Limitations of ECG algorithms in paced right bundle branch block with prior myocardial infarction

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Introduction

In patients with normal baseline cardiac conduction, a left bundle branch block (LBBB) pattern is expected with right ventricle (RV) pacing.[1] Paced right bundle branch block (RBBB) raises several concerns; inadvertent intraventricular left ventricle (LV) pacing is the most serious. Often, a 2-view chest radiograph is useful in assessing proper lead placement. Electrocardiogram (ECG) acquisition maneuvers and ECG-based algorithms have been developed to provide important confirmatory information.[2–4] While ECGs allow for rapid identification of uncomplicated RV pacing, clinicians must be aware of the pitfalls that can affect the diagnostic accuracy of an ECG-based approach in the context of prior myocardial infarction. We report a case of RBBB in true RV pacing in a patient who had a preexisting inferolateral Q-wave myocardial infarction, which limited the utility of ECG analysis in confirming RV lead placement.

KEY TEACHING POINTS

- In addition to radiographic modalities, established electrocardiogram (ECG) algorithms can be applied to help resolve concerns of proper electrode placement when right bundle branch block (RBBB) is observed in right ventricle pacing.
- In the setting of preexisting inferolateral infarction, the utility of these ECG algorithms is limited.
- In patients with preexisting RBBB and inferolateral infarction, right ventricular outflow tract electrode positioning gives the expected left bundle branch block and avoids the concern for possible electrode misplacement.

Case report

A 55-year-old man required an emergent dual-chamber pacemaker for complete atrioventricular block (Figure 1A). The presence of the RBBB on the postpacemaker ECG (Figure 1C), which was present on the baseline ECG (Figure 1B) but not evident when the patient was in complete heart block, raised concern for possible LV pacing. The patient had a history of myocardial infarction with drug-eluting stents placed in the mid-left anterior descending and mid-right coronary arteries. His baseline ECG showed normal sinus rhythm, RBBB, left axis deviation (LAD), and inferolateral infarction pattern (Figure 1B). A 2-view chest radiograph demonstrated proper placement of the pacing lead in the RV apex (Supplementary Figure 1).

We applied the ECG criteria suggested by Coman and Trohman[3] and Okmen and colleagues[4] and discovered that preexisting Q-wave infarcts limit their performance at detecting proper lead placement in the RV. The patient was discharged home with routine outpatient follow-up. The postoperative course was complicated by generator pocket infection and hematoma. He was hospitalized and treated with intravenous antibiotics. The generator and existing leads were extracted, and a new system was implanted on the right chest. The RV pacing lead was placed in the RV outflow tract (RVOT) with a resultant change in the baseline frontal axis from LAD to right axis deviation, and qR pattern in lead I and aVL, and an LBBB pattern in V_1 as expected (Supplementary Figure 1 and Figure 2B).

KEYWORDS Cardiac pacemaker; ECG algorithms; Paced RBBB; RV pacing; RVOT pacing
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Discussion

Here, we report a RBBB pattern in a patient who received a permanent pacemaker with true RV pacing. The differential diagnosis for paced RBBB includes transient damage to the right bundle fascicle, inappropriate placement of the lead in the LV, or LV pacing from a coronary sinus branch as commonly seen in cardiac resynchronization pacing.[5] Also contributing to the differential diagnosis are lead placement

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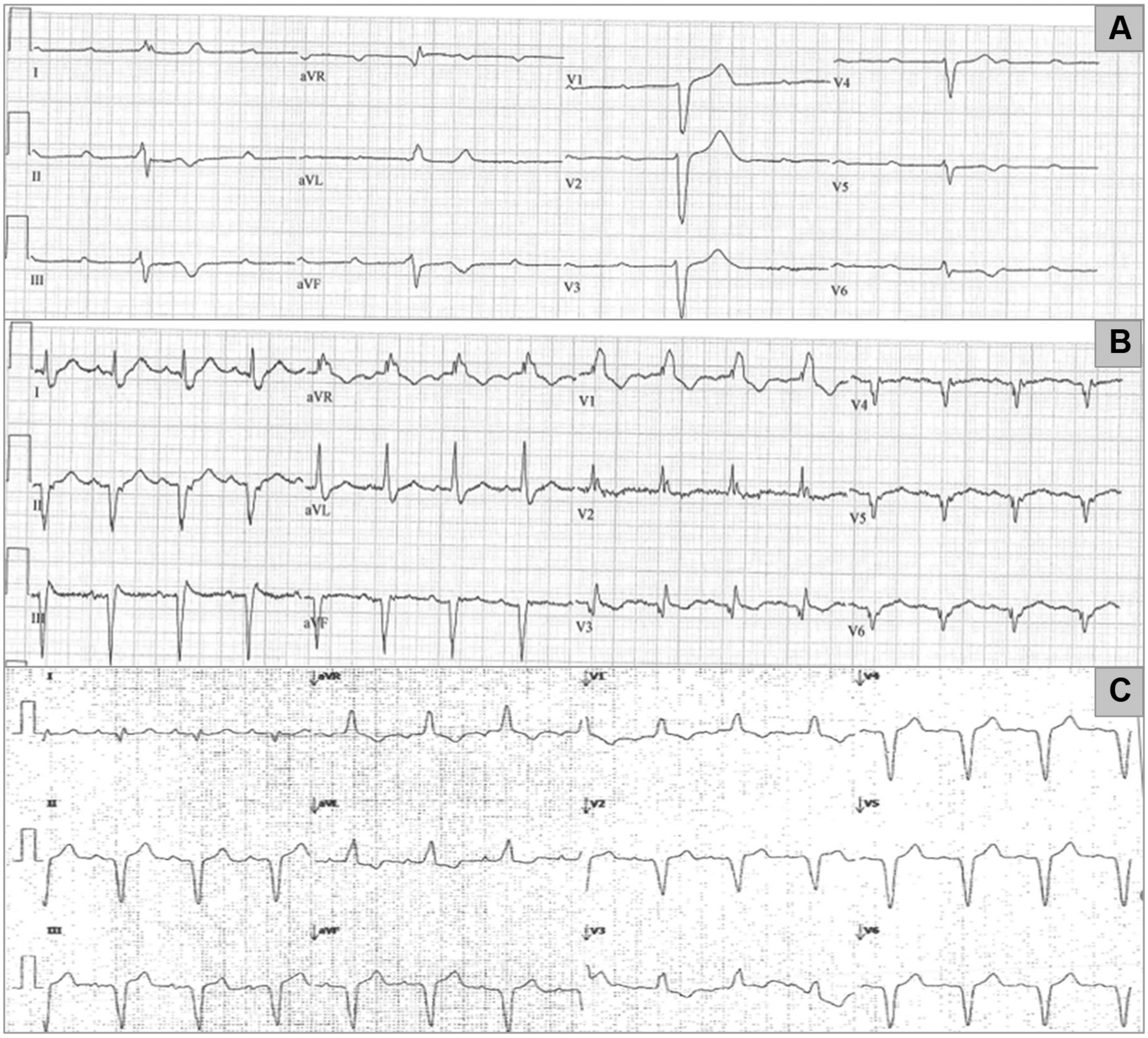

Figure 1 **A:** Complete atrioventricular block with escape rhythm and incomplete left bundle branch block on presentation. **B:** Baseline right bundle branch block (RBBB), prior inferolateral infarcts. **C:** Paced RBBB. Both the Coman-Trohman and Okmen criteria suggest left ventricle pacing: frontal axis is not between -30 and -90, there is no precordial transition at V_3, but this was not the case.

into the LV via a patent foramen ovale, septal defects or perforation, high placement of ECG electrode V_1, and right bundle branch disease with anterograde block in uncomplicated RV pacing.[1,6,7] The ECG of patients with RV apical pacing usually shows a wide QRS complex with LBBB and LAD, where there is positive or isoelectric QRS in lead I with negative QRSs in leads II and III.[8] RBBB pattern in the context of RV pacing can lead to additional procedures to confirm proper positioning of the RV electrode, which come at some time and financial cost. ECG acquisition maneuvers and systematic analysis of the surface ECG have been suggested to ensure rapid confirmation of proper RV lead placement. The Klein maneuver, which involves placing the V_1 and V_2 electrodes at 1 costal interspace below the usual position, has been shown to reveal the expected LBBB in patients with true RV pacing and RBBB pattern.[2] Okmen and colleagues proposed an algorithm to aid in the determination of proper lead placement.[4] In that study, a left superior frontal axis or precordial V_3 transition each demonstrated 97% sensitivity and 100% specificity in identifying true RV lead placement. This was an improvement on the previously reported 86% sensitivity and 99% specificity by Coman and Trohman, who had used a combined left superior axis and precordial transition by lead V_3 criteria.[3]

Our patient's preexisting RBBB and inferolateral infarct presented a challenge to the application of the ECG criteria. In this patient, RBBB is apparent when the native rhythm is present (Figure 1C). However, the RBBB pattern will persist during RV apical pacing and may be a source of concern (Figure 2A). Poor R-wave progression seen in Q-wave inferolateral infarcts also made it difficult to apply the algorithms to assess our patient's ECG. Our patient had poor precordial R-wave progression from V_3 through V_6, which violates the precordial transition by V_3, which is a criterion for both the Coman-Trohman and Okmen algorithms.

Several hypotheses have been proposed to account for true RV paced RBBB. It has been suggested that the right side of the RV septum may behave electrically as part of the left

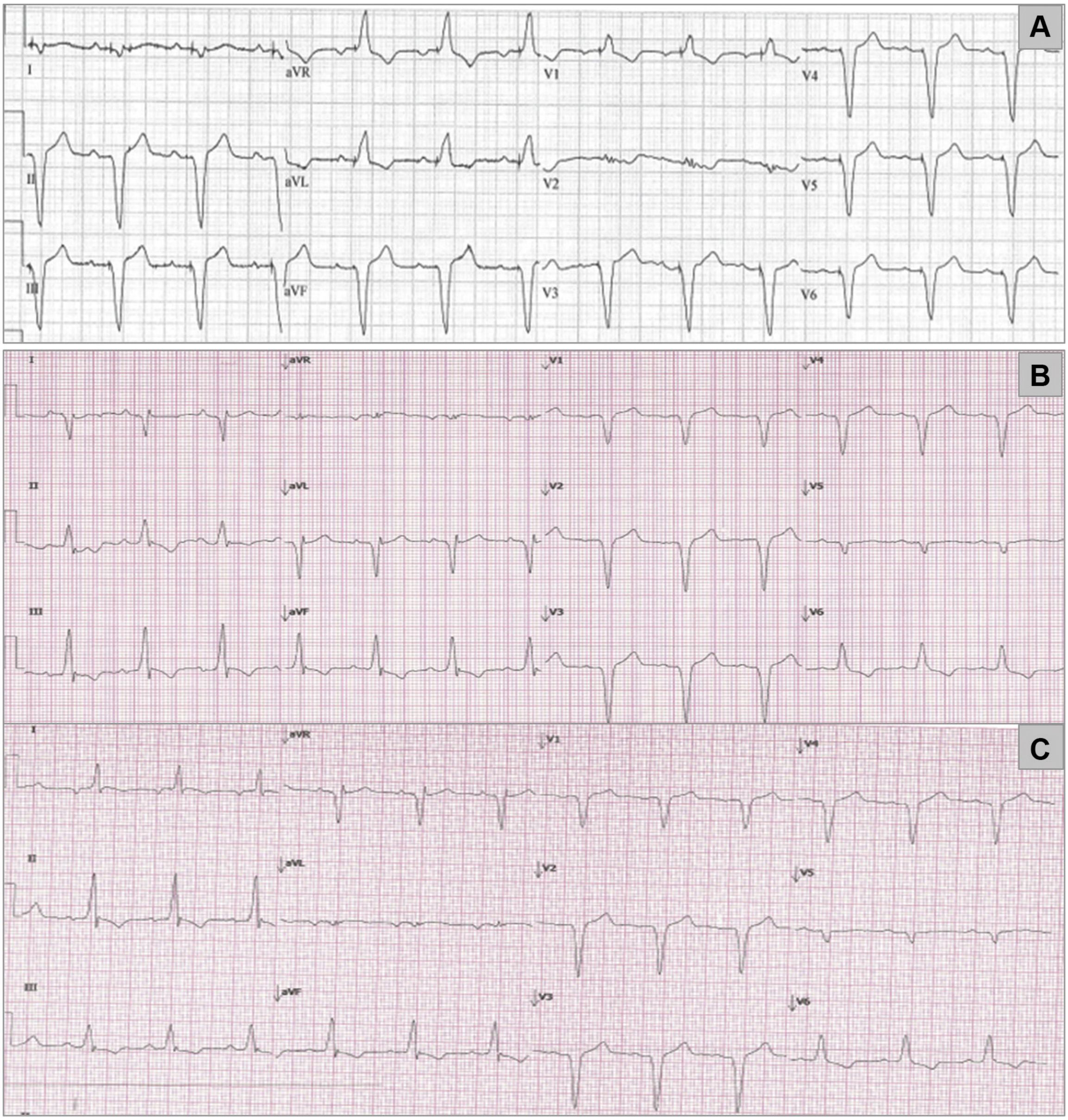

Figure 2 Patient hospitalized for pocket infection and hematoma. **A:** Existing apical right ventricle paced right bundle branch block (RBBB). **B:** New pacemaker with right ventricular outflow tract pacing with disappearance of the RBBB pattern, change in the baseline frontal axis from left axis deviation to right axis deviation, new left bundle branch block, and new qR pattern in lead I and aVL.

ventricle during apical pacing and that pacer stimuli are propagated through specialized conductive tissue rather than through myocardial tissue.[9] Thus, true RV pacing may appear as RBBB mimicking accidental LV pacing. In patients with preexisting RBBB, RV apical pacing causes activation delay on the right and persistent RBBB pattern.[7] In these same patients, RV septal pacing can result in a normalization of the QRS interval and morphology.[8] RVOT pacing in our patient resulted in the expected LBBB, thus eliminating the concern about proper electrode placement. The performance of surface ECG criteria when infarction is present has been shown to change based on pacing site.[10] RVOT pacing yields an equivalent finding of the expected LBBB like the Klein maneuver. Therefore, in patients with pre-existing RBBB, the RVOT may be the preferred site for RV pacing.

Conclusion

In the present case, preexisting inferolateral infarction limited the utility of the Coman-Trohman and Okmen algorithms to confirm proper lead placement in the RV. In such patients, a careful review of fluoroscopic images and 2-view chest radiographs should be favored as modalities to confirm proper lead placement. The RVOT may be the preferred site for RV pacing in patients with preexisting RBBB and may be a proactive alternative to the Klein maneuver.

Appendix

Supplementary data

Supplementary data associated with this article can be found in the online version at https://doi.org/10.1016/j.hrcr.2021.07.007.

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