The Diagnosis and Clinical Implications of Interatrial Block

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Abstract

Impaired interatrial conduction or interatrial block is now well-documented but is not described as an individual electrocardiographic (ECG) pattern in the majority of ECG literature. In fact the term *atrial abnormality* has been adopted to encompass both left atrial enlargement (LAE) and interatrial block. In this paper, we maintain that interatrial blocks and atrial enlargement are separate entities, and that interatrial blocks, similar to other types of blocks at sinoatrial, AV junctional, and ventricular level, exhibit a specific ECG pattern that may present first, second, and third degree types of conduction block. The third degree or advanced interatrial block (A-IAB) is frequently associated with atrial fibrillation/atrial flutter (AF/AFL), and constitutes a true newly-described syndrome.

Keywords

Bayes Syndrome, paroxysmal AF and interatrial block, P plus/minus in II, III, and VF, prevalence of Interatrial block

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It has been considered that an interatrial block exists when there is a delay of conduction in some part of the Bachmann's bundle zone.¹ The interatrial blocks are the most frequent and well-known blocks at atrial level. These are expressed in the electrocardiogram (ECG) by the presence of a P wave duration that equals or exceeds 120 milliseconds and presents usually a bimodal morphology, especially in leads I, II, VL or inferior leads. This represents partial IAB (P-IAB). If there is a P wave morphology $\pm$ in II, III, and VF with duration ≥ 120 ms, we speak about advanced interatrial block (A-IAB) (see *Figure 1*)¹⁻³.

Which are the P wave ECG Patterns that Meet the Criteria for Interatrial Block?

The P wave ECG Pattern of Interatrial Block May be Transient

The presence of transient deterioration of interatrial conduction, that is interatrial block, of first or third degree may appear in the same ECG recording on a beat-by-beat basis or in separate recordings. The first case may be considered as a part of the concept of atrial aberrancy, a term first coined by Chung⁴ in 1972, similar to ventricular aberrancy (see *later*)^{2,4}.

The P wave ECG Pattern of Interatrial Block May Appear without Associated Atrial Enlargement

The prolonged P wave duration (P-wave duration ≥ 120 milliseconds) may be present in the elderly but can also be a consequence of acute illness, such as pericarditis or acute myocardial infarction without atrial enlargement (ECG pattern of partial interatrial block P-IAB). In fact, in these cases, the duration of P wave may be as long as in left atrial enlargement (LAE), but the P loop does not move so clearly backwards, as in a figure 8 shape, which results in a much smaller negative P wave component in lead V1 (see *Figure 2*). The combination of LAE with advanced interatrial block (A-IAB) (wide P wave ≥ 120 milliseconds and $\pm$ in leads,

II, III, and VF) is very common but isolated cases of A-IAB may be seen. As the P wave often looks flat, to be accurate in the measurement in both types of IAB it is necessary to trace lines, as seen in *Figures 4* and *6*.

The P wave ECG Pattern May be Reproduced Experimentally (see *Figure 3*)

Experimental studies⁵ have demonstrated that cutting the Bachmann's bundle at either the right or left atrial side results in a typical ECG pattern with wide P wave with biphasic $\pm$ morphology in inferior leads. It was also demonstrated⁶ that an attenuation of interatrial conduction, without affecting atrioventricular conduction, may occur after ablation of interatrial conduction zones along the right atrial septum. This intervention produces partial interatrial conduction block with an increase of P wave duration.

Interatrial Blocks May be of First, Second, and Third Degree

The interatrial blocks, by analogy with other types of block, (sinoatrial, atrioventricular, and/or bundle-branch block at the ventricular level), may be of first (partial), second (transient interatrial block is part of atrial aberrancy), or third degree (advanced).

Electrocardiographic Pattern of First-degree (Partial) Interatrial Block (see *Figures 1-B, 4*)

The P wave has a normal electrical axis. The electrical impulse is conducted from the right to the LA through the normal propagation route but with a delay. The endocardial recording confirms that the coronary sinus activation time is delayed.

The ECG shows that (a) a P wave of 120 milliseconds or more, usually bimodal, is especially visible in leads I, II, or III, and (b) the P wave morphology in V1 in the absence of left atrial enlargement (LAE)

presents a P wave negative mode that is less evident than in cases of LAE, because in the absence of LAE, the P loop is directed in a less backward direction (see *Figures 2* and *4*).

However, in the instance of P wave duration of 120 milliseconds or more the presence of LAE is common. In fact, it has been considered that the wide and bimodal P wave of LAE is better explained in terms of underlying interatrial block rather than the longer distance that the impulse has to travel⁷.

LAE is often found in the elderly⁶, in patients with heart failure⁹ and those with other advanced heart diseases. We also demonstrated that it is a risk marker of atrial fibrillation/atrial flutter (AF/Afl)¹⁰.

Electrocardiographic Pattern of Second-degree Interatrial Block (see *Figure 5*)

Similar to the conduction block at the level of AV junction, SA junction, or the ventricles, the interatrial block may occur transiently on a beat-by-beat basis or may be recorded momentarily.

In a typical case, the morphology of the P wave may change in the same recording from interatrial block pattern (first or third degree) to normal pattern, usually transiently in relation to the preceding premature beats, before then again presenting the pattern of interatrial block. These changes may be considered as atrial aberrancy, similar to ventricular aberrancy^{2,4}.

Atrial aberrancy may also present a transient bizarre P wave without the morphology of interatrial block. In these cases, the location of the block is usually the right atrium.

Electrocardiographic Pattern of Third-degree (advanced) Interatrial Block (*Figures 6–8*)

The electrical impulse is blocked especially in the upper and middle part of the interatrial septum, in the Bachmann's bundle zone, and/or in the upper part of LA so that retrograde left atrial activation occurs mainly via muscular connections in the vicinity of coronary sinus^{2,3,11,12}. In rare occasions, the right atrium and LA can demonstrate dissociated electrical activity.

The ECG shows that (a) P wave duration of 120 milliseconds or more and (b) the morphology of P wave are usually bimodal in lead I and biphasic ($\pm$) in leads II, III, and VF because of caudocranial activation of the LA, and also often in V1 to V3–V5 (see *Figure 6*).

The electrophysiological mechanism underlying this ECG pattern has been explained using deductive ECG-VCG data correlated with recordings obtained from the high and low right atrium, coronary sinus, right pulmonary artery, and oesophagus and also with electroanatomic mapping^{11,12} (see *Figures 7* and *8*).

It has been also demonstrated that the block may be located in the LA not affecting conduction through the proximal Bachmann's bundle. However, this does not modify the terminal inferosuperior activation of the LA that explains the typical morphology $\pm$ in II, III, and VF. In fact, in dogs, the same $\pm$ morphology appears after cutting the Bachmann's bundle at the right and left sides of the septum⁵ (see *Figure 3*).

Bayés de Luna *et al*¹³ defined the ECG-VCG criteria and demonstrated that this type of block is a very specific (90 %) but insensitive

Table 1 : Prevalence of IAB in a Cohort of Global Population of 70–80 Years and 100 Years

	70-80 years (n=195)	100 years (n=81)	P Value
Normal P	101 of 195 (51.7 %)	23 of 81 (28.4 %)	p < 0.01
Pa-IAB	58 of 195 (29.7 %)	16 of 81 (19.7 %)	p = 0.09
Ad-IAB	15 of 195 (7.7 %)	21 of 81 (19.7 %)	p < 0.01
At Fr/FI	21 of 195 (10.8 %)	21 of 81 (19.7 %)	p < 0.01
Atrial Premature Beats	15 of 174 (8.6 %)	17 of 60 (28.3 %)	p < 0.01

Pa-IAB (partial interatrial block) Ad-IAB (advanced interatrial block) At Fr/FI (atrial fibrillation/flutter)

Figure 1: Left: Scheme of Atrial Activation in a Normal P wave (A), in Presence of Partial IAB (B), and of Advanced IAB (C). Right: Characteristics of the P loop and P wave in Each Case

We want to note that in normal conditions, the breakthrough in left atrium also occurs at the level of coronary sinus. The dotted line shows that the Bachmann's bundle is the preferential route of interatrial conduction. The remaining atrial activation is performed without preferential pathways. The primary left atrium breakthrough is in the Bachmann's bundle, and also often in the fossa ovalis area (see arrow).

Figure 2: (A and B) P wave Morphology in V1 and P loop in a Case of Isolated Partial Interatrial Block (B) and Associated with Left Atrial Enlargement (A)

The ECG has to be recorded with the electrode of V1 accurately located because if it is in a high location (3rd-2nd intercostal space) the depth of negativity in P and V1 is higher.

marker of LAE. The duration of P wave is 120 milliseconds or more (120–170 milliseconds in this sample of 83 cases). However, it is the morphology of the P wave ($\pm$ in inferior leads) that pinpoints that there is a retrograde activation of the LA. The positive mode of P waves in leads II, III, and VF is at times not well-observed, probably because of fibrosis, and the diagnosis of junctional rhythm due to an apparently negative P wave in II, III, and VF may be made. It was demonstrated that this type of block is very frequently accompanied by paroxysmal atrial arrhythmia, especially atypical atrial flutter in patients with valvular heart diseases and cardiomyopathies. As a result, this association is considered an ECG clinical syndrome^{10,14}.

Figure 3: Adapted from Experimental Bachmann's Bundle Block (Waldo *et al.* 1971)

Figure 4: This is an Example of Partial Interatrial Block without Left Atrial Enlargement

See the wide P wave duration (around 150 ms) in aVF and the predominant positivity of the P wave in V1. In cases of IAB, very often due to the presence of atrial fibrillation, the P wave is flat and difficult to measure. Therefore in some leads (in the figure for instance) P wave in V1 looks much shorter.

Figure 5: A Clear Example of Second-degree Advanced IAB

The $\pm$ P wave pattern is clearly seen in II in the first two complexes, then a PVC and after a long pause the refractory period of the atria is finished, and the next the P wave is normal. Later the ECG pattern of A-IAB again appears.

During long-term follow-up, especially in patients with mitral valve disease or cardiomyopathy, the successive appearance of first-degree and later third-degree interatrial block may be seen (see Figure 9).

Prevalence of IAB

In an in-hospital population, Spodick, using as a criterion of IAB the presence of P wave ≥ 100 ms, identified the prevalence of IAB (most likely partial IAB) in 47 % of the screened population (1,000 patients), being highly prevalent in the subgroup above 60 years of age¹⁵.

The prevalence of partial (P) and advanced A-IAB is rare before the age of 50. In our experience⁸ (see Table I), the prevalence is much higher with advancing age. In centenarians the prevalence of A-IAB is higher than that of P-IAB. Also ageing increases the prevalence of AF/Afl, being 10 % at ages 70–80 and 26 % in centenarians.

Recently, we have found in patients with heart failure a prevalence of A-IAB of 10 %⁹.

Identification of the Syndrome

Bayés de Luna *et al*¹⁰ reported on a single sample of patients with long-term follow-up to better characterise the incidence of atrial tachyarrhythmias in patients with advanced IAB (16 patients) and compared them with patients with partial IAB (22 patients) but similar echocardiographic parameters. The advanced IAB group presented a higher incidence of atrial flutter/fibrillation (15/16, 93.7 %) during a 30-month follow-up compared with the control group with partial IAB (6/22, 27.7 %) ($p < 0.0001$). At one year of follow-up, the incidence of arrhythmias was 80 % and 20 % respectively (see Figures 10 and 11).

Additionally, Holter monitoring showed that the prevalence of frequent premature atrial contractions (more than 60/h) was much more frequent in advanced (75 %) than in partial (25 %) IAB.

In 1998 Bayés de Luna, *et al* published a review paper in which they summarised all previous research published in this topic; suggesting that the association between advanced IAB and atrial tachyarrhythmias constitute a true syndrome¹⁴.

Since then, different groups have confirmed this association^{16–18} and a recent consensus on IAB has accepted the diagnostic criteria and clinical association of advanced IAB with atrial arrhythmias³. This association is now considered a unique syndrome that should be known as Bayes' Syndrome^{19,21}.

Should we Prevent Atrial Arrhythmias in Patients with IAB?

The strong relationship between advanced IAB and atrial flutter/fibrillation led us to investigate the possible role of preventing atrial arrhythmias using antiarrhythmic drugs²². A small comparative trial of patients with advanced IAB received either an antiarrhythmic drug or a placebo. A significant reduction of AF recurrences was observed at follow-up in the group receiving prophylactic antiarrhythmic medication. Despite the small sample, this study should be considered pioneering by suggesting the treatment of patients early on when advanced IAB is detected, in order to reduce the incidence of atrial arrhythmias. This hypothesis needs to be confirmed with larger studies and samples.

We have not tested the possible benefits of antithrombotic therapy in this group of advanced IAB, as currently, the presence of documented AF is still needed, to start anticoagulation medication. However, as an interesting hypothesis, it could be reasonable to consider anticoagulation if the patient presents with advanced IAB and a

CHA2DS2-vasc score 3 and the patient presents with advanced IAB. The evidence on the one hand shows that in patients with A-IAB there is an LA disfunction with important electromechanical changes²³ and on the other that in many instances the AF is a risk factor but not the actual cause of stroke²⁴ and it may be important to consider the possibility of treatment with antithrombotic therapy in patients with A-IAB and a CHA2DS2-vasc score 3, especially if they show atrial arrhythmias in Holter monitoring. This suggested hypothesis needs to be tested before making any convincing recommendations.

However, several studies with poor results have tried to resynchronise the atria with bi-atrial pacing. There is still no consensus whether this technique reduces the incidence of AF and this technique did not prove to be superior to sequential pacing³.

Research on this Topic

We would like to briefly review some of the important contributions different groups have published on this topic. Special attention should be paid to the group based in the USA and led by Dr Spodick who investigated several aspects of IAB and specifically its relation to stroke and to the electromechanical dysfunction of the left atrium associated with IAB^{24,25}.

Daubert's group from France, studied different aspects of atrial pacing associated with the presence of advanced IAB²⁶.

Garcia-Cosio's group from Spain performed interesting studies using intracardiac mapping, demonstrating the retrograde activation of the left atrium in these patients²⁷.

Platonov and Holmqvist studied the characteristics of the P wave morphology according to the manner of atrial activation and the relation of this pattern to atrial fibrillation^{28,29}.

In the past three years, the groups of Baranchuk and Conde from Canada and Argentina have added to the knowledge of the syndrome. Those findings considered the most important are: a) the presence of advanced IAB was a strong predictor of new atrial flutter/fibrillation post-cavotricuspid isthmus ablation for typical atrial flutter¹⁶; b) the presence of advanced IAB in patients with Chagas disease implanted with defibrillators was a strong predictor of new AF in the follow-up¹⁷; c) the presence of advanced IAB is highly prevalent in patients with sleep apnoea and this probably could explain the higher incidence of AF in these patients; d) treatment with CPAP could induce reverse atrial remodelling and resolution of IAB; and e) the presence of advanced IAB predicts new onset AF in patients with severe heart failure and RT¹⁸.

Future Directions

It is our intention to highlight the association of advanced IAB, which can be easily recognised in a surface 12-lead ECG, with atrial arrhythmias (specifically AF). Future investigations (some of them ongoing studies of our international collaboration group) should be considered:

- To create an international register that would allow for longitudinal follow-up of these patients.
- To perform studies to evaluate the prevalence of IAB and its association with atrial arrhythmias in different clinical settings including: a) after electrical cardioversion (larger observational studies)(ongoing); b) cardiac surgery for aortic and mitral valve replacement (ongoing); c) in

Figure 6: Typical ECG of Advanced Interatrial Block ($P \pm$ in II, III, and VF and Duration of 180 ms) in a Patient with Ischaemic Cardiomyopathy

When amplified we can see the beginning of P in the three leads.

Figure 7: Above: P-wave $\pm$ Morphology in I II and III Typical of Advanced Interatrial Block with Retrograde Conduction to the Left Atrium

Observe the angle between the direction of the activation in the first and second parts of the P wave measured. To the right, intra-oesophageal ECG (HE) and endocavitary registration high right atrium (HRA); low right atrium (LRA) demonstrate that the electrical stimulus moves first downwards (HRA-LRA) and then upwards (LRA-HE). Below: P loop morphology in the three planes with the inscription of the second part moving upwards.

Figure 8: Virtual Anatomic Rendering of the LA in a Patient with Typical Biphasic ($\pm$) Pwave in Leads II, III, and a VF Typical of Bachmann's Bundle Block

Note that early left atrial activation (white) occurs at the high septal wall, as expected for Bachmann's bundle conduction. Activation does not progress through the left atrial roof because of the presence of a large zone of low voltage (grey) that diverts activation toward the low septal (orange-yellow), then the low posterior (green) and finally the high posterior (violet) left atrial wall.

patients with heart failure (ongoing); d) in patients with hypertrophic cardiomyopathy and other forms of less frequent cardiomyopathies and e) in athletes.

- To determine the prevalence of IAB in special populations (i.e. atrial septum abnormalities, haemodialysis (ongoing), cryptogenic stroke, patients with fibrotic diseases).

Figure 9: Progressive Interatrial Block – Three ECGs from a Patient with Mitro-aortic Valve Disease

(A) P wave in II, III, and VF with normal atrial duration ($P=105$ ms) and P wave of pseudo P pulmonary type- (B) Four years later an intermediate morphology that corresponds to a first-degree interatrial block ($P=135$ ms) is recorded. (C) A typical advanced interatrial block appearing after five years with $P \pm$ morphology in II, III, and VF ($P=145$ ms).

Figure 10: Life Table Analysis of the Probability of Remaining Free of Supraventricular Tachyarrhythmias in Patients with Advanced Interatrial Block (IAB) and Retrograde Activation of the Left Atrium (RALA) and Controls

Figure 11: Two Atrial Flutter Morphologies in the Same Patient: Typical Atrial Flutter with Negative F Wave with Saw-teeth Morphology (b) and a Typical Atrial Flutter (a) with Positive F Wave

Observe the angle between the direction of the activation in the first and second parts of the P wave measured. To the right, intra-oesophageal ECG (HE) and endocavitary registration high right atrium (HRA); low right atrium (LRA) demonstrate that the electrical stimulus moves first downwards (HRA-LRA) and then upwards (LRA-HE). Below: P loop morphology in the three planes with the inscription of the second part moving upwards.

- To study the correlation by cardiac MR between advanced IAB ECG pattern and extension of atrial fibrosis.
- To confirm the hypothesis that early intervention with antiarrhythmic drugs may represent a reduction in the incidence of new AF.
- To determine whether patients with CHA2DS2-score > 3 and advanced IAB, regardless of the documentation of AF, would benefit from oral anticoagulation.
- To determine if there are any genetic influences.

Conclusion

Interatrial blocks are a separate entity from atrial enlargement and may be of first (partial), second degree (intermittent) or third degree (advanced). This ECG pattern may be transient, it may present simultaneously without left atrial enlargement (or not), and it may be reproduced experimentally. Advanced interatrial block presents a clear ECG pattern ($P \geq 120$ ms with a $\pm$ morphology in leads II, III and VF).

Although all IABs are more frequently associated with atrial arrhythmia, its incidence is much higher in advanced IABs when compared with partial IABs. The presence of advanced IAB associated with supraventricular arrhythmias constitutes a true syndrome, named as Bayes' Syndrome.

Further studies will help in characterising the syndrome in different clinical scenarios. ■

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