International Journal of Cardiology 286 (2019) 78–80

Contents lists available at ScienceDirect

International Journal of Cardiology

journal homepage: www.elsevier.com/locate/ijcard

Editorial

Defining left bundle branch block-Is this a roadblock to CRT delivery?☆

P.D. Lambiase

UCL Institute of Cardiovascular Science & Barts Heart Centre, Room 3.20, Rayne Institute, 5 University Street, London, WC1E 6JF, United Kingdom

ARTICLE INFO

Article history:
Received 4 February 2019
Received in revised form 11 March 2019
Accepted 14 March 2019
Available online 17 March 2019

Left bundle branch block (LBBB) represents a composite of multiple mechanisms of impaired myocardial conduction that promote a variety of surface ECG morphologies reflected in the plethora of diagnostic criteria which can be confusing [1–5]. The QRS complex in LBBB reflects the failure of optimal myocardial recruitment achieved by the normal functioning His-Purkinje network, a manifestation of a failure in coupling at one or multiple levels: within the left fascicles themselves, fascicular to myocardial conduction or intramyocardial conduction (Fig. 1). The classic M wave pattern in V6 reflects the rotation of an activation wavefront in the LV. Indeed, endocardial and more recently non-invasive ECG Imaging studies have demonstrated that there are 2 main patterns of activation-a Type 1 homogeneous depolarization and Type 2 U shaped pattern as the activation wavefront rotates around a region of fixed or functional block [6–8]. There has been a great deal of interest in attempting to predict the exact site of LBBB as this could have important implications not only for the siting of the coronary sinus LV lead but also predicting positive LV remodeling. A number of ECG markers of remodeling have been proposed including QRS duration, QRS area and the morphology of the intrinsicoid deflection [9–e12]. Fundamentally, if there is an excess of fibrosed myocardium, it is unlikely there is sufficient myocardial reserve to achieve adequate remodeling even if the lead is targeted outside scar.

In this edition A.M.W. van Stipdonk et al. go back to basics, regarding the definition of LBBB and compare the ability of clinicians to accurately diagnose LBBB according to each of the 4 commonest definitions. Not surprisingly, the simplest criteria (MADIT & Strauss scores) based on 4 features were the most consistently correctly utilized in defining LBBB, although 1 in 10 ECGs were still classified differently by the same observer and for 1 in 5 ECGs, the cardiologists differed on clinical judgement or the score. The concern is that there was a large inter and intra-observer error for each LBBB definition amongst these very experienced clinicians. This has potentially very important implications for the prescription of CRT with the possibility that patients that could benefit may not receive a CRT device if the more strict definitions are applied and the patients miscategorised.

A key issue in this paper is whether misjudging of LBBB pattern would have resulted in less CRT implants by these physicians in their daily practice and which ECG features are most commonly correctly applied. A deeper question is whether any of these definitions of LBBB impact on reverse remodeling. In the largest study to address this question examining 5 different LBBB classification schemes- it seems that QS or rS pattern in V1, notching/slurring in V5, V6 and absence of Q in V5, V6 are the most important criteria, whereas intrinsicoid time and T wave morphology seem to contribute less to the prediction of clinical response [e13].

It is well recognised that the longer the QRS duration is in LBBB, the greater the remodeling effect of CRT will be with the largest responses occuring when QRS duration is >150 ms [e12]. However, only a small proportion of patients have such broad QRS durations which has spurred investigation of other ECG markers to predict response even in non-LBBB cases. A recent study evaluated the QRS area in 1492 CRT recipients [e11]. QRS area, a marker of left lateral wall fibrosis, identified patients who did not experience the primary end point (death, transplantation, left ventricular assist device implantation) & echocardiographic remodeling better than QRS morphology and QRS duration. QRS area was the only independent electrocardiographic determinant associated with the primary end point; hazard ratio, 0.50 (0.35–0.71) & showed significant association with outcomes in both patients with and without LBBB and QRS ≥150 ms [9,e11].

Notching/slurring patterns in the precordial leads V1, V2, V5, and V6 and intrinsicoid deflection time are affected by the position of the heart in the chest and by appropriate positioning of electrodes [e14]. These variations alter the LBBB/non-LBBB diagnosis, based on AHA/ACC/HRS, ESC 2006 and Strauss definitions. In addition, measurement of QRS duration has its uncertainties with differences that can exceed 10–15 ms- enough to be clinically significant for qualifying a patient for CRT. Therefore, there is a real need to develop a universally accepted standard of ECG classification for ventricular conduction disturbance, as an ECG recording device industry standard, and to mandatorily prescribe its use in future CRT studies and in clinical practice guidelines.

With the advent of artificial intelligence & machine learning algorithms, the ECG databases of the randomised CRT trials & large cohorts could be re-examined to determine if there are specific derived higher

☆ PDL is supported by UCLH Biomedicine NIHR.
DOI of original article: https://doi.org/10.1016/j.ijcard.2019.01.051.
E-mail address: p.lambiase@ucl.ac.uk.

https://doi.org/10.1016/j.ijcard.2019.03.028

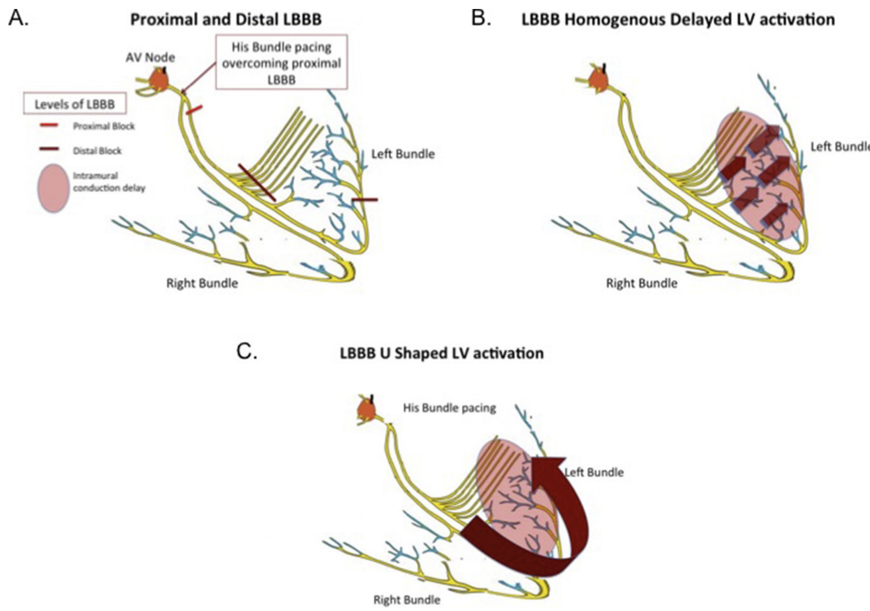

Fig. 1. Schematic diagram showing levels of left bundle branch block. A. Proximal or distal block in the left bundle branches. Distal block can occur due to lack of conduction at the fascicular-myocardial interface. Proximal block can be overcome by His pacing if this can engage the His-Purkinje system distal to the level of block and the remaining conduction system & myocardial conduction are intact to enable normal myocardial activation & a narrow QRS. B.More homogenous delayed conduction can occur across the LV wall or C. U shaped activation will occur around a site of intramural conduction delay with fixed/ functional block.

order features of the digitized ECG that can provide a more sophisticated prediction of likely remodeling outcomes or more information on the burden of myocardial scar e.g. Mid-QRS notching in the lateral leads strongly predicts a longer Q-LV interval [10]. This is increasingly relevant to the emergence of His Bundle pacing where intrinsic fascicular conduction & normal fasicicular-myocardial coupling is critical to determining if His pacing will engage the distal conduction system to correct LBBB. The importance of this mechanism was elegantly illustrated in restoring a narrow QRS in LBBB patients with His pacing using ECG-Imaging [e15]. Such information would be of great value in determining who is most likely to benefit from His pacing as opposed to an LV lead especially if there have been issues with coronary sinus LV lead placement due to difficult anatomy and an LV endocardial approach/surgical epicardial LV lead is being considered.

A simple automated ECG processing algorithm that accurately predicts the likelihood of benefit from His versus LV lead pacing could be developed to play a very useful cost-effective role in the pre-operative planning of CRT. Indeed if adequate long term cohort outcomes data were available combined with MR imaging data, then this digitized ECG analysis could be utilized to enable standardized & tailored CRT with important applications in improving patient prognosis through more objective patient selection criteria and lead targeting [e16–e17].

Potential conflicts of interest

PDL is supported by research grants from Medtronic and Boston Scientific.

References

[1] M. Brignole, A. Auricchio, G. Baron-Esquivias, et al., ESC guidelines on cardiac pacing and cardiac resynchronization therapy: the task force on cardiac pacing and resynchronization therapy of the European Society of Cardiology (ESC). Developed in collaboration with the European Heart Rhythm Association (EHRA), Eur. Heart J. 34 (2013) (2013) 2281–2329.

[2] B. Surawicz, R. Childers, B.J. Deal, et al., AHA/ACCF/HRS recommendations for the standardization and interpretation of the electrocardiogram: part III: intraventricular conduction disturbances: a scientific statement from the American Heart Association Electrocardiography and Arrhythmias Committee, Council on Clinical Cardiology; the American College of Cardiology Foundation; and the Heart Rhythm Society. Endorsed by the International Society for Computerized Electrocardiology, J. Am. Coll. Cardiol. 53 (2009) 976–981.

[3] A. Bayés De Luna, V.N. Batchvarov, M. MalikChapter, 1: the morphology of the electrocardiogram, in: A.J. Camm (Ed.), The ESC Textbook of Cardiovascular Medicine, Blackwell Publishing 2006, pp. 1–35.

[4] F.G. Cosío, J. Palacios, A. Pastor, A. Núñez, Chapter 2 the electrocardiogram, in: A.J. Camm (Ed.), The ESC Textbook of Cardiovascular Medicine, 2 ed.Oxford University Press 2009, pp. 29–83.

[5] D.G. Strauss, R.H. Selvester, G.S. Wagner, Defining left bundle branch block in the era of cardiac resynchronization therapy, Am. J. Cardiol. 107 (2011) 927–934.

[6] J.W. Fung, C.M. Yu, G. Yip, Y. Zhang, H. Chan, C.C. Kum, J.E. Sanderson, Variable left ventricular activation pattern in patients with heart failure and left bundle branch block, Heart 90 (1) (2004 Jan) 17–19.

[7] P.D. Lambiase, A. Rinaldi, J. Hauck, M. Mobb, D. Elliott, S. Mohammad, J.S. Gill, C.A. Bucknall, Non-contact left ventricular endocardial mapping in cardiac resynchronisation therapy, Heart 90 (1) (2004 Jan) 44–51.

[8] N. Varma, P. Jia, Y. Rudy, Electrocardiographic imaging of patients with heart failure with left bundle branch block and response to cardiac resynchronization therapy, J. Electrocardiol. 40 (6 Suppl) (2007 Nov-Dec) S174–S178.

[9] U.C. Nguyên, S. Claridge, K. Vernooy, E.B. Engels, R. Razavi, C.A. Rinaldi, Z. Chen, F.W. Prinzen, Relationship between vectorcardiographic QRS_{area}, myocardial scar quantification, and response to cardiac resynchronization therapy, J. Electrocardiol. 51 (3) (2018 May - Jun) 457–463.

[10] G. Pastore, M. Maines, L. Marcantoni, F. Zanon, F. Noventa, G. Corbucci, E. Baracca, S. Aggio, C. Picariello, D. Lanza, G. Rigatelli, M. Carraro, L. Roncon, S.S. Barold, ECG parameters predict left ventricular conduction delay in patients with left ventricular dysfunction, Heart Rhythm. 13 (12) (2016 Dec) 2289–2296.

[e11] A.M.W. van Stipdonk, I. Ter Horst, M. Kloosterman, E.B. Engels, M. Rienstra, H.J.G.M. Crijns, M.A. Vos, I.C. van Gelder, F.W. Prinzen, M. Meine, A.H. Maass, K. Vernooy, QRS area is a strong determinant of outcome in cardiac resynchronization therapy, Circ. Arrhythm. Electrophysiol. 11 (12) (2018 Dec), e006497.

[e12] A.R. Bryant, S.B. Wilton, M.P. Lai, D.V. Exner, Association between QRS duration and outcome with cardiac resynchronization therapy: a systematic review and meta analysis, J. Electrocardiol. 46 (2) (2013 Mar-Apr) 147–155.

[e13] M.L. Caputo, A. van Stipdonk, A. Illner, G. D'Ambrosio, F. Regoli, G. Conte, T. Moccetti, C. Klersy, F.W. Prinzen, K. Vernooy, A. Auricchio, The definition of left bundle branch block influences the response to cardiac resynchronization therapy, Int. J. Cardiol. 269 (2018 Oct 15) 165–169 (Epub 2018 Jul 17).

[e14] U.C. Nguyên, M. Potse, F. Regoli, et al., An in-silico analysis of the effect of heart position and orientation on the ECG morphology and vectorcardiogram parameters in patients with heart failure and intraventricular conduction defects, J. Electrocardiol. 48 (2015) 617–625.

[e15] A.D. Arnold, M.J. Shun-Shin, D. Keene, J.P. Howard, S.M.A. Sohaib, I.J. Wright, G.D. Cole, N.A. Qureshi, D.C. Lefroy, M. Koa-Wing, N.W.F. Linton, P.B. Lim, N.S. Peters, D.W. Davies, A. Muthumala, M. Tanner, K.A. Ellenbogen, P. Kanagaratnam, D.P. Francis, Z.I. Whinnett, His resynchronization versus biventricular pacing in patients

with heart failure and left bundle branch block, J. Am. Coll. Cardiol. 72 (24) (2018 Dec 18) 3112–3122.

[e16] F.Z. Khan, M.S. Virdee, C.R. Palmer, P.J. Pugh, D. O'Halloran, M. Elsik, P.A. Read, D. Begley, S.P. Fynn, D.P. Dutka, Targeted left ventricular lead placement to guide cardiac resynchronization therapy: the TARGET study: a randomized, controlled trial, J. Am. Coll. Cardiol. 59 (17) (2012 Apr 24) 1509–1518.

[e17] Z. Chen, M. Sohal, E. Sammut, N. Child, T. Jackson, S. Claridge, M. Cooklin, M. O'Neill, M. Wright, J. Gill, A. Chiribiri, T. Schaeffter, G. Carr-White, R. Razavi, C.A. Rinaldi, Focal but not diffuse myocardial fibrosis burden quantification using cardiac magnetic resonance imaging predicts left ventricular reverse modeling following cardiac resynchronization therapy, J. Cardiovasc. Electrophysiol. 27 (2) (2016 Feb) 203–209.