History of Electrocardiology

Paul Schweitzer, M.D. and Georg Couturier, M.D.

“The History of Bundle Branch Block”

Introductory Note to the Classic Article by Wilson, MacLeod, and Barker

The two main developments which stimulated the interest of the ECG pattern of bundle branch block (BBB) were Tawara's description of the intraventricular conduction system¹ and Einthoven's invention of the string galvanometer.² However, the diagnostic criteria of right and left BBB, as we know them today, underwent interesting evolution and were not clarified until the early 1930s and accepted years later.³ In 1985 Hollman³ published an outstanding and comprehensive article of the history of BBB. This topic was also reviewed by Burch and DePasquale in their book *A History of Electrocardiology*.⁴

Einthoven first recorded a bundle branch block (BBB) with the Lipman capillary electrometer and in the same patient, 31 years later, using the string galvanometer.³ In 1910, Eppinger and Rothberger⁵ reported the first experimental ECG study of BBB using an annoesophageal lead. These authors produced BBB or complete AV block by injection of silver nitrate into the intraventricular septum or cutting the bundle branches. In the annoesophageal lead, LBBB resulted in a prominent R wave with negative T wave while RBBB showed a rS pattern with positive T waves. A year earlier, the same authors⁶ created BBB without realizing its true nature. In 1913, Rothberger and Winterberg⁷ in their experimental research of BBB stressed the importance of the recording of leads I and III for the diagnosis of intraventricular conduction defects, particularly for differentiation between BBB and ventricular hypertrophy.

Lewis^{8,9} was the next investigator interested in the ECG diagnosis of BBB. He produced BBB either by squeezing the intraventricular septum with a

clamp or by cutting the bundles. In lead I, injury of the right bundle branch produced a qR with negative T wave, and in lead III a small r followed by a deep S wave with opposite T-wave polarity (Fig. 1). The ECG manifestation of LBBB was rS and positive T wave in lead I and qR with negative T wave in lead III (Fig. 2). In other words, the ECG patterns of right and left bundle branch block were reversed. Furthermore, Lewis^{8,9} considered the so-called RBBB and LBBB the common and uncommon type of intraventricular conduction defect, respectively. Lewis also suggested that transient bundle branch block could be due to acute or subacute infection. To support this assumption, he showed a transient “RBBB” in a patient with aortic valve disease and fever.⁹ However, because of the short and transient nature of the BBB, this was more likely a rate-related intraventricular conduction defect.

The next step in the ECG classification of BBB was the correlation between ECG and postmortem findings. In two patients, one with aortic regurgitation and the other with coronary artery disease and so-called RBBB, Eppinger and Stoerk¹⁰ found fibrosis of the right bundle branch and histologically normal left bundle. According to Wilson et al.,¹¹ this observation was one of the reasons for Lewis' misclassification of BBB. Subsequent studies, trying to correlate structural changes in the bundle branches with the ECG led to controversial results.¹²⁻¹⁵ As reviewed by Rossi,¹⁵ there is significant variation in the histological changes in patients with BBB. In addition to good correlation between bundle branch fibrosis and the ECG, there are patients with extensive fibrosis of both bundles

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Address for correspondence: Paul Schweitzer M.D. Heart Institute, Beth Israel Medical Center, First Avenue at 16 th Street, New York, NY 10003. Fax: (212) 420-2406; E-mail: pschweit@bethisraelny.org

Figure 1: The three limb leads labeled as RBBB showing qR with ST-segment depression and negative T wave in lead I and rS with ST elevation and positive T wave in lead III. (Reproduced from Lewis T: Clinical electrocardiography, p 29, 1924.)

or an involvement of the contralateral fascicle. Furthermore, not all patients with extensive damage of the intraventricular conduction system have a BBB on the ECG. In summary, structural changes of the intraventricular conduction system have limited value for localization of BBB. This suggestion was pointed out by Cohn and Lewis¹³ as early as 1914.

In the subsequent years, Lewis's proposed ECG criteria of BBB were challenged by Fahr.¹⁶ By applying the theory of the electric axis, Fahr arrived to the correct classification of BBB. However, Wilson and Herrmann¹⁷ rejected Fahr's suggestions because they were based on "theoretical considerations" rather than experimental data. Similarly, Mann,¹⁸ using a monocardigram, which was the first vectorial interpretation of the three limb leads, suggested the correct criteria for right and left BBB.

During the evolution of the ECG criteria of BBB, few authors pointed out the discrepancy between

left heart disease and so called RBBB. Probably the first was Rothberger and Wiinterberg⁷ who could not understand why a patient with aortic regurgitation had so called RBBB. Mann¹⁸ and others,¹⁹ including Einthoven²⁰ also questioned the higher incidence of so called RBBB in patients with left heart disease.

The diagnostic criteria of right and left BBB was finally settled by Barker and coworkers²¹ in a 30-year-old man with purulent pericarditis in whom the left fifth and sixth costal cartilage was removed. Based on the assumption that ventricular premature beats resemble contralateral BBB, Barker et al.²¹ stimulated various parts of the two ventricles that produced interesting ECG findings. In lead I, left ventricular extrasystoles had a prominent S wave similar to a RBBB, while right ventricular premature beats resembled LBBB. The QRS morphology in leads II and III was variable, depending on the site of stimulation. Positive QRS complexes

Figure 2: The three limb leads labeled as LBBB showing rS with ST-segment elevation and positive T wave in lead I and qR with ST-segment depression and negative T wave in lead III. (Reproduced from Lewis T: Clinical Electrocardiography, p.29, 1924.)

were seen during stimulation of the base and negative ones originating in the apex. Based on these results, Barker et al.²¹ suggested to reverse the ECG criteria for right and left BBB. This recommendation was further supported by two additional studies from the Ann Arbor group.^{11,22}

According to Wilson et al.,¹¹ the possible causes of Lewis' misclassification of right and left BBB were the following: (a) left bundle branch damage during squeezing of the intraventricular septum, (b) predominantly negative QRS complex in lead III in RBBB due to a vertical position of the dog's heart resembling LBBB, (c) Eppinger and Stoerk's¹⁰ report of right bundle branch lesions in patients with assumed RBBB. Burch and De Pasquale⁴ offered a fourth explanation that the dog's heart is suspended, like a pendulum, from the vertebral column and thus, its spatial orientation is difficult to control.

However, even after the reports of Wilson and his group^{11,21,22} and the studies of Fahr¹⁶ and Mann¹⁸, there was reluctance to accept the new ECG criteria of BBB. Lewis in 1937 acknowledged the controversy without accepting the new classification of BBB. He also suggested that localization of BBB is of limited clinical significance. Furthermore, in 1939, Scherf and Boyd²³ stated: "In view of these difficulties and with due regard for the status of our present knowledge, it seems advisable merely to state that a tracing shows "bundle branch block type." To this statement should be added the fact that it is the common or the uncommon type. The common type of bundle branch block corresponds to the right bundle branch block according to the classical nomenclature or left bundle branch block according to the new terminology and vice versa.¹¹ Finally, Lewis in the 6th edition of the *Electrocardiography and Clinical Disorders of the Heart Beat* correctly labeled the right and left bundle branch.²⁴

CONCLUSION

We reviewed the history of the ECG criteria of bundle branch block that illustrates how the combination of incomplete histological evaluation, poor correlation between histology and ECG, uncritical applications of experimental results to humans, and high respect for Lewis's work led to misclassification of intraventricular conduction defects.

REFERENCES

1. Tawara S. Das Reizleitungssystem des Säugetierherzens, G.Fischer, Jena 1906.
2. Einthoven W. Die galvanometrische Registrierung des menschlichen Electrocardiogram, zugleich eine Beurtheilung der Anwendung des Capillar-Electrometer in der physiologie. Pflug Arch Ges Physiol 1903;99:472-480. (English translation in: Classics of Cardiology eds. Willius FA, Keys TE, Krieger RE, Florida, 1961 pp. 722-728).
3. Hollman A. The history of bundle branch block. Medical History 1985;5(Suppl.): 82-102.
4. Burch GE, De Pasquale NP, Howell JD. A history of electrocardiography. Norman Publishing, San Francisco, 1990, pp. 165-175.
5. Eppinger H, Rothberger CJ. Über die folgen der Durchschneidung der Tawaraschen Schenkel des Reizleitungssystem. Zt Klin Med 1910;70:1-20.
6. Eppinger H, Rothberger CJ. Zur analyse des electrokardiogramms. Wien Klin Wschr 1909;22:1091-1098.
7. Rothberger CJ, Winterberg Zur Diagnose der einseitigen Blockierung der Reizleitung in den Tawaraschen Schenkeln. Zbl Herz Gefasskrankh 1913;5:206-208.
8. Lewis T. The spread of the excitatory process in the vertebrate heart. Part I-V. Phil Trans R Soc London, series B 1916;207:221-310.
9. Lewis T. Clinical Electrocardiography, Shaw&Sons, London, 1924, pp. 24-28.
10. Eppinger H, Stoerk O. Zur Klinik des Electrokardiogramms. Zt Klin Med 1910;71:157-164.
11. Wilson FN, Macleod AG, Barker PS. The interpretation of the initial deflection of ventricular complex of the electrocardiogram. Am Heart J 1931;6:637-664.
12. Cohn AE, Lewis T. A description of case of complete heart-block, including the post-mortem examination. Heart 1913; 4:7-4.
13. Cohn AE, Lewis T. The pathology of bundle branch lesions of the heart. Proc NY Path Soc 1914;14:207-216.
14. Oppenheimer BS, Pardee HEB. The site of the cardiac lesion in two instances of intraventricular heart block. Proc Soc Exper Biol Med 1920;17:177-179.
15. Rossi L. Histopathologic features of cardiac arrhythmias. Casa Editrice Abrosiana, Milano, 1969, pp. 193-240.
16. Fahr G. An analysis of the spread of the excitation wave in the human ventricle. Arch Int Med 1920;25:146-173.
17. Wilson FN, Herrmann GR. Bundle branch block and arborization block. Arch Int Med 1920;26:53-191.
18. Mann H. Interpretation of bundle-branch block by means of the monocardigram. Am Heart J 1931;4:447-457.
19. Carter EP. Clinical observation on defective conduction in the branches of the auriculo-ventricular bundle. Arch Int Med 1914;13:803-840.
20. Snellen HA. Willem Einthoven (1860-1927); Father of Electrocardiography. Kluwer Academic Publisher, Dordrecht, 1995 p. 94.
21. Barker PS, Macleod AG, Alexander J. The excitatory process observed in the exposed human heart. Am Heart J 1930;5:720-742.
22. Wilson FN, Macleod AG, Barker PS. The order of ventricular excitation in human bundle branch block, Am Heart J 1932;7:305-330.
23. Scherf D, Boyd LJ. Clinical Electrocardiography, Mosby CV, St Louis, 1939, p. 57.
24. Lewis T. Electrocardiography and clinical disorders of the heart beat. In Hollman A. The history of bundle branch block. Medical History 1985;Suppl 5: 82-102.