Interatrial block references in chronological order

1. **Lewis T, Meakins J, White PD. The excitatory process in the dog's heart. Part 1. The auricles. Phil Trans Roy Soc Lond. 1914;205:375–426.** The specialized conduction band was famously known as Bachmann's bundle (BB). It is easily seen as a trapezoidal band-like structure of collimated muscle fiber coursing on the atrial walls in front of the superior vena cava and straddles the convexities of the atrial walls, connecting them in the superior quadrant of the interatrial sulcus

2. **Bachmann G. The interauricular time interval. Am J Physiol 1916; 41:309–20.** Jean Gorge Bachman was born on July 18, 1977, in Mulhouse in the Alsace region and grew in Nancy, France. At the age of 20, he joined the merchant marines. He made more than 20 trips across the Pacific Ocean in this service. Obviously, he was an individualist. Later he settled in the United States in 1902 where he studied medicine at Jefferson Medical College in Philadelphia, graduating in 1907 as a physician. He was professor of physiology at the Atlanta College of Physicians and Surgeons from 1910 to 1915 at Emery University School of Medicine in Atlanta from 1915 to his retirement in 1947 at the age of 70, but continued to practice medicine for several years. He died at Emory University Hospital in November 1959.

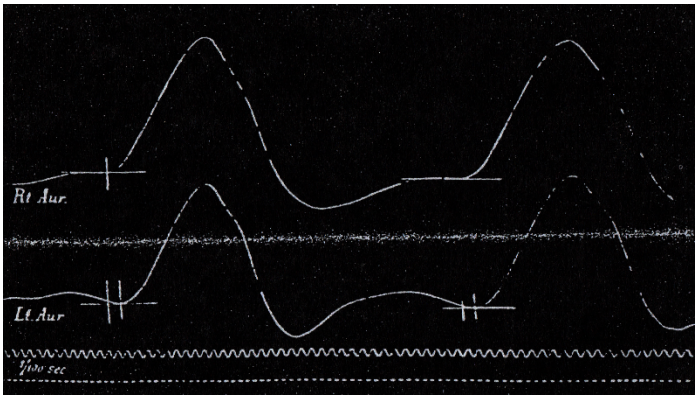
   He published numerous articles on cardiac electrophysiology and researched many subjects including venous pulse, arterial blood pressure measurement, and heart block. In 1934 he was one of the publishers of a physiology textbook. The Essentials of Physiology and Pharmacodynamics, published in Philadelphia. George Bachmann died in November 1959.

   In a 1916 he wrote an article for the American Journal of Physiology entitled "The interauricular time interval", Bachmann described in canine experiments the interatrial bundle, which was to be named after him, as an interatrial link allowing conduction from the right to the left atrium. The observation was made clamping the muscular bundle of fibers that connects both atria and caused a significant conduction delay (**Khaja 2005**).

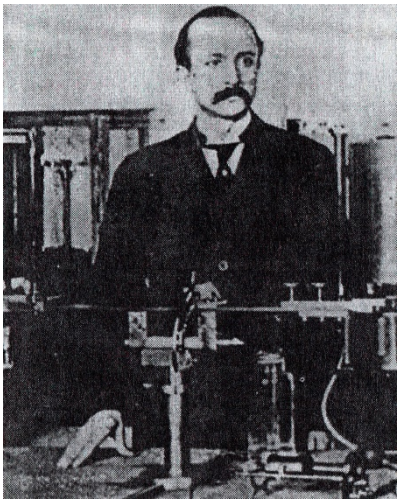
   Bachmann's bundle (BB), the Bachmann bundle or the interatrial tract is a branch of the anterior internodal tract that resides on the inner wall of the left atrium. BB) represents a distinct structure similar to the atrio-ventricular node and the His-Purkinje conduction system but without any insulating tissue. It is a broad band of cardiac muscle that passes from the right atrium, between the superior vena cava

and the ascending aorta (**James 1963**). Bachmann's bundle is, during normal sinus rhythm, the preferential path for electrical activation of the left atrium. It is therefore considered to be part of the "atrial conduction system" of the heart. BB cells have specialized electrophysiological properties like supernormal excitability and faster longitudinal conduction that can facilitate more rapid impulse transmission compared to the normal atrial tissue. In BB was described bradycardia-dependent or phase 4 block (**Sobrino 1974**). These authors presented a patient with a peculiar interatrial block. The ECG showed a short PR interval and negative P waves in II, III, and aVF, which were preceded, 0-07 s earlier, by another positive P wave present in the right precordial leads which were absent in the limb leads. From the study with His bundle electrograms, high right atrial electrograms, and bipolar esophageal electrocardiograms, it could be proved that atrioventricular, His-Purkinje, and right intra-atrial conduction were normal, and that P waves recorded in limb leads represented left atrial depolarization; whereas the ones in the right precordial leads corresponded to right atrial activation. The vectorial analysis from both P waves and atrial potentials showed that the left atrium was activated in a retrograde fashion, because of an interatrial block. This block was bradycardia dependent and it disappeared in the cycles shorter than 800 ms. Experimental blockage of this pathway causes prolongation and widening of the P wave, which is associated with an increased incidence of atrial fibrillation. Atrial pacing is effective in reducing the incidence of atrial fibrillation by preventing bradycardia, synchronizing the atria, limiting anisotropy and reducing the dispersion of refractoriness. Various animal and human studies have shown pacing near the right atrial insertion of BB to have a beneficial effect in patients with interatrial conduction delay and atrial tachyarrhythmias. This mode of atrial septal pacing is convenient, safe, reliable, and clinically as effective as multisite pacing.

His animal experiments to determinate the interatrial time interval mark the first time the contraction of the two atria were precisely measured. He was also able to identify the exact anatomical location of specific interatrial fibers.



Time displacement of an atrial contraction when the interatrial band is interrupted.



Jean George Bachmann 1877-1959

Hurst JW. Jean George Bachmann. Clin Cardiol. 1987 Feb;10(2):135-6.

3. **Papez J.W. Heart musculature of the atria. Am J Anat 1920-21;27:255-77.**

4. **DECHERD GM Jr, RUSKIN A, BRINDLEY P. Interatrial and sinoatrial block, with an illustrative case. Am Heart J. 1946 Mar; 31:352-63.** PMID: 21018740.

5. **BRADLEY SM, MARRIOTT HJ. Intraatrial block. Circulation. 1956 Dec; 14(6):1073-8. .(Full text free).**

6. **Thomas TN. "The connecting pathways between the sinus node and A-V node and between the right and the left atrium in the human heart". American Heart Journal. 1963;66(4):498–508.** doi:10.1016/0002-8703(63)90382-X.

7. **Horiba M. STIMULUS CONDUCTION IN ATRIA STUDIED BY MEANS OF INTRACELLULAR MICROELECTRODE. I. THAT IN BACHMANN'S BUNDLE. Jpn Heart J. 1963 Jul;4:333-45. No abstract available. PMID: 14045583**

8. **Cohen J, Scherf D. Complete interatrial and intra-atrial block (Atrial Dissociation). Am Heart J. 1965 Jul;70:23-34.**

9. **Wagner ML, Lazzara R, Weiss RM, Hoffman BF. Specialized conducting fibers in the interatrial band. Circ Res. 1966 May;18(5):502-18.(Full text free)** Abstract The interatrial band (Bachmann's bundle) was studied both in situ, in the adult dog, and in vitro, using excised canine atria. Electrograms recorded from this structure in the intact animal had a double intrinsic deflection during sinus rhythm,

and responded to rapid rates of atrial stimulation with alternation in both configuration and cycle length. Potassium infusions which produced atrial arrest with a sinoventricular rhythm did not abolish electrical activity in the interatrial band.Single fibers of the interatrial band, studied in vitro with microelectrodes, had distinctive transmembrane potentials different from those of ordinary atrial muscle fibers. Action potentials were characterized particularly by a high rising velocity (maximum dv/dt), of the same magnitude as that recorded from Purkinje fibers, and a prominent plateau. These fibers were sensitive to acetylcholine and more resistant to potassium arrest than ordinary atrial fibers. Conduction velocity in the interatrial band was consistently higher than in ordinary atrial muscle. Plots of sequential activation time against linear distance showed different conduction velocities in parallel linear paths, with the highest velocity in the path on the crest of the interatrial band. Due to rapid conduction through the interatrial band, simultaneous activation of right and left atrial points was demonstrated. It is concluded: 1) The interatrial band is not a homogeneous structure, but contains two fiber types. 2) In addition to ordinary atrial muscle, specialized conducting fibers are present in the interatrial band. 3) Impulse spread in the interatrial band is not radial or uniform. Rather, it occurs through several linear paths which probably have infrequent cross-connections.

10. **De Michelis S, Paparella P. Observations in a case of interatrial block. Cardiol Prat. 1967;1(1):Suppl:169-77.[Article in Italian]**

11. **Childers RW, Merideth J, Moe GK. Supernormality in Bachmann's bundle. An in vitro and in vivo study in the dog. Circ Res. 1968 Mar;22(3):363-70. Free article.** A supernormal phase of conduction between right and left atria was observed in the exposed hearts of anesthetized dogs. Interatrial conduction time of premature atrial responses was reduced by as much as 17% during the early phase of diastole, relative to the conduction interval of basic driven responses. The supernormal phase lasted from 60 to 140 msec and was greater at slower basic driving frequencies. A brief phase of supernormal excitability was also found in the specialized cells of Bachmann's bundle from puppy hearts in vitro. Supernormal conduction was not observed within the atrial appendages (i.e., in areas not supplied by specialized conducting bands); supernormal excitability was not demonstrable in cells of ordinary atrial myocardium. Although vagal stimulation abbreviated transatrial conduction time, atropine did not abolish the phase of supernormality.

    Anatomic and physiologic studies have demonstrated bands of specialized conduction fibers, not unlike the intraventricular specialized conduction system, within the mammalian atria. Morphologically distinct bundles coursing from the S-A node to the A-V node have been characterized by Robb and Petri and by James (2). Electrophysiologically,

these fibers, and those of Bachmann's interatrial band (3), differ from ordinary atrial myocardial fibers. Their transmembrane action potentials, unlike those of atrial fibers, are reported to have a somewhat faster rise time and a distinct phase 2 plateau (4). They appear to be much more resistant than atrial muscle to increased external potassium; propagated action potentials can be recorded in the specialized tracts at potassium concentrations which cause failure of transmission in atrial myocardium (4, 5). As a result, sinoventricular rhythm can persist in the absence of P waves during hyperkalemia (6). Like Purkinje fibers, the specialized fibers in Bachmann's bundle conduct impulses at a significantly higher velocity than the surrounding myocardium (4). Unlike Purkinje fibers, however, their action potential durations are significantly abbreviated by acetylcholine (4). In the present study, attempts were made to determine whether the functional refractory period of fibers in the interatrial band of the dog heart could be demonstrated to exceed that of ordinary atrial myocardium, as has been shown in similar comparisons of Purkinje fibers and ventricular muscle (7). In the course of these experiments, it was found that a supernormal phase of interatrial conduction could be consistently demonstrated in the anesthetized dog. In vitro studies were undertaken to determine whether a phase of supernormal excitability, like that observed in Purkinje fibers (8), could be demonstrated in the specialized fibers of Bachmann's bundle.

Methods IN VIVO STUDIES Mongrel dogs weighing 14 to 20 kg were anesthetized with intravenous sodium pentobarbital, 30 mg/kg. Artificial respiration was given, the chest was opened through a midsternal incision, and the heart was cradled in the opened pericardium. Cardiac innervation was not disturbed. Stimulating bipolar electrodes were attached to the tips of the right and left auricular appendages. Bipolar recording electrodes were attached to the medial faces of the two appendages 15 mm from the stimulating electrodes. Driving stimuli from a Tektronix pulse generator were applied to either the right or left atrium through an isolation transformer. Following each sixteenth driving pulse (Sx), a precisely timed test stimulus (S2) was delivered through the same stimulating electrodes. The SxS2 interval was varied progressively by small steps to scan the interval between two successive driving stimuli. Vagal stimulation, when employed, was delivered by a Grass stimulator through Harvard shielded electrodes applied to the distal end of the cut vagal trunks. IN VITRO STUDIES Mongrel puppies aged six weeks and weighing 2 to 3 kg were anesthetized by intraperitoneal sodium pentobarbital, 40 mg/kg. Under artificial respiration the chest was opened in the midline, and the entire heart was quickly excised and placed in Tyrode's solution or temporarily perfused through the aorta. The aorta and pulmonary artery were retracted, revealing the roof of the atria and the interatrial band. The atrial roof, together with adjacent right and left appendages, was rapidly separated from the rest of the heart. The preparation was then placed in a perfusion chamber. Bipolar silver electrodes were applied to the preparation for driving purposes. Glass microelectrodes of 14- to 20- megohm resistance filled with 2 M potassium citrate were used for intracellular recording and stimulating. The stimulation circuits consisted of two Tektronix pulse generators triggered by a device which permitted the application of a series of precisely regular basic pulses (Sx) applied through the bipolar external electrodes, followed by one or more test shocks (S2, S3) delivered to either the intracellular or external electrodes. Stimulus intervals were counted from a 100-kc crvstal oscillator.1 The external circuit consisted of the pulse generator, isolation transformer, and bipolar

chlorided silver electrodes applied to the right atrial side of the preparation. This circuit was employed to deliver 11 basic driving pulses of 4-msec duration at a cycle length of 600 msec. The application of test shocks (S2) through the microelectrode was achieved by a gated millisecond relay which prevented short circuit to ground. The recording apparatus was protected from this pulse by a diode short to ground. Transmembrane action potentials were recorded through an Argonaut negative capacitance electrometer, a Tektronix 565 oscilloscope, and a Grass kymograph camera. The test pulse (S2) was displayed on a second channel. A 100- mv calibrating signal battery and a potentiometer for voltage bucking were connected in a series with the indifferent electrode, a chlorided silver wire submerged in the bath. A differentiator was occasionally used to estimate the rate of rise of cellular action potentials. To test for supernormal excitability, a test pulse (S2) was delivered through the microelectrode. A second test pulse (S3) was delivered through the external electrodes 30 to 60 msec later. The S3 pulse always succeeded if So failed and was seen as an artifact on the plateau of the action potential when S2 was successful. Late diastolic threshold of the impaled cell was established by setting the S i interval at 400 msec and gradually raising the pulse amplitude of S2 until it succeeded and 53 failed. Using a fine adjustment potentiometer, the pulse strength was then lowered just enough to make S2 repeatedly fail. The S^o interval was then abruptly reduced to 200 msec or to a value at which S2 was successful. To confirm supernormality the S2 was repeatedly shifted to late diastole and back to show its continued failure and success in the late and supernormal phases, respectively. Results IN SITU DOG HEART A supernormal phase of conducti

12. **Sanna GP, Ventura L, Arcidiacono R, Vergani C.Complete interatrial block Minerva Med. 1969 Nov 3;60(88):4382-5.[Article in Italian]. PMID: 535568**

13. **Waldo AL, Vitikainen KJ, Kaiser GA, Malm JR, Hoffman BF. The P wave and P-R interval. Effects of the site of origin of atrial depolarization. Circulation. 1970 Oct;42(4):653-71.**

14. **Hutter AM Jr, Page DL.Atrial arrhythmias and lipomatous hypertrophy of the cardiac interatrial septum.Am Heart J. 1971 Jul;82(1):16-21**.Article in Italian

15. **Waldo AL, Bush HL Jr, Gelband H, Zorn GL Jr, Vitikainen KJ, Hoffman BF. Effects on the canine P wave of discrete lesions in the specialized atrial tracts. Circ Res. 1971;29(5):452-67.** (abstract available) Waldo *et al*. first demonstrated in canine experiments that after the transection of anterior internodal tract, the P-wave duration increased significantly though morphology and polarity remained the same. However, transection of the BB not only caused increased P-duration but also distorted its polarity and morphology

16. **Sangiorgi M, Cannata D. [Partial interatrial block with duplex atriogram and with double atrial heterotopic, unstable interferential rhythm]. G Ital Cardiol. 1972;2(5):655-64.**

17. **Yacoub MH, Schottenfeld M, Kittle CF. Hematoma of the interatrial septum with heart block secondary to dissecting aneurysm of the aorta. A clinicopathologic entity.Circulation. 1972 Sep;46(3):537-45.**

18. **Waldo AL, Kaiser GA, Bowman FO Jr, Malm JR.Etiology of prolongation of the P-R interval in patients with an endocardial cushion defect. Further observations on internodal conduction and the polarity of the retrograde P wave. Circulation. 1973 Jul; 48(1):19-26.**

19. **Legato MJ, Ferrer MI. Intermittent intra-atrial block: its diagnosis, incidence and implications. Chest. 1974 Mar;65(3):243-51.**

20. **Legato MJ, Bull MB, Ferrer MI. Atrial ultrastructure in patients with fixed intra-atrial block. Chest. 1974 Mar;65(3):252-61.**

21. **PMID: 4813831Lavezzaro G, Grassi T, Minetto E. Incomplete interatrial block of an advanced stage. Report of a case with endoesophageal and right intra-atrial recordings]. Minerva Cardioangiol. 1974 Dec;22(12):871-6.**

22. **Di Biase M, Rizzon P.[Interatrial block with retrograde activation of the left atrium G Ital Cardiol. 1975;5(3):323-31.** Article in Italian]Abstract Six cases with P wave abnormalities compatible, according to the criteria of Castillo and Vernant, with the diagnosis of block of the Bachmann's bundle, have been studied by means of intra-atrial and esophageal electrography. In two cases the P wave abnormalities were intermittent. In agreement with the results of Castillo and Vernant right atrial activation appears to be normal and coincides with the initial positive deflection of the P wave in leads II, III, and aVF. Left atrial activation starts at the end of the right atrial activation, coinciding with the terminal negative deflection of the P wave in leads II, III, and aVF and shows an abnormal progression from the lower part to the upper part of the atrium. This pattern of atrial depolarisation can only be explained by a block of the superior interatrial pathways. On the basis of the present findings it is supposed that the block occurs in a specialized type of atrial tissue rather than in the common atrial myocardium. From the clinical point of view it is of some interest to point out that this abnormal pattern of atrial depolarisation does not necessarily prolong the atrial depolarization and may not determine a terminal negative deflection of the P wave in lead II.

23. **Di Biase M, Lenti ML, Guglielmi R, Rizzon P.Incidence of interatrial conduction disorders of the Bachmann bundle block type. Boll Soc Ital Cardiol. 1975;20(5):449-52.** PMID: 1230178

24. **Lee YS, Lien WP.HIS bundle electrogram in rheumatic mitral valve disease with special reference to Bachmann's bundle block in P mitrale. Jpn Circ J.**

1975 Aug;39(8):935-45. Abstract HBEs were recorded from either the right or left ventricle or simultaneously from both in 26 patients with chronic rheumatic mitral stenosis alone or in association with other mild valvular lesions during the diagnostic cardiac catheterization. Eleven of the patients had auricular fibrillation. Of the remaining 15 patients with sinus mechanism and P mitrale in the surface electrocardiogram, 12 were noted to have H potential preceded the termination of P wave and gave P2H interval of negative value- so-called "Bachmann's bundle block". Among these, double atrial activities (A and A' waves) could be identified on the HBE recorded from the left ventricular endocardial surface with catheter electrodes positioned at the subarotic region in 7 patients studied. Interatrial conduction time (P1A' interval) measured in these patients was prolonged in all and ranged from 47 to 82 with an average of 66 msec. Prolongation of intraatrial (or internodal) conduction time was noted in only one patient who also had first degree A-V block and prolonged A-H interval. There was no correlation of either P1P2 or P2H interval to the degree of left atrial enlargement. The P1P2 or P2H interval also had no correlation with hemodynamic parameters. In patients with auricular fibrillation, all impulses unable to conduct to the ventricle were blocked proximal to the His bundle and concealed conduction was not observed distal to it.PMID: 1165605 [PubMed - indexed for MEDLINE]

25. **Waldo AL, Vitikainen KJ, Hoffman BF.The sequence of retrograde atrial activation in the canine heart. Correlation with positive and negative retrograde P waves. Circ Res. 1975 Aug;37(2):156-63**. Abstract: The relationship of P-wave polarity and morphology in leads II, III, and aVF to the sequence of atrial activation was studied in the canine heart when the atria were paced from the region of the sinus node or the posterior-inferior left atrium and when retrograde activation of the atria occurred with right ventricular epicardial pacing. Deeply negative P waves in leads II, III, and aVF which occurred when the posterior-inferior left atrium was paced were associated with true retrograde activation of the atria. Positive P waves recorded in leads II, III, and aVF during retrograde atrial capture with right ventricular pacing were associated with rapid retrograde spread of the impulse in the interatrial septum to the region of Bachmann's bundle from which site the impulse spread to depolarize significant portions of both atria in a manner similar to that demonstrated during pacing from the region of the sinus node. When the atria were paced from a site just anterior to the coronary sinus ostium, positive P waves recorded in leads II, III, and aVF were associated with early activation in the vicinity of Bachmann's bundle and later activation of the posterior-inferior left atrium. When the atria were paced from a site just posterior to the coronary sinus ostium, negative P waves in leads II, III, and aVF were associated with early activation of the posterior-inferior left atrium and later activation in the vicinity of

Bachmann's bundle. It was concluded that the time of arrival of the impulse at Bachmann's bundle relative to that at the posterior left atrium and the direction of spread of the impulse from and within Bachmann's bundle are critical in determining P-wave polarity and morphology.PMID: 1149190

26. **Lacina P, Srch M, Vortel V.[Mesothelioma of the septum interatriale (author's transl)]. Rechtsmed. 1975 Nov 11;76(2):123-7.** Abstract Sudden death of a 21-year-old women. The cause of death was mesothelioma situated in the region of the interatrial septum that has been manifested since childhood as a complete heart block. Neither gravidity nor delivery led to the aggravation of her state of health. The cause of this heart lesion, which was the mentioned rare tumor, was discovered only during the autopsy.

27. **Zoneraich O, Zoneraich S. Intraatrial conduction disturbances: vectorcardiographic patterns. Am J Cardiol. 1976 Apr;37(5):736-42.** Abstract Frank P loop vectorcardiograms were recorded in 30 normal subjects and in 40 patients who had intraatrial conduction disturbances alone or in association with cardiac disease. High magnification of the P loop (0.1 mv = 3 cm) permitted accurate measurement of the P loop duration, magnitude and direction. High-frequency recordings allowed optimal evaluation of the notches, bites and conduction delays in the PsE loop. Four vectorcardiographic patterns have been selected as counterparts of the four types of enlarged P waves seen in electrocardiograms of patients with atrial conduction disturbances. When intraatrial conduction disturbances coexisted with left atrial enlargment, the PsE loop was larger and smoother. The role of partial or complete block in the specific internodal or interatrial pathways is discussed. High magnification, high-frequency vectorcardiography of the P loop seems to be the best available method for determing a specific pattern of intraatrial conduction disturbance.PMID: 773161 doi: 10.1016/0002-9149(76)90368-4

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4. **Benchimol A:** Vectorcardiography. Baltimore, Williams & Wilkins, 1973, p 35–47
5. **Chow C-Te, Helm R:** Clinical Vectorcardiography. New York, Grune & Stratton, 1967, p 50–52
6. **Legato MJ, Ferrer MI:** Intermittent intra-atrial block: its diagnosis, incidence and implications. Chest 65:243–251, 1974
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10. **James TN, Sherf L:** Specialized tissues and preferential conduction in the atria of the heart. Am J Cardiol 28:414–427, 1971
11. **Keith A, Flack MW:** The form and nature of the muscular connections between the primary divisions of the vertebrate heart. J Anat Physiol 41:172–176, 1907
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15. **Bachmann G:** The inter-auricular time interval. Am J Physiol 41:309–314, 1916
16. **Holsinger JW Jr, Wallace AG, Sealy WC:** The identification and surgical significance of the atrial internodal conduction tracts. Ann Surg 167:447–453, 1968
17. **Waldo AL, Bush HL Jr, Gelband H, et al:** Effects on the canine P-wave of discrete lesion in the specialized atrial tracts. Circulation 29:452–467, 1971
18. **Burch GE, Giles TD:** Atrial vectorcardiogram in mitral valve disease. Cardiology 58:80–88, 1973
19. **Legato MJ, Bull B, Ferrer MI:** Atrial ultrastructure in patients with fixed intra-atrial block. Chest 65:252–261, 1974
20. **Zoneraich S, Zoneraich O:** Atrial tachycardia with high degree of intra-atrial block. J Electrocardiol 4:369–370, 1971

28. **Sobrino JA, del Rio A, Maté I, Sobrino N.Bradycardia-dependent interatrial block with retrograde left atrial activation.Br Heart J. 1977 Feb;39(2):222-5. (Full text available)Abstract.** A patient with a peculiar interatrial block is reported. The electrocardiogram showed a short PR interval and negative P waves in II, III, and aVF, which were preceded, 0-07 s earlier, by another positive P wave present in the right praecordial leads which were absent in the limb leads. From the study with His bundle electrograms, high right atrial electrograms, and bipolar esophageal electrocardiograms, it could be proved that atrioventricular, His-Purkinje, and right intra-atrial conduction were normal, and that P waves recorded in limb leads represented left atrial depolarization; whereas the ones in the right precordial leads corresponded to right atrial activation. The vectorial analysis from both P waves and atrial potentials showed that the left atrium was activated in a retrograde fashion, because of an interatrial block. This block was bradycardia dependent and it disappeared in the cycles shorter than 800 ms.

29. **Leier CV, Schaal SF.Dissimilar atrial rhythms. A patient with interatrial block.Br Heart J. 1977 Jun;39(6):680-4.(Full text available**) Abstract A patient with type A Wolff-Parkinson-White syndrome and prolonged interatrial conduction intervals developed atrial flutter during the course of an electrophysiological study. The atrial flutter blocked along the left-to-right conduction pathways in a Wenckebach pattern. The dissimilar atrial rhythms of right atrial tachycardia and left atrial flutter evolved as the interatrial block increased to 2:1 conduction. PMID: 884019 PMCID: PMC483298

30. **Sridharan MR, Horan LG, Flowers NC. Combined effects of graded hyperkalemia on activation and recovery. Am Heart J. 1979 May;97(5):622-30.** Abstract: We have demonstrated the progressive transmission delay in the A-V conduction system in graded hyperkalemia against a background of otherwise normal cations, and known blood gas relationships. This extends and further quantitates the work of others. We were unable to demonstrate sinoventricular conduction, as atrial activity was consistently recordable when surface P-waves disappeared. The His bundle appears to be the least susceptible conduction system structure to hyperkalemia. Finally, we have postulated the possible mechanism for the genesis of the sine wave, including loss of electrical gradient with resulting phase difference of QRS and T, associated with maintenance of His bundle activity with progressive, distal, Purkinje blockade. PMID: 34988

31. **Bayés de Luna AJ . Block at the auricular level [article in Spanish]. *Rev Esp Cardiol* . 1979;32:5–10.**

32. **Sherf L, James TN.Fine structure of cells and their histologic organization within internodal pathways of the heart: clinical and electrocardiographic implications.Am J Cardiol. 1979 Aug;44(2):345-69.** Abstract The fine structure of the normal internodal pathways was studied in 1 human and 2 canine hearts and correlated with histologic observations on more than 100 human and 10 canine hearts. From the electron microscopic studies six different kinds of myocardial cells were classified from two locations: the Eustachian ridge (posterior internodal pathway) and the Bachmann bundle (anterior internodal pathway). Five of the six kinds of cells (working myocardial cells, Purkinje-like cells, either broad or slender transitional cells and P cells, all previously described) were present in both locations. A sixth cell, pleomorphic and dark in appearance, with a special intertwined relation to P cells, is newly designated as an ameboid cell. It was found solely in the Eustachian ridge. In the same area a rare direct contact between a nerve and a myocardial cell was observed. The importance of these different kinds of cells, their respective cell connections, and their topographic locations inside the internodal pathways are discussed relative to certain functions such as rapid conduction and subsidiary pacemaking. The possible influence of these factors on clinical electrocardiographic changes is considered.PMID: 380316 [PubMed - indexed for MEDLINE]

33. **Anderson RH, Ho SY, Smith A, Becker AE. The internodal atrial myocardium. Anat Rec. 1981 Sep;201(1):75-82.** Abstract: The anatomical substrates of internodal conduction have long been a contentious topic. Debated first by the German Pathological Society in 1910, the consensus of established opinion for over half a century was that conduction between sinus and atrioventricular nodes

occurred through plain myocardium. This was a conclusion supported by Truex in 1961. Despite his restatement of this fact in 1976, it has become fashionable to describe internodal conduction as being mediated by specialized internodal pathways. To reinvestigate this problem we studied 22 human fetal and 32 human infant hearts. In each case it was possible to cut the atrial tissues as a single block of tissue and to examine serial sections through the internodal myocardium. The sinus node, atrioventricular node, and segments of atrioventricular ring specialized tissue were recognized as specialized tissue using the light microscope in each heart. In contrast, there was nothing "special" about the myocardium between the nodes, nor was it possible to recognize tracts on the basis of either histological appearance or cellular architecture. It is concluded that, from the standpoint of light microscopy, there is no evidence whatsoever to support the purported concept of specialized anatomical substrates for internodal conduction. PMID: 7305024 DOI: 10.1002/ar.1092010110

34. **Spach MS, Miller WT 3rd, Dolber PC, Kootsey JM, Sommer JR, Mosher CE Jr. The functional role of structural complexities in the propagation of depolarization in the atrium of the dog. Cardiac conduction disturbances due to discontinuities of effective axial resistivity. Circ Res. 1982 Feb;50(2):175-91. (full text available)**

35. **Husson J.Partial interatrial block].Arch Mal Coeur Vaiss. 1983 Aug;76(8): 959-63.** Abstract A case of interatrial block is reported, involving the upper part of left atrium, demonstrated by esophageal recordings at different levels. Abnormally retrograde atrial depolarization in the upper part of the left atrium was observed, but normal descending depolarization in the lower part of the left atrium suggested that interatrial conduction was blocked on the Bachmann bundle but was normal on the middle interatrial pathway. The surface ECG showed a P wave of normal duration; it was inverted in Lead III and a VF, and flat in Lead II with a normal PR interval. The author suggests a method of classification of interatrial block into three types. PMID: 6414429

36. **Bayés de Luna A , Fort de Ribot R , Trilla E , et al. Electrocardiographic and vectorcardiographic study of interatrial conduction disturbances with left atrial retrograde activation. *J Electrocardiol* . 1985;18:1–13**.

37. **Husson J, Froment C.Partial interatrial block due to a conduction defect of the preferential middle interatrial depolarization pathway Arch Mal Coeur Vaiss. 1985 Oct;78(10):1569-74**. Abstract The authors report the case of partial interatrial block arising in the mid zone of the left atrium as demonstrated by oesophageal recordings. These showed that atrial depolarisation descending normally in the superior part of the left atrium was abnormally retrograde in the inferior part; this

suggests a block of the mid-interatrial pathway and conduction via Bachmann's pathway in the upper part of the left atrium and via a retrograde pathway in the inferior region. The surface ECG showed a P wave of normal duration which was diphasic in Leads III and aVF with a normal PR interval. In addition, endocavitary recordings in the inferior part of the right atrium showed the presence of preatrial potentials potentials during three ectopic complexes, the significance of which is uncertain.PMID: 3938224

38. **Medrano GA, de Micheli A, Osornio A.Interatrial conduction and STa in experimental atrial damage. J Electrocardiol. 1987 Nov;20(5):357-63.** Abstract Right (RA) and left atrial (LA) damage was produced with a subepicardial infiltration of 96 degrees' alcohol in two groups of dogs. In six other dogs the left or right portion of the interatrial band was also injured. Conventional ECG and supplementary unipolar leads were recorded using photographic and direct inscription polygraphs at paper speeds of 50 and 100 mm/sec. Control, immediate postinjury and late tracings were obtained. A-V block was provoked to determine QTac. Slowing of heart rate and slight widening of the P wave and P-R interval were observed with both types of atrial damage. In four cases low right atrial rhythm was detected: two showed anatomo-histological sinus node involvement in right atrial injury. Qp waves were registered over the left precordium with necrosis of both sides, but were more frequent with RA damage. Damage of the left portion of the interatrial band delayed left atrial activation and split P waves in the precordial leads. Damage of the RA distorts the initial vectors, magnifying the left ones and simulating LA enlargement. The Qp registered on the RA is also detected by surface leads. Contrary distorted LA depolarization increases the RA vector and delays the left, ones, giving rise to greater asynchronsim and bimodal P waves. PMID: 3430104

39. **Vitali A, Battaglia C. Interatrial block in acute myocardial infarction. Description of a case].Minerva Cardioangiol. 1988 Jun;36(6):327-30. [Article in Italian]**

40. **Bayés de Luna A1, Cladellas M, Oter R, Torner P, Guindo J, Martí V, Rivera I, Iturralde P.Interatrial conduction block and retrograde activation of the left atrium and paroxysmal supraventricular tachyarrhythmia.Eur Heart J. 1988 Oct;9(10):1112-8**. Abstract (**Full text avaliable**)We studied 16 patients with electrocardiographic evidence of advanced interatrial block and retrograde activation of the left atrium (P greater than or equal to 0.12 s, and diphasic (+/-) P waves in 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 left atrium had a much higher incidence of paroxysmal supraventricular tachyarrhythmias (93.7%) during follow-up than did the control group, (27.7%) (P less than 0.001). Eleven of 16 patients (68.7%) with advanced interatrial block and retrograde activation of left atrium 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 left atrium and frequent atrial extrasystoles than to left atrial enlargement, because the control group with a left atrium of the same size, but without advanced interatrial block and retrograde activation of left atrium and with less incidence of atrial extrasystoles, had a much lower incidence of paroxysmal tachycardia.PMID: 3208776

41. **Bayés de Luna A1, Oter MC, Guindo J. Interatrial conduction block with retrograde activation of the left atrium and paroxysmal supraventricular tachyarrhythmias: influence of preventive antiarrhythmic treatment. Int J Cardiol. 1989 Feb;22(2):147-50.** Abstract: Patients with advanced interatrial conduction block with retrograde activation to the left atrium present a high incidence of supraventricular tachyarrhythmias. We report the value of preventive antiarrhythmic treatment in these patients.

42. **Dolber PC, Spach MS. Structure of canine Bachmann's bundle related to propagation of excitation. Am J Physiol. 1989 Nov;257(5 Pt 2):H1446-57. (full text available)**

43. **Spodick DH. Interatrial block and atrial arrhythmias. Am J Cardiol. 1996 Feb 1;77(4):326. PMID: 8607424**

44. **Ramsaran EK, Spodick DH. Electromechanical delay in the left atrium as a consequence of interatrial block. Am J Cardiol. 1996 May 15;77(12):1132-4.** Abstract: Right and left atrial electromechanical intervals and onsets of active right and left ventricular filling were measured in patients with interatrial block and compared with control patients. Left atrial mechanical activity is significantly delayed by interatrial block.

45. **Spodick DH. Electrocardiology Teacher Analysis and Review - Interatrial Block. Am J Geriatr Cardiol. 1997 Jul;6(4):54.** No abstract available. PMID: 11416423

46. **Spodick DH. Electrocardiology Teacher Analysis and Review - Complete Interatrial Block. Am J Geriatr Cardiol. 1997 Nov;6(6):54.** No abstract available. PMID: 11416437

47. Bayes de Luna A, editor. Clinical electrocardiography: a textbook. 2nd edition . 169 . New York (NY):: Willey-Blackwell (Futura Comany); 1998. Electrocardiographic alterations due to atrial pathology. p. 0879936827.

48. **Antz M1, Otomo K, Arruda M, Scherlag BJ, Pitha J, Tondo C, Lazzara R, Jackman WM.Electrical conduction between the right atrium and the left atrium via the musculature of the coronary sinus. Circulation. 1998 Oct 27;98(17):1790-5.** BACKGROUND: The purpose of this study was to determine whether the coronary sinus (CS) musculature has electrical connections to the right atrium (RA) and left atrium (LA) and forms an RA-LA connection.METHODS AND RESULTS: Six excised dog hearts were perfused in a Langendorff preparation. A 20-electrode catheter (2-4-2-mm spacing center to center) was placed along the CS. Excision of the pulmonary veins provided access to the LA, and a second 20-electrode catheter was placed along the LA endocardium opposite the CS catheter. An incision opened the CS longitudinally, and microelectrodes were inserted into the CS musculature and adjacent LA myocardium. Continuous CS musculature was visible along a 35+/-9-mm length of the CS beginning at the ostium. During lateral LA pacing, CS electrodes recorded double potentials, a rounded, low-frequency potential followed by a sharp potential. The rounded initial potential propagated in the lateral-to-septal direction and represented "far-field" LA activation (timing coincided with adjacent LA potentials and with action potentials recorded from microelectrodes in adjacent LA cells). The sharp potential represented CS activation (timing coincided with action potentials recorded from CS musculature). A distal LA-CS connection (earliest sharp potential in the CS during lateral LA pacing) was located 26+/-7 mm from the ostium. During RA pacing posterior to the CS ostium, CS electrodes recorded septal-to-lateral activation of the high-frequency potential, with slightly later activation of the rounded potential (LA activation). Incisions surrounding the CS ostium isolating the ostium from the RA had no effect on the CS musculature and LA potentials during RA pacing within the isolated segment containing the CS ostium. RA pacing outside the isolated segment delayed activation of the CS musculature until after LA activation, confirming that the RA-CS connection was located in the region of the CS ostium as well as confirming the presence of the LA-CS connection.CONCLUSIONS:In canine hearts, the CS musculature is electrically connected to the RA and the LA and forms an RA-LA connection.

49. **Parravicini U, Mezzani A, Bielli M, Di Camillo T, Pardo NF, Iraghi G, Zenone F, Zanetta M.DDD pacing and interatrial conduction block: importance of optimal AV interval setting. Pacing Clin Electrophysiol. 2000 Sep;23(9): 1448-50.**

50. **Harrild D1, Henriquez CA computer model of normal conduction in the human atria. Circ Res. 2000 Sep 29;87(7):E25-36.(full text available)** Abstract Although considerable progress has been made in understanding the process of wavefront propagation and arrhythmogenesis in human atria, technical concerns and issues of patient safety have limited experimental investigations. The present work describes a finite volume-based computer model of human atrial activation and current flow to complement these studies. Unlike previous representations, the model is three-dimensional, incorporating both the left and right atria and the major muscle bundles of the atria, including the crista terminalis, pectinate muscles, limbus of the fossa ovalis, and Bachmann's bundle. The bundles are represented as anisotropic structures with fiber directions aligned with the bundle axes. Conductivities are assigned to the model to give realistic local conduction velocities within the bundles and bulk tissue. Results from simulations demonstrate the role of the bundles in a normal sinus rhythm and also reveal the patterns of activation in the septum, where experimental mapping has been extremely challenging. To validate the model, the simulated normal activation sequence and conduction velocities at various locations are compared with experimental observations and data. The model is also used to investigate paced activation, and a mechanism of the relative lengthening of left versus right stimulation is presented. Owing to both the realistic geometry and the bundle structures, the model can be used for further analysis of the normal activation sequence and to examine abnormal conduction, including flutter. The full text of this article is available at http://www.circresaha.org.PMID: 11009627

51. **Sun H, Khoury DS. Electrical conduits within the inferior atrial region exhibit preferential roles in interatrial activation. J Electrocardiol. 2001 Jan;34(1): 1-14.** Abstract: Differences between conduction properties of interatrial conduits and their roles in initiation and maintenance of supraventricular arrhythmias remain unclear. Our objective was to determine details of interatrial activation in inferior atrial region and to correlate intra-atrial and interatrial activation patterns with the site of origin of atrial ectopic activation. In 9 dogs, basket-catheters carrying 64 electrodes were deployed into both the right atrium (RA) and left atrium (LA). A 10-electrode catheter was inserted into the coronary sinus (CS). Activation patterns of the RA, LA, and CS were compared during pacing in the CS, in RA inferoparaseptum posterior to Eustachian ridge-tendon of Todaro (TT), and in inferior RA near the CS ostium (anterior to TT). We found that pacing in proximal

and middle CS resulted in a RA breakthrough invariably at the CS ostium, consistent with conduction through a CS-RA connection. Meanwhile, LA breakthrough emerged in inferoposterior region (inferior to mitral annulus), suggesting conduction through a CS-LA connection. While pacing in distal CS, LA breakthrough shifted to middle posterolateral wall. Whereas, the RA was activated by the LA directly through the septum. During pacing in RA inferoparaseptum posterior to TT, the LA was activated directly through the septum at 22 +/- 4 ms. Whereas, during pacing anterior to TT, the LA was activated through both the CS and the septum while earliest activation was delayed by 38 +/- 5 ms. In conclusion, both the interatrial septum and CS musculature form electrical conduits in inferior atrial region in canine. Differences in activation properties between the conduits in inferior interatrial region result in selective interatrial activation patterns during ectopic activation. PMID: 11239365

52. **Roithinger FX1, Abou-Harb M, Pachinger O, Hintringer F.The effect of the atrial pacing site on the total atrial activation time.Pacing Clin Electrophysiol. 2001 Mar;24(3):316-22.** Abstract The effect of dual site pacing for prevention of atrial fibrillation may be due to synchronization of right and left atrial activation. Little is known, however, about the effect of pacing from single right atrial sites on differences in interatrial conduction. Twenty-eight patients without structural heart disease were studied following radiofrequency catheter ablation of supraventricular arrhythmias. Pacing was performed using standard multipolar catheters from the presumed insertion site of Bachmann's bundle, the coronary sinus ostium, the high lateral right atrium, and the right atrial appendage (n = 8 patients). Bipolar recording was performed from the distal coronary sinus, the high and low lateral right atrium, and the posterolateral left atrium (n = 13 patients). The longest conduction time from each pacing to each recording site was considered the total atrial activation time for the respective pacing site. During high right atrial pacing, the total atrial activation time was determined by the conduction to the distal coronary sinus (118 +/- 18 ms), during coronary sinus ostium pacing by the conduction to the high right atrium (94 +/- 18 ms), and during Bachmann's bundle pacing by the conduction to the distal coronary sinus (74 +/- 18 ms). The total atrial activation time was significantly shorter during pacing from Bachmann's bundle, as compared to pacing from other right atrial sites. Thus, in normal atria, pacing from the insertion of Bachmann's bundle causes a shorter total atrial activation time and less interatrial conduction delay, as compared to pacing from other right atrial sites. These findings may have implications for alternative pacing sites for prevention of atrial fibrillation. PMID: 11310300

53. **James TN.The internodal pathways of the human heart. Prog Cardiovasc Dis. 2001 May-Jun;43(6):495-535.PMID: 11431803 DOI: 10.1053/pcad.2001.24598 [PubMed - indexed for MEDLINE]**

54. **Bailin SJ1, Adler S, Giudici M.Prevention of chronic atrial fibrillation by pacing in the region of Bachmann's bundle: results of a multicenter randomized trial.J Cardiovasc Electrophysiol. 2001 Aug;12(8):912-7.** Author information 1Iowa Heart Center, Des Moines 50314, USA. mmcconville@iowaheart.comAbstractINTRODUCTION: Atrial pacing locations that decrease atrial activation and recovery time may be preferable in patients with a history of atrial arrhythmias. This multicenter prospective randomized study compared the efficacy of Bachmann's bundle (BB) region pacing to right atrial appendage (RAA) pacing in patients with recurrent paroxysmal atrial fibrillation (AF).METHODS AND RESULTS:Patients with standard pacing indications (n = 120, 70+/-11 years) were randomized to atrial pacing in either the RAA (n = 57) or BB region (n = 63). Implantation time was similar between groups (88+/-36 min [n = 38] for BB vs 83+/-34 min [n = 34] for RAA). No differences in pacing threshold, impedance, or sensing between BB and RAA groups were observed at implantation or after the 6-week, 6-month, and 1-year follow-up periods. Average length of follow-up was 12.6+/-7.4 months for the BB group and 11.8+/-8.0 months for the RAA pacing group. The percentage of atrial pacing was similar between groups (61%+/-34% RAA vs 65%+/-31% BB at 2 weeks after implant). BB atrial pacing significantly ($P < 0.05$) shortened p wave duration compared with sinus rhythm (123+/-21 msec vs 132+/-21 msec, n = 50) 2 weeks after implant. In contrast, p wave duration was longer during atrial pacing from the RAA position compared with sinus rhythm (148+/-23 msec vs 123+/-23 msec, n = 37). Additionally, p wave duration was shorter during BB pacing than during RAA pacing. Patients with BB pacing had a higher ($P < 0.05$) rate of survival free from chronic AF (75%) compared with patients with RAA pacing (47%) at 1 year.CONCLUSION:BB region pacing is safe and effective for attenuating the progression of AF.

55. **Jairath UC, Spodick DH. Exceptional prevalence of interatrial block in a general hospital population. Clin Cardiol. 2001 Aug;24(8):548-50.** PMID: 11501606 Free Article Abstract BACKGROUND: Interatrial block (IAB: P wave > or = 110 ms) is a strong correlate of left atrial (LA) enlargement and an important predictor of supraventricular tachyarrhythmias, notably atrial fibrillation and flutter. It is surprising that, despite its association with arrhythmias and its effects on the electromechanical properties of the left atrium, there is widespread neglect of this common abnormality.HYPOTHESIS: The study was undertaken to investigate the prevalence of IAB in a general hospital population.METHODS: We prospectively evaluated the electrocardiograms of 1,000 consecutive adult patients. analyzed for

P-wave duration.RESULTS:Our results showed a very high prevalence of IAB (41.1% of patients in sinus rhythm and 32.8% of all patients). As expected, it was more common in patients aged > 60 years.CONCLUSIONS: Given this unusually high prevalence of IAB in hospital patients and its ominous portents (LA enlargement. thrombosis and embolism, arrhythmias), physicians should be aware of its frequency and computer software should be programmed to recognize it.

56. **Spodick DH. Effect of interatrial block on left atrial function. J Cardiol. 2001 Sep;38(3):169-71.** PMID: 11577614

57. **Goyal SB, Spodick DH. Electromechanical dysfunction of the left atrium associated with interatrial block. Am Heart J. 2001 Nov;142(5):823-7.** PMID: 11685169

58. **Ho SY, Anderson RH, Sánchez-Quintana D. Gross structure of the atriums: more than an anatomic curiosity? Pacing Clin Electrophysiol. 2002 Mar;25(3): 342-50.** Abstract: Despite the extensive literature concerning atrial arrhythmias, there are relatively few articles on the anatomy of the atrial chambers. Since electrophysiological mapping and interventional treatments of atrial arrhythmias involve entering the chambers, this article reviews the gross structures to provide a better understanding of the atriums, the septum, and the connecting great veins. In addition, based on the human heart, differences between porcine and canine hearts are highlighted. The right and left atriums are characterized by morphologically distinct appendages. The right atrium contains prominent muscular bundles and an extensive array of pectinate muscles. The distal ramifications of the terminal crest lead to the "flutter" isthmus. By contrast, the left atrium has relatively smooth walls. The atrial septum is limited to the valve of the oval fossa and its immediate muscular rim. Atrial musculature extends beyond the veno-atrial junctions to the outside of the pulmonary veins. The longest sleeves are around the upper pulmonary veins, and similar sleeves are seen around the superior caval vein. The structure of the atrium is more than an anatomic curiosity. It has practical implicationsfor mapping and interventional procedures. PMID: 11990664

59. **Ho SY, Anderson RH, Sánchez-Quintana D. Atrial structure and fibres: morphologic bases of atrial conduction. Cardiovasc Res. 2002 May;54(2): 325-36. PMID: 12062338 (full text available)** doi:10.1016/S0008-6363(02)00226-2.

60. **Anderson RH, Brown NA, Webb S. Development and structure of the atrial septum. Heart. 2002 Jul;88(1):104-10. (full text available)** The relationship between anatomy and function has long been recognised. Understanding the gross structure, and the myoarchitecture, of the atriums is fundamental to investigations

into the substrates and therapy of atrial fibrillation. Based primarily on our experience with normal human hearts, this review provides, firstly, a basis of comparison of gross structures as seen in the clinical situation, and in animals commonly used in experimental studies. Secondly, we discuss the general arrangement of myocardial fibres with respect to gross topography in the normal human heart. The right atrium is dominated by an extensive array of pectinate muscles within the extensive appendage, whereas the left atrium is relatively smooth-walled, with a much smaller tubular appendage. Myoarchitecture displays parallel alignment of fibres along distinct muscle bundles, such as the terminal crest and Bachmann's bundle. Within the smooth wall of the left atrium, there is a marked transmural change in the orientation of the muscular fibres. Abrupt changes in orientation, and mixed arrangements, are common between bundles. Other than Bachmann's bundle, the muscular bridges which provide interatrial connections, and connections between the left atrium and the coronary sinus and inferior caval vein, are highly variable. Inhomogeneities both in gross structure and myoarchitecture are common in the normal heart. These should be taken into account when investigating hearts from patients known to have had a history of arrhythmias, in devising computer models, or when refining diagnostic and therapeutic strategies.KeywordsAblationArrhythmia (mechanisms)Computer modellingHisto(patho)logySinus nodeSupraventr. arrhythmiaVeins

61. **Betts TR, Ho SY, Sanchez-Quintana D, Roberts PR, Anderson RH, Morgan JM. Three-dimensional mapping of right atrial activation during sinus rhythm and its relationship to endocardial architecture. J Cardiovasc Electrophysiol. 2002 Nov;13(11):1152-9.** Abstract: INTRODUCTION: Previous mapping studies of right atrial (RA) activation during sinus rhythm have been limited by the use of epicardial electrode plaques in open chest subjects or microelectrodes in the excised heart. This study describes global RA endocardial activation patterns using high-density mapping and compares the results with underlying endocardial architecture. METHODS AND RESULTS: Noncontact mapping of the RA was performed in 21 anesthetized swine. Isopotential and isochronal maps were superimposed upon three-dimensional reconstructions of RA geometry. Hearts were excised and endocardial dissection performed. Two patterns of RA activation were recorded. The site of earliest endocardial activation occurred either laterally at a position consistent with the terminal crest or superiorly at the junction between the superior caval vein and RA appendage. The subsequent spread of depolarization followed the longitudinal orientation of muscle fibers. Areas of conduction delay and block were seen at the junction between the terminal crest and posterior wall, the cavotricuspid isthmus, and around the margins of the triangle of Koch. Endocardial dissection at these sites demonstrated complex fiber orientation. A lateral site of earliest

activation demonstrated a more prominent display of conduction delay or block. CONCLUSION: The spread of the sinus impulse follows endocardial myofiber orientation and is dictated by the site of earliest activation. Even during sinus rhythm, anisotropic conduction results in areas of conduction block or delay. These findings have implications in the development of reentrant arrhythmias and may influence surgical or electrophysiologic procedures.

62. **Lemery R1.Bi-atrial mapping of atrial arrhythmias.Card Electrophysiol Rev. 2002 Dec;6(4):378-82**.Abstract Cardiac mapping of atrial activation was originally performed in animals during open chest preparations, using epicardial electrodes. The development of endocardial egg-shaped multiple electrodes provided detailed assessment of the minimum number of wavelengths required to sustain atrial fibrillation (AF), as well as the role of interatrial connections during AF. Subsequently, several studies on bi-atrial epicardial high-density mapping in animals and humans also reported on the importance of interatrial connections, as well as the specific characteristics of the left atrium as compared with the right atrium during chronic AF. Endocardial bi-atrial mapping studies using electrode catheters were reported using basket-shaped catheters carrying 64 electrodes. Animal studies suggested that septal activation was asynchronous and discordant, while a human study outlined the multiple origins of atrial ectopic beats following DC cardioversion in patients with chronic atrial fibrillation. The advent of non-fluoroscopic mapping systems significantly changed our approach to percutaneous endocardial mapping. Simultaneous bi-atrial studies using electroanatomic mapping were performed in sinus rhythm as well as in atrial flutter. These studies demonstrated the predominance of interatrial conduction over Bachmann's Bundle and the coronary sinus-left atrial connection during respectively, sinus rhythm and atrial flutter. Simultaneous bi-atrial non-contact mapping was initially performed during porcine studies and later in humans, demonstrating asynchronous and discordant septal activation both during sinus rhythm or left lateral atrial pacing. Preliminary studies from simultaneous bi-atrial non-contact mapping in humans in whom AF occurred spontaneously or was induced suggests three main types of atrial activation, consisting of left atrial drivers causing the right atrium to fibrillate following conduction over interatrial connections, the right atrium independently sustaining AF, even after pulmonary vein disconnection, and both atria fibrillating independently without activation over interatrial connections. Bi-atrial mapping has been essential for our understanding of normal and abnormal atrial activation, and ultimately may provide new approaches for ablation of atrial fibrillation.PMID: 12438816

63. **Asad N, Spodick DH. Prevalence of interatrial block in a general hospital population. Am J Cardiol. 2003 Mar 1;91(5):609-10.** No abstract available. PMID: 12615274

64. **Agarwal YK, Aronow WS, Levy JA, Spodick DH. Association of interatrial block with development of atrial fibrillation. Am J Cardiol. 2003 Apr 1;91(7): 882.** No abstract available. PMID: 12667579

65. **Farah HH, Spodick DH. Effect of interatrial block on coronary sinus contraction. Am J Cardiol. 2003 Apr 15;91(8):1004-6, A7-8.** No abstract available. PMID: 12686350

66. **Lemery R, Guiraudon G, Veinot JP. Anatomic description of Bachmann's bundle and its relation to the atrial septum. Am J Cardiol. 2003 Jun 15;91(12): 1482-5, A8.**

67. **Spodick DH. Unappreciated prevalence of interatrial block and associated consequences: a poorly perceived pandemic. Mayo Clin Proc. 2004 May;79(5): 668-70.** Review. No abstract available. PMID: 15132410

68. **Lemery R1, Soucie L, Martin B, Tang AS, Green M, Healey J.Human study of biatrial electrical coupling: determinants of endocardial septal activation and conduction over interatrial connections. Circulation. 2004 Oct 12;110(15): 2083-9.**BACKGROUND: The relative contribution of the atrial septum and interatrial connections to biatrial activation is a fundamental concept of human cardiac electrophysiology that has yet to be fully characterized. The purpose of the present study was to determine how both atria are coupled electrically.METHODS AND RESULTS:Twenty patients (16 men; mean age 54+/-11years) with a history of symptomatic atrial fibrillation (AF) underwent simultaneous biatrial noncontact mapping before catheter ablation of AF. The multiple electrode array catheters were positioned, respectively, in the left atrium (LA; transseptally) and the right atrium (RA). In all but 2 patients, isopotential maps revealed that endocardial septal activations of the RA and LA were separate, independent, and asynchronous of each other. Interatrial conduction was related to the site of initial atrial depolarization, revealing conduction over Bachmann's bundle in all patients during sinus rhythm, high RA pacing, and pacing from the LA appendage. Pacing from the coronary sinus was associated with conduction over the interatrial connection at the level of the coronary sinus in all patients, and conduction over Bachmann's bundle also occurred in 5 (26%) of 19 patients. Interatrial conduction over the fossa ovalis occurred in only 2 (2%) of the 116 segments analyzed.CONCLUSIONS:Electrical coupling of the RA and LA in humans is predominantly provided by muscular connections at the level of Bachmann's bundle and the coronary sinus. The true

septum (the fossa ovalis and its limbus) of the RA and LA is asynchronous and discordant, usually without contralateral conduction during sinus rhythm or atrial pacing.PMID: 15466628 DOI: 10.1161/01.CIR.0000144461.83835.A1[PubMed - indexed for MEDLINE] Free full textShare on FacebookShare on TwitterShare on Google+

69. **Lorbar M, Levrault R, Phadke JG, Spodick DH. Interatrial block as a predictor of embolic stroke. Am J Cardiol. 2005 Mar 1;95(5):667-8. PMID: 15721117**

70. **Ariyarajah V, Spodick DH. Advanced interatrial block: a classic electrocardiogram. Cardiology. 2005;104(1):33-4.** PMID: 15942182

71. **Ariyarajah V, Asad N, Tandar A, Spodick DH. Interatrial block: pandemic prevalence, significance, and diagnosis. Chest. 2005 Aug;128(2):970-5.** Review. No abstract available. PMID: 16100193

72. **Frisella ME, Robinette MM, Spodick DH. Interatrial block: pandemic prevalence concealed by anachronistic electrocardiographic standards. Clin Cardiol. 2005 Aug;28(8):381-3.** PMID: 16144214 Free Article

73. **Sakamoto S, Nitta T, Ishii Y, Miyagi Y, Ohmori H, Shimizu K. Interatrial electrical connections: the precise location and preferential conduction. J Cardiovasc Electrophysiol. 2005 Oct;16(10):1077-86.** Abstract: BACKGROUND: The atria are assumed to be connected electrically to each other at the level of the Bachmann's bundle, coronary sinus (CS) musculature, and interatrial septum, and these connections may have an important role in the interatrial conduction and perpetuation of various types of atrial tachyarrhythmias. However, the number, location, and preferential connections of the interatrial conduction related to the site of activation have not been examined yet. METHODS: The endocardium of both atria and the CS were mapped during continuous pacing from the left superior and inferior pulmonary veins, right pulmonary veins, upper and lower right atrium, or right atrial septum at various paced cycle lengths in 14 canines. The electrograms were recorded by custom-made form-fitted electrodes mounted on a specially designed device that allowed the septal aspects of the electrode forms to be spatially fixed to each other accurately. RESULTS: Four distinct interatrial electrical connections were identified at the Bachmann's bundle, CS, and antero-superior and postero-inferior septa. Decremental conduction was not seen in any of the connections. Bachmann's bundle was the most preferential connection during pacing from any epicardial site. The transseptal connections were evident only during pacing from the interatrial septum. The preference among the four connections was determined by the site of

stimulation and the propagation of the activation related to the myocardial architecture. CONCLUSION: These unique preferential connections may play a significant role in the interatrial conduction and perpetuation of atrial tachyarrhythmias. PMID: 16191118 DOI: 10.1111/j.1540-8167.2005.40659.x

74. **Khaja A; Flaker G. "Bachmann's Bundle: Does It Play a Role in Atrial Fibrillation?". Pacing and Clinical Electrophysiology. 2005 Aug;28(8):855–63.** doi:10.1111/j.1540-8159.2005.00168.x. PMID 16105015. Erratum in Pacing Clin Electrophysiol. 2005 Sep;28(9):1012. Abstract BACKGROUND: Cardiac anatomists have known the presence of a group of specialized fibers connecting the right and left atrium for years. However, only recently have clinical cardiologists come to recognize the potential importance of this specialized conduction system. Anatomical and microscopic studies have shown that the Bachmann's bundle (BB) represents a distinct structure similar to the atrio-ventricular node and the His-Purkinje conduction system but without any insulating tissue.RESULTS:BB cells have specialized electrophysiological properties like supernormal excitability and faster longitudinal conduction that can facilitate more rapid impulse transmission compared to the normal atrial tissue. Experimental blockage of this pathway causes prolongation and widening of the P wave, which is associated with an increased incidence of atrial fibrillation. Atrial pacing is effective in reducing the incidence of atrial fibrillation by preventing bradycardia, synchronizing the atria, limiting anisotropy and reducing the dispersion of refractoriness. Various animal and human studies have shown pacing near the right atrial insertion of BB to have a beneficial effect in patients with interatrial conduction delay and atrial tachyarrhythmias. This mode of atrial septal pacing is convenient, safe, reliable, and clinically as effective as multisite pacing.CONCLUSION:This article is an effort to define the special properties of BB and its possible role in prevention of atrial fibrillation by permanent pacemakers. PMID:16105015DOI:10.1111/j.1540-8159.2005.00168.x

75. **Frisella ME1, Robinette MM, Spodick DH.Interatrial block: pandemic prevalence concealed by anachronistic electrocardiographic standards. Clin Cardiol. 2005 Aug;28(8):381-3.** Abstract BACKGROUND: Interatrial block (IAB; P waves 2 > or =110 ms duration) has been reported in over 40% of unselected patients in sinus rhythm at widely separated general hospitals. It is thus of "pandemic" proportions. It should be better appreciated because it represents a large, baggy, poorly functional left atrium and is a forerunner of atrial fibrillation, atrial flutter, and other arrhythmias. HYPOTHESIS: A search of all 12 leads will disclose the true prevalence of IAB in contrast to traditional reliance on lead II, as widely proposed in textbooks and other literature. METHODS: In all, 500 consecutive unselected electrocardiograms (ECGs) were investigated using every lead and a magnifying graticule. For greater specificity, a minimal P duration of > or =120 ms was selected. RESULTS: Thirty-one ECGs were discarded because of atrial arrhythmia, poor baseline, or undetectable P waves, leaving a base of 469 ECGs, the denominator for the results. A total of 182 patients had IAB, representing 38.8% of this series. The widest P wave was usually found in multiple leads (95.1% of patients). The widest P waves were found only in precordial leads in 59 patients

and only in limb leads in 18 patients. "Traditional" lead II detected only 97 cases (53.3%), and IAB was found more frequently in leads V3 and V4. CONCLUSIONS: Results confirm the pandemic frequency of IAB in one-third of hospitalized patients. Interpreters of ECGs should seek IAB in all 12 leads since reliance on lead II alone resulted in only 53.3% of the total cases. Its prevalence and serious implications with regard to patients' current and future status make this necessary.PMID: 16144214[PubMed - indexed for MEDLINE]

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80. **Ariyarajah V, Mercado K, Apiyasawat S, Puri P, Spodick DH. Correlation of left atrial size with p-wave duration in interatrial block. Chest. 2005 Oct; 128(4):2615-8. PMID: 16236933**

81. **Ariyarajah V, Apiyasawat S, Moorthi R, Spodick DH. Potential clinical correlates and risk factors for interatrial block. Cardiology. 2006;105(4):213-8. PMID: 16498245**

82. **Ariyarajah V, Spodick DH. Progression of partial to advanced interatrial block. J Electrocardiol. 2006 Apr;39(2):177-9. PMID: 16580415**

83. **Ariyarajah V1, Spodick DH.Progression of advanced interatrial block to atrial flutter: a prospectively-followed case.Cardiology. 2006;106(3):161-3. Epub 2006 Apr 21.** Abstract Interatrial block (IAB; P wave > or = 110 ms), commonly associated with left atrial enlargement and its electromechanical dysfunction, is also a significant correlate of atrial tachyarrhythmias. While the arrhythmogenic mechanisms of atrial fibrillation and atrial flutter may indeed differ, there is actually considerably less literature showing evidence of prospective progression of IAB, be it partial or advanced, to atrial flutter. We present a unique case of atrial flutter occurring within months of diagnosis of advanced IAB in an otherwise healthy

female to briefly generate our discussion on the possible reasons for this scenario.Copyright 2006 S. Karger AG, Basel.PMID: 16636546 DOI: 10.1159/000092771

84. **Ariyarajah V, Puri P, Kranis M, Wilner DA, Spodick DH. Prevalence of interatrial block in the Program of All-Inclusive Care for the Elderly (PACE). Am J Geriatr Cardiol. 2006 May-Jun;15(3):174-7. PMID: 16687970**

85. **Seemann G1, Höper C, Sachse FB, Dössel O, Holden AV, Zhang H.Heterogeneous three-dimensional anatomical and electrophysiological model of human atria.Philos Trans A Math Phys Eng Sci. 2006 Jun 15;364(1843): 1465-81. (free text)** Abstract Investigating the mechanisms underlying the genesis and conduction of electrical excitation in the atria at physiological and pathological states is of great importance. To provide knowledge concerning the mechanisms of excitation, we constructed a biophysical detailed and anatomically accurate computer model of human atria that incorporates both structural and electrophysiological heterogeneities. The three-dimensional geometry was extracted from the visible female dataset. The sinoatrial node (SAN) and atrium, including crista terminalis (CT), pectinate muscles (PM), appendages (APG) and Bachmann's bundle (BB) were segmented in this work. Fibre orientation in CT, PM and BB was set to local longitudinal direction. Descriptions for all used cell types were based on modifications of the Courtemanche et al. model of a human atrial cell. Maximum conductances of Ito, IKr and ICa,L were modified for PM, CT, APG and atrioventricular ring to reproduce measured action potentials (AP). Pacemaker activity in the human SAN was reproduced by removing IK1, but including If, ICa,T, and gradients of channel conductances as described in previous studies for heterogeneous rabbit SAN. Anisotropic conduction was computed with a monodomain model using the finite element method. The transversal to longitudinal ratio of conductivity for PM, CT and BB was 1:9. Atrial working myocardium (AWM) was set to be isotropic. Simulation of atrial electrophysiology showed initiation of APs in the SAN centre. The excitation spread afterwards to the periphery near to the region of the CT and preferentially towards the atrioventricular region. The excitation extends over the right atrium along PM. Both CT and PM activated the right AWM. Earliest activation of the left atrium was through BB and excitation spread over to the APG. The conduction velocities were 0.6ms-1 for AWM, 1.2ms-1 for CT, 1.6ms-1 for PM and 1.1ms-1 for BB at a rate of 63bpm. The simulations revealed that bundles form dominant pathways for atrial conduction. The preferential conduction towards CT and along PM is comparable with clinical mapping. Repolarization is more homogeneous than excitation due to the heterogeneous distribution of electrophysiological properties and hence the action

potential duration. PMID: 16766355 DOI: 10.1098/rsta.2006.1781[PubMed - indexed for MEDLINE] Free full text

86. **Ariyarajah V, Spodick DH. The Bachmann Bundle and interatrial conduction. Cardiol Rev. 2006 Jul-Aug;14(4):194-9. Review. PMID: 16788332** Abstract: The cardiac conduction system (CCS) is responsible for generation and systematic conduction of cardiac impulses. The Bachmann Bundle (BB), considered one of its several accessory impulse-conducting pathways, plays a fundamental role in interatrial conduction. Delay in this pathway leads to prolongation of the P wave on the electrocardiogram (interatrial delay or block), which in turn is a precursor for atrial tachyarrhythmias, mainly atrial fibrillation and significant left atrial electromechanical dysfunction. As such, the magnitude of its sequelae has necessitated a flurry of investigations that have been targeted toward its prevention and management. Although current studies on the use of angiotensin-converting enzyme inhibitors and atrial pacing have indeed shown some promise, it would be shortsighted to overlook and circumvent the actual underlying lesion-BB abnormality. Thus, a thorough understanding of the CCS and interatrial conduction is essential. We review current literature on the BB and discuss potential mechanisms that affect its conduction. PMID: 16788332 DOI: 10.1097/01.crd.0000195221.26979.2b

87. **Ariyarajah V, Apiyasawat S, Spodick DH. Optimal P-wave duration for bedside diagnosis of interatrial block. Ann Noninvasive Electrocardiol. 2006 Jul;11(3):259-62. PMID: 16846442**

88. **Ariyarajah V, Apiyasawat S, Puri P, Spodick DH. Specific electrocardiographic markers of P-wave morphology in interatrial block. J Electrocardiol. 2006 Oct; 39(4):380-4. PMID: 16895770**

89. **Ariyarajah V, Apiyasawat S, Spodick DH. Association of Duke prognostic treadmill scores with change in P-wave duration during exercise tolerance tests in patients with interatrial block and coronary heart disease. Am J Cardiol. 2006 Sep 15;98(6):786-8.** PMID: 16950185

90. **Ariyarajah V, Frisella ME, Spodick DH. Reevaluation of the criterion for interatrial block. Am J Cardiol. 2006 Oct 1;98(7):936-7.** PMID: 16996878

91. **Ariyarajah V1, Apiyasawat S, Najjar H, Mercado K, Puri P, Spodick DH.Frequency of interatrial block in patients with sinus rhythm hospitalized for stroke and comparison to those without interatrial block.Am J Cardiol. 2007 Jan 1;99(1):49-52.Abstract** Interatrial block (IAB; P wave > or =110 ms) is a potent correlate of left atrial (LA) enlargement and electromechanical dysfunction and a strong predictor of atrial tachyarrhythmias, in particular, atrial fibrillation.

Although these associations increase its risk for embolism, i.e., cardioembolic stroke, such a phenomenon has been inadequately investigated. We investigated 85 general hospital patients who had been admitted to the neurologic unit between January 2003 and December 2004 for embolic stroke. Of those, 66 patients who had electrocardiograms that showed sinus rhythm were evaluated for IAB and categorized as those with IAB and those without (controls). Medical records were then reviewed for common co-morbidities and stroke risk factors, high-resolution carotid artery Doppler ultrasonographic study reports, and 2-dimensional echocardiograms obtained during the current admission for embolic stroke; 40 patients (61%) had IAB. There was a 55% prevalence of LA enlargement (diameter in the parasternal long-axis view > or =40 mm, p <0.001). LA thrombi and/or spontaneous contrast ("smoke") were noted on echocardiograms in 6 patients with IAB (15%) but not in any of the controls (p = 0.038). Five of those 6 patients with such LA thrombi had dilated LA cavities. In conclusion, IAB could be a risk for embolic stroke due to its known sequelae of LA dilation and electromechanical dysfunction that predispose to thrombosis. If prospective studies prove this to be so, the need for anticoagulation use in such patients should be investigated. PMID: 17196461 DOI: 10.1016/j.amjcard.2006.07.060

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93. **Ariyarajah V, Fernandes J, Kranis M, Apiyasawat S, Mercado K, Spodick DH. Prospective evaluation of atrial tachyarrhythmias in patients with interatrial block. Int J Cardiol. 2007 Jun 12;118(3):332-7.** PMID: 17027099.

94. **Ariyarajah V , Puri P , Apiyasawat S , et al. Interatrial block: a novel risk factor for embolic stroke? *Ann Noninvasive Electrocardiol.* 2007;12:15–20.**

95. **Spodick DH, Ariyarajah V, Apiyasawat S. Higher prevalence of cardiovascular events among patients with abnormal atrial depolarization and coronary artery disease at 18 months' post-exercise tolerance testing. Am Heart Hosp J. 2007 Fall;5(4):236-40. PMID: 17982305**

96. **Holmqvist F1, Platonov PG, Carlson J, Havmöller R, Waktare JE, McKenna WJ, Olsson SB, Meurling CJ.Variable interatrial conduction illustrated in a hypertrophic cardiomyopathy population. Ann Noninvasive Electrocardiol. 2007 Jul;12(3):227-36.** Abstract BACKGROUND: Patients with hypertrophic cardiomyopathy (HCM) have a high incidence of atrial fibrillation. They also have a

longer P-wave duration than healthy controls, indicating conduction alterations. Previous studies have demonstrated orthogonal P-wave morphology alterations in patients with paroxysmal atrial fibrillation. In the present study, the P-wave morphology of patients with HCM was compared with that of matched controls in order to explore the nature of the atrial conduction alterations.METHODS AND RESULTS:A total of 65 patients (45 men, mean age 49 +/- 15) with HCM were included. The control population (n = 65) was age and gender matched (45 men, mean age 49 +/- 15). Five minutes of 12-lead ECG was recorded. The data were subsequently transformed to orthogonal lead data, and unfiltered signal-averaged P-wave analysis was performed. The P-wave duration was longer in the HCM patients compared to the controls (149 +/- 22 vs 130 +/- 16 ms, P < 0.0001). Examination of the P-wave morphology demonstrated changes in conduction patterns compatible with interatrial conduction block of varying severity in both groups, but a higher degree of interatrial block seen in the HCM population. These changes were most prominent in the Leads Y and Z. CONCLUSION: The present study suggests that the longer P-wave duration observed in HCM patients may be explained by a higher prevalence of block in one or more of the interatrial conduction routes. PMID: 17617068 DOI: 10.1111/j.1542-474X.2007.00166.x[PubMed - indexed for MEDLINE]

97. **Gialafos E1, Psaltopoulou T, Papaioannou TG, Synetos A, Dilaveris P, Andrikopoulos G, Vlasis K, Gialafos J, Stefanadis C. Prevalence of interatrial block in young healthy men<35 years of age. Am J Cardiol. 2007 Sep 15;100(6): 995-7.** AbstractInteratrial block (IAB; P-wave duration>or=110 ms) is highly prevalent and is strongly associated with atrial tachyarrhythmias and left atrial dysfunction. Very few studies have examined IAB in young healthy subjects. The aim of the present study was to demonstrate the prevalence of IAB and its possible relation with clinical variables in 1,353 young healthy men. It was found that 9.1% of healthy men aged<35 years and 5.4% of those aged<20 years had P-wave durations>or=110 ms. The frequent presence of IAB in leads II, V3, and V5 was also observed. Age and heart rate were independent significant determinants of IAB. In conclusion, IAB is a frequent phenomenon, even at young ages. Thus, the early recognition of IAB might be important, possibly contributing to the prevention of future cardiovascular complications.PMID: 17826385 DOI: 10.1016/j.amjcard. 2007.04.041

98. **Platonov PG1.Interatrial conduction in the mechanisms of atrial fibrillation: from anatomy to cardiac signals and new treatment modalities. Europace. 2007** Suppl 6:vi10-6**.** Abstract Areas of slow conduction and conduction block are important prerequisites for re-

entry known to underlie atrial fibrillation (AF). Experimental and clinical data show that AF is associated with global lowering of atrial propagation velocity and the presence of defects in the interatrial conduction routes. The increasing data from anatomical studies demonstrate the possible prerequisites for conduction disturbances that could be primarily because of anatomical variability in interatrial connections or because of age-related development of fibrotic changes in the atrial musculature. More detailed descriptions of the structure and function of the interatrial connections other than Bachmann's bundle have become available and, as a result, the role of these connections in the mechanisms of AF is increasingly appreciated. Interatrial pacing studies show promising results, but further studies on larger amounts of materials are required in order to identify the population of patients who would benefit more effectively from this treatment as well as the optimal pacing technique. Therefore, more extensive documentation is required before therapeutic modalities aimed at improving interatrial conduction will become a part of the clinical routine in the management of AF patients. PMID: 17959684 DOI: 10.1093/europace/eum201[PubMed - indexed for MEDLINE] **Fre full text**

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101.**Ariyarajah V, Ali M, Spodick DH. Intermittent advanced atrial depolarization abnormality? Cardiology. 2008;110(1):68-72. PMID: 17934272**

102.Ariyarajah V, Shaikh N, Spodick DH. Exercise-induced improvement in atrial depolarization abnormality in a patient after treatment with beta-adrenergic blockers. Cardiology. 2008;111(1):36-40. doi: 10.1159/000113425. PMID: 18239390

103.**Ariyarajah V, Fernandes J, Apiyasawat S, Spodick DH. Differences in echocardiographic indices between patients with partial and advanced interatrial conduction delay. Am Heart Hosp J. 2008 Winter;6(1):42-7. PMID: 18256557**

104.**Platonov PG1, Mitrofanova L, Ivanov V, Ho SY.Substrates for intra-atrial and interatrial conduction in the atrial septum: anatomical study on 84 human hearts.Heart Rhythm. 2008 Aug;5(8):1189-95. doi: 10.1016/j.hrthm. 2008.04.025**. Abstract BACKGROUND: Technical developments in the management of atrial arrhythmias revived interest into the detailed knowledge of

atrial anatomy. The atrial septum (AS), known for its complex structure, has been particularly difficult to study, and our knowledge of the muscular bundles providing routes for intra-atrial and interatrial conduction within the AS remains limited. OBJECTIVE: The purpose of this study was to describe myocardial arrangement within the AS and adjacent parts of atrial walls for delineation of possible substrates for interatrial and intra-atrial conduction. METHODS: Human heart specimens from 84 postmortem studies were studied using conventional morphometric assessment, blunt dissection, and light microscopy of serial histological sections of AS. RESULTS: Interatrial muscular connections are present anteriorly, posteriorly between right pulmonary veins, and inferiorly between the coronary sinus and the right inferior pulmonary vein. The inferior connections can be more prominent than the Bachmann bundle. Atrial musculature in the fossa ovalis consists of muscular bands isolated by fatty tissue from the endocardium of the right and left atrium. They are arranged along the anterior-posterior axis and have connections with left atrial myocardium. Myocardial fascicles in the posterior-inferior and superior portions of the muscular rim of fossa ovalis originate on the right atrial side and can be traced toward the atrioventricular node.CONCLUSION:The general myocardial arrangement in the AS and adjacent regions of atrial walls are important for understanding propagation of atrial activation for selection of the optimal treatment strategy.Comment inThe myocyte relative to atrial myocardial architecture. [Heart Rhythm. 2008]PMID: 18675231 DOI: 10.1016/j.hrthm.2008.04.025

105. **Raja A, Ariyarajah V, Fernandes J, Apiyasawat S, Khadem A, Barac I, Spodick DH. Differences in treadmill exercise tolerance parameters between patients with partial and advanced interatrial depolarization abnormality. Am J Cardiol. 2008 Oct 1;102(7):866-70. doi: 10.1016/j.amjcard.2008.05.026. PMID: 18805112**

106. **Baranchuk A, Michael K, Syed U, Simpson CS, Redfearn DP. Intermittent interatrial block after electrical cardioversion for atrial fibrillation. J Electrocardiol. 2008 Nov-Dec;41(6):662-4.** doi: 10.1016/j.jelectrocard. 2008.03.005.PMID: 18462744

107. **Spodick DH. Advanced ('third-degree' or 'complete') interatrial block. Am Heart Hosp J. 2009 Summer;7(1):63-4. No abstract available. PMID: 19742437**

108. **Ho SY, Sánchez-Quintana D. The importance of atrial structure and fibers. Clin Anat. 2009 Jan;22(1):52-63.** Abstract: Atrial structures are important in the current era of cardiac interventions using percutaneous transcatheter procedures. Understanding their locations and component parts helps to reduce risks of procedural-related damage. The general arrangement of the myofibers that make up the atrial walls is reviewed to provide a morphologic basis for atrial conduction and potential substrates of arrhythmias. The right atrium, dominated by its appendage, is characterized by having an extensive array of pectinate muscles. These extend almost perpendicularly from the terminal crest. The left atrium has relatively smooth walls and a small tubular-shaped appendage. The myofibers show changes in orientations when traced through the thickness of the walls. Extensions of atrial myocardium onto the pulmonary veins and the superior caval vein are common. Apart from Bachmann's bundle, there are other muscular bridges of variable numbers and sizes that provide interatrial connections, connections between the left atrium and the coronary sinus, and connections between the muscular sleeves of the right pulmonary veins and the right atrium. The purpose of this review is to summarize the three-dimensional arrangement of gross atrial structures, the myoarchitecture and variations in muscular interatrial connections. These are important features in intra- and interatrial conduction.PMID: 18470938 doi: 10.1002/ca.20634.

109. **Spodick DH, Ariyarajah V, Goldberg R. Interatrial block: correlation with P-terminal force. Clin Cardiol. 2009 Apr;32(4):181-2. doi: 10.1002/clc.20329. PMID: 19353697 Free Article** Abstract **BACKGROUND AND HYPOTHESIS:** Interatrial block (IAB: P-duration > 100 ms) is poorly recognized in hospital populations. In addition to reduced left atrial function and left atrial enlargement it predicts atrial fibrillation and other arrthymias. P-terminal force (Ptf): +/- biphasic P in lead V(1) > or = area of 1 small square on the electrocardiogram (ECG) grid also indicates left atrial abnormality, particularly left atrial enlargement. These 2 should be related. We determined the intercorrelation. **METHODS AND RESULTS:** Two blinded observers evaluated 500 consecutive patients' ECGs for both Ptf and IAB utilizing all 12 leads for IAB and V(1) for Ptf. Measurement differences were resolved in a consensus conference. Among 482 usable ECGs, IAB and Ptf were strongly and significantly correlated (chi(2) = 68.041; P < or = .001). **CONCLUSION:** IAB and Ptf are significantly and strongly correlated and one should be expected in the majority of cases when the other is recognized.PMID: 19353697DOI:10.1002/clc.20329

110. **Spodick DH, Ariyarajah V. Interatrial block: the pandemic remains poorly perceived. Pacing Clin Electrophysiol. 2009 May;32(5):667-72. doi: 10.1111/j.1540-8159.2009.02343.x.** Review. PMID: 19422591Abstract Interatrial block (IAB; P duration >or=110 ms) is a common electrocardiogram abnormality, which in addition to reduced left atrial function predicts atrial fibrillation and other arrhythmias. P terminal force (Ptf) +/- biphasic P in lead V(1)>or= the area of one small square on the grid also indicates left atrial abnormality, particularly left atrial enlargement, which is a strong correlate of IAB. Among 482 consecutively recorded electrocardiograms, IAB and Ptf were strongly and significantly correlated (chi(2)= 68.041; P <or= 0.001).In conclusion, interatrial block exists in pandemic proportions in unselected hospital patients. Because of its pathologic implications it requires widespread attention which, heretofore, has been lacking.PMID: 19422591 DOI: 10.1111/j.1540-8159.2009.02343.x

111. **Fernandes J, Ariyarajah V, Apiyasawat S, Spodick DH. Prospective assessment of cardiovascular events in patients with partial and advanced interatrial conduction delay: a preliminary observation. Int J Cardiol. 2009 Jun 12;135(1):124-5. doi: 10.1016/j.ijcard.2008.01.016. PMID: 18486248.**

112. **Havmöller R1, Carlson J, Holmqvist F, Olsson B, Platonov P. Evolution of P-wave morphology in healthy individuals: a 3-year follow-up study.Ann Noninvasive Electrocardiol. 2009 Jul;14(3):226-33. doi: 10.1111/j.1542-474X.2009.00301.x**.Abstract BACKGROUND: Orthogonal P-wave morphology in healthy men and women has been described using unfiltered signal-averaged technique and holds information on interatrial conduction. The stability of P-wave morphology in healthy subjects over time is not fully known. METHODS: Sixty-seven healthy volunteers were investigated (29 males, aged 63 +/- 14 years, 48 females, 60 +/- 13 years). Orthogonal lead data (X, Y, and Z) were derived from standard 12-lead ECGs (recording length 6 minutes, sampling rate 1kHz, resolution 0.625 muV) recorded at baseline (BL), and 3 years later at follow-up (FU). P waves were then signal-averaged and analyzed regarding P-wave morphology, locations of maxima, minima, zero-crossings, and P-wave duration (PWD). RESULTS: No differences of P-wave variables were observed at FU compared to BL, including PWD (127 +/- 12 vs 125 +/- 14 ms at BL and FU, respectively, n.s.). In 59 of the 67 subjects (88%), the P-wave morphology was unaltered at FU. However, in the remaining eight cases a distinctively different morphology was observed. The most common change (P=0.030) was from negative polarity to biphasic (-/+) in Lead Z (n=5). In one case the opposite change was observed and in two cases transition into advanced interatrial block morphology was evident at FU. CONCLUSIONS: In the majority of healthy subjects, P-wave morphology is stable at 3-year FU. Subtle morphological changes, observed principally in Lead Z, suggest variation of

interatrial conduction. These changes could not be detected by measuring conventional PWD that remained unchanged in the total population. PMID: 19614633 DOI: 10.1111/j.1542-474X.2009.00301.x[PubMed - indexed for MEDLINE]

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114.**Baranchuk A, Parfrey B, Lim L, Morriello F, Simpson CS, Hopman WM, Redfearn DP, Fitzpatrick M. Interatrial block in patients with obstructive sleep apnea. Cardiol J. 2011;18(2):171-5.** PMID: 21432824 **Free Article**

115.**Spodick DH. Acute pericarditis superimposed on right bundle branch block, posterior fascicular block, and interatrial block. Am Heart Hosp J. 2011 Winter;9(2):112-3. No abstract available. PMID: 24839648**

116.Proietti R, Mafrici A, Spodick DH. Dynamic variations of P-wave duration in a patient with acute decompensated congestive heart failure. Cardiol J. 2012;19(1):95-7. PMID: 22298177 Free Article

117.Zhao J1, Butters TD, Zhang H, Pullan AJ, LeGrice IJ, Sands GB, Smaill BH.An image-based model of atrial muscular architecture: effects of structural anisotropy on electrical activation.Circ Arrhythm Electrophysiol. 2012 Apr; 5(2):361-70. doi: 10.1161/CIRCEP.111.967950. (Full text free) Abstract BACKGROUND: Computer models that capture key features of the heterogeneous myofiber architecture of right and left atria and interatrial septum provide a means of investigating the mechanisms responsible for atrial arrhythmia. The data necessary to implement such models have not previously been available. The aims of this study were to characterize surface geometry and myofiber architecture throughout the atrial chambers and to investigate the effects of this structure on atrial activation. METHODS AND RESULTS: Atrial surface geometry and myofiber orientations were reconstructed in 3D at 50×50×50-μm(3) resolution from serial images acquired throughout the sheep atrial chambers. Myofiber orientations were determined by Eigen-analysis of the structure tensor. These data have been incorporated into an anatomic model that provides the first quantitative representation of myofiber architecture throughout the atrial chambers. By simulating activation on this 3D structure, we have confirmed the roles of specialized myofiber tracts such as the crista terminalis, pectinate muscles, and the Bachman bundle on the spread of activation from the sinus node. We also demonstrate how the complex myocyte arrangement in the posterior left atrium contributes to activation time dispersion adjacent to the pulmonary veins and

increased vulnerability to rhythm disturbance generated by ectopic stimuli originating in the pulmonary vein sleeves. CONCLUSIONS: We have developed a structurally detailed, image-based model of atrial anatomy that provides deeper understanding of the role that myocyte architecture plays in normal and abnormal atrial electric function. PMID: 22423141 DOI: 10.1161/CIRCEP.111.967950

118. **Chhabra L, Srinivasan I, Sareen P, Anand C, Spodick DH. Interatrial block - a novel risk factor for acute mesenteric ischemia. Indian J Gastroenterol. 2012 Jul;31(4):191-4. PMID: 22763894.**

119. **Bayés de Luna A1, Platonov P, Cosio FG, Cygankiewicz I, Pastore C, Baranowski R, Bayés-Genis A, Guindo J, Viñolas X, Garcia-Niebla J, Barbosa R, Stern S, Spodick D.Interatrial blocks. A separate entity from left atrial enlargement: a consensus report.J Electrocardiol. 2012 Sep;45(5):445-51. doi: 10.1016/j.jelectrocard.2012.06.029**.AbstractImpaired interatrial conduction or interatrial block is well documented but is not described as an individual electrocardiographic (ECG) pattern in most of ECG books, although the term atrial abnormalities to encompass both concepts, left atrial enlargement (LAE) and interatrial block, has been coined. In fact, LAE and interatrial block are often associated, similarly to what happens with ventricular enlargement and ventricular block. The interatrial blocks, that is, the presence of delay of conduction between the right and left atria, are the most frequent atrial blocks. These may be of first degree (P-wave duration >120 milliseconds), third degree (longer P wave with biphasic [±] morphology in inferior leads), and second degree when these patterns appear transiently in the same ECG recording (atrial aberrancy). There are evidences that these electrocardiographic P-wave patterns are due to a block because they may (a) appear transiently, (b) be without associated atrial enlargement, and (c) may be reproduced experimentally. The presence of interatrial blocks may be seen in the absence of atrial enlargement but often are present in case of LAE. The most important clinical implications of interatrial block are the following: (a) the first degree interatrial blocks are very common, and their relation with atrial fibrillation and an increased risk for global and cardiovascular mortality has been demonstrated; (b) the third degree interatrial blocks are less frequent but are strong markers of LAE and paroxysmal supraventricular tachyarrhythmias. Their presence has been considered a true arrhythmological syndrome.Copyright © 2012 Elsevier Inc. All rights reserved.Comment inInteratrial block vs left atrial enlargement. [J Electrocardiol. 2012]PMID:22920783DOI:10.1016/j.jelectrocard. 2012.06.029

120. **Chhabra L, Chaubey VK, Kothagundla C, Bajaj R, Kaul S, Spodick DH. P-wave indices in patients with pulmonary emphysema: do P-terminal force and**

interatrial block have confounding effects? Int J Chron Obstruct Pulmon Dis. 2013;8:245-50. doi: 10.2147/COPD.S45127. PMID: 23690680 Free PMC Article

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126.Chhabra L, Devadoss R, Chaubey VK, Spodick DH. Interatrial block in the modern era. Curr Cardiol Rev. 2014 Aug;10(3):181-9. Review. PMID: 24827803 Free PMC Article

127.**Proietti R, Russo V, Sagone A, Viecca M, Spodick DH. [Interatrial block: an under-recognized electrocardiographic diagnosis with important clinical-therapeutic implications]. G Ital Cardiol (Rome). 2014 Oct;15(10):561-8. doi: 10.1714/1672.18308. Review. Italian. PMID: 25424020**

128.**Almehairi M, Baranchuk A, Johri A, Caldwell J. An unusual cause of automatic mode switching in the absence of an atrial tachyarrhythmia. Pacing Clin Electrophysiol. 2014 Jun;37(6):777-80.** doi: 10.1111/pace.12296. No abstract available. PMID: 24215336

129. **Conde D, van Oosten EM, Hamilton A, Petsikas D, Payne D, Redfearn DP, Hopman WM, Bayés de Luna A, Baranchuk A. Prevalence of interatrial block in patients undergoing coronary bypass graft surgery. Int J Cardiol. 2014 Feb 15;171(3):e98-9.** doi: 10.1016/j.ijcard.2013.12.002. No abstract available. PMID: 24351418

130. **Conde D, Baranchuk A. [Interatrial block as anatomical-electrical substrate for supraventricular arrhythmias: Bayés syndrome]. Arch Cardiol Mex. 2014 Jan-Mar;84(1):32-40.** Abstract: In this article, we aimed to establish that interatrial block exists as an anatomical-electrical entity, which should be considered a true block. Interatrial block presents with different degrees as other blocks in the conduction system. It shows a correlation with the left atrium size, however, it can be seen in patients with normal atrial size too. Interatrial block is strongly associated with atrial arrhythmias and it could be considered a predictor of cardioembolic stroke. Interatrial block is an expression of atrial electrical remodeling and dysfunction. IAB can be transient and in certain clinical circumstances, may be reversible. The contribution of endocardial mapping has increased our knowledge of the anatomy and pathophysiology of interatrial block. Magnetocardiography could be a possible non-invasive procedure to further investigate this entity. The interatrial block classification should include first, second and third degree or alternatively, in order to simplify the terminology: partial or advanced. The P wave morphology should always be taking into consideration when diagnosing this condition. Finally, without the initial description of interatrial block made by Dr. Bayés de Luna, it would be impossible to understand interatrial block as an anatomical and electrical substrate for atrial arrhythmias. It is our opinion that this represents a major contribution to the knowledge of electrocardiography and electrophysiology, and makes commendable that this arrhythmic syndrome should be called «Bayés' syndrome». doi: 10.1016/j.acmx.2013.10.004. Review. Spanish.

131. **Enriquez A, Conde D, Hopman W, Mondragon I, Chiale PA, de Luna AB, Baranchuk A. Advanced interatrial block is associated with recurrence of atrial fibrillation post pharmacological cardioversion. Cardiovasc Ther. 2014 Apr; 32(2):52-6.** Abstract: INTRODUCTION: Management of atrial fibrillation (AF) is hampered by frequent recurrences after restoration of sinus rhythm. Delayed interatrial conduction has been associated with the development of AF in different clinical settings. The aim of our study was to assess whether advanced interatrial block (aIAB) was associated with AF recurrence after pharmacological cardioversion with two different antiarrhythmic drugs. METHODS: We included 61 patients with recent onset AF without structural heart disease that underwent successful pharmacological cardioversion. Thirty-one patients received a single oral dose of propafenone, and 30 patients received iv vernakalant. A 12-lead ECG (filter

150 Hz, 25 mm/s, 10 mm/mV) after conversion was evaluated for the presence of interatrial block (IAB); partial (pIAB): P-wave duration > 120 ms, and advanced (aIAB): P-wave > 120 ms and biphasic morphology (±) in inferior leads. Clinical follow-up and electrocardiographic recordings were performed for a 12-month period. RESULTS: Age was 58 ± 10.4 years and 50.8% were male. aIAB was present in 11 patients (18%) and pIAB in 10 (16.4%). At 1-year follow-up, 22 patients (36%) had AF recurrence. The recurrence rate with aIAB was 90.9% versus 70% in those with pIAB and 12.5% in normal P-wave duration (P = 0.001). The presence of aIAB was strongly associated with AF recurrence (odds ratio 18.4 in multivariable modeling). Recurrence was not affected by the drug used for cardioversion (P = 0.92). CONCLUSION: Advanced interatrial block is associated with higher risk of AF recurrence at 1 year after pharmacological cardioversion, independent of the drug used. PMID: 24417765 DOI: 10.1111/1755-5922.12063

132. **Huo Y1, Mitrofanova L2, Orshanskaya V2, Holmberg P3, Holmqvist F3, Platonov PG3.P-wave characteristics and histological atrial abnormality.J Electrocardiol. 2014 May-Jun;47(3):275-80. doi: 10.1016/j.jelectrocard. 2014.01.011.** Fibro-fatty transformation is believed to be the leading cause of deteriorated atrial conduction; however, any direct assessment in relation to P-wave characteristics is lacking. We sought to assess P-wave morphology (PWM) and duration (PWD) in relation to histology of the atrial myocardium.OBJECTIVE: Atrial specimens were collected from 11 patients who died from cardiovascular causes (7 men; median age 73 years). METHODS:Tissue samples were taken at the level of superior and inferior PVs, center of posterior left atrial wall, terminal crest (CT) and Bachmann's bundle (BB) for assessment of fibro-fatty tissue extent. Standard 12-lead ECGs in sinus rhythm recorded during hospital stay were used for manual assessment of P-wave. Partial interatrial block (pIAB) was defined as a prolonged (≥ 120 ms) and bimodal P-wave in any lead on 12-lead ECG. RESULTS:The median PWD was 160 (120-200) ms. Fibrosis extent in CT highly correlated to PWD ($r=0.914$, $p<0.001$). The combination of fibrosis extent and fatty tissue in BB (16%, range 1%-41%), CT (18%, range 3%-47%) or superior PV (15%, range 6%-24%) correlated to PWD ($r=0.627$, $p=0.039$; $r=0.795$, $p=0.003$; and $r=0.668$, $p=0.025$, respectively). pIAB pattern was observed in 10 subjects; however, it was not associated with either fibrosis or fatty tissue content at any sampling location. CONCLUSIONS: Our findings further support causal association between PWD and the extent of structural abnormalities in the atrial myocardium and the major atrial conduction routes. KEYWORDS: Fibro-fatty transformation; P-wave duration; P-wave morphologyPMID: 24602335 DOI: 10.1016/j.jelectrocard.2014.01.011

133. **Enriquez A, Conde D, Femenia F, de Luna AB, Ribeiro A, Muratore C, Valentino M, Retyk E, Galizio N, Hopman WM, Baranchuk A. Relation of interatrial block to new-onset atrial fibrillation in patients with Chagas cardiomyopathy and implantable cardioverter-defibrillators. Am J Cardiol. 2014 May 15;113(10):1740-3.** Abstract: Chagas cardiomyopathy is an endemic disease in Latin America. A significant proportion of patients develop atrial fibrillation (AF), which may result in stroke and increased morbidity or mortality. Interatrial block (IAB) has been associated with the development of AF in different clinical scenarios. The aim of our study was to determine whether IAB can predict new-onset AF in patients with Chagas cardiomyopathy and implantable cardioverter-defibrillators (ICDs). We conducted a retrospective study of patients with Chagas cardiomyopathy and ICDs from 14 centers in Latin America. Demographics, clinical, and device follow-up were collected. Surface electrocardiograms were scanned at 300 dpi and maximized ×8. Semiautomatic calipers were used to determine P-wave onset and offset. Partial IAB was defined as a P wave of >120 ms and advanced IAB as a P wave of >120 ms with biphasic morphology (±) in inferior leads. AF events and ICD therapies were reviewed during follow-up by 2 independent investigators. A total of 80 patients were analyzed. Mean age was 54.6 ± 10.4 years, and 52 (65%) were male. Mean left ventricular ejection fraction was 40 ± 12%. IAB was detected in 15 patients (18.8%), with 8 (10.0%) partial and 7 (8.8%) advanced. During a follow-up of 33 ± 20 months, 11 patients (13.8%) presented with new AF. IAB (partial + advanced) was strongly associated with new AF ($p < 0.0001$) and inappropriate therapy by the ICD ($p = 0.014$). In conclusion, IAB (partial + advanced) predicted new-onset AF in patients with Chagas cardiomyopathy and ICDs. PMID: 24698463 doi: 10.1016/j.amjcard.2014.02.036.

134. **Baranchuk A, Conde D, Enriquez A, de Luna AB. P-wave duration or P-wave morphology? Interatrial block: seeking for the Holy Grail to predict AF recurrence. Ann Noninvasive Electrocardiol. 2014 Jul;19(4):406-8.** PMID: 24829074 DOI: 10.1111/anec.12156.

135. **Petersson R1, Berge HM, Gjerdalen GF, Carlson J, Holmqvist F, Steine K, Platonov PG.P-wave morphology is unaffected by atrial size: a study in healthy athletes.Ann Noninvasive Electrocardiol. 2014 Jul;19(4):366-73. doi: 10.1111/anec.12132**. Abstract BACKGROUND: Orthogonal P-wave morphology has previously been described in different populations, but its relation to atrial size has not been studied in detail. In this study, we investigated whether atrial size affects P-wave morphology in athletes, who are known to have different degrees of atrial enlargement.METHODS:A total of 504 healthy, male, professional soccer players were included (median age 25 years). All underwent echocardiographic and 12-lead

electrocardiographic (ECG) recordings. The ECG was transformed into orthogonal leads, using the inverse Dower transform. The association between echocardiographic parameters and standard P-wave measures (i.e., orthogonal morphology, left atrial abnormality assessed as negative P-wave terminal force [PTF] in lead V1 > 0.04 mm × s, and duration) was analyzed.RESULTS:The vast majority had either type 1 P-wave morphology (75%) (positive leads X and Y and negative lead Z) or type 2 P-wave morphology (22%) (positive leads X and Y and biphasic lead Z [negative/positive]). Left atrial enlargement (≥29 mL/m(2)) was found in 79% on echocardiography. There was no significant difference in left atrial end-systolic volume, left or right atrial diameters, or right atrial area between individuals with different P-wave morphologies. ECG signs of left atrial abnormality were found in eight subjects, who did not have significantly larger left atrial dimensions than the rest.CONCLUSIONS:We demonstrated that P-wave morphology does not depend on the size of the atria in young, healthy athletes, and that PTF is not a reliable marker of left atrial enlargement in the current population.KEYWORDS:P-wave morphology; atrial electrophysiology; atrium;echocardiography; electrocardiographyPMID: 24517470 DOI: 10.1111/anec.12132

136. **Chhabra L, Devadoss R, Chaubey VK, Spodick DH1.nteratrial block in the modern era.Curr Cardiol Rev. 2014 Aug;10(3):181-9(Full text avaliabel otimo)**.AbstractInteratrial block (IAB; P-wave duration ≥ 110 ms), which represents a delay in the conduction between the atria, is a pandemic conduction abnormality that is frequently underappreciated in clinical practice. Despite its comprehensive documentation in the medical literature, it has still not received adequate attention and also not adequately described and discussed in most cardiology textbooks. IAB can be of varying degrees and classified based on the degree of P-duration and its morphology. It can transform into a higher degree block and can also manifest transiently. IAB may be a preceding or causative risk factor for various atrial arrhythmias (esp. atrial fibrillation) and also be associated with various other clinical abnormalities ranging from left atrial dilation and thromboembolism including embolic stroke and mesenteric ischemia. IAB certainly deserves more attention and prospective studies are needed to formulate a standard consensus regarding appropriate management strategies.PMID: 24827803 PMCID: PMC4040870

137. **Enriquez A, Conde D, Villuendas R, Bayes-Genis A, de Luna AB, Baranchuk A. To the Editor--interatrial block and atrial fibrillation: invasive and noninvasive measurements may help to define the syndrome. Heart Rhythm. 2014 Nov;11(11):e197-8.** doi: 10.1016/j.hrthm.2014.07.029. No abstract available.

138.Chhabra L, Chaubey VK, Spodick DH. Letter by Chhabra et al regarding article, "Prevalence and prognostic significance of abnormal P terminal force in lead V1 of the electrocardiogram in the general population".Circ Arrhythm Electrophysiol. 2015 Feb;8(1):243. doi: 10.1161/CIRCEP.114.002646. No abstract available.PMID: 25691561 Eranti et al1 report an interesting correlation between an underappreciated electrocardiogram parameter, that is, P terminal force (PTF), and mortality. Indeed, PTF magnitude ≥0.04 mm·ms, if present along with an interatrial block (P-wave duration >110 ms), is considered highly specific and reasonably sensitive for diagnosing left atrial enlargement.2 The determination of PTF is restricted to lead V1, wherein lead placement error has a significant potential to result in the misinterpretation of PTF.3 Therefore, accounting interatrial block (which looks at all the precordial leads) along with the PTF and its relationship to the mortality remains an important consideration.2 In particular, authors did not take into consideration the effect of chronic lung disease (especially emphysema) on the PTF. In one of our previous works, we demonstrated that PTF may often be falsely increased in these patients and interpretation of left atrial enlargement in such patients based on PTF alone should be made with caution.4 This is because emphysema causes diaphragmatic flattening because of hyperinflation and creates a downward pull on the heart/right atrium via the dense pericardial ligament.5 Hence, the standard V1 chest lead in patients with emphysema ultimately monitors electric forces of a much lower-situated right atrium, which probably records the atrial depolarization vector going in opposite direction from the lead V1, resulting in a predominant negative P deflection.4 In fact, a totally negative P wave rather than a biphasic P wave were common in emphysematous patients. How did authors compute the PTF in cases with a totally negative P wave in V1 remains somewhat unclear from the current study? In addition, emphysema/chronic lung disease was not accounted, which may have played an independent role in mortality and mighthave played a confounding role in the relationship between PTF and mortality.

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2. Chhabra L, Devadoss R, Chaubey VK, Spodick DH. Interatrial block in the modern era. Curr Cardiol Rev. 2014;10:181–189.

3. Spodick DH, Ariyarajah V, Goldberg R. Interatrial block: correlation with P-terminal force. Clin Cardiol. 2009;32:181–182. doi: 10.1002/clc.20329. 4.

4. Chhabra L, Chaubey VK, Kothagundla C, Bajaj R, Kaul S, Spodick DH. P-wave indices in patients with pulmonary emphysema: do P-terminal force and interatrial block have confounding effects? Int J Chron Obstruct Pulmon Dis. 2013;8:245–250. doi: 10.2147/COPD.S45127. 5.

5. Chhabra L, Sareen P, Gandagule A, Spodick D. Computerized tomographic quantification of chronic obstructive pulmonary disease as the principal

determinant of frontal P vector. Am J Cardiol. 2012;109:1046–1049. doi: 10.1016/j.amjcard.2011.11.036.

139. **Conde D, Baranchuk A, Bayés de Luna A. Advanced interatrial block as a substrate of supraventricular tachyarrhythmias: a well recognized syndrome. J Electrocardiol. 2015 Mar-Apr;48(2):135-40.** Abstract: Interatrial blocks (IABs) are well described and accepted in the scientific community. In the last four decades major discoveries were made including its physiopathology, ECG presentation, classification and association with atrial tachyarrhythmias (advanced IAB). This article will briefly review the state of the art on the understanding of advanced IAB as an electrical substrate for atrial tachyarrhythmias as well as the future directions. doi: 10.1016/j.jelectrocard.2014.12.015. Review. PMID: 25637273

140. **Marano M, D'Amato A, de Luna AB, Baranchuk A. Hemodialysis affects interatrial conduction. Ann Noninvasive Electrocardiol. 2015 May;20(3): 299-300.** doi: 10.1111/anec.12252. No abstract available. PMID: 25545395

141. **Conde D, Seoane L, Gysel M, Mitrione S, Bayés de Luna A, Baranchuk A. Bayés' syndrome: the association between interatrial block and supraventricular arrhythmias. Expert Rev Cardiovasc Ther. 2015 May;13(5): 541-50.** Abstract: The past few years have given rise to extensive research on atrial conduction disorders and their clinical relevance. Most notably, an association between interatrial block and supraventricular arrhythmias has been discovered. This disorder, recently termed 'Bayés' syndrome', has important clinical implications. In this article, the authors review normal atrial conduction and associated disorders. A particular focus is placed on Bayés' syndrome and the relationship between interatrial block and supraventricular arrhythmias in different clinical scenarios. The report also outlines the current progress in the study of this syndrome and highlights areas requiring further investigation. PMID: 25907617 DOI: 10.1586/14779072.2015.1037283

142. **Enriquez A, Conde D, Redfearn DP, Baranchuk A. Progressive interatrial block and supraventricular arrhythmias. Ann Noninvasive Electrocardiol. 2015 Jul;20(4):394-6**. Abstract: Interatrial conduction disorders are frequent in patients with structural heart diseases, including hypertension, coronary disease, and hypertrophic cardiomyopathy, and they are strongly associated with atrial tachyarrhythmias, especially atrial fibrillation and flutter. Conduction delays lead to dispersion of refractory periods and participate in initiating and maintaining reentry circuits, facilitating atrial arrhythmias. In this case, the changing pattern over time is a manifestation of progressive atrial remodeling and conduction delay. The terminal negative component of the P wave in the inferior leads suggests block of the electrical impulse in the Bachman bundle zone, with retrograde activation of the left

atria via muscular connections at the coronary sinus. This has been reproduced in experimental models and confirmed by endocardial mapping. Physicians should be aware of the association between advanced interatrial block and development of atrial arrhythmias as its recognition could prompt early and aggressive antiarrhythmic treatment. PMID: 25201217 DOI: 10.1111/anec.12208

143. **Enriquez A, Sarrias A, Villuendas R, Ali FS, Conde D, Hopman WM, Redfearn DP, Michael K, Simpson C, De Luna AB, Bayés-Genís A, Baranchuk A. New-onset atrial fibrillation after cavotricuspid isthmus ablation: identification of advanced interatrial block is key. Europace. 2015 Aug;17(8): 1289-93.** PMID: 25672984 **Free Article**

144. **Baranchuk A, Bayés de Luna A. The P-wave morphology: what does it tell us? Herzschrittmacherther Elektrophysiol. 2015 Sep;26(3):192-9.** Abstract: P-wave morphology and duration reveals several aspects of the atria: Proper function, fibrosis, dyssynchrony, and activation paths can be inferred from the surface P-wave analysis. Surface electrocardiogram (ECG) can help differentiating enlargements of the atria from conduction defects including intra- and interatrial block. The purpose of this paper is to review normal atrial morphology and the most relevant abnormal patterns. PMID: 26264481 DOI: 10.1007/s00399-015-0385-3

145. **Sarrias A, Villuendas R, Baranchuk A, de Luna AB, Bayes-Genis A. To the Editor--Interatrial block: Another risk to take into account after radiofrequency ablation of typical atrial flutter. Heart Rhythm. 2015 Sep; 12(9):e119-20.** PMID: 25576778 DOI: 10.1016/j.hrthm.2015.01.006

146. **van Oosten E, Baranchuk A. Interatrial Block Is Not a Predictor of Post-CABG Atrial Fibrillation. J Cardiothorac Vasc Anesth. 2015 Oct;29(5):e63.** PMID: 26006160 DOI: 10.1053/j.jvca.2015.03.004

147. Nielsen JB , Kühl JT , Pietersen A , et al. P-wave duration and the risk of atrial fibrillation: results from the Copenhagen ECG Study. *Heart Rhythm.* 2015; 12:1887–1895.

148. **Sadiq Ali F, Enriquez A, Conde D, Redfearn D, Michael K, Simpson C, Abdollah H, Bayés de Luna A, Hopman W, Baranchuk A. Advanced Interatrial Block Predicts New Onset Atrial Fibrillation in Patients with Severe Heart Failure and Cardiac Resynchronization Therapy. Ann Noninvasive Electrocardiol. 2015 Nov;20(6):586-91.** Abstract: BACKGROUND: Advanced interatrial block (aIAB) on the surface electrocardiogram (ECG), defined as a P-wave duration ≥120 milliseconds with biphasic (±) morphology in inferior leads, is frequently associated with atrial fibrillation (AF). The aim of this study was to determine whether preoperative aIAB could predict new-onset AF in patients with

severe congestive heart failure (CHF) requiring cardiac resynchronization therapy (CRT). METHODS:Retrospective analysis of consecutive patients with CHF and no prior history of AF undergoing CRT for standard indications. A baseline 12-lead ECG was obtained prior to device implantation and analyzed for the presence of aIAB. ECGs were scanned at 300 DPI and maximized 8×. Semiautomatic calipers were used to determine P-wave onset and offset. The primary outcome was the occurrence of AF identified through analyses of intracardiac electrograms on routine device follow-up. RESULTS: Ninety-seven patients were included (74.2% male, left atrial diameter 45.5 ± 7.8 mm, 63% ischemic). Mean P-wave duration was 138.5 ± 18.5 milliseconds and 37 patients (38%) presented aIAB at baseline. Over a mean follow-up of 32 ± 18 months, AF was detected in 29 patients (30%) and the incidence was greater in patients with aIAB compared to those without it (62% vs 28%; P < 0.003). aIAB remained a significant predictor of AF occurrence after multivariate analysis (OR 4.1; 95% CI, 1.6-10.7; P < 0.003). CONCLUSION: The presence of aIAB is an independent predictor of new-onset AF in patients with severe CHF undergoing CRT. PMID: 25639950 DOI: 10.1111/anec.12258

149. **Enriquez A, Marano M, D'Amato A, de Luna AB, Baranchuk A. Second-degree interatrial block in hemodialysis patients. Case Rep Cardiol. 2015;2015:468493.** PMCID: PMC4338407 DOI: 10.1155/2015/468493 **Free Article**

150. **Marano M, Baranchuk A. Left atrial dynamic function and interatrial block in hemodialysis patients: the importance of P-wave morphology analysis. Eur Rev Med Pharmacol Sci. 2015;19(11):1941-2.** MID: 26125250 **Free Article**

151. **Sadiq Ali F, Enriquez A, Redfearn D, Baranchuk A. P-wave pseudonormalization after iatrogenic coronary sinus isolation. J Electrocardiol. 2016 Jan-Feb;49(1):13-4.** doi: 10.1016/j.jelectrocard.2015.08.030.PMID: 26381799

152. **Baranchuk A, de Luna AB, Breithardt G. To the Editor--The role of advanced interatrial block pattern as a predictor of atrial fibrillation. Heart Rhythm. 2016 Mar;13(3):e87.** doi: 10.1016/j.hrthm.2015.11.024. No abstract available. PMID: 26598323

153. **Martínez-Sellés M1, Massó-van Roessel A2, Álvarez-García J3, García de la Villa B4, Cruz-Jentoft AJ5, Vidán MT6, López Díaz J7, Felix Redondo FJ8, Durán Guerrero JM9, Bayes-Genis A10, Bayes de Luna A2; Investigators of the Cardiac and Clinical Characterization of Centenarians (4C) registry. Interatrial block and atrial arrhythmias in centenarians: Prevalence, associations, and clinical implications. Heart Rhythm. 2016 Mar;13(3):645-51.**

doi: 10.1016/j.hrthm.2015.10.034. Abstract BACKGROUND: Data are lacking on the characteristics of atrial activity in centenarians, including interatrial block (IAB). OBJECTIVE: The aim of this study was to describe the prevalence of IAB and auricular arrhythmias in subjects older than 100 years and to elucidate their clinical implications. METHODS: We studied 80 centenarians (mean age 101.4 ± 1.5 years; 21 men) with follow-ups of 6-34 months. Of these 80 centenarians, 71 subjects (88.8%) underwent echocardiography. The control group comprised 269 septuagenarians RESULTS: A total of 23 subjects (28.8%) had normal P wave, 16 (20%) had partial IAB, 21 (26%) had advanced IAB, and 20 (25.0%) had atrial fibrillation/flutter. The IAB groups exhibited premature atrial beats more frequently than did the normal P wave group (35.1% vs 17.4%; P < .001); also, other measurements in the IAB groups frequently fell between values observed in the normal P wave and the atrial fibrillation/flutter groups. These measurements included sex preponderance, mental status and dementia, perceived health status, significant mitral regurgitation, and mortality. The IAB group had a higher previous stroke rate (24.3%) than did other groups. Compared with septuagenarians, centenarians less frequently presented a normal P wave (28.8% vs 53.5%) and more frequently presented advanced IAB (26.3% vs 8.2%), atrial fibrillation/flutter (25.0% vs 10.0%), and premature atrial beats (28.3 vs 7.0%) (P < .01).CONCLUSION:Relatively few centenarians (<30%) had a normal P wave, and nearly half had IAB. Our data suggested that IAB, particularly advanced IAB, is a pre-atrial fibrillation condition associated with premature atrial beats. Atrial arrhythmias and IAB occurred more frequently in centenarians than in septuagenarians.KEYWORDS:Atrial fibrillation; Bayes syndrome; Centenarian; Interatrial block

154.Martínez-Sellés M1, Fernández Lozano I2, Baranchuk A3, Bayes-Genis A4, Bayés de Luna A5.Should We Anticoagulate Patients at High Risk of Atrial Fibrillation?Rev Esp Cardiol (Engl Ed). 2016 Apr;69(4):374-6. doi: 10.1016/j.rec.2016.01.008. Epub 2016 Mar 2.PMID: 26944349 DOI: 10.1016/j.rec.2016.01.008[PubMed - in process]

155.O'Neal WT1, Zhang ZM2, Loehr LR3, Chen LY4, Alonso A5, Soliman EZ2.Electrocardiographic Advanced Interatrial Block and Atrial Fibrillation Risk in the General Population.Am J Cardiol. 2016 Jun 1;117(11):1755-9. doi: 10.1016/j.amjcard.2016.03.013. Epub 2016 Mar 18. Abstract Although advanced interatrial block (aIAB) is an established electrocardiographic phenotype, its prevalence, incidence, and prognostic significance in the general population are unclear. We examined the prevalence, incidence, and prognostic significance of aIAB in 14,625 (mean age = 54 ± 5.8 years; 26% black; 55% female) participants

from the Atherosclerosis Risk in Communities (ARIC) study. aIAB was detected from digital electrocardiograms recorded during 4 study visits (1987 to 1989, 1990 to 1992, 1993 to 1995, and 1996 to 1998). Risk factors for the development of aIAB were examined using multivariable Poisson regression models with robust variance estimates. Cox regression was used to compute hazard ratios and 95% CIs for the association between aIAB, as a time-dependent variable, and atrial fibrillation (AF). AF was ascertained from study electrocardiogram data, hospital discharge records, and death certificates thorough 2010. A total of 69 participants (0.5%) had aIAB at baseline, and 193 (1.3%) developed aIAB during follow-up. The incidence for aIAB was 2.27 (95% CI 1.97 to 2.61) per 1,000 person-years. Risk factors for aIAB development included age, male gender, white race, antihypertensive medication use, low-density lipoprotein cholesterol, body mass index, and systolic blood pressure. In a Cox regression analysis adjusted for sociodemographics, cardiovascular risk factors, and potential confounders, aIAB was associated with an increased risk for AF (hazard ratio 3.09, 95% CI 2.51 to 3.79). In conclusion, aIAB is not uncommon in the general population. Risk factors for developing aIAB are similar to those for AF, and the presence of aIAB is associated with an increased risk for AF.PMID: 27072646 PMCID: PMC4898264 [Available on 2017-06-01] DOI: 10.1016/j.amjcard. 2016.03.013

156. **Henmi R1, Ejima K1, Shoda M1, Yagishita D1, Hagiwara N1.Interatrial Conduction Time Can Predict New-Onset Atrial Fibrillation After Radiofrequency Ablation of Isolated, Typical Atrial Flutter.J Cardiovasc Electrophysiol. 2016 Jul 16. doi: 10.1111/jce.13040.** [Epub ahead of print]Abstract INTRODUCTION: Many patients with successful atrial flutter (AFL) ablation will develop atrial fibrillation (AF) during follow-up. This study aimed to determine whether prolonged interatrial conduction time (IACT) is associated with risk for new-onset AF after ablation of isolated, typical AFL.METHODS: Participants were 80 consecutive patients who underwent successful radiofrequency ablation of isolated, typical AFL from 2004 to 2012. Patients with any history of AF prior to AFL ablation were excluded. IACT was defined as the interval from the earliest onset of the P-wave on the ECG to the latest activation in the coronary sinus catheter during sinus rhythm measured after AFL ablation. New-onset AF was identified from 12-lead ECGs, 24-hour ambulatory monitoring, and device interrogations.RESULTS:During a mean follow-up of 4.1 ± 2.5 years after successful AFL ablation, 22 patients (27.5%) developed new-onset AF. Cox regression multivariate analysis demonstrated that IACT was the independent predictor of new-onset AF after AFL ablation (hazard ratio: 1.03; 95% confidence interval: 1.00-1.06; P = 0.02). IACT was accurate in predicting new-onset AF (AUC

= 0.70). The optimal cut-off point of IACT for predicting new-onset AF was 120 milliseconds (sensitivity 47.6%, specificity 89.8%). Kaplan-Meier curves showed that new-onset AF after AFL ablation was significantly higher in patients with IACT ≥120 milliseconds than in patients with IACT< 120 milliseconds (P = 0.0016).CONCLUSION:Prolonged IACT predicted new-onset AF after ablation of isolated AFL. This finding may contribute to guiding decisions regarding the maintenance of anticoagulation after AFL ablation.© **2016 Wiley Periodicals, Inc.KEYWORDS:P-wave; atrial fibrillation; atrial flutter; catheter ablation; cavotricuspid isthmus ablation; interatrial conduction timePMID: 27422488 DOI: 10.1111/jce.13040**

157.**Gul EE, Baranchuk A. Advanced interatrial block as a predictor of atrial fibrillation following catheter ablation in the left atrium. J Cardiol. 2016 Sep; 68(3):269.** doi: 10.1016/j.jjcc.2016.01.011. No abstract available. PMID: 26917194

158.**Martínez-Sellés M, Robledo LA, Baranchuk A. Interatrial Block and the Risk of Ischemic Stroke. J Atheroscler Thromb. 2016 Sep 6.** [Epub ahead of print] No abstract available. PMID: 27600796 DOI: 10.5551/jat.37242. **Free Article**

159.**Britton S, Alexander B, Baranchuk A. Paced Interatrial Block in Bayés' Syndrome. Rev Esp Cardiol (Engl Ed). 2016 Nov 4. pii: S1885-5857(16)30279-1.** doi: 10.1016/j.rec.2016.09.014. [Epub ahead of print] English, Spanish. No abstract available. PMID: 27825717

160.**Alexander B, Rodriguez C, de la Isla LP, Islas F, Quevedo PJ, Nombela-Franco L, Hopman W, Malik P, Baranchuk A. The impact of advanced Interatrial block on new-onset atrial fibrillation following TAVR procedure. Int J Cardiol. 2016 Nov 15;223:672-73.** doi: 10.1016/j.ijcard.2016.08.083. No abstract available. PMID: 27568987

161.**Martínez-Sellés M, Baranchuk A, Elosua R, de Luna AB. Rationale and design of the BAYES (Interatrial Block and Yearly Events) registry. Clin Cardiol. 2016 Nov 24.** doi: 10.1002/clc.22647. [Epub ahead of print] PMID: 27883210 **Free Article**

162..**Rago A1, Russo V2, Papa AA2, Ciardiello C3, Pannone B4, Mayer MC4, Cimmino G2, Nigro G2.The role of the atrial electromechanical delay in predicting atrial fibrillation in beta-thalassemia major patients.J Interv Card Electrophysiol. 2016 Nov 22.** [Epub ahead of print] Abstract BACKGROUND: Paroxysmal atrial tachyarrhythmias frequently occur in beta-thalassemia major (β-TM) patients. The aim of the current study was to evaluate the atrial electromechanical delay (AEMD) in a large β-TM population with normal cardiac function and its relationship to atrial fibrillation (AF) onset. METHODS: Eighty β-

TM patients (44 men, 36 women), with a mean age of 36.2 ± 11.1 years, and 80 healthy subjects used as controls, matched for age and gender, were studied for the occurrence of AF during a 5-year follow-up, through 30-day external loop recorder (ELR) monitoring performed every 6 months. Intra-AEMD and inter-AEMD of both atria were measured through tissue Doppler echocardiography. P-wave dispersion (PD) was carefully measured using 12-lead electrocardiogram (ECG). RESULTS:Compared to the healthy control group, the β-TM patients showed a statistically significant increase in inter-AEMD, intra-left AEMD, maximum P-wave duration, and PD. Dividing the β-TM group into two subgroups (patients with or without AF), the inter-AEMD, intra-left AEMD, maximum P-wave duration, and PD were significantly higher in the subgroup with AF compared to the subgroup without AF. There were significant good correlations of intra-left AEMD and inter-AEMD with PD. A cut-off value of 40.1 ms for intra-left AEMD had a sensitivity of 76.2% and a specificity of 97.5% in identifying β-TM patients with AF risk. A cut-off value of 44.8 ms for inter-AEMD had a sensitivity of 81.2% and a specificity of 98.7% in identifying this category of patients.CONCLUSIONS:Our results showed that the echocardiographic atrial electromechanical delay indices (intra-left and inter-AEMD) and the PD were significantly increased in β-TM subjects with normal cardiac function. PD and AEMD represent non-invasive, inexpensive, useful, and simple parameters to assess the AF risk in β-TM patients.KEYWORDS:Atrial electromechanical delay; Atrial fibrillation; Beta-thalassemia major; P-wave dispersion PMID: 27878421 DOI: 10.1007/s10840-016-0201-y[PubMed

163. **Tereshchenko LG5.Screening entire healthcare system ECG database: Association of deep terminal negativity of P wave in lead V1 and ECG referral with mortality. Author informationInt J Cardiol. 2016 Nov 10;228:219-224. doi: 10.1016/j.ijcard.2016.11.128**. [Epub ahead of print] AbstractBACKGROUND:Each encounter of asymptomatic individuals with the healthcare system presents an opportunity for improvement of cardiovascular disease (CVD) awareness and sudden cardiac death (SCD) risk assessment. ECG sign deep terminal negativity of the P wave in V1 (DTNPV1) was shown to be associated with an increased risk of SCD in the general population. OBJECTIVE: To evaluate association of DTNPV1 with all-cause mortality and newly diagnosed atrial fibrillation (AFib) in the large tertiary healthcare system patient population. METHODS: Retrospective double cohort study compared two levels of exposure (automatically measured amplitude of P-prime (Pp) in V1): DTNPV1 (Pp from -100μV to -200μV) and ZeroPpV1 (Pp=0). An entire healthcare system (2010-2014) ECG database was screened. Medical records of children and patients with previously diagnosed AFib/atrial flutter (AFl), implanted pacemaker or cardioverter-defibrillator were excluded. DTNPV1 (n=3,413) and ZeroPpV1

(n=3,405) cohorts were matched by age and sex. Primary outcome was all-cause mortality. Secondary outcomes were newly diagnosed AFib/AFl. Median follow-up was 2.5 y. RESULTS: DTNPV1 was associated with all-cause mortality (HR 1.95(1.64-2.31); P<0.0001) and newly diagnosed AFib (HR 1.29(1.04-1.59); P=0.021) after adjustment for CVD, comorbidities, other ECG parameters, medications, and index ECG referral. Index ECG referral by a cardiologist was independently associated with 34% relative risk reduction of mortality (HR 0.66(0.52-0.84); P=0.001), as compared to ECG referral by a non-cardiologist. **CONCLUSION:** DTNPV1 is independently associated with twice higher risk of all-cause death, as compared to patients without P prime in V1. Life-saving effect of the index ECG referral by a cardiologist requires further study. KEYWORDS: Electrocardiogram; Health system; Mortality; Patient education PMID: 27865189 DOI: 10.1016/j.ijcard.2016.11.128 [PubMed - as supplied by publisher]

164. **Lacalzada-Almeida J1, García-Niebla J2, Bayés-de Luna A3.Speckle-Tracking Echocardiography and Advanced Interatrial Block. Rev Esp Cardiol (Engl Ed). 2016 Dec 8. pii: S1885-5857(16)30371-1. doi: 10.1016/j.rec.2016.11.014. [Epub ahead of print]** Author information: PMID: 27939771 [PubMed - as supplied by publisher]

165. **Baranchuk A1, Bayés de Luna A. The P-wave morphology: what does it tell us? Herzschrittmacherther Elektrophysiol. 2015 Sep;26(3):192-9. doi: 10.1007/s00399-015-0385-3. Abstract:** P-wave morphology and duration reveals several aspects of the atria: Proper function, fibrosis, dyssynchrony, and activation paths can be inferred from the surface P-wave analysis. Surface electrocardiogram (ECG) can help differentiating enlargements of the atria from conduction defects including intra- and interatrial block. The purpose of this paper is to review normal atrial morphology and the most relevant abnormal patterns. PMID: 26264481 [PubMed - indexed for MEDLINE]

166. **Martínez-Sellés M1, Massó-van Roessel A2, Álvarez-García J3, García de la Villa B4, Cruz-Jentoft AJ5, Vidán MT6, López Díaz J7, Felix Redondo FJ8, Durán Guerrero JM9, Bayes-Genis A10, Bayes de Luna A2; Investigators of the Cardiac and Clinical Characterization of Centenarians (4C) registry.Interatrial block and atrial arrhythmias in centenarians: Prevalence, associations, and clinical implications.Heart Rhythm. 2016 Mar;13(3):645-51. doi: 10.1016/j.hrthm.2015.10.034. Epub 2015 Oct 28.**Author information: 1Hospital General Universitario Gregorio Marañón y Universidad Europea y Universidad Complutense, Madrid, Spain. Electronic address: mmselles@secardiologia.es.2. Fundació Investigació Cardiovascular, ICCC, Barcelona, Spain. 3 Hospital de la Santa Creu i Sant Pau, Universitat Autònoma de

Barcelona, Barcelona, Spain. 4Hospital de Manacor, Mallorca, Spain. 5Hospital Universitario Ramón y Cajal, Madrid, Spain. 6Hospital General Universitario Gregorio Marañón, Universidad Complutense, Madrid, Spain. 7Hospital Clínico Universitario de Valladolid, Valladolid, Spain. 8Centro de Salud "Villanueva Norte," Villanueva de la Serena, Badajoz, Spain. 9Hospital de Mérida, Badajoz, Spain. 10Hospital Universitari Germans Trias i Pujol, Universitat Autònoma de Barcelona, Barcelona, Spain.

Comment in The power of P in the elderly: Small biphasic wave, big impact. [Heart Rhythm. 2016]Reply to the Editor--Prevalence of interatrial block during lifetime. [Heart Rhythm. 2016]Letter to the Editor--Prevalence of interatrial block during lifetime. [Heart Rhythm. 2016]**Abstract BACKGROUND:** Data are lacking on the characteristics of atrial activity in centenarians, including interatrial block (IAB).**OBJECTIVE:** The aim of this study was to describe the prevalence of IAB and auricular arrhythmias in subjects older than 100 years and to elucidate their clinical implications. **METHODS:** We studied 80 centenarians (mean age 101.4 ± 1.5 years; 21 men) with follow-ups of 6-34 months. Of these 80 centenarians, 71 subjects (88.8%) underwent echocardiography. The control group comprised 269 septuagenarians. **RESULTS:** A total of 23 subjects (28.8%) had normal P wave, 16 (20%) had partial IAB, 21 (26%) had advanced IAB, and 20 (25.0%) had atrial fibrillation/flutter. The IAB groups exhibited premature atrial beats more frequently than did the normal P wave group (35.1% vs 17.4%; $P < .001$); also, other measurements in the IAB groups frequently fell between values observed in the normal P wave and the atrial fibrillation/flutter groups. These measurements included sex preponderance, mental status and dementia, perceived health status, significant mitral regurgitation, and mortality. The IAB group had a higher previous stroke rate (24.3%) than did other groups. Compared with septuagenarians, centenarians less frequently presented a normal P wave (28.8% vs 53.5%) and more frequently presented advanced IAB (26.3% vs 8.2%), atrial fibrillation/flutter (25.0% vs 10.0%), and premature atrial beats (28.3 vs 7.0%) ($P < .01$). **CONCLUSION:** Relatively few centenarians (<30%) had a normal P wave, and nearly half had IAB. Our data suggested that IAB, particularly advanced IAB, is a pre-atrial fibrillation condition associated with premature atrial beats. Atrial arrhythmias and IAB occurred more frequently in centenarians than in septuagenarians.

167.Gul EE1, Pal R2, Caldwell J3, Boles U1, Hopman W4, Glover B1, Michael KA1, Redfearn D1, Simpson C1, Abdollah H1, Baranchuk A1.Interatrial block and interatrial septal thickness in patients with paroxysmal atrial fibrillation undergoing catheter ablation: Long-term follow-up study.Ann Noninvasive Electrocardiol. 2016 Dec 25. doi: 10.1111/anec.12428. [Epub ahead of

print]Author information:1Heart Rhythm Service, Kingston General Hospital, Queen's University, Kingston, ON, Canada.2Department of Cardiology, Kingston General Hospital, Queen's University, Kingston, ON, Canada.3Hull & East Yorkshire NHS Trust and Hull York Medical School, Hull, United Kingdom. 4Department of Public Health Sciences, Queen's University, Kingston, ON, Canada.

Abstract BACKGROUND: Interatrial block (IAB) is a strong predictor of recurrence of atrial fibrillation (AF). IAB is a conduction delay through the Bachman region, which is located in the upper region of the interatrial space. During IAB, the impulse travels from the right atrium to the interatrial septum (IAS) and coronary sinus to finally reach the left atrium in a caudocranial direction. No relation between the presence of IAB and IAS thickness has been established yet. OBJECTIVE: To determine whether a correlation exists between the degree of IAB and the thickness of the IAS and to determine whether IAS thickness predicts AF recurrence. **METHODS:** Sixty-two patients with diagnosis of paroxysmal AF undergoing catheter ablation were enrolled. IAB was defined as P-wave duration ≥120 ms. IAS thickness was measured by cardiac computed tomography. **RESULTS**: Among 62 patients with paroxysmal AF, 45 patients (72%) were diagnosed with IAB. Advanced IAB was diagnosed in 24 patients (39%). Forty-seven patients were male. During a mean follow-up period of 49.8 ± 22 months (range 12-60 months), 32 patients (51%) developed AF recurrence. IAS thickness was similar in patients with and without IAB (4.5 ± 2.0 mm vs. 4.0 ± 1.4 mm; p = .45) and did not predict AF. Left atrial size was significantly enlarged in patients with IAB (40.9 ± 5.7 mm vs. 37.2 ± 4.0 mm; p = .03). Advanced IAB predicted AF recurrence after the ablation (OR: 3.34, CI: 1.12-9.93; p = .03). **CONCLUSIONS:** IAS thickness was not significantly correlated to IAB and did not predict AF recurrence. IAB as previously demonstrated was an independent predictor of AF recurrence.

168.Barbosa-Barros R1, Alexander B2, Baranchuk A3. Interatrial Block in Brugada Syndrome.Rev Esp Cardiol (Engl Ed). 2017 Jan 24. pii: S1885-5857(16)30451-0. doi: 10.1016/j.rec.2016.12.028Author information. PMID: 28130006 DOI: 10.1016/j.rec.2016.12.028

169.**Wu JT, Wang SL, Chu YJ, Long DY, Dong JZ, Fan XW, Yang HT, Duan HY, Yan LJ, Qian P.CHADS2 and CHA2DS2-VASc Scores Predict the Risk of Ischemic Stroke Outcome in Patients with Interatrial Block without Atrial Fibrillation.J Atheroscler Thromb. 2017 Feb 1;24(2):176-184. doi: 10.5551/jat.34900** Author information. Abstract AIM: To evaluate the role of CHADS2 and CHA2DS2-VASc scores in predicting the risk of ischemic stroke or transient ischemic attack (TIA) outcomes in patients with interatrial block (IAB) without a

history of atrial fibrillation (AF). METHODS: A retrospective study was conducted, including 1,046 non-anticoagulated inpatients (612 males, 434 females; mean age: 63±10 years) with IAB and without AF. IAB was defined as P-wave duration ＞120 ms using a 12-lead electrocardiogram. CHADS2 and CHA2DS2-VASc scores were retrospectively calculated. The primary outcomes evaluated were ischemic stroke or TIA. RESULTS: During the mean follow-up period of 4.9±0.7 years, 55 (5.3%) patients had an ischemic stroke or TIA. Receiver operating characteristic (ROC) curve analysis showed that the CHADS2 score [area under the curve (AUC), 0.638; 95% confidence interval (CI), 0.562-0.715; P=0.001] and the CHA2DS2-VASc score (AUC, 0.671; 95% CI, 0.599-0.744; P＜0.001) were predictive of ischemic strokes or TIA. Cut-off point analysis showed that a CHADS2 score ≥3 (sensitivity=0.455 and specificity=0.747) and a CHA2DS2-VASc score ≥4 (sensitivity=0.564 and specificity=0.700) provided the highest predictive value for ischemic stroke or TIA. The multivariate Cox regression analysis showed that CHADS2 [hazard ratio (HR), 1.442; 95% CI, 1.171-1.774; P=0.001] and CHA2DS2-VASc (HR, 1.420; 95% CI, 1.203-1.677; P＜0.001) scores were independently associated with ischemic stroke or TIA following adjustment for smoking, left atrial diameter, antiplatelet agents, angiotensin inhibitors, and statins.**CONCLUSIONS:** CHADS2 and CHA2DS2-VASc scores may be predictors of risk of ischemic stroke or TIA in patients with IAB without AF. PMID: 27301462 PMCID: PMC5305678 DOI: 10.5551/jat.34900

170.Martínez-Sellés M1, Robledo LA, Baranchuk A. Interatrial Block and the Risk of Ischemic Stroke.J Atheroscler Thromb. 2017 Feb 1;24(2):185-186. doi: 10.5551/jat.37242. Epub 2016 Sep 6. Author information PMID: 27600796 PMCID: PMC5305679 DOI: 10.5551/jat.37242

171.Wu JT, Long DY, Wang SL.Interatrial Block and Risk of Ischemic Stroke - Reply. J Atheroscler Thromb. 2017 Feb 1;24(2):187-188. doi: 10.5551/jat.37572. PMID: 27629529 Free PMC Article

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Author information

Abstract BACKGROUND: Interatrial block which is defined as P wave duration longer than 120 milliseconds is underappreciated but highly prevalent electrocardiographic abnormality and associated with atrial tachyarrhythmias and ischemic stroke. Impaired left atrial mechanics and atrial fibrillation are potential

mechanisms contributing to the embolic events associated with interatrial block. Detection of atrial high rate episodes by cardiac implantable electronic devices provides clinicians to diagnose asymptomatic atrial fibrillation. The relation between interatrial block and asymptomatic atrial fibrillation can provide an insight to the increased risk of ischemic stroke in patients with interatrial block.

METHODS: We prospectively evaluated 367 patients who were implanted dual chamber pacemaker due to sinus node dysfunction (SND) between January 2015 and December 2015. Twelve lead electrocardiograms were analyzed to diagnose interatrial block before pacemaker implantation. Six months after the implantation, pacemakers were interrogated to detect atrial high rate episodes. Patients were divided into two groups in terms of presence or absence of atrial high rate episodes.

RESULTS: Atrial high rate episodes were detected in 107 (30.1%) patients during their device interrogation. Interatrial block was found in 115 (32.4%) patients out of total study population. Sixty-seven (27.0%) patients in AHRE (-) group had interatrial block while 48 (44.9%) patients had in AHRE (+) group. Prevalence of interatrial block was statistically significantly higher in AHRE (+) patients ($P<0.01$).

CONCLUSION: Occurrence of atrial high rate episodes, a surrogate for asymptomatic atrial fibrillation, is statistically significantly higher in patients with interatrial block.

173.Martínez-Sellés M1.Prevalence and incidence of interatrial block in global population and in different clinical situations.J Geriatr Cardiol. 2017 Mar; 14(3):158-160. doi: 10.11909/j.issn.1671-5411.2017.03.006

174.**Bayés de Luna A1, Baranchuk A2, Alberto Escobar Robledo L1, Massó van Roessel A1, Martínez-Sellés M3. Diagnosis of interatrial block.J Geriatr Cardiol. 2017 Mar;14(3):161-165. doi: 10.11909/j.issn.1671-5411.2017.03.007**.

Author information KEYWORDS: Atrial fibrosis; Diagnosis; Interatrial block

PMID: 28592957 PMCID: PMC5460060 DOI: 10.11909/j.issn.1671-5411.2017.03.007

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Author informationKEYWORDS:Atrial fibrillation; Bachmann's bundle; Bayés syndrome; Interatrial blockPMID: 28592959 PMCID: PMC5460062 DOI:10.11909/j.issn.1671-5411.2017.03.005

176.**Benito EM, De Luna AB, Baranchuk A, Mont L.Extensive atrial fibrosis assessed by late gadolinium enhancement cardiovascular magnetic resonance associated with advanced interatrial block electrocardiogram pattern**.Europace. 2017 Mar 1;19(3):377. doi: 10.1093/europace/euw294 Author information PMID: 28395012 DOI: 10.1093/europace/euw294

177.Fernández-Fernández FJ1.Atrial Fibrillation: Interatrial Block May Be an Underdiagnosed and Easily Recognizable Risk Factor.Mayo Clin Proc. 2017 Apr;92(4):681-682. doi: 10.1016/j.mayocp.2017.01.022.Author informationPMID: 28385202 DOI: 10.1016/j.mayocp.2017.01.022

178.Morin DP, Bernard ML, Madias C, Rogers PA, Thihalolipavan S, Estes NA 3rd3.In Reply-Atrial Fibrillation: Interatrial Block May Be an Underdiagnosed and Easily Recognizable Risk Factor.Mayo Clin Proc. 2017 Apr;92(4):682. doi: 10.1016/j.mayocp.2017.02.006.Author informationPMID: 28385203 DOI: 10.1016/j.mayocp.2017.02.006

179.Martínez-Sellés M1, Baranchuk A2, Elosua R3, de Luna AB4.Rationale and design of the BAYES (Interatrial Block and Yearly Events) registry.Clin Cardiol. 2017 Apr;40(4):196-199. doi: 10.1002/clc.22647Author information Abstract The prevalence of interatrial block (IAB) is high in the elderly, particularly in those with heart disease. Despite this high prevalence-and the association of IAB with the risk of atrial fibrillation (AF), stroke, and cognitive decline-little information exists about the prognosis of older patients with IAB. P-wave duration and morphology are associated with risk of developing AF, stroke, and cognitive decline in elderly patients with structural heart disease. The aim of the Interatrial Block and Yearly Events (BAYES) registry is to assess the impact of IAB on the risk of AF and stroke during 3 years of follow-up. A series of 654 ambulatory patients age ≥70 years with heart disease from 35 centers will be included in 3 similar-size groups of patients. Group A: normal P-wave duration (<120 ms); Group B: partial IAB (P-wave duration ≥120 ms without biphasic [plus/minus] morphology in the inferior leads II, III, and aVF); and Group C: advanced IAB (P-wave duration ≥120 ms with biphasic [plus/minus] morphology in the inferior leads II, III, and aVF). Patients will be managed according to current recommendations. The 2 primary endpoints are defined as (1) AF duration >5 minutes and documented in any form of electrocardiographic recording; and (2) stroke. Results from this study might significantly improve the knowledge of IAB and its impact on the outcome of elderly patients with heart disease and could open the door to the use of

anticoagulation therapy in some elderly patients with IAB.© 2016 Wiley Periodicals, Inc.KEYWORDS:interatrial block; elderly; atrial fibrillation; strokePMID: 27883210 DOI: 10.1002/clc.22647

180. **Britton S, Barbosa-Barros R, Alexander B, Baranchuk A.Progressive interatrial block associated with atrial fibrillation in a patient with hypertrophic cardiomyopathy.Ann Noninvasive Electrocardiol. 2017 May; 22(3). doi: 10.1111/anec.12403.** Author informationAbstract Progressive interatrial block is a clinically significant condition that has previously been reported in various patient populations. It is a manifestation of progressive fibrosis affecting the Bachmann region. This report presents a case of progressive interatrial block associated with atrial fibrillation in the context of hypertrophic cardiomyopathy.© 2016 Wiley Periodicals, Inc.KEYWORDS:Bayés' syndrome; atrial fibrillation; hypertrophic cardiomyopathy; interatrial block PMID: 27615799 DOI: 10.1111/anec.12403

181. **Britton S, Alexander B, Baranchuk A.Paced Interatrial Block in Bayés' Syndrome.Rev Esp Cardiol (Engl Ed). 2017 Jul;70(7):592. doi: 10.1016/j.rec.2016.09.014** [Article in English, Spanish] Author information PMID: 27825717DOI10.1016/j.rec.2016.09.014

182. **Lacalzada-Almeida J, García-Niebla J, Bayés-de Luna A.Speckle-Tracking Echocardiography and Advanced Interatrial Block.Rev Esp Cardiol (Engl Ed). 2017 Jul;70(7):591. doi: 10.1016/j.rec.2016.11.014.** [Article in English, Spanish] Author information PMID: 27939771 DOI: 10.1016/j.rec.2016.11.014

183. **Gul EE, Pal R, Caldwell J, Boles U, Hopman W4, Glover B, Michael KA, Redfearn D, Simpson C, Abdollah H, Baranchuk A1.Interatrial block and interatrial septal thickness in patients with paroxysmal atrial fibrillation undergoing catheter ablation: Long-term follow-up study.Ann Noninvasive Electrocardiol. 2017 Jul;22(4). doi: 10.1111/anec.12428.**

184. **Chhabra L, Gowdar S. Interatrial Block to Guide the Thromboembolic Prevention Strategy: Should It be the Next Step? Am J Cardiol. 2017 Aug 1;120(3):e7.** doi: 10.1016/j.amjcard.2016.05.029.Author information PMID: 27269990 DOI: 10.1016/j.amjcard.2016.05.029