVF (5%) also defined as Type I atypical aIAB by another proposed terminology. (23)

In agreement with earlier observations (13), the presence of biphasic +/- P waves in lead III only was associated with LA enlargement, but not related to an increased AF risk, thus supporting its interpretation as a non-specific intermediate phenotype.(13) It was earlier suggested that the caudocranial activation of LA – the hallmark of advanced IAB – is present first when the final part of biphasic P-wave falls in the negative hemifield in aVF (31). Since strictly defined advanced IAB is a rare observation in population-based cohorts we would argue that the presence of biphasic P-waves in lead aVF should be the corner stone of the aIAB definition, as we used in our study.

MVP score

To the best of our knowledge our study is the first in which MVP score was validated in an epidemiologic cohort. We have found that MVP score 4 (the maximal value observed in our cohort) predicted incidence of AF with 6-fold risk increase, independently from LA enlargement. The predictive value of MVP score has previously been shown in patients undergoing coronary angiography, (15) in patients with ischemic stroke, (17) and after pulmonary vein isolation. (16) Contrary to the published data, as our study was performed in elderly participants without severe cardiovascular disorders, we did not have subjects with high risk according to the MVP score e.g. with score above 4. Our findings however, are in agreement with earlier studies (16, 17) that identified the best cut-off for AF prediction as MVP>3.

P-wave axis

Though being a part of the standard ECG analysis, P-wave axis has been assessed as a marker of AF risk only recently. A measurement between 0° and + 75° is considered normal while a deviation from normal range might reflect atrial abnormalities and is related to the presence of IAB. Though in our study the mean value of P-wave axis was within normal range, we found

that P-wave axis > + 75° independently predicted AF. Our findings support earlier observations of P-wave axis as a marker of increased predisposition to AF. (6, 8)

Study limitations

Our study was performed on a relatively outdated cohort and the management of AF has been considerably improved since then. However, we believe that this limitation has not influenced our findings as we focused on ECG data in AF prediction and used Swedish National Patient Registry for identification of incident AF, i.e. the methodology with repeatedly proven validity. (24, 25) It is however possible that the information regarding incident AF obtained from the national register might have underestimated the true prevalence of AF.

These limitations have to be considered in the light of the quality of ECG data presented in this study. We have used an automatic algorithm for P-wave analysis, thus eliminating the risk of subjectivity in assessment of P-wave duration and morphology.

Conclusion

The association of IAB with LA enlargement indicates that abnormal P-wave morphology may reflect structural changes in atria and serve as an ECG marker of LA abnormalities, but with low sensitivity for detection of LA enlargement. Our study provides detailed account of the prevalence and prognostic importance of different ECG variants of aIAB supporting the use of biphasic P wave morphology in lead aVF as the basis for aIAB definition.

Conventional P-wave indices have limited value in AF prediction on a population basis. Only right P-wave frontal axis deviation and the MVP risk score demonstrated significant association with incident AF.

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Table 1. Morphology-Voltage-P-wave duration score.

Variable	Value	Score
Morphology	No interatrial block	0
	Partial interatrial block	1
	Advanced interatrial block	2
Voltage in lead I	>0.20 mV	0
	0.10-0.20 mV	1
	<0.10 mv	2
P-wave duration	<120 ms	0
	120-140 ms	1
	>140 ms	2

Table 2: Baseline clinical, ECHO and P-wave characteristics of the participants.

Variable	**All (n=983)**	**New onset AF (n=66)**	**No AF (n=917)**	**P value**
Age (years), mean ± std	**70±5**	**71±4**	**70±5**	**0.046**
Female gender, n (%)	356 (36)	24 (36)	332 (36)	1.000
BMI (Kg/m^2), mean ± std	28±4	29±5	28±4	0.146
Diabetes mellitus, n (%)	284 (29)	23 (35)	261 (29)	0.264
Currently smoking, n (%)	169 (17)	10 (15)	159 (17)	0.738
Use of antihypertensives, n (%)	**480 (49)**	**48 (73)**	**432 (47)**	**<0.001**
Echocardiography				
Left atrial systolic diameter, mm, mean ± std	**40±5**	**43±7**	**40±5**	**<0.001**
Left atrial area, sm^2, mean ± std	**20±4**	**22±5**	**20±4**	**<0.001**
Left atrial enlargement, n (%)*	**353 (38)**	**41 (70)**	**312 (36)**	**<0.001**
Left ventricular ejection fraction, %, mean ± std	**61±8**	**56±12**	**61±7**	**<0.001**
Electrocardiography				
P-wave duration, ms, mean ± std	114±16	114±21	114±15	0.874
PR interval, ms, mean ± std	170±29	173±38	169±28	0.367
P-terminal force in lead V_1, mm ´ ms, mean ± std	27±21	29±27	26±20	0.398
Abnormal P-terminal force in lead V_1, n (%)	251 (26)	20 (30)	231 (25)	0.381
P positive amplitude in lead I, μV, mean ± std	**82±27**	**73±31**	**83±27**	**0.005**
P positive amplitude in lead II, μV, mean ± std	109±44	109±44	117±44	0.170
Interatrial Block, n (%):				
P-wave duration > 120 ms, n (%)	**413 (42)**	**36 (55)**	**377 (41)**	**0.039**
Partial IAB, all three inferior leads positive (pIAB-0)	**199 (20)**	**20 (30)**	**179 (20)**	**0.040**
Partial IAB: lead III affected** (pIAB-1)	145 (15)	10 (15)	135 (15)	0.859
Advanced IAB: leads III and aVF affected (aIAB-2)	45 (5)	5 (8)	40 (4)	0.219
Typical advanced IAB: leads III, aVF, II affected (aIAB-3)	15 (1.5)	0 (0)	15 (1.6)	0.616
Unclassified	9 (1)	1 (1.5)	8 (1)	0.466
MVP score, mean ± std	**1±1**	**2±1**	**1±1**	**0.012**

MVP score 0, n (%)	**545 (50)**	**28 (42)**	**517 (56)**	**0.025**
MVP score 1, n (%)	**40 (4)**	**3 (5)**	**37 (4)**	
MVP score 2, n (%)	**131 (13)**	**10 (15)**	**121 (13)**	
MVP score 3, n (%)	**250 (25)**	**21 (32)**	**229 (25)**	
MVP score 4, n (%)	**17 (2)**	**4 (6)**	**13 (1)**	
P-wave axis, °, mean ± std	**46±25**	**52±26**	**45±24**	**0.033**
Abnormal P-wave axis, n (%)	**99 (10)**	**12 (18)**	**87 (10)**	**0.033**
P-wave axis < 0 °, n (%)	60 (6)	4 (6)	56 (6)	
P-wave axis > 75 °, n (%)	**39 (4)**	**8 (12)**	**31 (3)**	
P-wave duration over P-wave vector magnitude, ms/mV, mean ± std	1358±676	1464±805	1355±666	0.187

*- left atrial enlargement defined as left atrial area > 20 sm^2;

** - P-wave morphology either negative or biphasic

Table 3. The prevalence of P-wave indices in patients with left atrial (LA) enlargement vs patients with normal size of left atria.

	LA enlargement, n=353	Normal LA, n=574	P value
P-wave duration ≥ 120 ms, n (%)	**188 (53)**	**201(35)**	**< 0.001**
Partial IAB: none of inferior leads affected (pIAB-0)	83 (24)	106 (19)	0.065
Partial IAB: lead III affected (pIAB-1)	**70 (20)**	**66 (12)**	**0.001**
Advanced IAB: leads III and aVF affected (aIAB-2)	**23 (7)**	**19 (3)**	**0.033**
Typical advanced IAB:leads III, aVF, and II affected (aIAB-3)	8 (2)	6 (1)	0.168
Unclassified, n (%)	4 (1)	4 (1)	0.488
Abnormal P-terminal force in V1, n (%)	102 (29)	132 (23)	0.052
MVP score 0, n (%)	**154 (44)**	**360 (63)**	**< 0.001**
MVP score 1, n (%)	20 (6)	19 (3)	
MVP score 2, n (%)	59 (17)	63 (11)	
MVP score 3, n (%)	111 (31)	127 (22)	
MVP score 4, n (%)	9 (3)	5 (1)	
Abnormal P-wave axis, n (%)	41 (12)	54 (9)	0.316
P-wave axis less 0 °, n (%)	32 (9)	26 (5)	
P-wave axis more 75 °, n (%)	9 (3)	28 (5)	

Table 4. Sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) of P-wave indices to be associated with left atria (LA) enlargement and/or incident atrial fibrillation (AF).

	Left atrial enlargement				Incident atrial fibrillation			
Variable	Sensitivity	Specificity	PPV	NPV	Sensitivity	Specificity	PPV	NPV
PWD≥120 ms	53%	65%	48%	69%	55%	59%	9%	95%
pIAB-1	20%	89%	51%	64%	15%	85%	7%	93%
aIAB-2	7%	97%	55%	63%	8%	95%	11%	93%
MVP 4	3%	99%	64%	62%	6%	99%	24%	94%
P-wave axis > 75°	3%	95%	24%	61%	12%	97%	21%	94%

PWD – P wave duration

pIAB - 1 – interatrial block with biphasic/negative P-wave in lead III

aIAB – 2 - interatrial block with biphasic/negative P-wave in lead III and aVF

MVP – score combining P-wave morphology, voltage in lead I and length of P-wave

Figure 1. ECG examples of partial interatrial block (IAB) with positive P-waves in all three inferior leads (pIAB-0), with positive P-waves in aVF, II and biphasic P-waves in III (pIAB-1), advanced IAB with biphasic P-waves in aVF, III (aIAB-2) and advanced IAB with biphasic P-waves in all three inferior leads (aIAB-3).

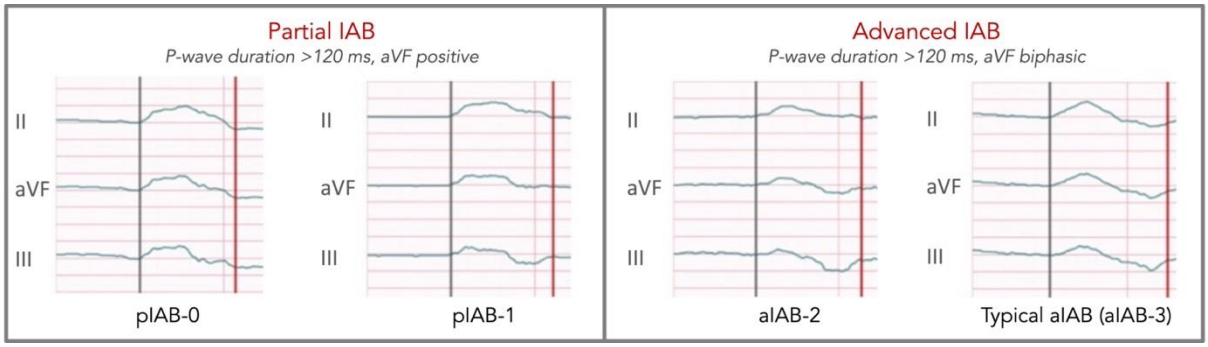

Figure 2. Kaplan-Meier survival curve showing the association of advanced interatrial block (aIAB-2) with biphasic or negative P-wave in leads III and AVF with incudent atrial fibrillation (AF) during follow-up (log rank p=0.037).

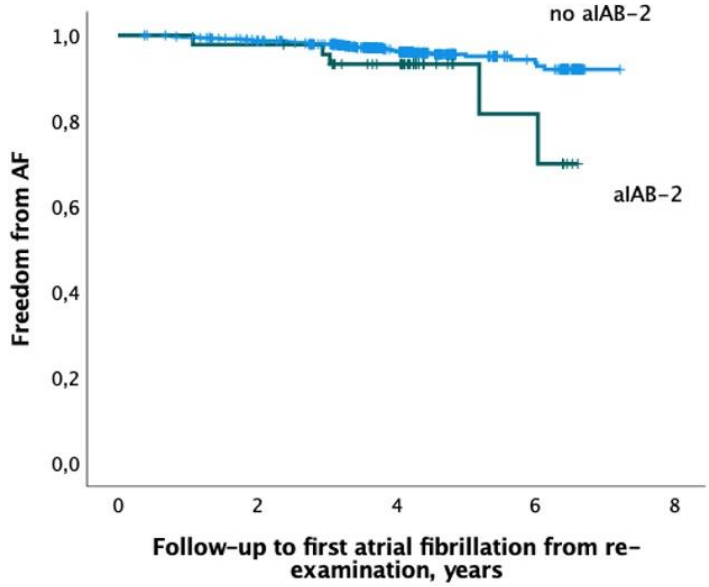

Figure 3. Kaplan-Meier survival curve showing the association of MVP (morphology-voltage-P-wave duration) score 4 with development of atrial fibrillation (AF) during follow-up (log rank p=0.006).