Clinical Pearl

Preventing Central Venous Catheter Misplacement: Lessons from a Catheter Malposition

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Abstract:

Central venous catheter (CVC) insertion is not only a very crucial procedure in critical care areas but also a very risky one. Performing the procedure under ultrasound guidance has improved safety, however, catheter malposition remains a frequent complication. Malposition bears risks of dysfunction and thrombosis. In this case report, we look into the case of a 26 years old female with recurrent pancreatitis who developed septic shock and required CVC placement. Chest X-ray done after the procedure revealed misplacement of the catheter tip in the ipsilateral subclavian vein rather than the lower third of the superior vena cava (SVC). The catheter was then removed immediately and replaced under ultrasonography (USG) guidance. We are going to delve into the anatomical and technical factors causing such malposition as well as the role of methods like manometry and electrocardiographic (ECG) tip navigation to complement USG for real-time tip confirmation. We close our discussion with saying that a multi-modal approach, pushing beyond the limits of USG-guided catheter placement, is essential to prevent such predicament and its associated morbidity, particularly in unstable patients where landmark techniques may be attempted.

Keywords: *Central Venous Catheterization; Catheter Malposition; Complications, Subclavian Vein; Septic Shock; Patient Safety; Ultrasonography.*

Introduction

Central venous catheter placement is an indispensable procedure in the management of critically ill patients as it enables vasopressor infusion, fluid resuscitation, and monitoring[1]. The junction of superior vena cava (SVC) and the right atrium (the cavoatrial junction) or within the lower third of the SVC is considered to be widely accepted as the optimum tip position of a CVC[2]. Catheter malposition, which is defined as a placement of the tip anywhere outside this zone, is a much-acknowledged complication with an incidence rate between 3.3% to 12.8% as reported[3]. Sites where the malposition commonly leads to are ipsilateral internal jugular or subclavian vein, contralateral brachiocephalic vein, or the azygos vein.

As much of a clinical interest a catheter malposition is, it is equally significant for the life of a patient undergoing the procedure. A misplaced catheter may lead to clinical hazards like inadequate drug delivery, venous thrombosis, catheter dysfunction, perforation, and cardiac tamponade[4]. Even though using live USG guidance for the procedure has drastically reduced the immediate complications like arterial puncture and pneumothorax, it still cannot guarantee an accurate final tip positioning[5]. In this case report, we will be elucidating on a case of ipsilateral subclavian vein malposition, a complication that accentuates the need for a comprehensive strategy that ensures not only safe venous access but also accurate tip placement.

Case presentation

Patient Information & Clinical Course: A 26 years old female, known case of recurrent pancreatitis, was admitted in our General Intensive Care Unit (GICU) with high grade fever, severe epigastric pain and vomiting. After admission, her condition started deteriorating rapidly, soon resulting in her going into septic shock (hypotension refractory to fluid boluses, tachycardia, tachypnea). Thus, she was in urgent need of a central venous for vasopressor administration.

Procedure: In our GICU, a right internal jugular vein (IJV) catheterization was attempted. Taking into account the patient's restlessness and the urgency of the procedure, landmark-based Seldinger technique was chosen for the procedure. The needle was advanced under maximal sterile precaution, dark blood was aspirated freely. Then, the guidewire passed through the needle also advanced smoothly. A triple lumen catheter was inserted over the guidewire to a depth of 16 cm from the skin surface. All the ports were checked by aspiration and flushed. The catheter was then secured and resuscitation via vasopressors was initiated.

Post-procedural Findings: After the procedure was done, an anteroposterior (AP) chest X-ray was done to confirm tip position and rule out a pneumothorax.

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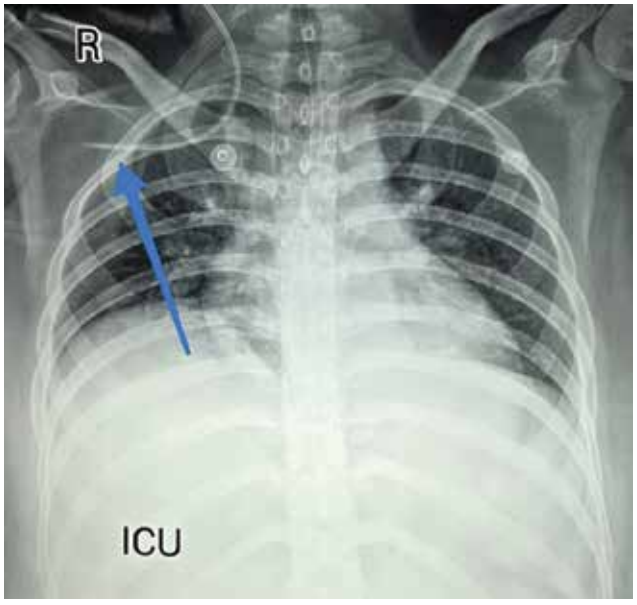

Figure 1: Anteroposterior (AP) chest X-ray showing the misplaced central venous catheter. The catheter tip (arrow) is found to be inside the right subclavian vein curving laterally and superiorly rather than descending downwards to the superior vena cava. No pneumothorax was seen however.

The X-ray exhibited the catheter tip to be placed inside the proximal part of the right subclavian vein. The catheter took a superior and lateral course rather than descending downwards medially towards the SVC (Fig 1).

Management and Outcome: Considering the immediate need for central access and the subsequent misplaced central catheter, the misplaced was removed and replaced with a new one under direct USG guidance. Post-procedure X-ray revealed correct placement of the catheter tip this time in the SVC. Her septic shock was managed successfully; vasopressors were weaned off over the next 72 hours. The new CVC was also removed on day 5.

Discussion

This case demonstrates a classic CVC malposition inside the ipsilateral subclavian vein. Even though using landmark technique achieved success in ensuring venous access in this case, it failed to ensure proper final tip position, thus highlighting the limitations of using only one method.

Mechanism of Misplacement

i. **Anatomical Aspects and Technical Error:** The main causative factor for this specific instance of malpositioning is accidental cannulation or guidewire passage into a tributary of the subclavian vein, such as the external jugular, internal jugular, or cephalic vein, rather than cannulating the subclavian vein itself[7]. In a landmark 'blind' technique, the performer maneuvers relying on surface anatomical landmarks, which can direct the needle pathway into a tributary vessel. As such, the guidewire can preferentially travel in the path of least resistance in a tributary vessel rather than making the turn into the brachiocephalic vein. The circumstantial evidence would suggest that the tip of the needle was most likely at the intersection of the subclavian and internal jugular vein, with subsequent guidewire passage anterior into the internal jugular vein or in a reverse manner into the distal subclavian/ axillary vein.

ii. **Unrecognized Resistance:** The performer noted a "smooth" passage of the guidewire. However, resistance is a relative phenomenon and subjective in nature. The guidewire can continue to feel this way, especially when a patient is hypovolemic with low venous pressure. Use of manometry with a sterile column or a transducer placed on the needle could have given an indication if pressure measurements were low or damped, pointing towards a smaller, peripheral vein in such a case[8].

iii. **Catheter Characteristics:** Characteristics of the catheter, such as rigidity and curvature, may play a part in this occurrence. The progression of a stiff catheter over an improperly placed guidewire can solidify an incorrect path.

Clinical Significance and Prevention

A non-central catheter placed in the subclavian vein. Chemical phlebitis, thrombosis, and extravasation are potential hazards when vasopressor drugs/hyperosmolar solutions are infused through a non-central catheter [4]. The catheter can potentially become non-functional because of interaction with the vein wall. A variety of methods need to be adopted in order to prevent this condition. They include protocol-oriented steps:

1. **First Line Application of Ultrasound:** The usage of ultrasound guidance in elective central venous catheterization is recommended by the National Institute for Health and Care Excellence in all situations where possible [9]. Ultrasound guidance helps in visualizing the needle entering into the vein and hence prevents improper positioning during the first attempt.
2. **Verification of the Centrality of the Guidewire:** Before dilation takes place, it is important to establish the intravascular nature of the guidewire. Techniques used in establishing this include bedside ultrasound scanning of the guidewire in the target vein, following it towards the heart, or with the aid of a fluoroscope if available[10].
3. **Intraprocedural Tip Localization Techniques:** Pure reliance on a post-procedure chest X-ray is a reactive approach. A proactive course of action is advisable:
    a. Tip Navigation: In a manner proved in the successful second attempt, this technique can offer confirmative real-time information on successful positioning of the guidewire or catheter tip in a cavoatrial space according to characteristic P-wave changes in a modified ECG lead[6].
    b. Transesophageal Echocardiography (TEE) or Transthoracic Echocardiography (TTE): With access to monitoring, direct observation of the catheter in the Superior Vena Cava or Right Atrium can be achieved.
4.

Awareness and Training: The operating team must be educated to be mindful of the possibility of tip malposition despite a successful blood aspiration. Techniques taught can focus on the idea that a "free flow of blood" defines a venous rather than a final tip position.

Conclusion

This case clearly shows that effective central catheter access is a two-fold process that involves both safe venous access and accurate tip placement. While ultrasound guidance is imperative for the access process, it does not contribute to accurate tip placement. Malposition of a subclavian catheter in a patient with septic shock, which is promptly corrected, is still a potentially avoidable risk. This risk can be reduced by implementing an optimized care bundle, which should associate both ultrasound guidance for access with a tip verification step, such as ECG guidance navigation systems, for accurate tip placement. In critical patients who require landmark approaches, it is critical to ensure prompt radiographic verification.

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