敏感和特定的ECG标准用于诊断AMI在LBBB患者中。Di Marco等人在《美国心脏协会杂志》(JAHA)1中提出的增强标准是一个可能性。Sgarbossa等在1996年引入了新的AMI诊断标准，仅基于ST段变化，敏感性为36%，特异性为96%，阳性预测值为88%。2当时的这些新标准代表了一个新的方法，但后来Smith等在他们的改进Sgarbossa标准3中，其敏感性为91%，特异性为90%。3,4在随后的病例-对照研究中，45例急性冠状动脉阻塞和249例对照组的敏感性为80%，特异性为99%。4在Smith等的研究3的基础上，Di Marco等人在该研究中，敏感性为93%，特异性为94%，这与原来的Sgarbossa标准2的33%和99%，以及改进的Sgarbossa标准3,4的68%和94%。所有这些标准都是基于同一患者群体。因此，新的方法代表了一项显著的改进，特别是在与更早期的方法相比，对敏感性的影响。

**定义LBBB**

作者选择了一种相对传统的LBBB定义，QRS持续时间>0.12秒，V1中的QS或rS复合体，以及I、V5或V6导联中R波峰时间>60ms的无Q波。1但是，他们落在了研究小组中，研究小组的大小也很小。3。一项随访的对照研究评估了同样的标准，结果是45例急性冠状动脉阻塞和249例对照组的80%敏感性和99%特异性。4。Smith等的研究3的修改是用一个新标准替换一个Sgarbossa标准(STj ≥0.5 mV discordant with QRS)，即[Sj/Samp] ≥0.25与STj ≥0.1 mV在相同的导联。

见Di Marco等人文章。

在Di Marco等人文章中，敏感性和特异性在107位患者的测试组中分别为93%和94%。1这与原来的Sgarbossa标准2的33%和99%以及改进的Sgarbossa标准3,4的68%和94%。所有这些标准都是基于同一患者群体。因此，新的方法代表了一项显著的改进，特别是在与更早期的方法相比，对敏感性的影响。

**关键词:** 辨论，ECG，ECG标准，左束支传导阻滞，心肌梗死

Correspondence to: Peter W. Macfarlane, DSc, Electrocardiology Core Lab, New Lister Building, Royal Infirmary, 10 Alexandra Parade, Glasgow G31 2ER, Scotland, United Kingdom. E-mail: peter.macfarlane@glasgow.ac.uk

The opinions expressed in this article are not necessarily those of the editors or of the American Heart Association.

For Disclosures, see page 5.

© 2020 The Author. Published on behalf of the American Heart Association, Inc., by Wiley. This is an open access article under the terms of the Creative Commons Attribution-NonCommercial-NoDerivs License, which permits use and distribution in any medium, provided the original work is properly cited, the use is non-commercial and no modifications or adaptations are made.

JAHA is available at: www.ahajournals.org/journal/jaha

J Am Heart Assoc. 2020;9:e017119. DOI: 10.1161/JAHA.120.017119

1
therapy, and hence they were using a strict definition of LBBB. Whether the definition of LBBB by Strauss et al would have altered results in the current study is a question that cannot be answered here.

Figure 1 shows an example of LBBB in a 76-year-old woman. The reader is invited to review this ECG, and in the absence of any clinical details, consider the interpretation. Further discussion of this example will follow.

**METHODS**

In the study of Di Marco et al, all ECGs were interpreted visually by 2 cardiologists and there was an exceptionally high agreement between them (κ coefficient=0.98). Measurements >0.1 mV (1 mm) were made to the nearest 0.05 mV. This does raise the question that if ST amplitude, for example, happened to be bordering on 0.1 mV (eg, 0.095 mV), then it could have possibly influenced a cardiologist aware of a threshold of 0.1 mV. Of course, such a situation could affect both sensitivity and specificity, but it might mean that if automated methods were used for ECG interpretation of a new test set at some future point, the results of automated versus manual interpretation could differ.

The biggest difference between the new criteria and the original Sgarbossa criteria is that the new approach is not a point scoring system. The new criteria of Di Marco et al have 2 major differences compared with previous criteria:

1. Although the Sgarbossa criteria used ST depression ≥0.1 mV as a criterion for AMI only in leads V1 to V3 with a dominant Q or S wave, the new approach extends this criterion to any lead (ie, where the ST depression and the QRS complex are "concordant");
2. A completely new criterion, applicable in any lead, of ST deviation ≥0.1 mV, which is "discordant" with the QRS complex where the dominant QRS wave ≤0.6 mV (ie, the STj amplitude is oppositely directed to the dominant QRS deflection). Note that this is not peak to peak QRS amplitude.

These 2 new criteria, together with an existing Sgarbossa criterion (namely, ST elevation ≥0.1 mV), which is concordant with the QRS complex, constitute the new so-called Barcelona algorithm, which is positive if any 1 of the 3 above mentioned criteria is met.

**VOLTAGES IN LBBB**

The interesting new criterion is the use of a low-voltage QRS complex together with ST deviation. It therefore is of some interest to consider the vectorcardiogram of LBBB, as shown in Figure 2.

The classic LBBB pattern has a relatively narrow QRS loop and slow inscription signified by the close spacing of the dots that form the loop. In general terms, the T-wave loop is oppositely directed from the QRS loop. Leads that are directed essentially parallel to the QRS loop, particularly in the transverse plane (eg, a precordial lead, such as lead V1 or V2), will have a high QRS voltage. Leads that are more directed at right angles to the VCG loop, such as V4 and V5 in this example, will have lower voltages because the
The voltage in V5 is less than one quarter of the voltage in V1. Thus, it can be expected that there will be a large variation in the amplitude of the QRS complex in ECGs with LBBB. This can also be seen in Figure 1 of the article by Di Marco et al. There is therefore a small probability that evolving ST depression in the left lateral leads from V4, for example, toward V6 in an LBBB recorded from a patient without an AMI could therefore be associated with a low-voltage QRS complex.

Figure 2. A 12-lead ECG and derived vectorcardiogram (VCG) demonstrating left bundle branch block.

The 3 planes of the VCG are transverse (T), frontal (T), and left sagittal (LS). The 3 orthogonal leads X, Y, and –Z, from which the VCG is constructed, are directed similarly to V6, aVF, and V2, respectively.
This might account for the slightly reduced specificity of 94% in the new Barcelona criteria compared with 99% in the Sgarbossa criteria, but of course sensitivity is exceptionally high in the former at 93% compared with 33% in the latter.

ST depression in LBBB with a QRS amplitude ≤0.6 mV will undoubtedly occur in subjects without an AMI, possibly meeting the new Barcelona criterion of discordant ST deviation ≥0.1 mV. Of course, it is unrealistic to expect all criteria to be 100% specific! Sperry et al.8 suggested that LBBB does not deter assessment of low-QRS voltage in patients with cardiac amyloidosis, for example. Other well-known causes of low voltage, such as chronic obstructive pulmonary disease, can occasionally occur in a patient with an LBBB.9 So, it would be unreasonable to expect any ECG criterion to be perfectly specific, but the Barcelona criteria do manage to marry a high specificity to a high sensitivity.

SENSITIVITY AND SPECIFICITY

All the measurements in this study were made manually. In their supplementary data, the authors give an example where approximation of a measurement could lead to a different interpretation of one of the modified Sgarbossa criteria, depending on whether approximation of ST depression was 0.15 or 0.2 mV. This is because the ratio |STj/Samp| was involved. In the new Barcelona criteria, no ratios are involved. However, a similar situation must arise where the amplitude of an R or S wave could be 0.62 mV when measured by computer but a manual estimate measuring to the nearest 0.05 mV could be 0.6 mV. In the latter case, this wave would meet one of the Barcelona thresholds, being ≤0.6 mV, whereas the automated measurement would not. Of course, it could be argued development of the criteria is based on manual measurements and therefore application would also apply to manual measurements but clearly there is scope for variation here, as in any manual versus automated ECG measurement.

The authors performed a separate assessment of specificity on 214 hospital patients without any evidence of an AMI who had not undergone cardiac catheterization. Specificity of the Barcelona criteria remained high at 90%, although this was the lowest specificity of all criteria.

Perhaps one of the most surprising aspects of the new criteria is the fact that discordant ST depression in V6, for example, can be regarded as a positive indicator of myocardial infarction if the R-wave amplitude is ≤0.6 mV. This criterion had a surprisingly high specificity of 94%, even when assessed together with concordant ST elevation.

For this reason, the author made a rapid review of 50 cases of LBBB selected at random from a local database of several hundred thousand ECGs recorded mainly in a hospital setting. Time did not permit analysis of a larger sample. However, it was found that 94% of examples had a maximum R or S wave ≤0.6 mV in ≥1 lead. There is therefore scope for checking the new Barcelona criterion of significant discordant ST deviation.

It should also be noted that in Fig. 2, the R amplitude in V5 is approximately 0.5 mV and the STj depression exceeds 0.1 mV and so the Barcelona algorithm is positive.

ECG EXAMPLE

With the above discussion in mind, the reader is encouraged to review again the ECG of Figure 1. Measurements quoted below were derived from automated analysis of the ECG using software from the author’s laboratory.10

The leads of most interest are V2 and V4. The ST amplitude in V2 is 0.542 mV, meeting one of the Sgarbossa criteria, but this does not produce a score sufficient to report AMI. The S-wave amplitude in V2 is 2.841 mV and so in this lead |STj/Samp|=0.19 and so the modified Sgarbossa criteria3 are not met. This criterion was not met in any other lead. The new Barcelona criterion of discordant ST deviation ≥0.1 mV is met in V4, where ST amplitude is 0.105 mV and the dominant S wave is 0.482 mV and hence ≤0.6 mV. In summary, this ECG should be reported as showing AMI according to the new Barcelona criteria.

CLINICAL APPLICABILITY

Di Marco et al.1 point out that, in their cohort of patients referred for primary percutaneous coronary intervention, 63% unnecessarily underwent cardiac catheterization, no doubt in keeping with recommended guidelines, although the Sgarbossa criteria, with a specificity of 96%, were available, having been established in 1996. As the authors point out, the current European Society of Cardiology guidelines11 advise that in a patient with a clinical suspicion of ongoing ischemic symptoms, an ECG showing LBBB should be regarded as an ST-segment–elevation myocardial infarction equivalent, even if there was a previous ECG showing LBBB. These guidelines also emphasized that the presence of a (presumed) new LBBB does not predict a myocardial infarction. Nonetheless, if the new criteria can be externally validated, they could on occasion be a valuable aid in decision making.

FURTHER STUDIES

The high sensitivity and specificity of the new Barcelona algorithm require to be assessed in an
independent population, either manually or with automated techniques. It sometimes happens that criteria developed in one center do not perform so well when evaluated in another center. On the other hand, it could be argued that the established Sgarbossa criteria performed similarly in the Barcelona validation sample as in the original study. Nevertheless, few ECG criteria have been shown through the years to be the order of 93% to 94% sensitive and specific and only time will tell whether the outstanding performance of the criteria set out in the article of Di Marco et al will stand the test of independent assessment.

ARTICLE INFORMATION

Affiliations
From the Institute of Health and Wellbeing, University of Glasgow, Scotland, United Kingdom.

Disclosures
None.

REFERENCES

1. Di Marco A, Rodriguez M, Cinca J, Bayes-Genis A, Ortiz-Perez JT, Ariza-Solé A, Sanchez-Salado JC, Sionis A, Rodriguez J, Toledano B, et al. New electrocardiographic algorithm for the diagnosis of acute myocardial infarction in patients with left bundle branch block. J Am Heart Assoc. 2020;9:e015573. DOI: 10.1161/JAHA.119.015573.

2. Sgarbossa EB, Pinski SL, Barbagelata A, Underwood DA, Gates KB, Topol EJ. JUGSTO-1 (Global Utilization of Streptokinase and Tissue Plasminogen Activator for Occluded Coronary Arteries) Investigators. Electrocardiographic diagnosis of evolving acute myocardial infarction in the presence of left bundle-branch block. N Engl J Med. 1996;334:481–487.

3. Smith SW, Dodd KW, Henry TD, Dvorak DM, Pearce LA. Diagnosis of ST elevation myocardial infarction in the presence of left bundle branch block with the ST elevation to S-wave ratio in a modified Sgarbossa rule. Ann Emerg Med. 2012;60:766–776.

4. Meyers HP, Limkakeng AT, Jaffa EJ, Patel A, Thelning BJ, Rezaie SR, Stewart T, Zhuang C, Pera VK, Smith SW. Validation of the modified Sgarbossa criteria for acute coronary occlusion in the setting of left bundle branch block: a retrospective case-control study. Am Heart J. 2015;170:1255–1264.

5. Willems JL, Robles de Medina EO, Bernard R, Coumel P, Fisch C, Kriklé D, Mazur NA, Meijler FL, Mogensen L, Mort P, et al. Criteria for intraventricular conduction disturbances and pre-excitation. J Am Coll Cardiol. 1985;5:1261–1275.

6. Surawicz B, Childers R, Deal BJ, Gettes LS. AHA/ACCF/HRS recommendations for the standardization and interpretation of the electrocardiogram, part III: intraventricular conduction disturbances. J Am Coll Cardiol. 2009;53:976–981.

7. Strauss DG, Selvester RH, Wagner GS. Defining left bundle branch block in the era of cardiac resynchronisation therapy. Am J Cardiol. 2011;107:927–934.

8. Sperry BW, Vranian MN, Hseriom J, Hachamovitch R, Hanna M. QRS duration and left bundle branch block do not deter assessment of low voltage in cardiac amyloidosis. Circulation. 2015;132(suppl 3):A10961.

9. Laratta CR, van Eeden S. Acute exacerbation of chronic obstructive pulmonary disease: cardiovascular links. Biomed Res Int. 2014;2014:528789.

10. Macfarlane PW, Devine B, Clark E. The University of Glasgow (Uni-G) ECG analysis program. Comput Cardiol. 2005;32:451–454.

11. Ibanez B, James S, Agewall S, Antunes MJ, Bucciarelli-Ducci C, Bueno H, Calafiore ALP, Crea F, Goudevenos JA, Halvorsen S, et al. ESC Scientific Document Group. 2017 ESC guidelines for the management of acute myocardial infarction in patients presenting with ST-segment elevation. Eur Heart J. 2018;39:119–177.