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Right Bundle Branch Block ECG morphology post right ventricular pacing – A lesson in hindsight.

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Take Home Messages

- Transvenous right ventricular pacing normally results in a paced rhythm with LBBB morphology.
- Pre-existing RBBB does not necessarily increase the likelihood of a RBBB pattern post RV pacing
- RBBB morphology post intended RV pacing may indicate perforation and incorrect lead placement in the coronary sinus or the left ventricle.
- RBBB morphology post RV pacing can also be benign/uncomplicated in some individuals. Several pre, intra and post procedural checks can be done to confidently confirm lead position.

Introduction

Transvenous right ventricular (RV) pacing normally results in a paced rhythm with left bundle branch block (LBBB) morphology. Right bundle branch block (RBBB) morphology post intended RV pacing may suggest interventricular septal/free wall perforation, lead placement in the coronary sinus or accidental left ventricular (LV) lead placement, either through a patent foramen ovale/atrial septal defect (PFO/ASD) or through subclavian artery access. (1) However, RBBB morphology can occur in some patients with uncomplicated RV lead position. (1–3) This can be due to several proposed mechanisms including: right sided conduction system disease, retrograde direction of the pacemaker stimulus through the right bundle branch to the atrio-ventricular node (AVN), early activation of the left ventricle through abnormal conduction pathways and a profound septal lead screw during implantation, causing earlier LV activation. (3–6)

Nonetheless, the presence of RBBB morphology on a 12-lead electrocardiogram (ECG) post RV pacemaker implant should prompt assessment into potential complications. The aim of this review is to summarise the intra-procedural manoeuvres for confirming lead position as well the approach to RBBB morphology should this be encountered post-implantation.

Pre-procedure

A thorough history and examination are pertinent to any clinical assessment. The key elements, relevant to this topic are whether the patient has any known anatomical variations, congenital heart disease e.g. septal defects and any previous cardiac procedures and/or surgery. For example, RBBB is common following right ventriculotomy or infundibular resection for tetralogy of Fallot repairs and is thought to be due to interruption of the peripheral right ventricular conduction system. Damage to the proximal RBB might also occur in ventricular septal defect repair. (7,8) A 12 lead ECG would be able to illicit RBBB on a pre-procedural assessment. However, it is important to note that pre-existing RBBB does not necessarily increase the likelihood of a RBBB pattern post RV pacing.(4) Therefore if post-RV pacing RBBB is encountered in these patients, the same checks to confirm lead position should still be performed (see post-procedure section).

Intra-procedural

The randomised, prospective multicentre septal position of ventricular ICD electrodes study randomised patients to an apical vs mid-septal defibrillator lead position to evaluate the safety of the RV mid-septal position.(9) In a secondary analysis of this study, Tzeis et al found that the prevalence of RBBB morphology following RV pacing was significantly higher in apical vs septal lead positioning (1.9% vs 27.5%, $p < 0.001$).(4) This was corroborated by Barold et al in an earlier study. (6) RV septal pacing is thought to be more physiological given the proximity to the conduction system. Despite observational evidence that sustained RV apical pacing may impact LV systolic function in some patients, published randomised trials have not found any significant difference in clinical outcomes between RV septal *versus* RV apical pacing for patients with high degree AV block or even in those undergoing cardiac resynchronisation therapy (CRT). (10–12) Current guidelines therefore, do not preferentially recommend one RV position over the other in all patients, except in elderly or female patients with a BMI <20 kg/m^2 who tend to have thinner RV apices and are at greater risk of lead perforation. (11,13) The decision on lead position is on an individual patient basis and operator dependent. The RV septum is currently often the preferred

position. (14) However, whilst RV septal position carries a lower risk of perforation, there is a higher risk of displacement compared to the RV apical position. Regardless of the chosen site, it is paramount that pacing lead position and stability is confirmed intra-procedurally with both fluoroscopy, intracardiac electrogram (EGM) and stability checks.

The coronary sinus (CS) is in close relation to the tricuspid valve, with its ostium lying between the posterior leaflet and the septum, bordering the base of the triangle of Koch. There have been a few reports of unintentional placement of the lead in the CS, but the incidence remains unclear. (15) Pacing in a standard tributary of the CS would cause a RBBB morphology on a 12-lead ECG post -procedure. Except in CRT and conduction system pacing, chest leads are not always available during implantation. The limb leads can be checked for a left ward axis and the EGM could reveal an unusual current of injury with poor capture and high pacing thresholds if the lead is lodged within the CS. See figure 1. (14)

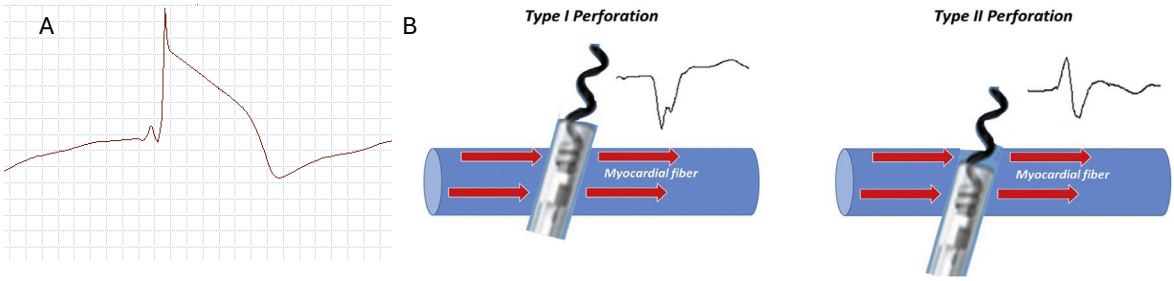


Figure 1. (A) EGM showing a normal current of injury in RV lead placement. Note the positive ST segment. (B) EGMs showing two types of morphology in perforation. Adapted from Ponnusamy et al. (16)

Additionally, the correct lead position can be checked in the left anterior oblique (LAO 40^0) and right anterior oblique (RAO 30^0) views. The RAO view will confirm an apical, septal or RVOT lead position. The LAO view distinguishes an anterior from posterior orientation. An RV mid-septal lead tip should point towards the 3 o'clock position whilst an apical lead should have a more anterior orientation, with the tip towards a five o'clock position compared to a more posterior direction if for example, sited in the CS. (See figure 2) (14,17). Due to patient variabilities such as a rotated or dilated heart, and intra-procedural patient position, traditional routine fluoroscopy

views might not always be accurate. Squala et al prospectively recruited 100 patients into either a classical group, where lead position was checked using standard RAO 30^0 and LAO 40^0 views, or the individualised group, where a superior vena cava- inferior vena cava (SVC-IVC) guidewire was used as a reference for the ideal position of the RV septal lead in the LAO view. Septal/free wall RV lead position was correctly identified (confirmed by transthoracic echocardiogram) in 48/50 (96%) patients in the individualised group versus 38/50 (76%) in the classical group (p= 0.004), with the correct degree of LAO being approximately 60^0 in most patients. (18)

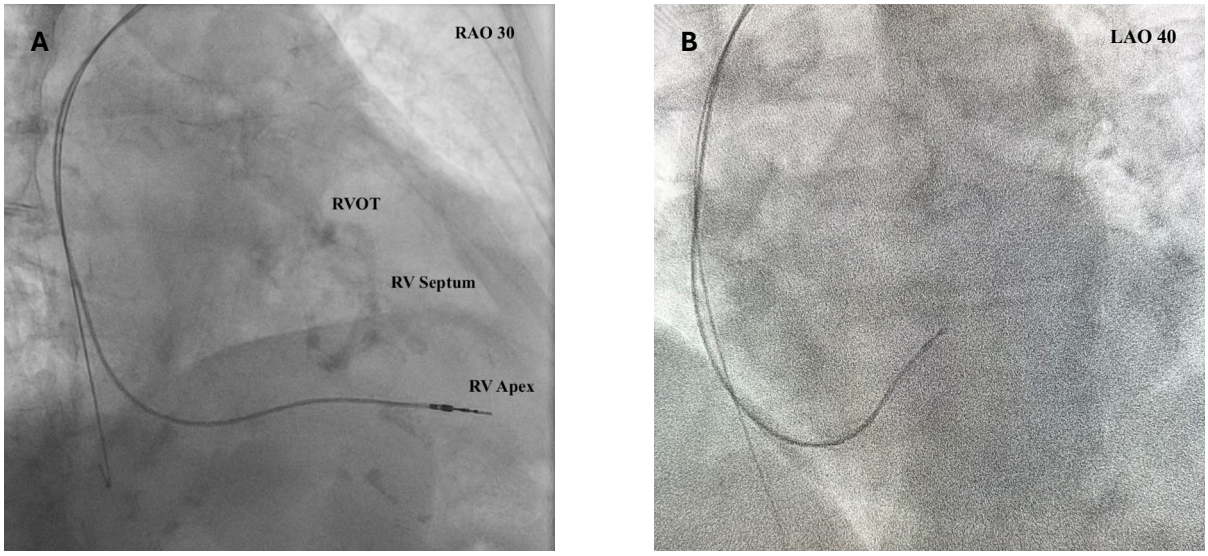
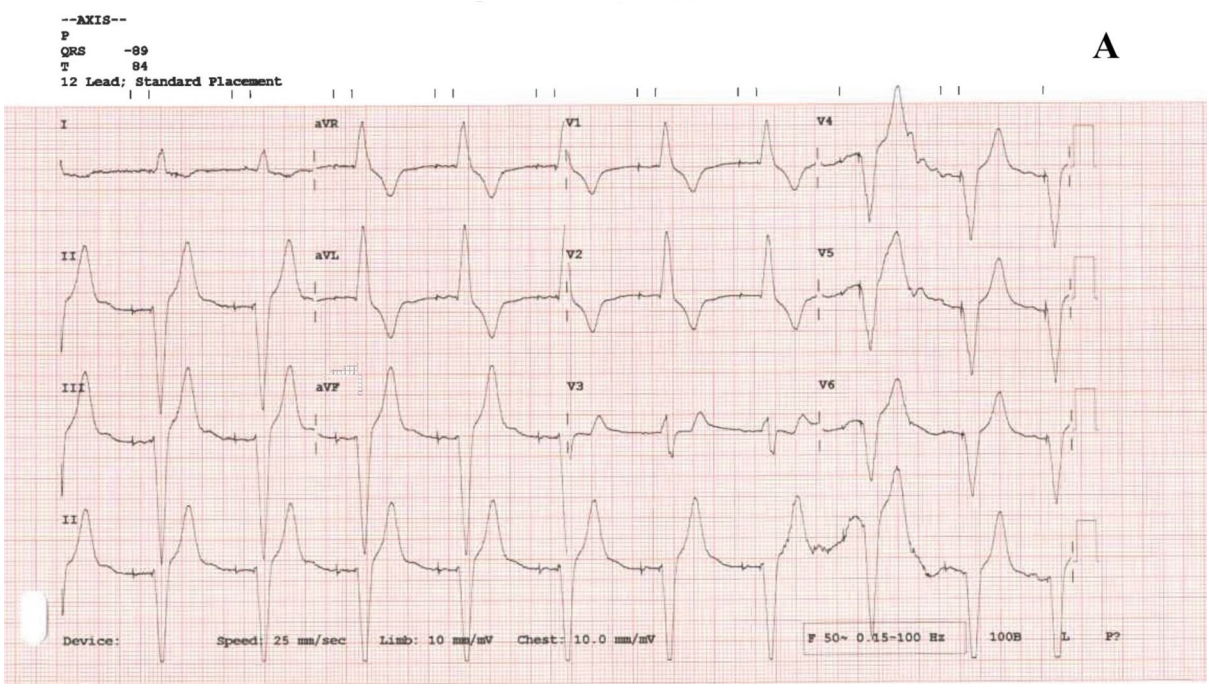


Figure 2. Fluoroscopy RAO and LAO views**.** (A) RAO 30^0 view confirming the position of an RV apical lead. (B) **LAO** 40^0 view confirming the position of an RV septal lead with tip posteriorly towards the spine. The tip would be facing away from the spine if at the RV free wall. LAO-left anterior oblique, RAO-right anterior oblique, RVOT-right ventricular outflow tract.

Post-procedure

A CXR, 12-lead ECG and pacing checks are often performed pre discharge. If the paced ECG shows RBBB (Figure 3), the steps in Figure 4 should be employed to confirm lead position and the absence of complications. The first thing is to always ensure that all chest and limb leads are placed in the correct position.

Klein et al postulated that because the net QRS vector during RV pacing is left and superior in the frontal plane. Placement of V1 and V2 leads below a plane perpendicular to this axis will record a negative QRS waveform characteristic of the typical LBBB seen in uncomplicated RV pacing. On the other hand, placement of V1 and V2 leads above a plane perpendicular to the net QRS vector will produce a positive QRS waveform seen in pseudo-RBBB. The Klein manoeuvre therefore involves placing V1 and V2 one intercostal space lower, to unmask the expected LBBB morphology. (19) This manoeuvre is not always effective. Assessment of the frontal plane axis as well as precordial transition offers better specificity. See Figure 3.



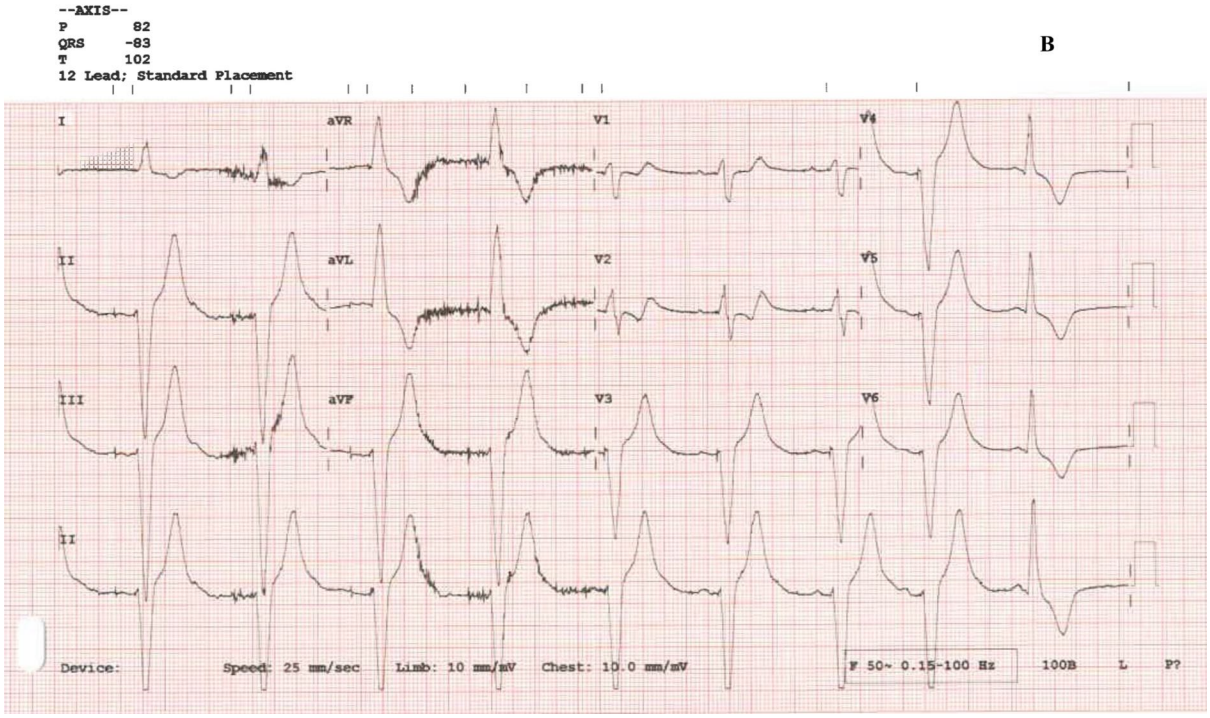


Figure 3: 12-lead ECGs post RV-pacing showing RBBB. ECG A shows a paced RBBB, frontal plane axis of -45^0 to $\pm 180^0$ and precordial transition at V3 with standard position of leads V1 and V2. ECG B is following Klein's manoeuvre i.e. placing V1 and V2 one intercostal space lower.

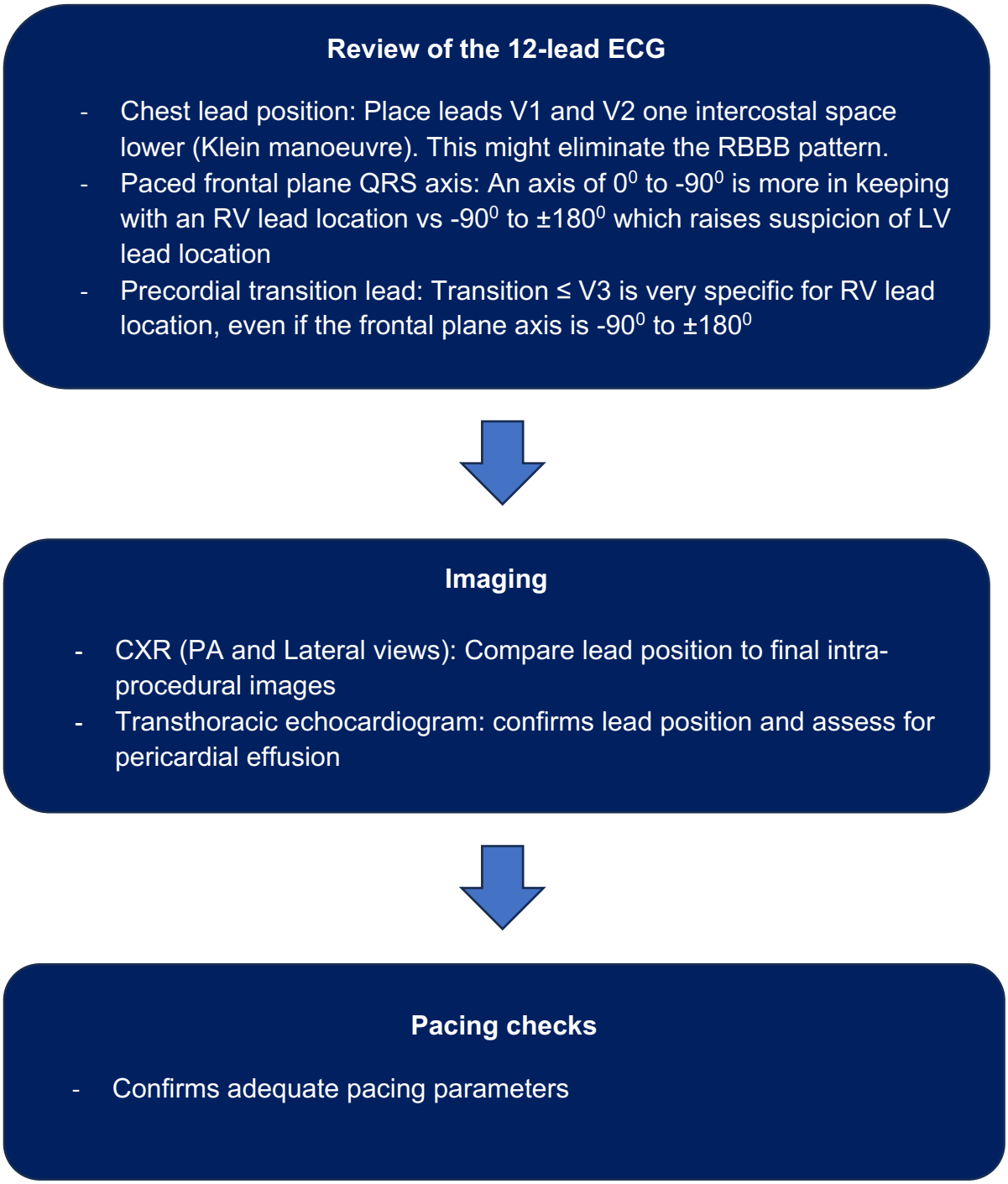


Figure 4: Algorithm for addressing RBBB morphology on a 12-lead ECG following RV pacing. PA-posteroanterior. Adapted from Almehairi et al. (20)

Conclusion

RBBB ECG morphology following RV pacing can be uncomplicated. However, perforation and lead malposition/displacement must be ruled out. It is very useful to anticipate complications before and during implantation. Intra-procedural confirmation of the lead position with the manoeuvres above will complement the post-procedural assessment and hopefully eliminate the regretful nature of hindsight.

Disclosures:

None

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