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Case report
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Tachycardia-dependent bilateral bundle branch block in ischemic heart disease with systolic dysfunction: case report and review of prognostic implications

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Abstract

A proper characterization of frequency-dependent bundle branch blocks can provide useful prognostic information in some clinical situations. Often, this physiological event may be due to an extensive damage of infrahisian system, which poses a high risk of developing advanced atrioventricular block requiring pacemaker implantation. We describe the case of a 62 year-old man with chronic ischemic heart disease who exhibited alternating tachycardia-dependent bundle branch block during stress test. We discuss the main prognostic implications of this unusual event in the context of systolic dysfunction.

Introduction

Aberrant conduction (aberrancy) consists on the transient occurrence of a ventricular conduction disorder in the absence of previous bundle branch block (BBB), pre-excitation or drug effect. Physiologically, aberrant conduction occurs primarily by rate-dependent block [1].

Conduction velocity through specific myocardium depends on maximum slope and peak amplitude of phase 0; variables that are closely related with transmembrane potential before stimulation. If a cell of His-bundle or infrahisian tissue receives a premature stimulus during phase 3, then the transmembrane potential will be less negative, there will be fewer fast sodium channels available for activation and the slope of phase 0 will decrease, resulting in slower conduction during next activation. This physiological event is called phase 3 or tachycardia-dependent bundle branch block (BBB) [1]. From a morphological point of view, this phenomenon mainly adopts left bundle branch block pattern (LBBB) [2]. From an epidemiological point of view, the tachycardia-dependent bundle branch block is rarely observed in daily practice, with a prevalence of less than 0.5% during ECG exercise testing [3],[4],[5].

As permanent bundle branch block represents a marker of advanced coronary artery disease, it is easy to understand that prognosis in tachycardia-dependent bundle branch block will be worse in this heart disease, with an increased risk of hard events such as all-cause mortality, nonfatal myocardial infarction, need for percutaneous intervention or coronary bypass surgery, development of ventricular tachyarrhythmias and permanent bundle branch block [6]. In turn, this entity may manifest an extensive damage of infrahisian system at high risk of progression to advanced atrioventricular block and need for pacemaker implantation[6],[7],[8],[9],[10],[11].

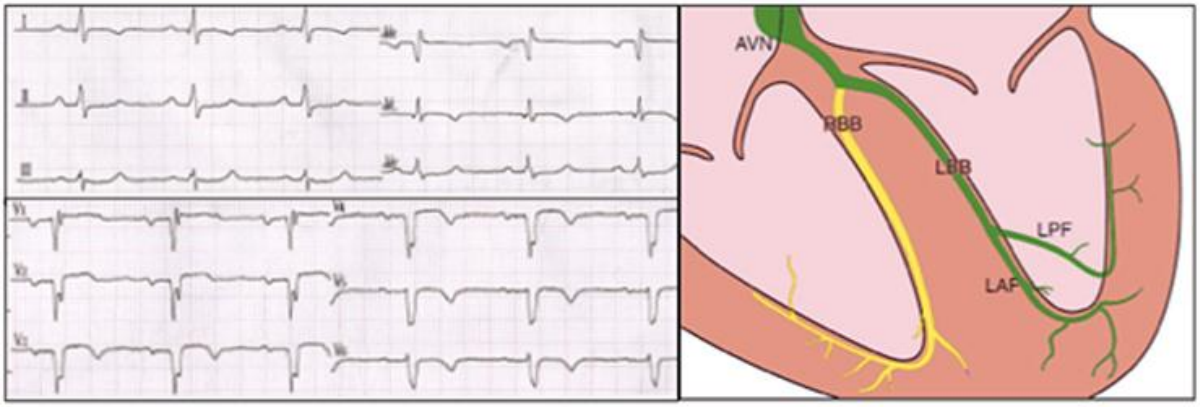
We describe the case of a 62-years old man with chronic ischemic heart disease who exhibited alternating tachycardia-dependent bundle branch block during EKG stress test, discussing main prognostic implications of this unusual event in the context of systolic dysfunction.

Case presentation

A 62-year-old hypertensive man with chronic ischemic heart failure was controlled on an outpatient basis in the Multidisciplinary Heart Failure Unit, receiving optimal doses of carvedilol, furosemide, spironolactone, enalapril, aspirin and atorvastatin. The results of Doppler echocardiography were: left ventricular systolic diameter: 54 mm; septal thickness: 7 mm; left atrial area: 22 cm2; left ventricle ejection fraction: 30% (ellipsoid method); apical akinesia and septal dyskinesia with hypocontractility in the rest of left ventricle, mild mitral and tricuspid regurgitations. The patient was referred to EKG stress test to define the functional class of symptoms.

Exercise protocol

A progressive effort on a cycle ergometer (Astrand protocol) under surface 12-lead EKG and blood pressure monitoring during exercise and recovery until normalizing blood pressure and heart rate was performed. Written informed consent was provided before the test. At baseline the patient had a normal nutritional status and was eupneic. Heart auscultation: 65 bpm regular rate, normal sounds, apical murmur II/VI (Levine) with minimal axillary irradiation. Lung fields were clear and the rest of the examination was normal. Baseline EKG showed sinus rhythm and incomplete right bundle branch block (RBBB). Figure 1 shows ventricular conduction pattern at rest. Surface EKG tracing obtained before exercise (panel A) showed: 65 bpm sinus rhythm, PR interval = 190 ms, QRS duration = 110 ms, anterior scar, incomplete right bundle branch block (grade 1), signs of septoapical dyskinesia (black arrow), normal corrected QT interval. Panel (B) illustrates the pattern of conduction through His-Purkinje system, showing partially delayed conduction in right His bundle branch (yellow). Impulse conduction through left His bundle branch is shown in green.



AVN: atrioventricular node, RBBB: right bundle branch, LBBB: left bundle branch, LAF: left anterior fascicle, LPF: left posterior fascicle.

Figure 1. Ventricular conduction at baseline

The patient reached a maximum load of 600 kgmts during exercise (6.14 mets, NYHA functional class: IIA), referring tired legs and limiting dyspnea. Table 1 summarizes clinical and EKG data during stress test. During fifth minute of exercise (heart rate: 115 bpm) a complete left bundle branch block followed by varying degrees of delay in conduction through both His bundles was recorded (Figure 2).

Stage	Load	Time	HR	SBP	DBP	Angina Index	DP	ST-depression	Arrhyttmias-conduction disturbances	Auscultation
Baseline	0	3	85	130	90	0	11050	0	Incomplete RBBB	N
I	300	3	105	170	90	0	17850	0	Incomplete RBBB	N
II	600	3	115	180	90	0	20700	0	Incomplete LBBB	N
Recovery 1	0	1	110	170	80	0	-	Not valid	variable	N
Recovery 2	0	3	105	150	80	0	-	Not valid	Variable	N
Recovery 3	0	5	100	130	80	0	-	1 mm	Variable	N
Recovery 4	0	7	95	120	80	0	-	0	Incomplete RBBB	N

Table 1. Clinical and EKG data obtained during stress test and recovery (at baseline, during Astrand protocol and until seven minutes of recovery)

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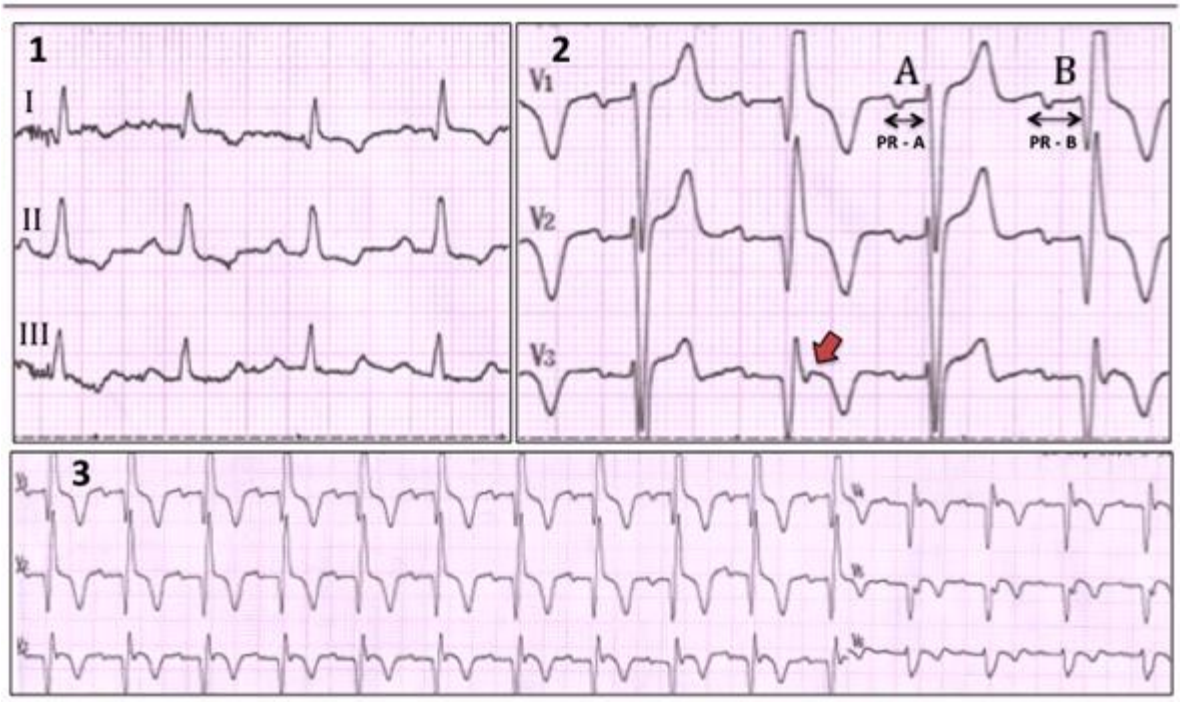

Figure 2. Ventricular conduction during recovery (first minute)

Figure 2 shows ventricular conduction during first minute of recovery. Conduction through right bundle branch was variable; slightly delayed with QR or Qr morphology (Part 1 of the diagram), adopting 2:1 sequence (Part 2 of diagram) or even severely delayed with complete and permanent right bundle branch block (Part 3 of diagram). In 2A right bundle branch conducted and in 2B it was delayed (2: 1 block in right bundle branch). PR interval in B (PR-B = 245 ms) was longer than in A (PR-A = 190 ms) since conduction was produced only through left bundle branch in B, always with first-degree block (see Figure 1). Reverse septal activation in A and B determined that large anterior non-activated myocardium would manifest as QR or qR morphology and signs of dyskinesia (red arrow).

The sequence of ventricular conduction during EKG stress test is summarized in Figure 3. Note that baseline ventricular conduction at a heart rate of 100 bpm was restored during recovery; reappearing with a longer cycle length which appeared in acceleration (360 ms vs. 315 ms, see Table 1). This situation is called "linking phenomenon" [11] and has been attributed to persistent concealed transeptal conduction during deceleration [12].

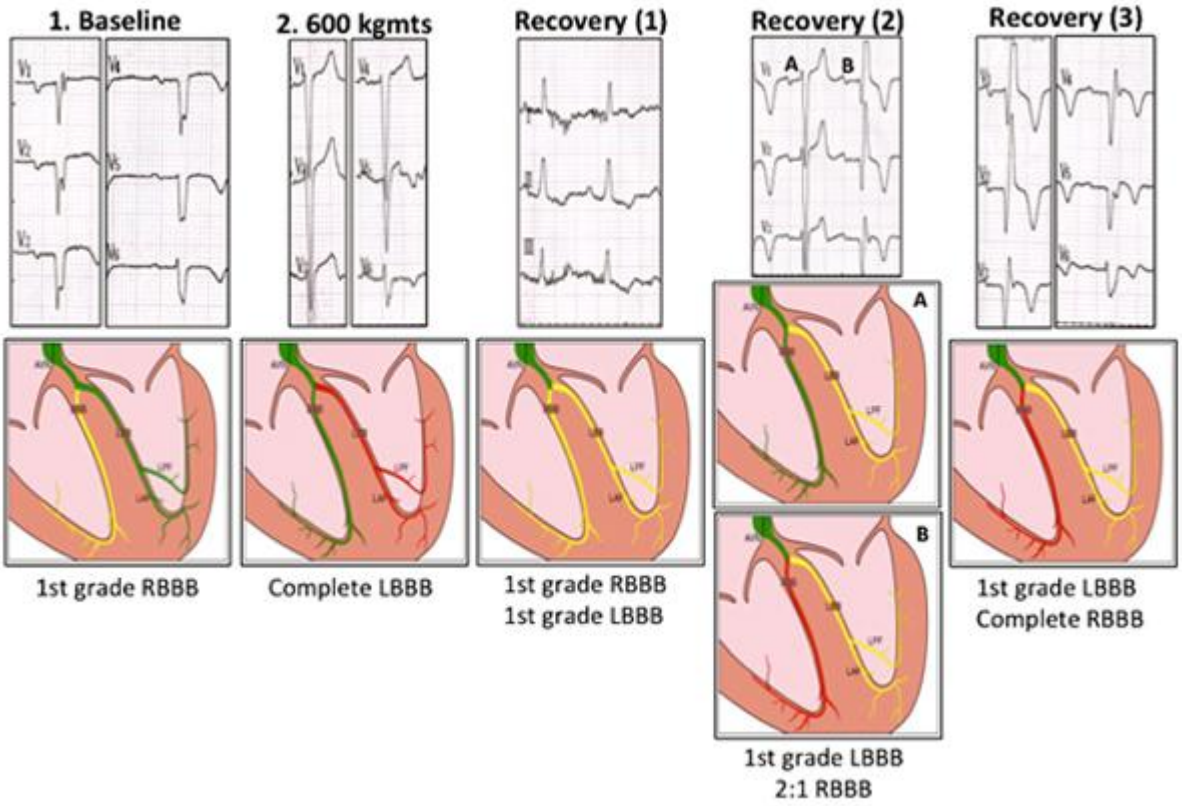

Figure 3. Evolution of ventricular conduction during EKG stress test

At the beginning of the exercise, delay of conduction through His left bundle branch was discrete (first degree), constant through right bundle branch (yellow) and constantly normal through left branch (green). During next stage (600 kmts), under the influence of circulating catecholamines, conduction through right bundle branch improved (green) and resulted in complete left bundle branch block morphology (left bundle branch in red). The delay observed in conduction through right bundle branch was variable in first minute of recovery; sometimes discrete (PE 1: right branch in yellow), sometimes in 2: 1 - Mobitz II sequence (PE 2 A: right bundle branch in green, PE 2 B: right bundle branch in red) and sometimes was complete and permanent (PE 3). So, severely altered conduction through both His bundles at different moments of EKG stress test (red) suggested an extensive damage of His-Purkinje system unmasked during exercise (see text).

Chronotropic response was adequate to treatment with beta-blockers. A Duke score of +5 conferred a moderate risk of major cardiovascular events in next 2 years.

Discussion

Serial EKG records are required to diagnose a tachycardia-dependent bundle branch block, accurately detecting the exact moment when bundle branch block pattern appears, and then assuming that QRS complex is widened at some time immediately prior. Furthermore, the definition of conduction from the atria to ventricles requires all beats were preceded by similar P wave and PR interval to previous rhythm. These steps are essential for diagnosis.

Tachycardia-dependent bundle branch block is the most frequently observed paroxysmal aberrant conduction. Their clinical manifestations are highly variable, ranging from isolated fascicular block to complete atrioventricular block [13]. Bilateral His-Purkinje system disease can be manifested by alternant bundle branch block, an entity that includes bundle branch block pattern intermittently recorded in an isolated tracing or, as in this case, coexisting simultaneously in the same EKG [14],[15],[16],[17],[18],[19],[20],[21].

This phenomenon is often found in patients with advanced ischemic heart disease, extensive scar and/or bilateral degenerative fibrosis of ventricular conduction system at multiple levels [22],[23]. The more common alternating bundle branch block morphology is complete left bundle branch block alternating with normal ventricular conduction. Less commonly, complete right bundle branch block alternating with normal or incomplete right bundle branch block conduction is observed. The documented case of bilateral beat-to-beat bundle branch block alternation is an extremely unusual phenomenon.

Since first description published by Braun et al. in 1951 [17], literature has referred almost exclusively to reports of isolated cases exhibiting alternating bundle branch block [8],[10],[14],[18],[19],[20]. Wu et al. described nine cases of alternating bundle branch block evaluated by electrophysiological atrial pacing and hisian recordings [21]. Alternating bundle branch block occurrence was mostly associated with incomplete block in a bundle branch and sudden complete block in the other. While pathological specimens were not available, authors suggested that clinical course of alternating bundle branch block was mainly related to the severity of underlying heart disease and not to next development of advanced atrioventricular block.

It is clear that alternating bundle branch block phenomenon is a consequence of an extensive damage of infrahisian conduction system with potential high risk of progression to advanced atrioventricular block, both during myocardial infarction [22],[23] and stable chronic coronary disease [24],[25]. In our case, in wich alternating bundle branch block pattern was accompanied by a variable delay in atrioventricular conduction at baseline, progression to complete AV block is imminent [10],[24]. However, pacemaker implant in this clinical setting is still an indication based on anecdotal evidences, mostly reported during past decades. Current experts recommendations suggest to proceed with pacemaker implantation as soon as alternating bundle branch block is documented, even in the absence of previous syncope (class I recommendation, level of evidence C) [26].

In the few clinical cases with coronary artery disease and severe systolic dysfunction that develop alternating bundle branch block requiring pacemaker implantation it becomes very important to closely monitor clinical, electrocardiographic and functional outcomes after right ventricle stimulation and timely indicate the upgrade to biventricular pacing [26]. Otherwise, maintaining right ventricle endocardium stimulation could induce a worsening of symptoms and progressive deterioration of contractile function associated with interventricular and left ventricular dissynchrony [27].

In a small, placebo-controlled prospective trial Kanoupakis et al. examined the electrophysiological impacts of carvedilol treatment in 31 individuals with chronic systolic dysfunction (left ventricular ejection fraction: 26 + 8% in control group vs. 28 + 7% in carvedilol group) [33]. Researchers found that carvedilol prolonged the ventricular refractory period without significant changes in physiological parameters of repolarization as corrected QT interval or monophasic records in 90% of repolarization. Furthermore, changes in refractoriness were strongly correlated with left ventricular ejection fraction, suggesting that patients with better systolic function respond with greater physiological changes. However, this study only included patients with non-ischemic dilated cardiomyopathy who underwent a short period of carvedilol treatment. So, its findings cannot be extrapolated to our case. Even if these results were confirmed more widely, it is unlikely to have practical importance on usual drug therapy of chronic systolic dysfunction. Meanwhile, even in subjects with severe systolic dysfunction developing alternating bundle branch block, positive benefits of non-cardioselective β-blockers in terms of mortality, symptomatic improvement, ejection fraction and development of ventricular tachyarrhythmias widely exceed the risk of accelerated progression to advanced atrioventricular block [34],[35].

Conclusions

Bilateral alternating tachycardia-dependent bundle branch block is an exceptional finding. Its presentation in chronic coronary disease is a sign of extensive damage in ventricular conduction system at high risk of serious events including progression to advanced atrioventricular block requiring pacemaker implantation. Sometimes it also requires biventricular pacing. In individuals with permanent bundle branch block at baseline, EKG stress test may unmask an exacerbation of these changes in the form of tachycardia-dependent aberrant conduction alternating different morphologies, a situation that takes immediate prognostic and therapeutic relevance.

Notes

From the editor

This article was originally submitted in Spanish and was translated into English by the authors. The *Journal*has not copyedited this version.

Ethical aspects

The Editorial Board of Medwave considered the data included in this report do not disclose patient's identity, thus written informed consent was unnecessary.

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Declaration of conflicts of interest

The authors completed the conflict of interests declaration form from the ICMJE and declared not having any conflict of interests with the matter dealt herein. Forms can be requested from the responsible author or the editors.

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