

Right Bundle Branch Block Morphology of the Paced QRS Complex and Diaphragmatic Capture During Temporary Transvenous Pacing: Where is the Pacing Catheter?

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Temporary cardiac pacing can reestablish circulatory integrity and normalize hemodynamics that are acutely compromised by a slow heart rate. However, complications can occur in over 20% of patients treated with temporary pacing.¹⁻³ Without recognition of the potential complications, the adverse effects can outweigh the beneficial effects. Regardless of the site of lead insertion, fluoroscopic guidance during the procedure greatly facilitates anatomically accurate lead placement. On occasion, the urgency of the clinical situation may preclude the use of fluoroscopy, and lead introduction is then performed with only electrocardiographic guidance. A full understanding of cardiac and vascular anatomy is necessary before attempting pacemaker insertion so that complications can be minimized and recognized when they do occur, especially when the procedure is done without fluoroscopic assistance.

We report a case of inadvertent left pericardiophrenic vein cannulation during emergent transvenous pacing that was recognized because of the combination of right bundle branch block (RBBB) morphology of the paced QRS complex and diaphragmatic stimulation. The differential diagnosis of RBBB morphology of the paced QRS complex and diaphragmatic stimulation during transvenous temporary pacing, both individually and in combination, are also discussed.

Case Report

A 63-year-old hospitalized man with no prior cardiac history developed unexplained complete heart block with bradycardia and hemodynamic compromise requiring emergent temporary transvenous pacing. The procedure was successful but was performed without fluoroscopic guidance. The left internal jugular vein was used for venous access because the right internal jugular vein had recently been instrumented. Using a traditional Seldinger technique, the left internal jugular vein

was accessed and a 7 French (Fr) sheath was inserted. A 6 Fr balloon-tipped pacing catheter was inserted through the venous sheath and advanced 35 cm until ventricular pacing was achieved. The pacing catheter and venous sheath were secured via subcutaneous sutures. While an adequate heart rate with ventricular pacing was achieved, the temporary pacer was also causing diaphragmatic stimulation — even at thresholds below ventricular capture. Attempts to relocate the temporary pacing wire to a more favorable location were unsuccessful. The patient required intubation and mechanical ventilation for hypoventilatory respiratory failure, possibly related to the diaphragmatic pacing stimulation.

A post-procedure 12-lead electrocardiogram (ECG) showed successful ventricular pacing but with a RBBB morphology of the paced QRS complex (Figure 1). A post-procedure chest x-ray did not readily identify the location of the pacing wire because the lung fields were obscured due to pulmonary edema and morbid obesity (Figure 2). The location of the pacing wire was later determined to be in left pericardiophrenic vein due to the combination of RBBB paced QRS morphology and diaphragmatic stimulation caused by the pacing of the left pericardiophrenic nerve. When the patient went for permanent pacemaker insertion, fluoroscopy confirmed the location of the temporary wire in the left pericardiophrenic vein pacing the lateral epicardial surface of the left ventricle as well as the left hemi-diaphragm (Figure 3).

Discussion

While this case is not unique in describing inadvertent cannulation of the left pericardiophrenic vein,^{4,5} it serves as an example of a unique potential complication that can occur during temporary pacemaker insertion or other central venous inserted catheters, *i.e.*, Swan-Ganz catheter placement. A comprehensive understanding of cardiac and venous anatomy is necessary before attempting pacemaker insertion so that complications can be minimized and recognized when they do occur.

The differential diagnosis for RBBB morphology of the paced QRS complex can be divided into four different sub-categories:

1. The catheter is in the right ventricle, but its position is in the posterior most portion of the right ventricle, far from the chest wall and precordial ECG leads V1-3, and results in a RBBB-paced QRS morphology.
2. The catheter is in the left ventricular endocardial cavity. This can occur via a variety of mechanisms (Figure 4, Panel A):
 - a. Intra-arterial rather than venous placement.
 - b. Passing the catheter through an inter-atrial communication — such as an atrial septal defect (ASD) or patent foramen ovale (PFO) — between the right and left atrium, and then through the mitral valve to the left ventricle.

- c. Passing the catheter through an inter-ventricular communication such as a ventricular septal defect (VSD) or inadvertent right ventricular septal puncture.
3. The catheter enters the coronary venous system and is pacing the epicardial surface of the left ventricle. This also can occur via a variety of mechanisms (Figure 4, Panel B):
- a. The catheter inadvertently enters the coronary sinus from the right atrium and is advanced over the left ventricular surface through the tributary coronary sinus veins.
- b. The catheter is advanced via a persistent left superior vena cava, enters into the coronary sinus, and is advanced over the left ventricular surface through the tributary coronary sinus veins.
- c. The catheter enters the pericardiophrenic vein from the left brachiocephalic vein and is pacing the lateral left ventricular epicardial surface from the pericardiophrenic bundle overlying the heart, but is not actually in contact with the myocardium.
4. The catheter perforates the myocardium, enters the pericardial space, and paces both the epicardial left ventricle and the phrenic nerve, causing diaphragmatic capture.

Diaphragmatic stimulation occurs when the right or left phrenic nerve is paced. Stimulation of the right phrenic nerve is rare, but can be accomplished by having the catheter placed at the posterolateral wall of the right atrium. This generally only occurs during permanent pacemaker lead implantation in the right atrium or if the atrial pacing lead has dislodged and is in the superior vena cava. Stimulation of the left phrenic nerve can occur during temporary pacemaker insertion, when placed into the left pericardiophrenic vein as in this case. It can also occur at high pacing outputs in lateral veins of the coronary sinus venous system. Additionally, if a lead placed in the right ventricular apex punctured through the right ventricle and migrated to the left lateral pericardial space, stimulation of the left phrenic nerve and diaphragmatic capture could occur.

The combination of diaphragmatic capture and RBBB-paced QRS morphology during temporary pacemaker insertion is cause for concern and can be accomplished by pacing from the left pericardiophrenic vein or left lateral branches of the coronary sinus venous system. RBBB pacing morphology due to endocardial left ventricular pacing should not cause diaphragmatic capture.

Conclusion

The presence of a RBBB-paced QRS morphology should always be cause for concern, and careful investigation as to the precise location of the pacing lead should ensue. In addition, diaphragmatic stimulation should alert the operator to

pacing of either the right or left phrenic nerve and the potential catheter positions that can cause this. The unique combination of both RBBB-paced QRS morphology and diaphragmatic stimulation suggests pacing from the left pericardiophrenic vein, left lateral branches of the coronary venous system, or from the pericardial space overlying the left ventricle.

References

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Figure 1. Post temporary transvenous pacemaker insertion ECG showing a ventricularly paced rhythm at 80 beats per minute with RBBB pacing morphology.



Figure 2. Post temporary transvenous pacemaker insertion chest x-ray showing cardiomegally, congestive heart failure, satisfactory position of the endotracheal tube, tunneled left subclavian hemodialysis catheter, and left internal jugular pacing catheter with an obscured distal tip.



Figure 3. Fluoroscopic image of the temporary transvenous pacing catheter positioned in the left pericardiophrenic vein along the lateral aspect of the left ventricle.

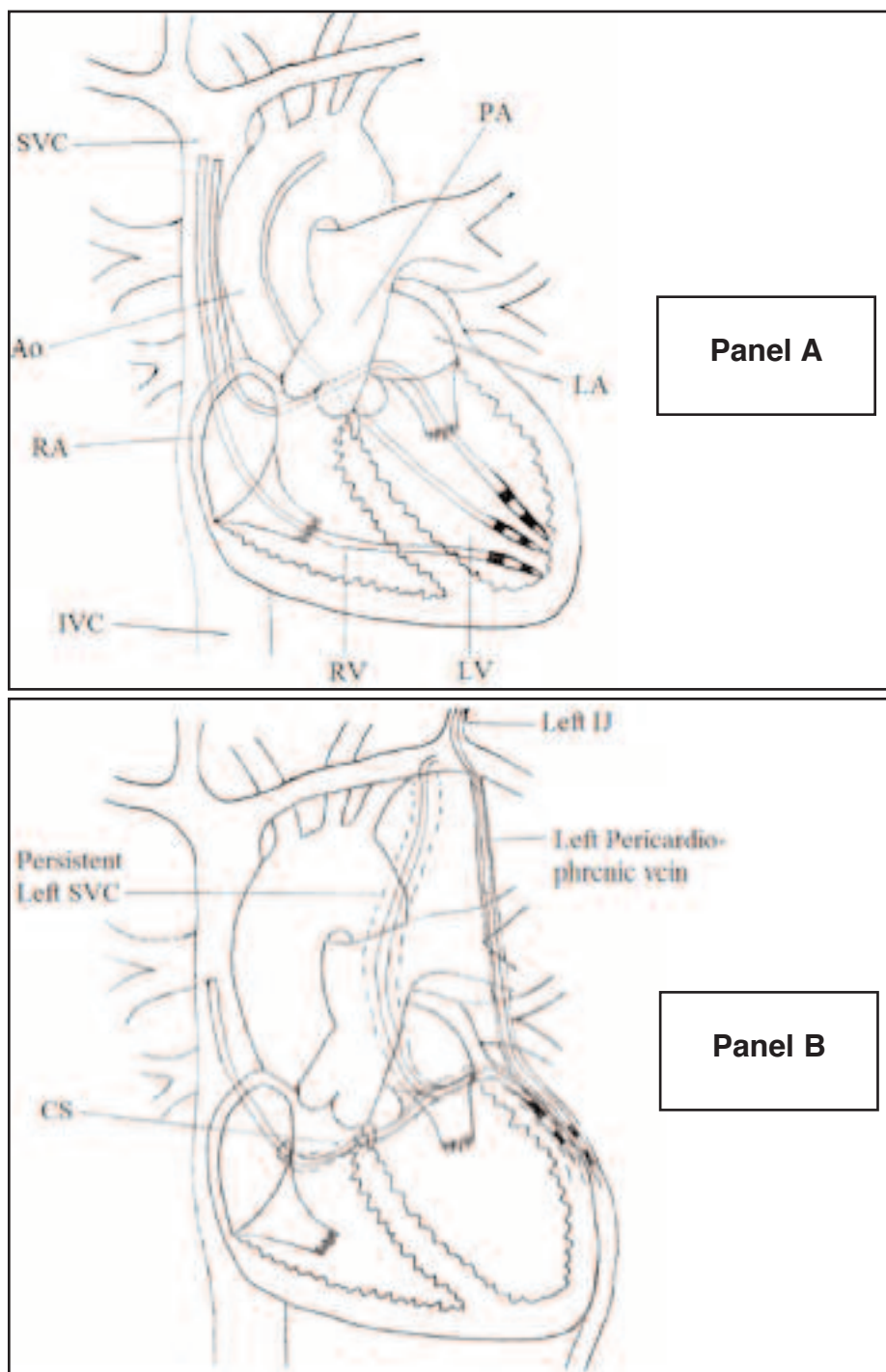


Figure 4. Schematic drawings of potential vascular catheter courses to reach the left ventricular endocardium (Panel A) and the coronary venous system (Panel B). SVC = superior vena cava, Ao = aorta, RA = right atrium, IVC = inferior vena cava, RV = right ventricle, LV = left ventricle, PA = pulmonary artery, LA = left atrium, CS = coronary sinus, IJ = internal jugular vein.