Paradoxical Electrocardiographic Rhythm During Peripherally Inserted Central Catheter Insertion from Persistent Left Superior Vena Cava

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Abstract

Introduction: A persistent left superior vena cava is one of the most common thoracic vascular anomalies, present in approximately 0.5% of the general population. The most common presentation is both a right and left superior vena cava, communicating through an innominate vein. In rare cases, complete absence of a right sided superior vena cava may have dispersion of pacemaker and conduction tissue leading to abnormal electrocardiography readings.

Case Description: This case report describes the insertion of a peripherally inserted central catheter via the right basilic vein utilising ultrasound and electrocardiographic guidance during which atypical P-waves were noted. Post procedure chest x-ray found the catheter to be positioned to the left side of the chest.

Discussion and Evaluation: Initial management was to assess whether the catheter was placed in the arterial system. Catheter transduction and blood gas analysis demonstrated the peripherally inserted central catheter was situated in the venous system. Computer tomography was then used to assess the patient’s vasculature, demonstrating a persistent left vena cava with absence of a right vena cava.

Conclusion: This case describes the successful placement of a right basilic peripherally inserted central catheter in a patient with a persistent left vena cava with an absent right superior vena cava using ultrasound and electrocardiographic guidance.

Keywords: Persistent left superior vena cava, vena cava, peripherally inserted central catheter
Introduction

The insertion and use of central venous access devices (CVADs) has become the mainstay for patients requiring extended intravenous therapy in a variety of clinical settings. In particular, the insertion of peripherally inserted central catheters (PICCs) has grown substantially in recent years.\(^1\)\(^2\) As a result, the incidental identification of venous anomalies during catheter placement has also increased.\(^3\)\(^-\)\(^6\)

One of the most common vascular anomalies of the thorax is a persistent left superior vena cava (PLSVC), present in approximately 0.5% of the general population with a higher prevalence in patients with known congenital heart abnormalities.\(^7\)\(^,\)\(^8\) A PLSVC occurs in multiple forms with the most common variation being the presence of both a left and right superior vena cava (SVC) with a communicating innominate vein.\(^9\)

A more rare presentation is the absence of a right SVC where a sole SVC drains directly into the right atrium via the coronary sinus or into the left atrium resulting in a right-to-left shunt.\(^10\)

Electrocardiography (ECG)-guided CVAD placement is frequently used to provide real-time, accurate tip confirmation during an insertion procedure. The ECG-guided method for tip location relies on the identification and changing amplitude of a patient’s P wave by using the catheter as an intravascular electrode.\(^11\) This is accomplished by either injecting a column of ionic solution such as saline into the catheter, or by inserting a metal guide wire into the catheter and attaching the system to an ECG readout device. As the catheter moves within the vessel the changing amplitude of the P-wave provides directional and positional information about the catheter tip.\(^12\)

Under normal conditions, as a catheter travels toward the right atrium, the amplitude of the P wave increases above the isoelectric line providing an exaggerated, positive P wave deflection; however, anomalies in the thoracic vascular anatomy involving nodal conductive tissue may affect intracavitary P wave amplitude changes on CVAD insertion.\(^11\)\(^-\)\(^13\) We present a case of a PICC placement in which paradoxical P wave amplitude changes were noted and attributed to atypical thoracic vasculature.

Case Presentation

A 33-year-old man with a history of recent anterior resection, stricturoplasty, and division of adhesions for recurrent small bowel obstruction secondary to Crohn’s disease was referred to the Liverpool Hospital Central Venous Access Service. The patient required the placement of a double-lumen PICC for the administration of total parenteral nutrition to provide ongoing nutritional support.

The left basilic vein was chosen for cannulation after vascular assessment and the PICC was placed using maximal barrier precautions, aseptic technique, and with ultrasound and ECG guidance. During the insertion procedure, a negative P wave in relation to the isoelectric line was noted and was persistently more negative as the catheter was advanced (Figure 1). Normally, this would signal that the catheter was directing away from the SA node; however, ultrasound scanning of the left internal jugular vein found no evidence of the catheter. After manipulation of the catheter, an aberrant pathway was suspected and the PICC was removed.

A new double-lumen PICC was then placed using the right basilic vein under full barrier precautions, aseptic technique with ultrasound, and ECG guidance. A negative P wave in relation to the isoelectric line was again identified. Scanning of the patient’s right internal jugular vein found no evidence of the catheter. The catheter was left in place and a chest radiograph was ordered. The postprocedure radiograph demonstrated an aberrant passage of the PICC, crossing the midline on the radiographic image and descending down the left side of the mediastinum (Figure 2).

Initially, catheter placement in the arterial system was suspected; however, pressure transduction of the catheter and blood gas analysis confirmed venous placement. Computed tomography was performed demonstrating a PLSVC with the absence of the right SVC. The left SVC was found to drain into the coronary sinus (posterior and inferior) of the heart (Figure 3).

Discussion

The finding of an absent right vena cava is uncommon, occurring in approximately 10% of patients presenting with a PLSVC.\(^14\) The most common variation is a PLSVC accompanied by a right SVC that is bridged by an innominate vein, occurring in approximately 0.5% of the general population and up to 12% of patients with known congenital abnormalities.\(^14\)

A PLSVC is an aberrant development of the primitive heart vessels in the first few weeks of embryonic development and is typically associated with other congenital cardiac abnormalities such as atrial and/or ventricular septal defects that may include abnormal distribution and connection of pulmonary veins.\(^15\) The PLSVC is a result of failure of the left cardinal

![Figure 1. Catheter insertion illustrating negative P wave deflection on intravascular ECG trace.](image-url)
vein to regress during embryonic development, which prevents the dominant right cardinal vein from eventually forming the SVC.10,14

This particular combination of vascular anomalies is rare and was first reported in 1862. A PLSVC (with absent right vena cava) will usually empty into the right atrium by way of the coronary sinus; however, it can also directly empty into the left atrium creating a right-to-left shunt.7,16 Importantly, as seen in this case, electrocardiographic changes may be seen with inverted P waves in leads II and III of the ECG.16

In patients with a PLSVC, nodal cells may be normal but have significant alteration in their arrangement, leading to conduction abnormalities.17 One exemplar is a PLSVC that drains via the coronary sinus, in which a large ostium forms with adjacent embryonic nodal tissue. This conductive tissue may cause an aberrant conduction pathway around the coronary sinus resulting in the negative P wave deflections in leads II and III of the ECG.16,18

Structural cardiothoracic defects involving a PLSVC with no right SVC can result in impulse generation from the coronary sinus due to well-formed pacemaker tissue originating from the left sinus horn during embryogenesis.19,20 The abnormal P wave deflection is attributed to this aberrant pathway between the SA node to the AV node rather than a conduction defect, explaining its incidental findings from unrelated clinical procedures.20,21

Variations in thoracic anatomy can pose challenges when placing CVADs and other vascular devices such as pacemaker wires and pulmonary artery catheters as a result of the variation in the vasculature or conduction pathways.10 The use of guide wires and dilators can pose procedural risks, particularly when catheters are inserted via the jugular, axillary, or subclavian veins where the risk of vessel injury or perforation is increased.22 Serious intraprocedural complications, including cardiac arrest, have been reported upon manipulation of a guide wire or catheter in patients with PLSVC.7

Catheter malposition is of significant concern in this cohort where anatomic variation of other thoracic vessels such as the azygos vein may be present.7 This of course increases the risk of catheter-related thrombosis, which is known to occur in malpositioned catheters, but may be exaggerated if the pathway to the atra is tortuous.22,23

To date there are no recommendations for CVAD tip termination for patients with a PLSVC. There is consensus that the CVAD tip should not enter or terminate in the coronary sinus due to the risk of dysrythmia, vessel wall erosion with ensuing tamponade, or coronary sinus thrombosis.21,24

In this case presentation, the patient had a relative straight path toward a large coronary sinus. The catheter tip was not abutting any vasculature and the catheter aspirated and flushed satisfactorily. Choosing to insert the catheter via any other upper anatomic site such as internal jugular or subclavian veins would have made no difference to final catheter tip termination. The decision was made to leave the catheter in place and use as indicated.

Conclusions

Electrocardiographic guidance has been shown to accurately place CVADs in optimal positions for intravenous therapy. This case study has highlighted that rare, anomalous thoracic vasculature, such as an absent right SVC, may affect the ability to use and rely solely on technology such as ECG to navigate a catheter into position. Even a plain chest radiograph is not
sufficient to exclude inadvertent arterial placement. Trans-
ducing the catheter and/or blood gas analysis are quick and
simple ways to determine arterial or venous placement; how-
ever, a computed tomography scan to assess vascular anatomy
and catheter placement is recommended for definitive assess-
ment as well as providing documentation of the anatomic ab-
normality in the event of future medical intervention.

Disclosures
The authors have no conflicts of interest to disclose.

References
use of central venous access devices within and outside of
the intensive care unit: results of a survey among hospitals
in the prevention epicenter program of the Centers for Dis-
ease Control and Prevention. Infect Control Hosp Epidem-
iol. 2003;24(12):942-945.
peripherally inserted central catheter use and outcomes in
3. Roldán FA, Fernández IS, Garza FZM, Gullón GR. Up-
date on the use of ultrasound in vascular anomalies. Actas
rior vena cava and left renal vein: risks in aortic surgery.
renal vein: multidetector computed tomography angiogra-
phy findings and its clinical importance. Acta Radiolog-
6. Trigaux J-P, Vandroogenbroek S, De Wispelaere J-F,
Lacrosse M, Jamart J. Congenital anomalies of the inferior
vena cava and left renal vein: evaluation with spiral CT.
left superior vena cava: case reports and clinical implications.
Int J Cardiol. 2006;113(2):242-246.
8. Konstantinou E, Mariolts K, Katsoulas T, Velecheris D,
Tsitsimelis D, Bonatsos G. Persistent left superior vena
cava leads to catheter malposition during PICC Port place-
access through a persistent left superior vena cava: a case
10. Goyal SK, Punnam SR, Verma G, Ruberg FL. Persistent
left superior vena cava: a case report and review of litera-
11. Walker G, Chan RJ, Alexandrou E, Webster J,
Rickard C. Effectiveness of electrocardiographic guid-
S4, S6, S8-S12.
12. Pitiiruti M, Bertollo D, Briglia E, et al. The intracavitary
ECG method for positioning the tip of central venous cath-
Factors influencing intracavitary electrocardiographic P
wave changes during central venous catheter placement.
14. Sohns JM, Fassbauer M, Staab W, et al. Persistent left su-
perior vena cava detected after central venous catheter in-
15. Sarodia BD, Stoller JK. Persistent left superior vena cava:
case report and literature review. Respir Care. 2000;45(4):
411-416.
17. Buenger PC, Neufeld DA, Moore JC, Carter GA. Persistent
left superior vena cava and associated structural and func-
18. Patten B. The development of the sinoventricular conduc-
19. Momma K, Linde LM. Abnormal rhythms associated with
persistent left superior vena cava. Pediatr Res. 1969;3(3):
210-216.
20. Heye T, Wengenroth M, Schipp A, Dengler TJ,
Grenacher L, Kauffmann GW. Persistent left superior vena
cava with absent right superior vena cava: morpho-
logical CT features and clinical implications. Int J Cardiol.
21. Thomas D. Placement of a peripherally inserted central
catheter line in a persistent left superior vena cava: a re-
view of positioning and clinical implications. J Assoc
22. Hamilton HC, Foxcroft D. Central venous access sites for
the prevention of venous thrombosis, stenosis and infec-
tion in patients requiring long-term intravenous therapy.
23. Schummer W, Sakr Y, Schummer C. Towards optimal
central venous catheter tip position. In: Intensive Care
24. Schummer W, Schummer C, Hoffmann E, Gerold M.
Persistent left superior vena cava: clinical implications
2002;17(5):304-308.