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CASE REPORT

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Minimally invasive approach to managing brachiocephalic trunk cannulation complicating central venous catheterization: a case report

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Abstract

Background Central venous catheterization, crucial for device insertion, monitoring, medication, and fluid resuscitation, commonly uses the subclavian, internal jugular, and femoral veins. Despite its general safety, complications like arterial puncture can be life-threatening, requiring rapid diagnosis and treatment.

Case presentation A 74-year-old woman in the recovery phase of cerebral infarction underwent right subclavian vein catheterization. The catheter was mistakenly placed in the brachiocephalic trunk, with its tip in the ascending aorta, as confirmed by computed tomography (CT) and digital subtraction angiography (DSA). With the high surgical risk and the complexity of endovascular treatment, catheter replacement was chosen. One month after the initial placement, the catheter was replaced with a smaller one, and another month later, it was retracted without complications. Follow-up CT and DSA revealed no leakage, with the patient's vitals remaining stable. A three-month post-discharge phone follow-up confirmed the patient's continued stability.

Conclusion This case demonstrates the effective use of a catheter replacement technique as a minimally invasive repair method when other options are impractical. Ultrasound guidance is also recommended to improve the procedure's accuracy and safety.

Keywords Central venous catheterization, Brachiocephalic trunk, Cannulation, Catheter replacement

Background

Central venous (CV) catheterization is a vital procedure used for various purposes, including device insertion (such as pacemakers and implantable cardioverter-defibrillators), hemodynamic monitoring, the administration of medications, and rapid fluid resuscitation [1, 2]. Subclavian vein, internal jugular vein and femoral vein are commonly used access routes. Although CV catheterization is widely practiced and generally considered safe, numerous complications such as arterial puncture, hemothorax, pneumothorax, and infection have been reported [3]. Among these, accidental arterial

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cannulation can be particularly life-threatening [4]. Rapid diagnosis and prompt treatment are essential when this complication arises.

This case describes a patient who underwent unintended cannulation of the brachiocephalic trunk during CV catheterization. The complication was addressed through a catheter replacement approach, which involved an exchange of the CV catheter and the establishment of a sinus tract for successful repair.

Case presentation

A 74-year-old female patient in the recovery phase of cerebral infarction was admitted to our neurology department. She received neurotrophic therapy, lipid-lowering and plaque stabilization treatment, as well as anticoagulation and anti-infective therapy. Due to prolonged bed rest, the patient's pulmonary infection worsened, complicated by heart failure and respiratory failure, with oxygen saturation fluctuating between 80 and 90%. She was transferred to the ICU for higher level of care. Despite anti-infective therapy, sputum clearance, and suctioning, her oxygen saturation remained unstable at around 80%. To protect her airway, tracheal intubation was performed.

As peripheral intravenous access was difficult, the patient underwent CV catheterization via the right subclavian vein using a 7-F double-lumen catheter to establish intravenous access and monitor CVP. Due to blood backflow from the right subclavian vein catheter, the infusion was paused. Blood gas analysis from the catheter showed 7.51 of pH, 93.2 mmHg of PO_2, 36.5 mmHg of PCO_2, 99.4% of SO_2, 5.6 mmol/L of base excess, and 3.2 mmol/L of lactate. It was suspected that the catheter had been mistakenly placed in an artery. A computed tomography (CT) scan and digital subtraction angiography (DSA) both indicated that the catheter had entered the brachiocephalic trunk, with its tip located in the ascending aorta (Figs. 1A and B and 2A and B). Prolonged arterial catheter placement poses risks like bleeding, infection, and thrombosis. Additionally, the puncture site is near the origins of the right subclavian and right common carotid arteries, complicating endovascular treatment. Surgery was recommended but declined due to the patient's condition and the family's concerns about the high risk associated with the procedure. Since the patient was asymptomatic and the puncture site showed no issues, regular catheter care and changes were advised, with plans to remove the catheter once a sinus tract forms.

One month later, the CV catheter was replaced with a 5-F single-lumen catheter under DSA guidance. DSA and follow-up CT scans showed no leakage from the brachiocephalic trunk (Figs. 1C and D and 2C and D). Another month later, DSA revealed a sinus tract between the skin puncture site and the unintended puncture point of the brachiocephalic artery, without applying pressure to the puncture site (Fig. 2E). After applying pressure to the puncture site, the catheter was gradually withdrawn near the mispuncture point, and angiography showed no significant leakage into surrounding tissues or the internal jugular vein (Fig. 2F). The catheter was retracted, leaving the guidewire in place to prevent bleeding and facilitate the insertion of a new catheter and surgical repair. Concurrent imaging showed no sign of bleeding (Fig. 1E and F). Two days later, the guidewire was retracted, and CT again showed no bleeding (Fig. 1G and H). Two weeks after the procedure, the patient's vital signs were stable: temperature 36 °C, heart rate 80 bpm, respiration 16 breaths per minute, and blood pressure 104/58 mmHg. There were no signs of hematoma or swelling. Hemoglobin levels remained steady between 87 and 115 g/L for. For financial and medical convenience reasons, the family requested that the patient be transferred to a local hospital. A telephone follow-up three months after discharge indicated that the patient's condition remained stable, and rehabilitation treatment was continuing.

Discussion

Accidental arterial puncture occurs in approximately 1.3% of subclavian approaches and can sometimes result in acute hemorrhages and hemothorax [5–7]. Arteries commonly affected include the carotid, subclavian, brachiocephalic, vertebral, and aorta. Although there are no standardized guidelines for addressing arterial injuries resulting from CV catheterization, it is important to consider the artery's anatomy and lesion, patient comorbidities, and the feasibility and risks of the intervention before deciding on the treatment approach [8, 9]. When an artery injury occurs at a site where compression is feasible, it can be effectively managed by removing the needle and manual external compression. However, if the injury occurs at a non-compressible site, such as arterial cannulation, complications like cervical-thoracic hematoma, hemothorax, pseudoaneurysm, arteriovenous fistula, and cerebrovascular accident can arise [10]. Such complications pose significant management challenges and require careful consideration of various strategies.

The main treatment options for arterial cannulation include surgical intervention, endovascular procedures, or a combination of both. Surgery is preferred if the injury is accessible and the patient is stable. For critically ill patients, endovascular methods like occlusion balloons, percutaneous closure devices, and stents may be more suitable [4]. A case of accidental right subclavian artery catheterization was effectively managed with an occlusion balloon, demonstrating its utility for arterial injuries during CV catheterization [11]. Additionally, percutaneous closure devices have successfully

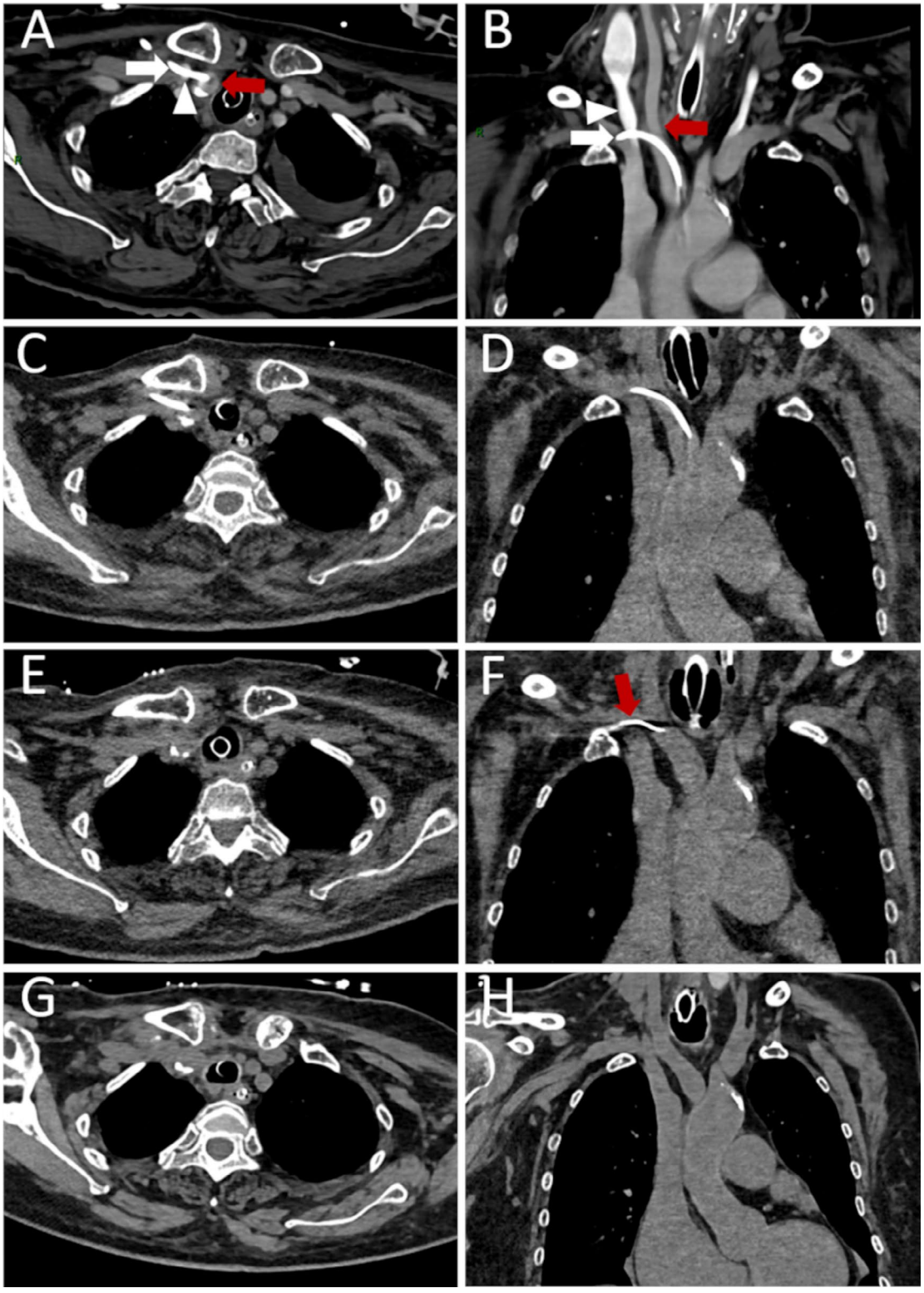

Fig. 1 Contrast-enhanced computed tomography (CT) scan of CV catheterization. Three days after catheter misplacement (**A**, **B**), CT scan showed that the double-lumen catheter (white arrow) entered the brachiocephalic trunk (red arrow) via the right internal jugular vein (arrowhead). One month later, the original catheter was replaced with a single-lumen catheter (**C**, **D**), and no hematoma was observed. Another month later, the catheter was retracted (**E**, **F**), while the guidewire was left in place (red arrow). CT confirmed no signs of hematoma. Two days after the guidewire was also retracted, CT again showed no signs of hematoma (**G**, **H**)

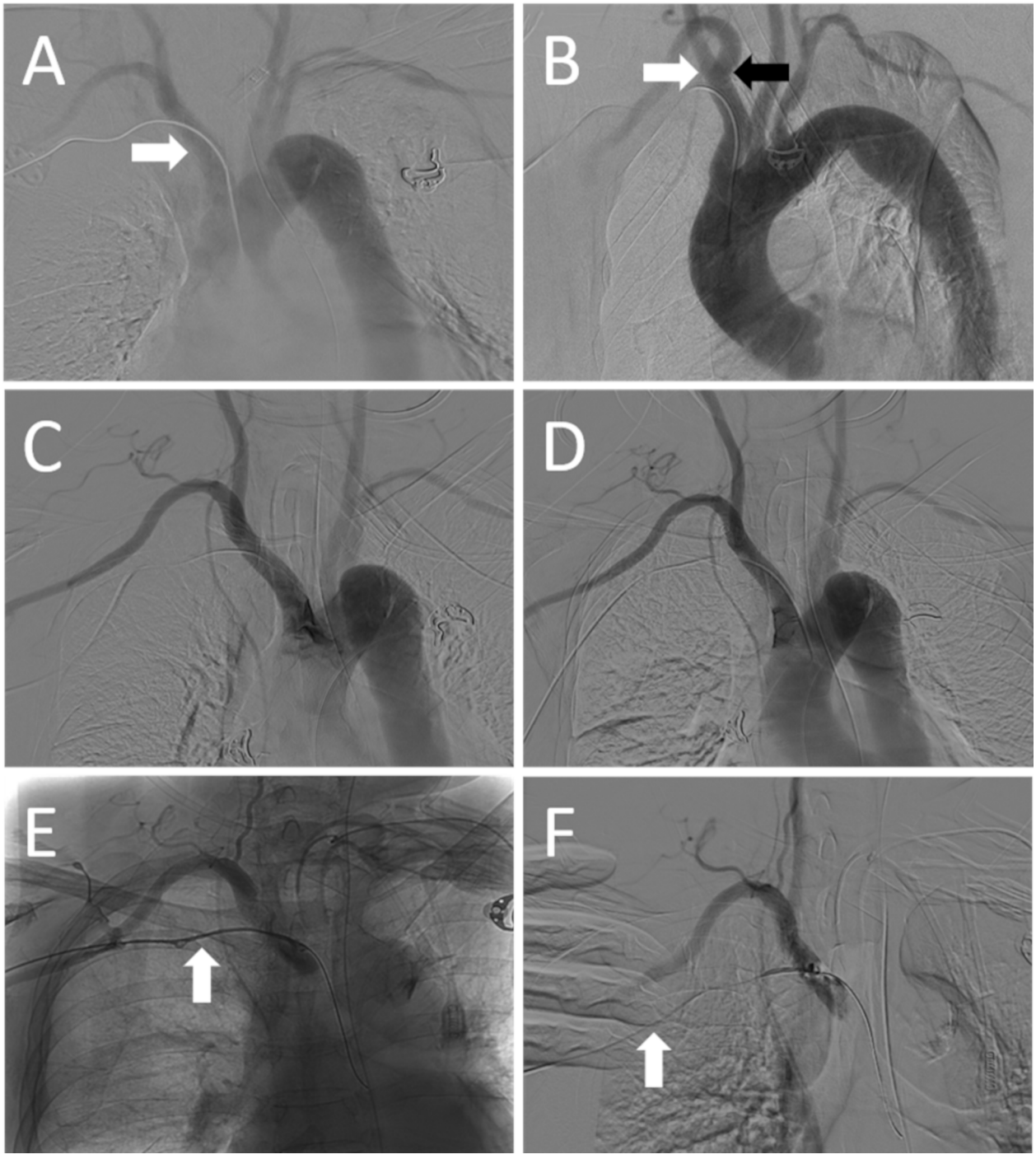

Fig. 2 Digital subtraction angiography (DSA) of CV catheterization. **A**, **B**: Three days post-misplacement, DSA showed the double-lumen catheter in the ascending aorta (white arrow) and its proximity to the right common carotid and subclavian arteries (arrows). **C**, **D**: One month later, after single-lumen replacement, DSA showed no contrast leakage. **E**: DSA showed a sinus tract (white arrow) between the skin puncture site and the brachiocephalic artery. **F**: After applying pressure and withdrawing the catheter, angiography confirmed no leakage into surrounding tissues or the internal jugular vein

sealed arterial punctures by compressing the site with an absorbable anchor inside the artery and an external collagen sponge [10, 12]. Some authors have suggested an endovascular approach with a stent-graft, which has proven successful in treating vascular injury caused by inadvertent puncture. An iatrogenic injury to the innominate vein from a misplaced internal jugular catheter was managed with a customized fenestrated endograft aligned with the internal jugular vein and a new tunneled catheter inserted into the superior vena cava

[13]. Additionally, successful endovascular repair of an innominate artery bifurcation injury with ongoing mediastinal extravasation was achieved using two kissing balloon-expandable covered stents, effectively repairing the injury and maintaining patency in both distal branches [14]. However, the success of such procedures depends on specific anatomical factors. Careful patient selection is crucial: a stent-graft is most suitable when blood flow beyond the injury is intact, the artery has a straight course, and its diameter is adequate for stent placement to prevent distal ischemia [15].

In our case, given the patient's deep arterial cannulation site, merely retracting the catheter and applying external compression could lead to additional complications. Furthermore, this method is contraindicated for catheters 7-Fr and larger, as it may cause uncontrollable bleeding, pseudoaneurysm, and arteriovenous fistula [16]. The elderly patient had a history of a large cerebral infarction leading to hemiplegia, along with heart and respiratory failure, and was in generally poor condition. Considering the high risk associated with surgery such as severe pulmonary infection, surgery was deemed too risky. The balloon can temporarily control bleeding, but if a hematoma or pseudoaneurysm develops after its removal, a covered stent may be needed. Given that the brachiocephalic trunk puncture site was less than 1 cm from the origins of the right subclavian and common carotid arteries, placing a covered stent could obstruct these arteries and lead to ischemic events. Inserting two covered stents would be technically challenging, costly, and might face issues with stent sizing and availability. Furthermore, the tortuous anatomy of the brachiocephalic trunk also increases the difficulty of balloon and stent placement. In principle, a ProGlide vascular closure device or a vascular plug could be used for repair. However, the puncture site was 8 cm from the brachiocephalic trunk entry point, exceeding the 6–7 cm operational range of these devices. Additionally, the depth of the puncture site would make it difficult to monitor the effectiveness of the closure. Therefore, we ruled out endovascular procedures. Considering the patient's lack of symptoms and to minimize trauma and costs while reducing complication risks, we opted to replace the catheter with a smaller one and wait for a sinus tract to form before removal. In previous cases, a hemodialysis catheter mistakenly placed in the brachiocephalic artery was successfully extracted, and the artery was repaired through a minimally invasive upper sternotomy [17]. Compared to the case and the other mentioned treatments, the catheter replacement approach is less invasive and more cost-effective, although it is more time-consuming. After two interventional procedures, the patient experienced no complications like local hematoma, hemothorax, or pseudoaneurysm, and hemoglobin levels remained stable. Thus, with the required expertise, catheter replacement is a practical and safe alternative when surgical or endovascular options are not feasible.

Utilizing appropriate supportive techniques can improve the success of CV catheterization and reduce the risk of complications [2]. Many studies recommend the use of ultrasound (US) guidance for CV catheterization. Ultrasound (US) provides direct visualization of the target vessel and improves catheterization accuracy. It reduces overall complications by 71–74%, decreases arterial punctures by 72–79%, shortens access time by 30.5 s, and requires 1.19 fewer attempts compared to the landmarkguided technique, thereby supporting its use in CV catheterization [18, 19]. When ultrasonography is unavailable or difficult to access and there is suspicion of arterial perforation, intervention may be guided by anatomical reference points. Blood gas analysis, pressure transduction, and/or chest X-ray are also valuable in confirming catheter positioning.

Conclusion

We report a rare and challenging case of brachiocephalic trunk cannulation after CV catheterization. This case illustrates the successful use of a CV catheter replacement approach for brachiocephalic trunk repair, highlighting its effectiveness as a minimally invasive treatment when surgical or endovascular options are unavailable. Furthermore, US guidance is recommended to enhance the accuracy and safety of CV catheterization.

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Author contributions
Deng HH and Chen B contributed equally to this work. The treatment plan was designed by Pang FW, Deng HH and Chen B. Patient treatment was performed by Deng HH, and Chen B. Deng HH and Pang FW wrote the manuscript. Deti Peng and Pang FW participated in manuscript revision. All authors approved the final version of the manuscript.

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Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Informed consent was obtained from the patient.

Competing interests
The authors declare no competing interests.

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