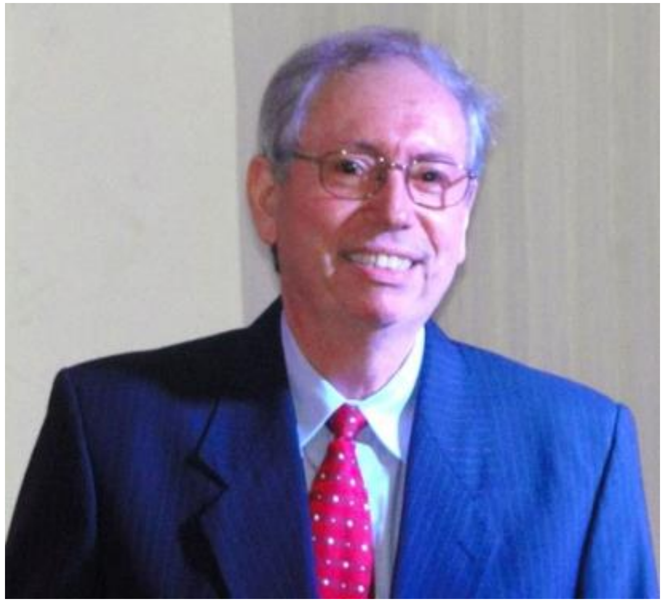
ECG/VCG demonstration of advanced/complete interatrial block with repetitive paroxysmal atrial fibrillation episodes in a elderly woman: Bayés' syndrome



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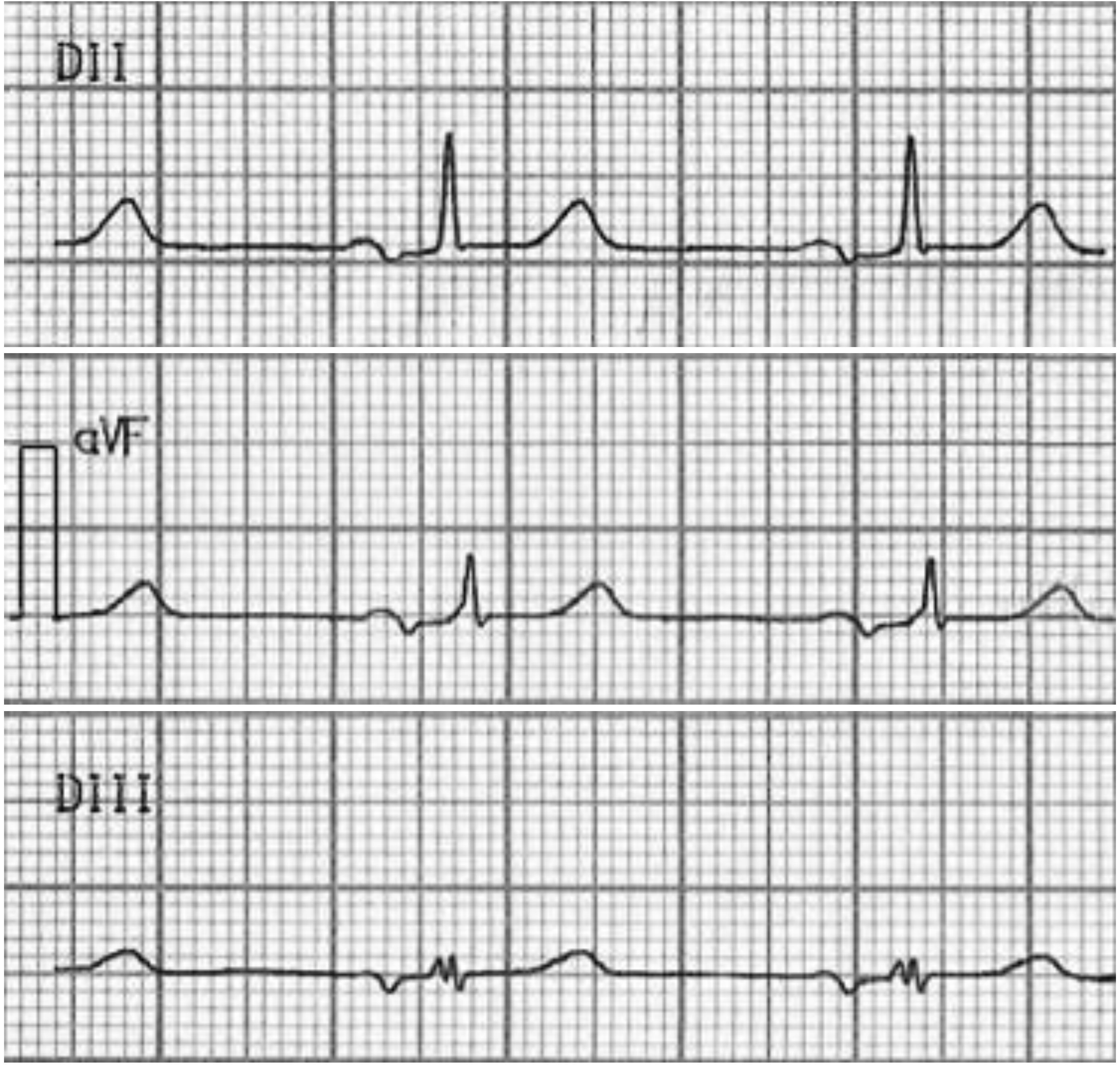
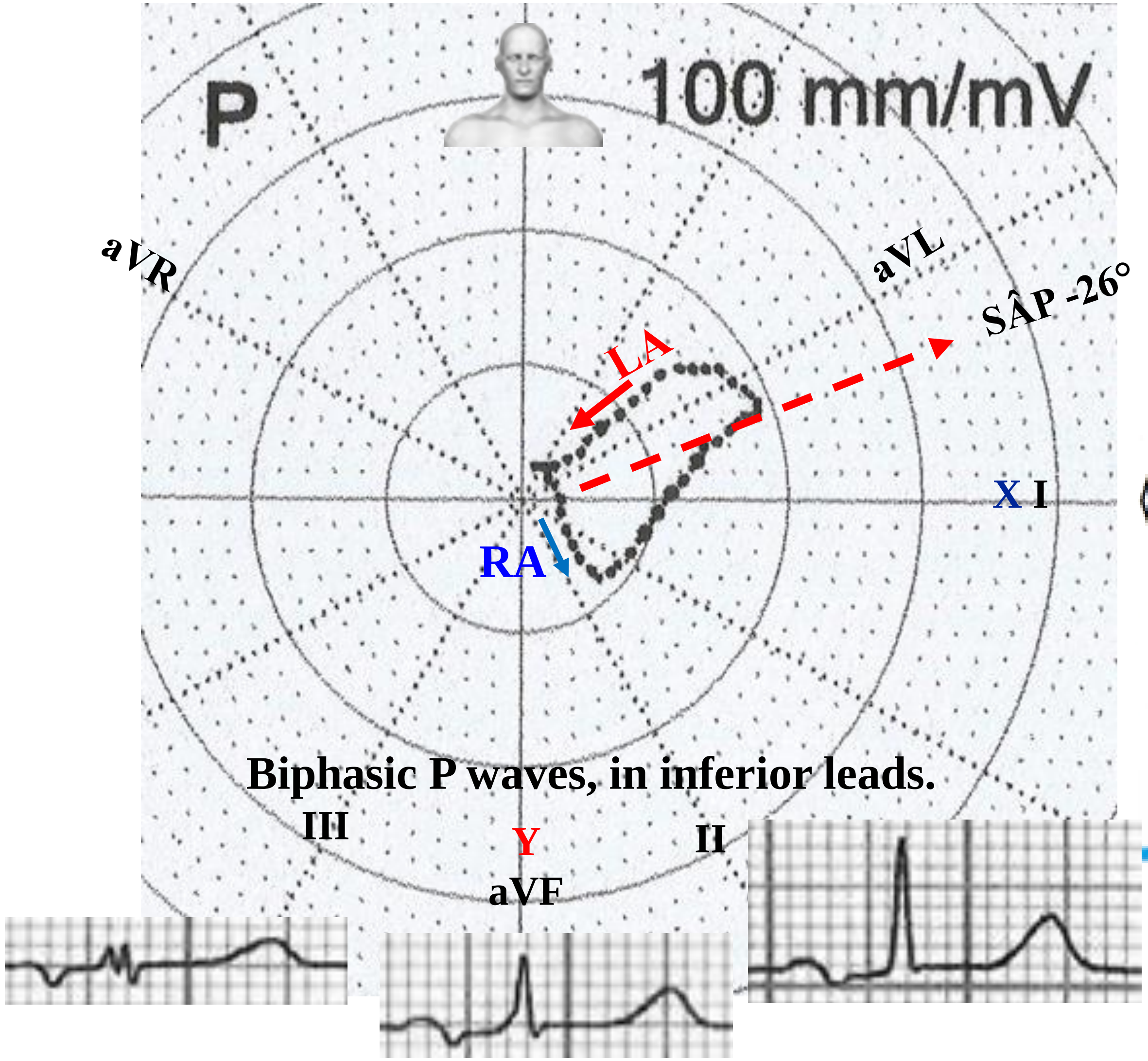
Clinical diagnosis: Elderly patient with a history of progressive cognitive deficit and repetitive episodes of symptomatic paroxysmal atrial fibrillation

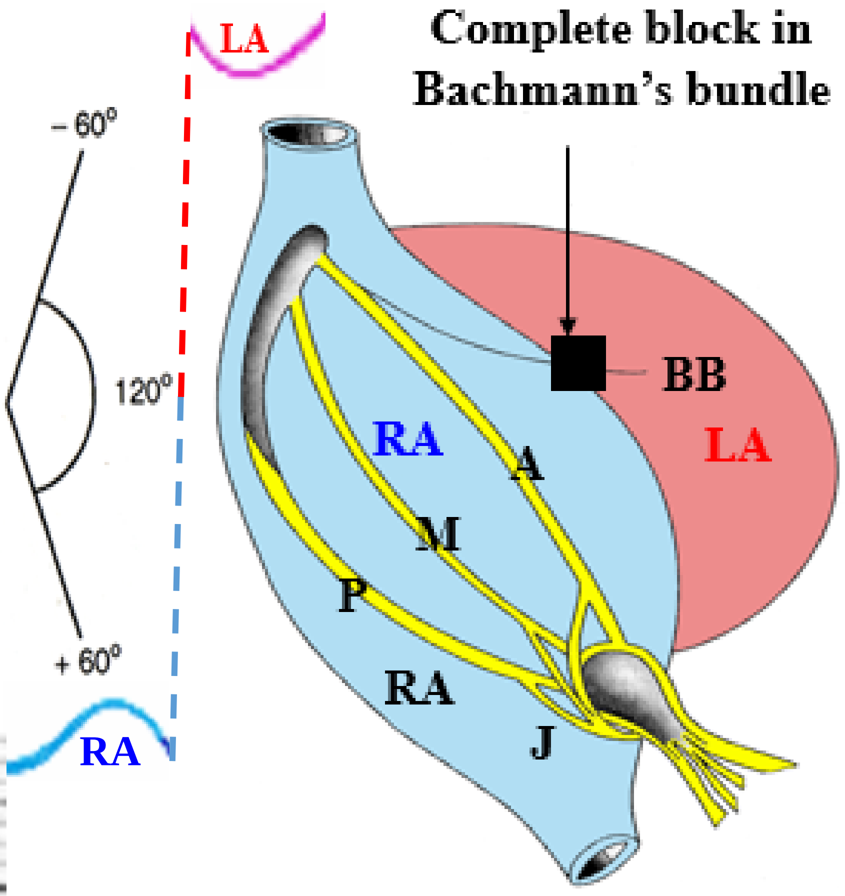
Electrocardiographic diagnosis: Atrial fibrillation with a high rate of ventricular response (mean HR = 147 bpm).

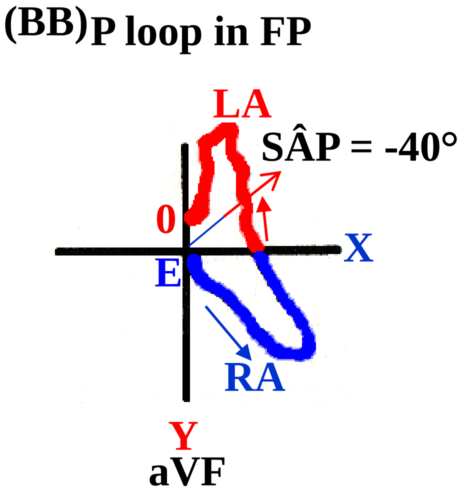


Inferior leads after the spontaneous reversal of atrial fibrillation to sinus rhythm. Note the P-waves wit plus-minus/biphasic pattern in II, III and aVF and prolonged P duration (≥120 ms): Advanced, third degree or complete interatrial block (cIAB): Bayés'syndrome.

The P-loop in the Frontal Plane (FP) in a case of complete interatrial block (cIAB): Bayés s syndrome







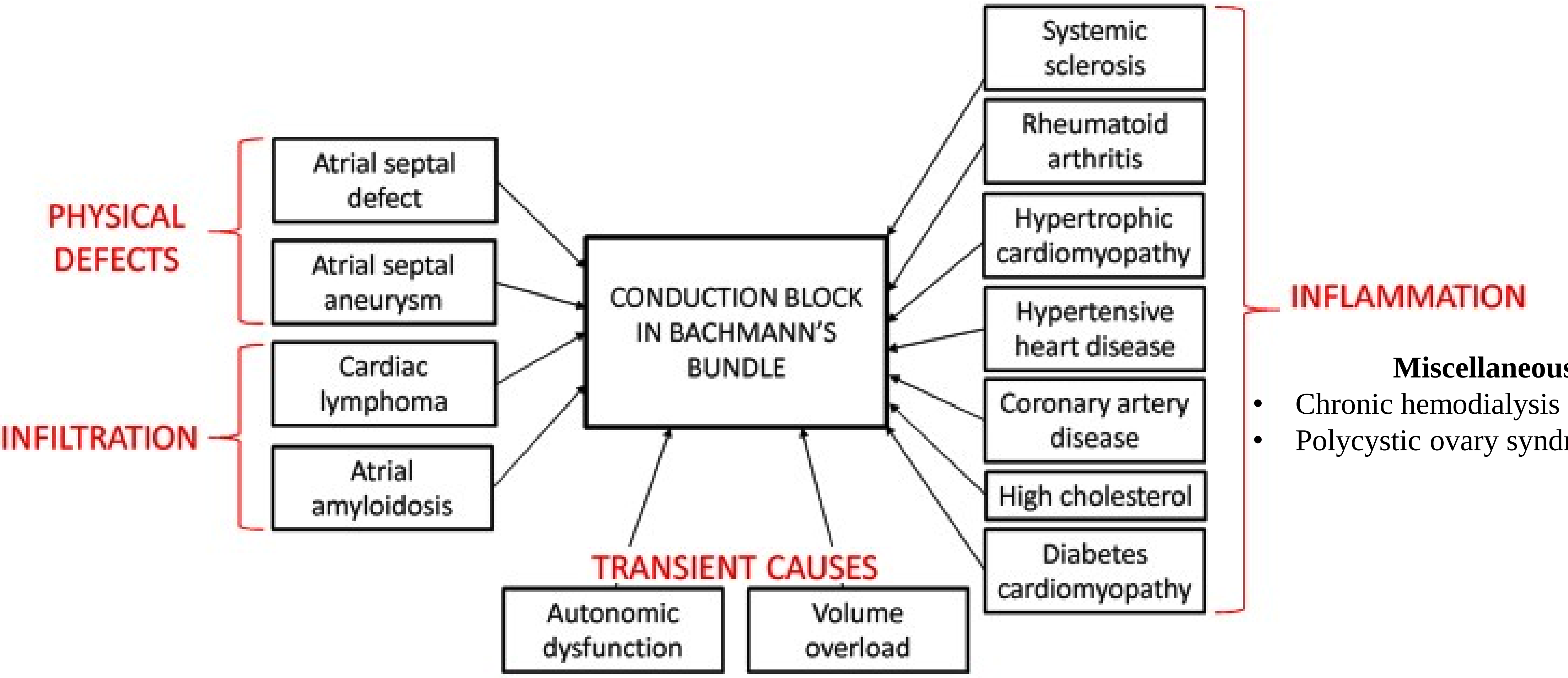
Abnormal caudal-cranial activation of LA (**Britton 2016**)

Electrical impulse is blocked/delayed in Bachmann's muscular interatrial bundle (BB) (**Bachman 1916, 1941**), consequently retrograde caudo-cephalic left atrial activation (**LA**) occurs. Note the existence of an open angle between the vector of the first portion of the P-wave (**RA**) and the last portion (**LA**). Vectorcardiographic studies demonstrates retrograde activation of the **LA**. Consequently P loop/wave in orthogonal lead "Y", aVF, II and III is biphasic- plus-minus ±. **LA** activation occurs by an alternate route rather than proceeding from right to left via the BB.

Bayés' syndrome refers to abnormal caudal-cranial activation of the left atrium owing to fibrosis of the Bachmann bundle region predisposing patients to interatrial dyssynchrony and AF (**Britton 2016a**). IAB has further been classified into partial IAB (pIAB) with two categorized degrees (first and second) and third, advanced or complete degree IAB, which is seen on the surface electrocardiogram (ECG) as P waves≥120 ms, advanced IAB (aIAB) in which P waves are also prolonged but with a biphasic morphology depicting a negative terminal portion in the inferior leads (II, III, and aVF) (**Britton 2016b**). IAB has a strong association with atrial arrhythmias, left atrial enlargement (LAE), and electro-mechanical disyncrony, increasing the risk of cerebrovascular accidents as well as myocardial and mesenteric embolic ischemia (**Tse 2016**).

IAB, particularly advanced IAB, is a pre-AF condition associated with premature atrial beats contractions. Atrial arrhythmias and IAB are more frequently in centenarians than in septuagenarians (**Martínez-Sellés 2016; Conde 2015a**).

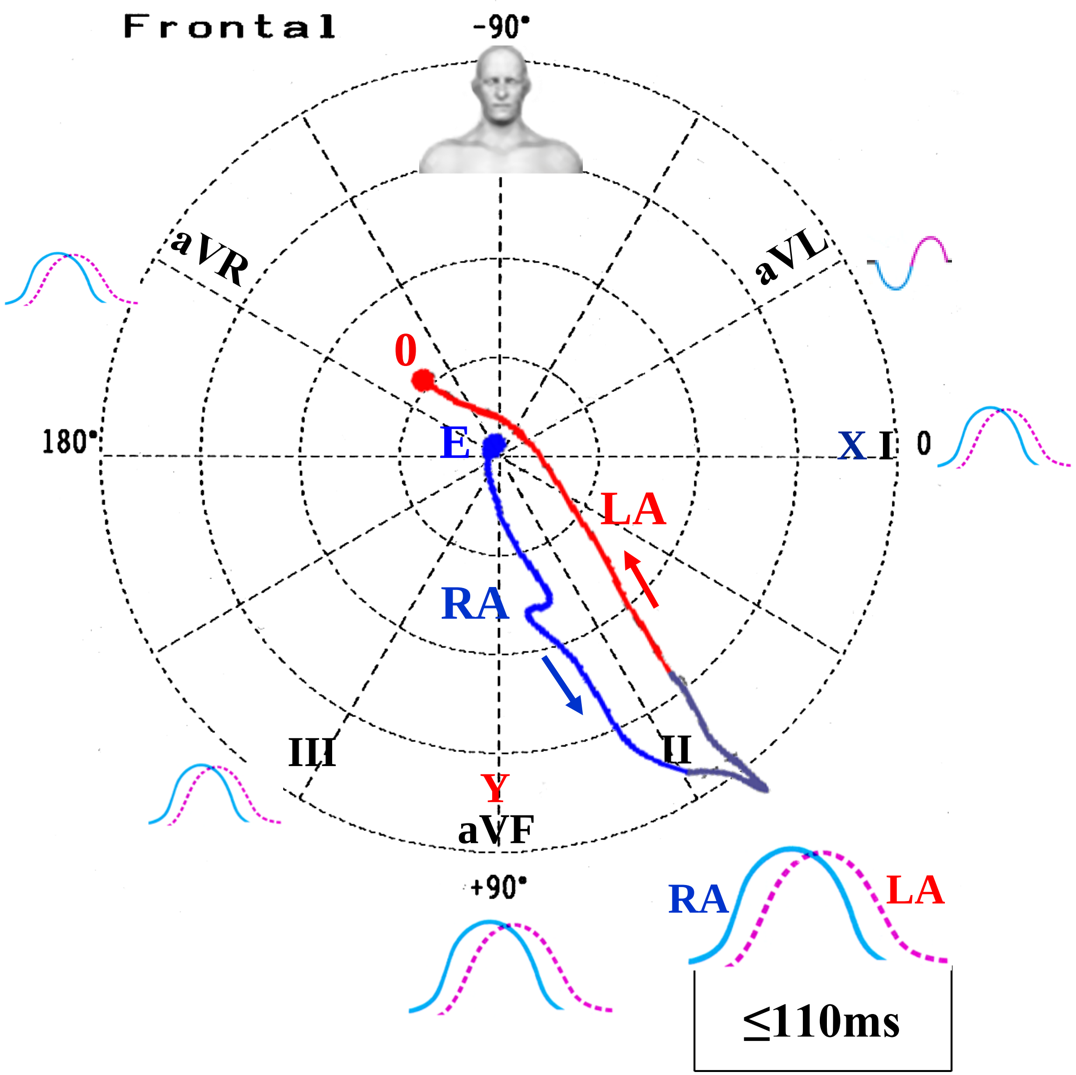
Main causes of Bayés' syndrome



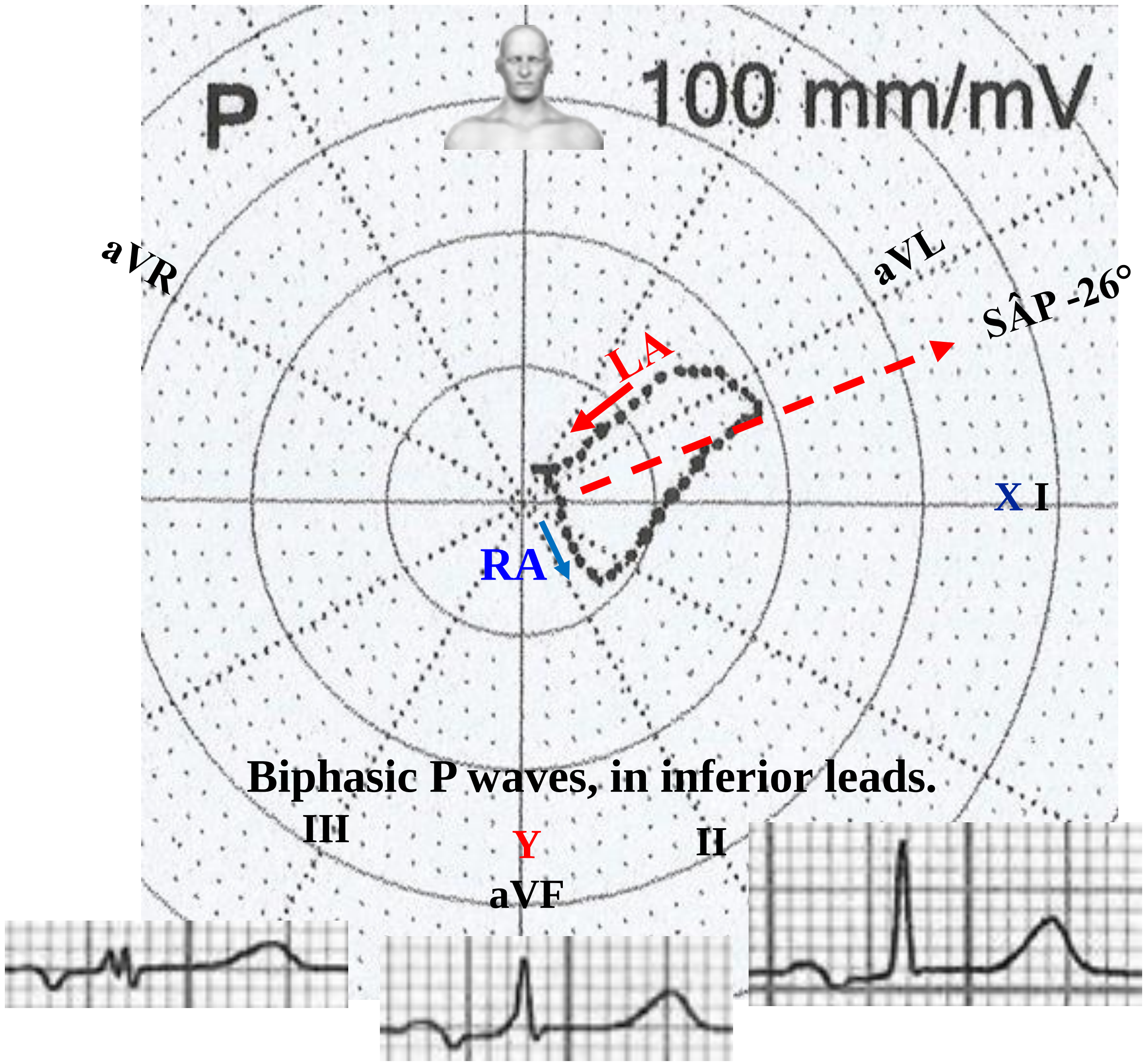
Miscellaneous causes

- Chronic hemodialysis (**Marano 2016**)
- Polycystic ovary syndrome (**Russo 2016**)

Normal P-loop/P-waves in the FP



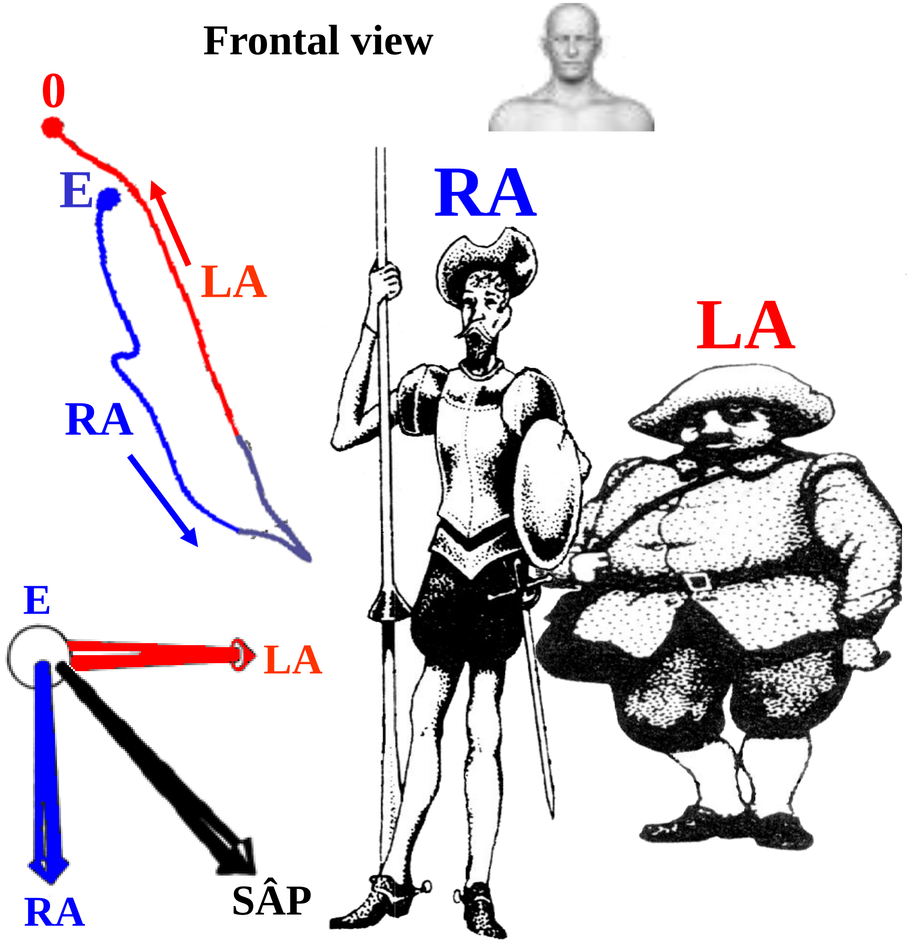
P-loop in the FP/P-waves in inferior leads in Bayés' syndrome

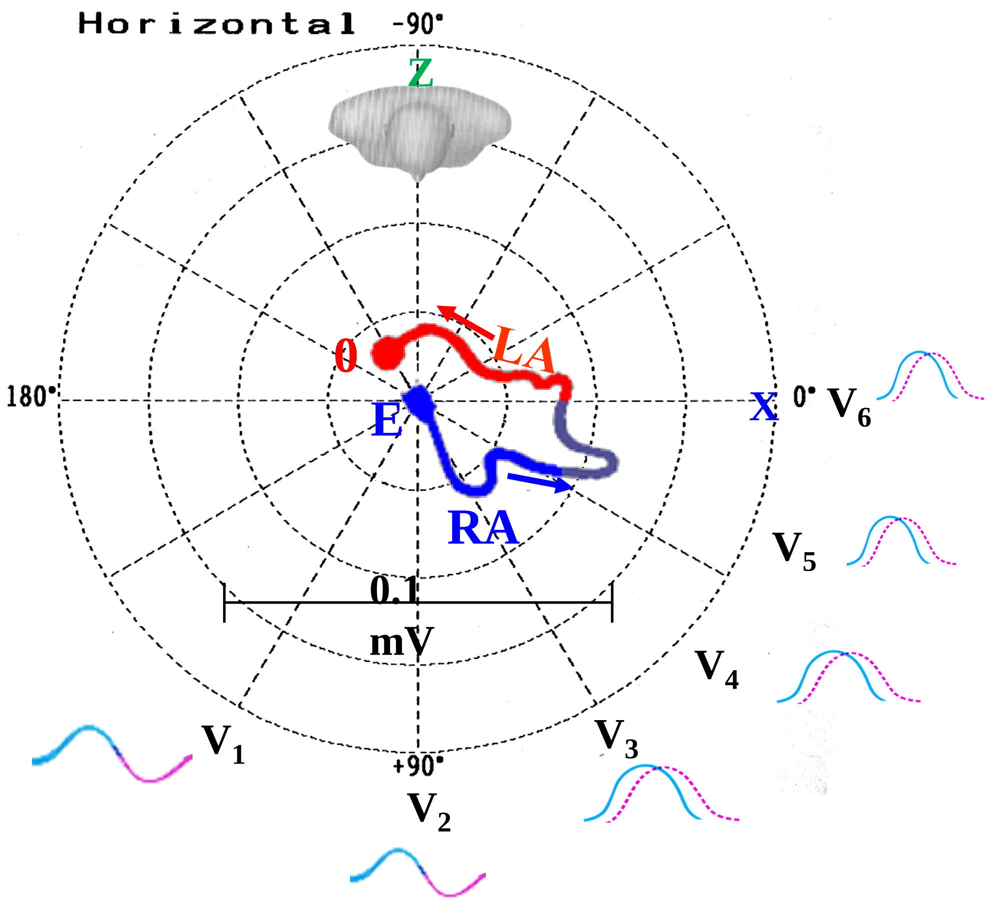


P-duration ≥120ms + Plus-minus P-wave polarity in inferior leads

The true shape of the P wave is very irregular and is best seen in ECGs averaged over many beats (**Potse 2016**).

Spatial outline of biatrial chamber activation in both the FP and HP





RA - "Don Quixote". In the front & to the right.

LA - "Sancho Panza". In the back and to the left.

Normal P wave

P wave: It is the first wave of ECG that represents the depolarization wave of the biatrial chamber.
Items to be analyzed:

I) Polarity
II) Voltage or amplitude
III) Duration
IV) Morphology (aspect or shape).

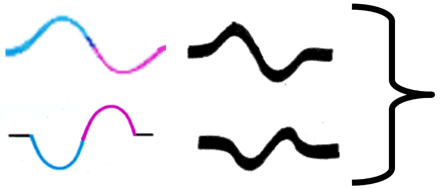
I) P-wave Polarity

a) Positive: 

b) Negative: 

c) Positive-negative or “plus-minus”: ±

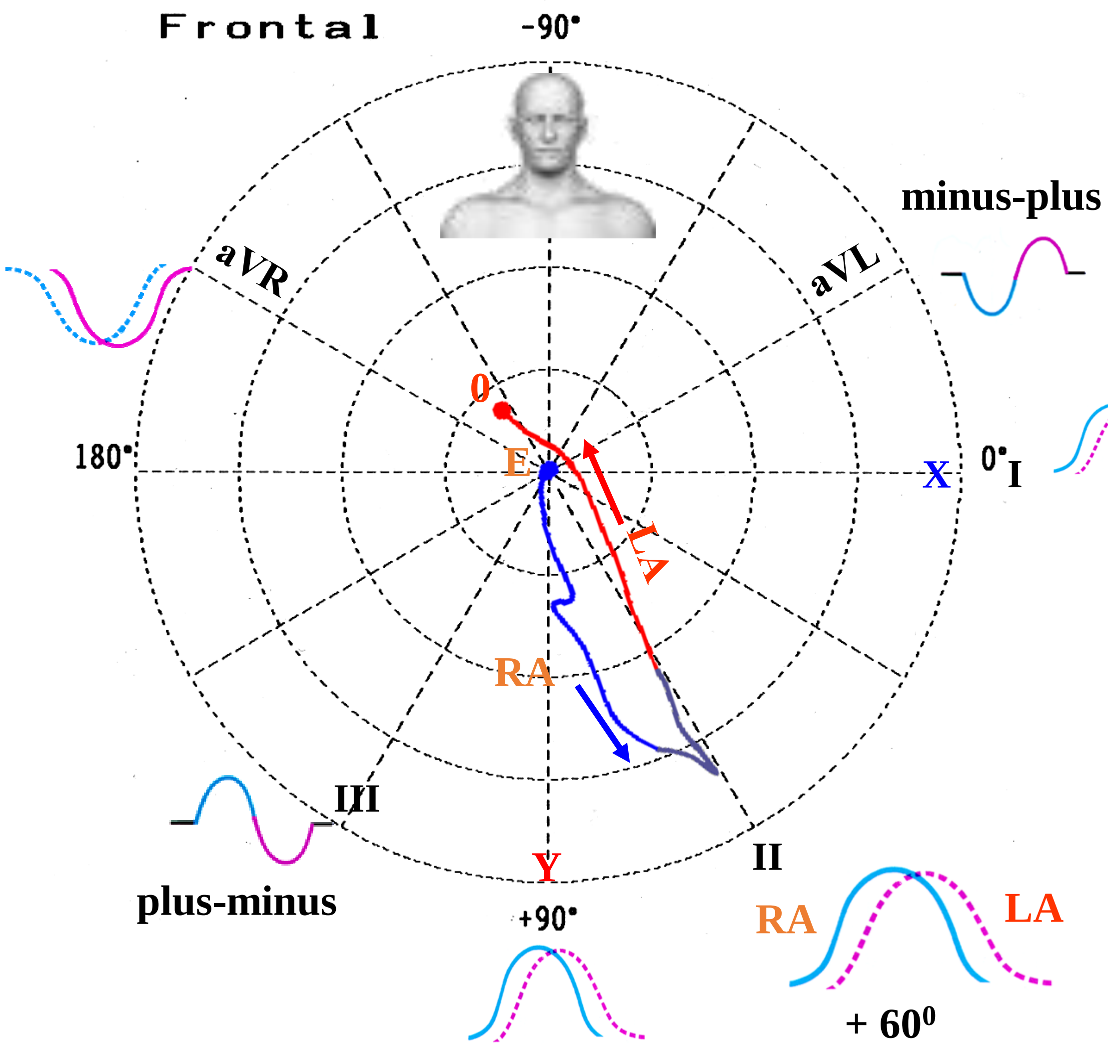
d) Negative-positive or “minus-plus”:



Biphasic

In the frontal plane (FP) P wave is always positive in II, I and aVF, always negative in aVR, and variable in III and aVL. In III it could be plus-minus, negative or positive. In aVL it could be minus-plus, positive or negative.
In the Horizontal plane (HP) P wave is always positive from V3 to V6 and variable in V1-V2: positive or plus-minus.

P-wave polarity and P-loop in the Frontal Plane

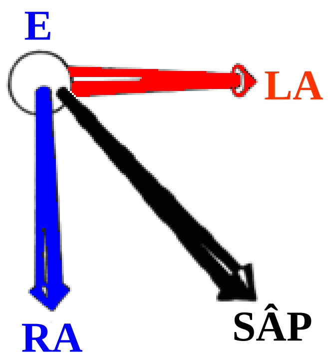


P wave polarity is always negative in aVR, always positive in II, I and aVF, and variable in III and aVL.

III could be plus-minus and aVL minus-plus

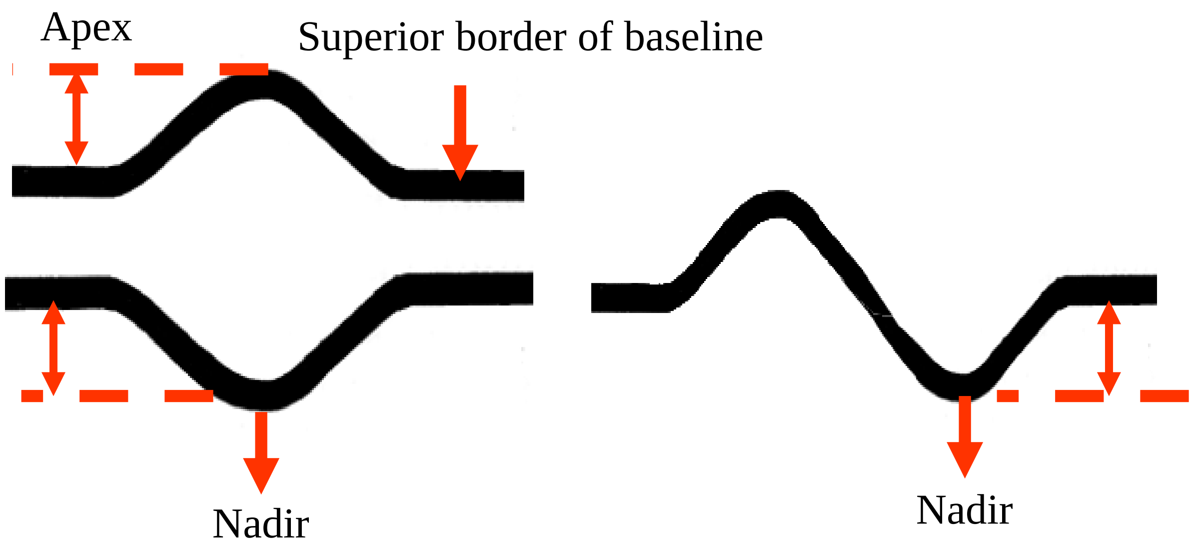
The P-loop begins in the E point located below and to the left of the 0 point.

P-loop ends in the 0 point.



II) Normal P-wave voltage or amplitude

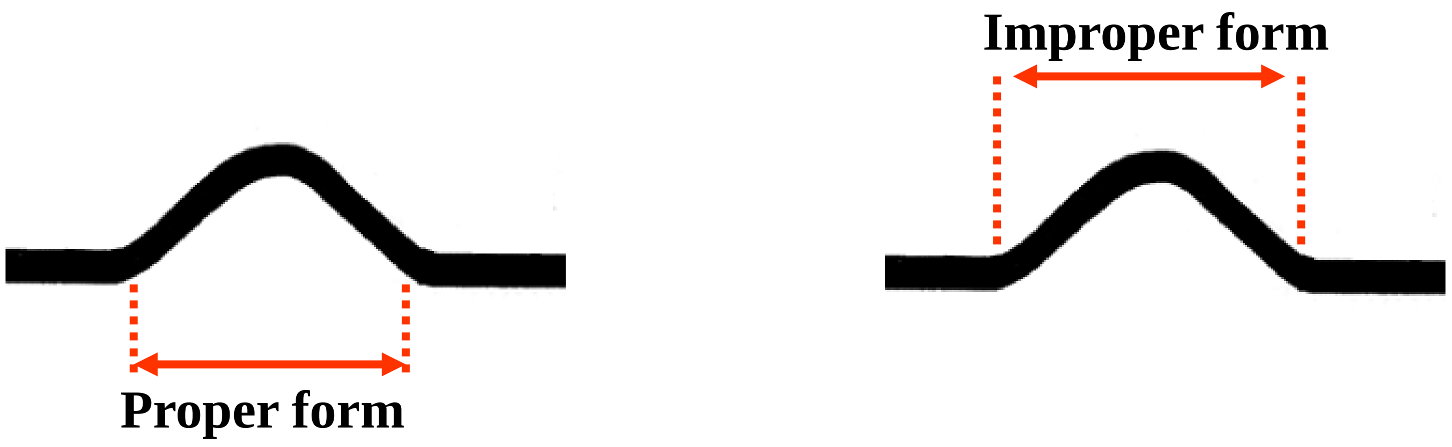
Proper measurement of voltage of P-wave



Since 1935, it is admitted that the normal maximal value of P wave voltage or amplitude is 2.5 mm, within the range of 0.5 mm to 2.5 mm (or 0.05 to 0.25 mV). However, this value has been questioned by Asad et al, because of low sensitivity in patients carriers of COPD, who suffer frequent exacerbations of pulmonary decompensation. Both the amplitude and the direction of the vector of the P wave are dynamic and may reflect the stress of the right atrial wall or "**RA** strain" (**Asad 2003**).

III) Normal P-wave duration and measurement

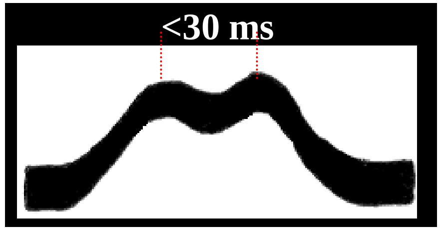
Appropiate measurement of P-wave duration



Age range	Normal maximal value of P-wave duration
0 to 12 months	80 ms (two little squares)
1 to 12 years	90 ms
> 12 years	100 ms. (2.5 little squares)
Seniors	≤110 ms

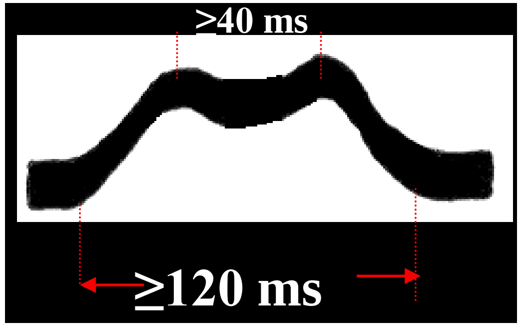
IV) Normal P-wave shape

Normal bifid or bimodal P wave



Normal, Chronic Amygdalitis, Diabetes, Vagotonia

Abnormal bifid or bimodal P wave



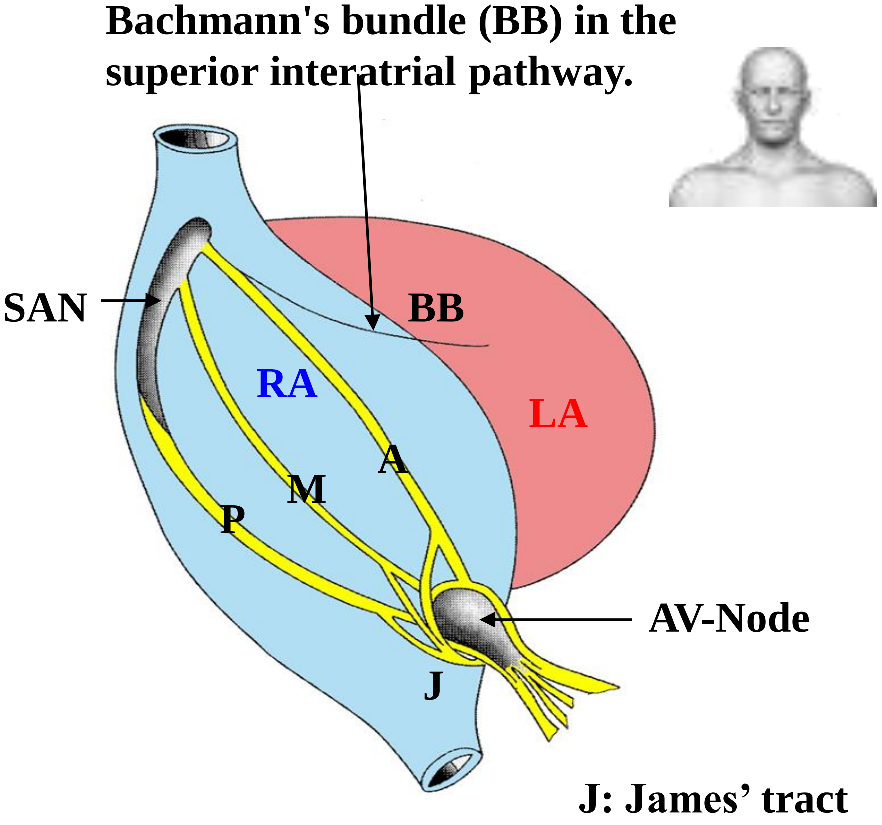
Left atrial enlargement (LAE) or interatrial block (IAB)

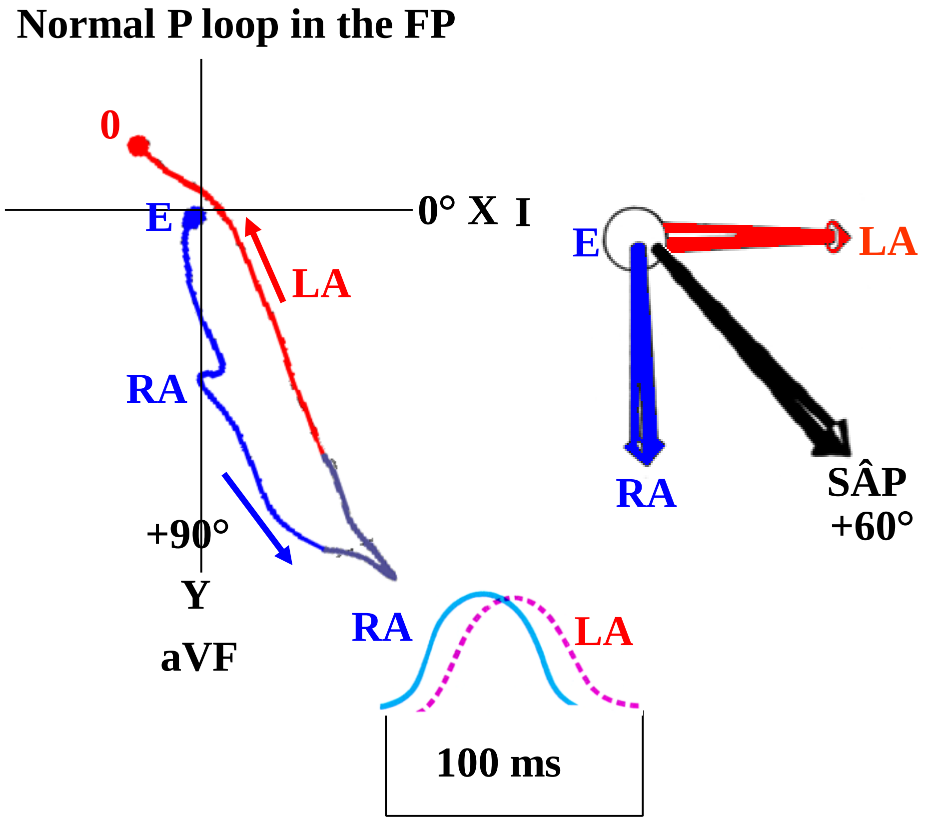
"Left atrial abnormalities"

Note: The term left atrial abnormalities was coined and widely used to encompass both atrial enlargement and interatrial block.(**Lee 2007**) Established ECG criteria for LAE do not reliably reflect LAE and lack sufficient predictive value to be useful clinically. P-wave abnormalities should be noted as nonspecific LA abnormalities, with the term "LAE" no longer used. The presence of at least one ECG criteria for LAE is sensitive but not specific for anatomic LAE. Individual criteria for LAE, including P mitrale, P wave axis <30°, or negative P terminal force in V1 (NPTF-V1) > 0.04 s.mm are highly specific, though not sensitive. ECG is highly specific but insensitive for RAE. Individual ECG P wave changes do not reliably both detect and predict anatomic atrial enlargement **(Tsao 2008)**. The normal shape of P wave is rounded and monophasic, and there may be small notches (more frequent in V_3 and V_4) and the distance between these notches should not exceed 30 ms (0.03 s). Notches in P wave with distance between the apexes of ≥ 40 ms (0.04 s) constitutes a sign of left atrial enlargement (LAE) or interatrial block by Bachmann's bundle (BB), in charge of activating the left atrium (**LA**).

Normal atrial conduction in the Frontal Plane

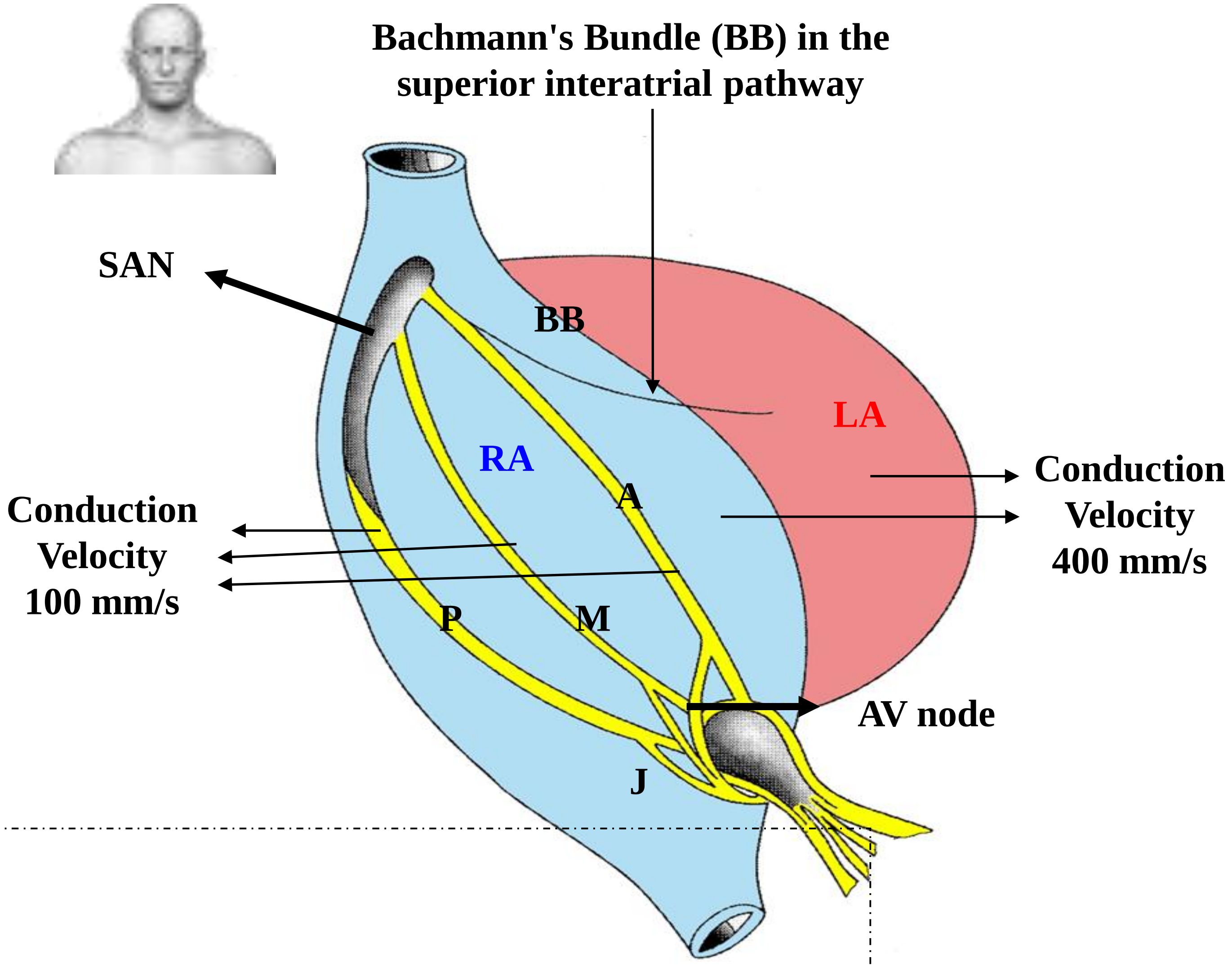
E point: it constitutes the zero point of VCG and it remains stationary before the onset of the P loop. It corresponds to the isoelectric line between the T wave and the P wave of ECG. The E letter corresponds to the cardiac dipole. It is the beginning of the P loop and ends in the so-called 0 point.





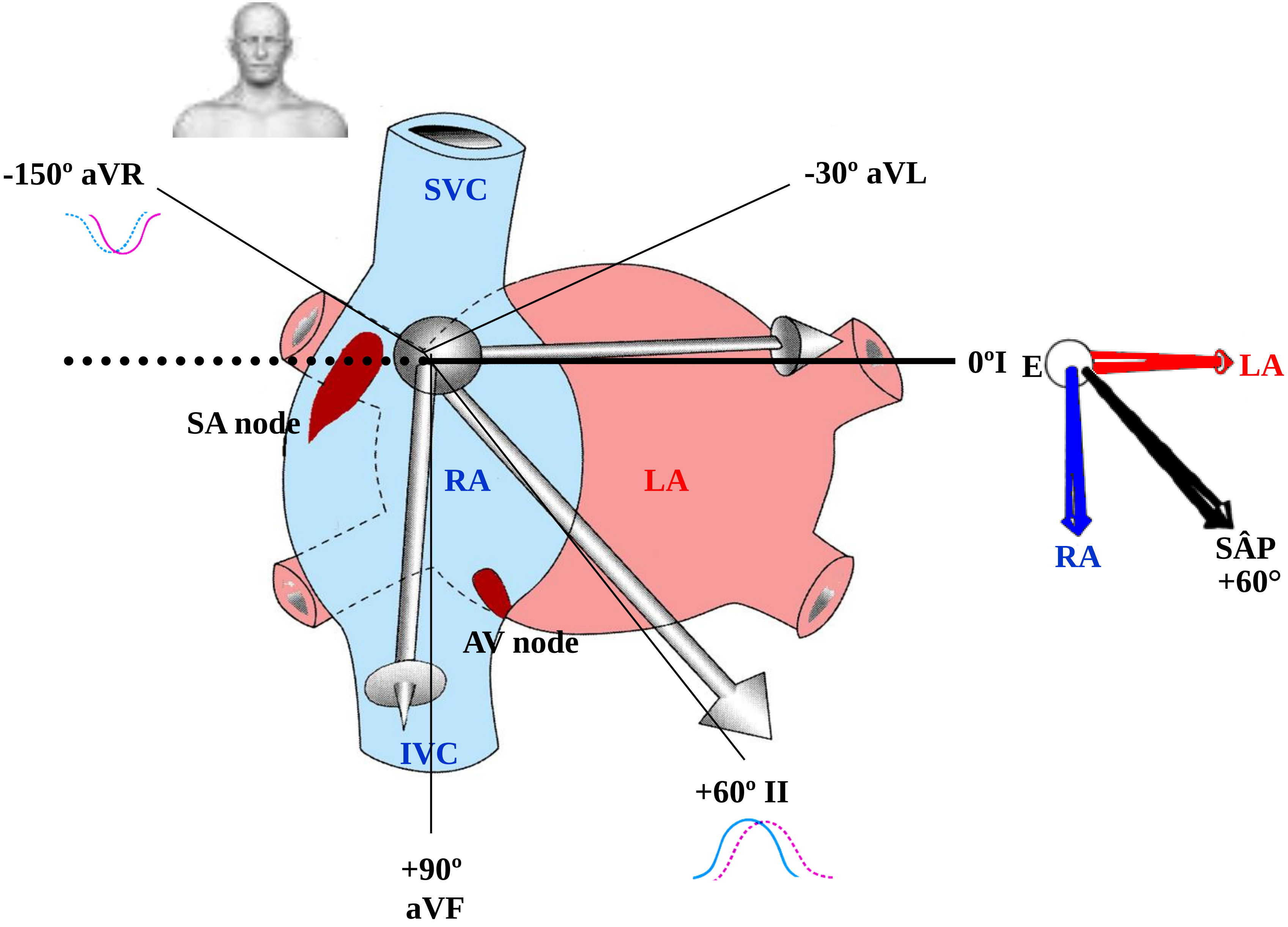
P loop: loop of small voltage corresponding to the depolarization of the biatrial chamber. The initial part corresponds to the right atrium (**RA**) (between 0 and 70 ms), next the interatrial septum (between 20 and 45 ms), and finally the left atrium (between 30 and 90 ms). To make an analysis possible, it is necessary to amplify: 1 mV = 30 cm. The P loop begins in the **E** point and ends in the so-called 0 point. The former has an anterior and inferior location in relation to the latter. The P loop is open because atrial repolarization (Tp loop) is diametrically opposite to the P loop.

Mode of atrial depolarization
Current hypothesis A: preferential pathways

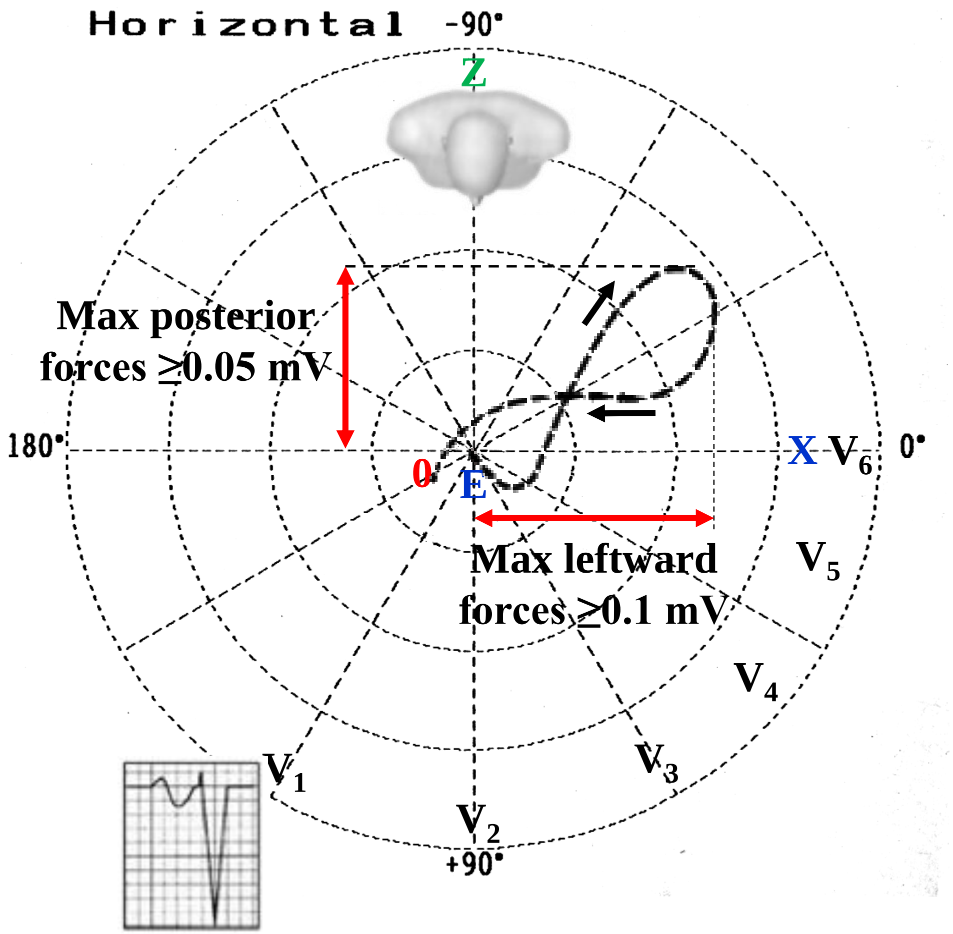


A = Anterior Internodal Bundle
M = Middle Internodal Bundle
P = Posterior Internodal Bundle
BB = Bachmann’s Bundle
J – James’s tract
SAN: The Sinoatrial node, abbreviated SA node or SAN, also called the sinus node

Anterior (frontal) view of biatrial chamber & its activation process

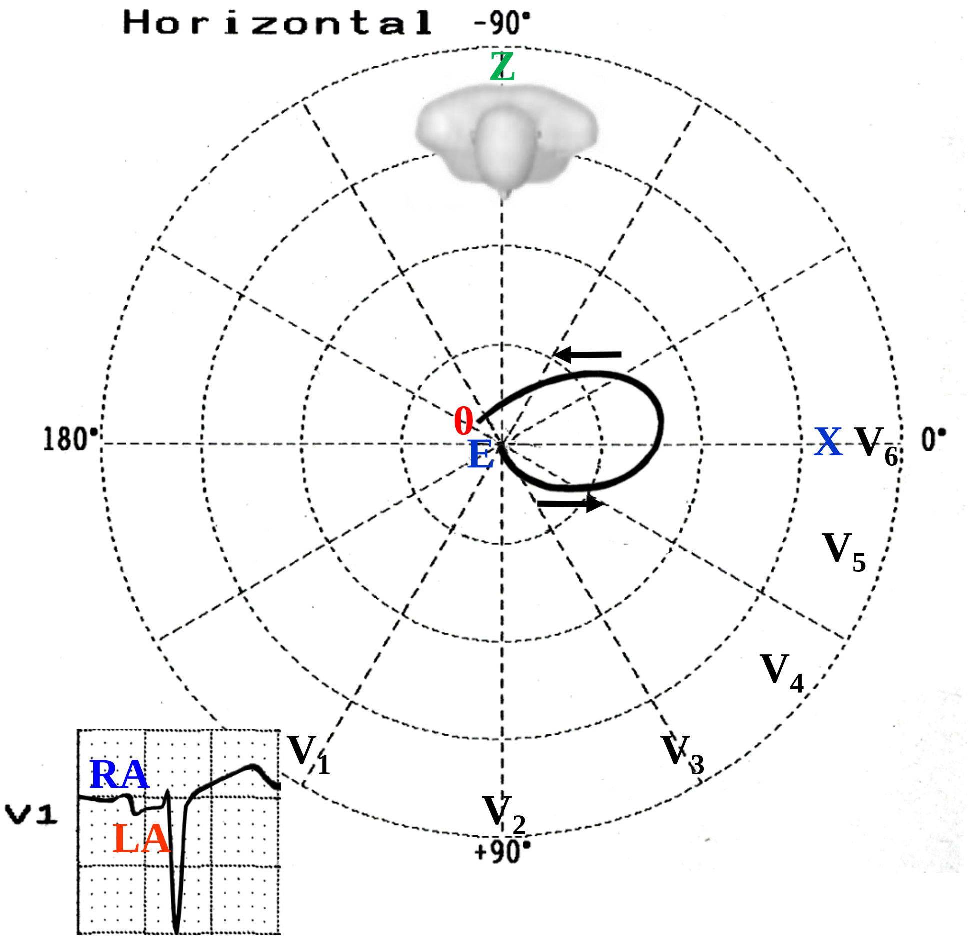


P-loop morphology and rotation in the HP in cases of isolated LAE



P-loop with figure in 8 rotation, bow tie morphology, maximal P vector located in left posterior quadrant: ≥0.10 mV in adults and ≥0.14 mV in <16 years old.

P-loop morphology and rotation in the HP in cases of isolated partial or advanced IAB



Bayés de Luna A et al (**Bayés de Luna 1988**) studied 16 patients with ECG evidence of advanced interatrial block and retrograde activation of the left atrium (LA): P duration ≥ 120ms, and plus-minus biphasic (+/-) P waves in inferior leads II, III, and VF.

Eight patients had valvular heart disease, four had dilated cardiomyopathy and four had other forms of heart disease.

Patients with valvular heart disease and cardiomyopathy were compared with a control group of 22 patients with similar clinical and echocardiographic characteristics, but without this type of interatrial block. Patients with advanced interatrial block and retrograde activation of the LA had a much higher incidence of paroxysmal supraventricular tachyarrhythmias (93.7%) during follow-up than did the control group. Eleven of 16 patients (68.7%) with advanced interatrial block and retrograde activation of LA had atrial flutter (atypical in seven cases, typical in two cases, and with two or more morphologies in two cases). Six patients from the control group (27.7%) had sustained atrial tachyarrhythmias (five atrial fibrillation and one typical atrial flutter). The atrial tachyarrhythmias were due more to advanced interatrial block and retrograde activation of LA and frequent PACs than to LAE, because the control group with a LA of the same size, but without advanced interatrial block and retrograde activation of LA and with less incidence of PACs, had a much lower incidence of paroxysmal tachycardia. Bayés de Luna et al (**Bayés de Luna 1989**) demonstrated the value of preventive antiarrhythmic treatment in patients with advanced interatrial block. Advanced interatrial block as a predictor of AF following catheter ablation in the LA (**Gul 2016**).

ECG/VCG diagnostic criteria of Bayés' syndrome

1. Biphasic P waves, in inferior leads (**Bayés de Luna 1988**).
2. P duration ≥120ms. Although the term atrial abnormalities to encompass both concepts, LAE and interatrial block, has been coined (**Bayés de Luna 2012**). P-wave shape, polarity and duration reveals: proper function, fibrosis, dyssynchrony, and activation paths can be inferred from the surface P-wave analysis. The ECG differentiates LAE from intra- and interatrial block (**Baranchuk 2015**).
3. Advanced interatrial block in sinus rhythm (**Baranchuk 2016**)
4. Angle between the first portion (RA) and end portion (LA) >90º (**Bayés de Luna 1977**)
5. Orthogonal Y lead plus-minus with the final negative portion ≥ 40ms
6. ≥ 40ms final portion of P loop upstart orthogonal X and Z leads.
7. Final portion of P loop delayed, notches and slurrings in the last part of the P loop
8. High Esophageal lead with positive P wave polarity and delayed
9. Low Esophageal lead with plus-minus P wave polarity and delayed
10. Intracavitary ECG with P wave activation craniocaudal inside the RA.
11. Intracavitary ECG with P wave activation caudal-cranial inside LA.

A complex view on the topic of IAB has been provided by the “school” represented by Antonio Bayes de Luna. In this issue, the review paper by Bayes de Luna and coauthors (**Conde 2015b**) summarizes the concept of an IAB syndrome due to conduction impairment in Bachmann's Bundle. IAB as a syndrome, was first described by Bayes de Luna 30 years ago (**Bayés de Luna 1985**). Supporting papers covering most aspects of the pathophysiology, the ECG and VCG descriptions, and the association with supraventricular tachyarrhythmias, including the consensus paper in 2012 (**Bayés de Luna 1985, 1988, 2012**). The current knowledge of the topic by this “Bayes de Luna School” shows that advanced AIB associated with supraventricular arrhythmias qualifies for a clinical syndrome. Actually the term “Bayes' syndrome” has been already used in some papers, acknowledging Antoni Bayes de Luna's dedicated work in this field, e.g. (**Conde 2014a,b**). The paper in his issue of the JECG (**Conde 2015b**) stimulates acceptance of the concept that IAB has achieved the stature has achieved the stature to be defined as a complex syndrome, supported by the current level of evidence and accepted by the scientific community. Additionally, it encourages electrocardiologists to enhance their current knowledge regarding the IAB topic, and understanding would benefit from direct evidence from measuring the conduction velocity in Bachman's bundle. This would lead not only to improvement in diagnosis, but also to therapy of conduction disturbance (**Bacharova 2015**).

Detection of atrial high rate episodes by cardiac implantable electronic devices provides clinicians to diagnose asymptomatic AF. The relation between interatrial block and asymptomatic AF can provide an insight to the increased risk of ischemic stroke in patients with interatrial block (**O'Neal 2016**). Occurrence of atrial high rate episodes, a surrogate for asymptomatic AF, is statistically significantly higher in patients with interatrial block (**Tekkesin 2016**).

IAB and a high CHADS2 score independently and synergistically predict new onset AF in patients in sinus rhythm, indicating an approximately 12-fold higher risk in patients with both IAB and a high CHADS2 score. Patients meeting these criteria should have more aggressive early intervention to prevent AF (**Wu 2016**).

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