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PICTORIAL ESSAY

Endovascular Management of Iatrogenic Neck Vascular Injury After Central Venous Catheterisation

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INTRODUCTION

Central venous line placement is a common procedure in both elective and emergency settings across different medical and surgical specialties. The jugular and subclavian approaches are common methods of central venous catheterisation in the neck, which can be performed by traditional methods based on anatomical landmarks or under ultrasound guidance.[1]

Though rare, iatrogenic neck arterial injury can occur during attempts at central venous catheterisation, leading to serious complications such as arterial perforation with active bleeding, pseudoaneurysm, arteriovenous fistula, arterial dissection, or vascular occlusion resulting in neurological or ischaemic sequelae. Risk factors include obesity, short neck, and emergency catheterisation.[2,3] Surgical approaches to repair injured arteries may involve extensive dissection or open-cardiothoracic surgical repair and vascular grafting, and often require general anaesthesia. These may entail prolonged recovery and may not be tolerated by critically ill or elderly patients.

Endovascular management of central venous line complications and retrieval of retained indwelling catheters or their components can be a promising first-line treatment option in view of its minimally invasive nature, high success rate with reduced morbidity, and enhanced recovery compared with open surgery. It may be performed under local anaesthesia.

Treatment plans for arterial complications should be individualised based on the type of complication, relationship to adjacent vital vessels, angiographic factors, and patients' underlying health conditions. The pros and cons of different endovascular treatment options need to be examined.

With increasing use of long-term indwelling venous

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catheters, it is vital that clinicians be aware of the associated risks of retained catheter component(s) within veins or failed catheter removal due to an adherent fibrin sheath. Forceful removal may further jeopardise blood vessels or result in device fragmentation or embolisation.

This article reviews cases of successful treatment of the iatrogenic complications of neck arterial catheterisation during central venous catheterisation as well as of unintentionally retained catheters or their fragments from neck veins, with illustration of different endovascular treatment techniques.

ARTERIAL INJURY

The subclavian, brachiocephalic, and carotid arteries are in close proximity to the internal jugular and subclavian veins, placing them at risk of iatrogenic injury during venous catheterisation. Reflux of pulsatile or fresh blood within the catheter, neck haematoma, abnormal catheter course, or acute neurological deficit should raise suspicion for arterial injury. The risk of complications increases with the calibre of the device that punctured the artery.[4,5]

In the setting of iatrogenic carotid artery puncture by small-calibre vascular access needles (e.g., ≤ 20-G), the risk of major complications is relatively low, with needle removal and external compression being a feasible management option with a low complication rate.[5] However, in the case of subclavian or brachiocephalic artery injury, haemostasis by compression alone may be ineffective due to lack of an underlying bone to facilitate compression in the supraclavicular region, and is associated with a higher complication rate.[3]

Ideally, operators should confirm the venous location of the vascular access needle prior to insertion of large-bore vascular dilator, sheath or catheter, because of the higher complication rates if these instruments are unintentionally introduced into the arterial system.[4] If iatrogenic large-bore catheter injury occurs (such as insertion of a catheter > 7 Fr or a vessel dilator[4,5]), operators should refrain from immediate withdrawal of the malpositioned catheter from major arteries, as the catheter can still tamponade the vessel, limiting bleeding and providing an endovascular access route for closure of the arterial perforation. Intravascular balloon tamponade against the arterial puncture site for temporary haemostasis can also be helpful while contemplating definitive treatment. A misplaced dilator or large-bore catheter should be left in place as recommended by the Practice Guidelines for Central Venous Access 2020 by the American Society of Anesthesiologists[4] prior to removal. Urgent resuscitation, multidisciplinary consultation with interventional radiologists, vascular or cardiothoracic surgeons should be sought to devise an individualised treatment plan. If the site of arterial injury is clearly visible and surgically accessible, treatment options may include direct surgical arterial repair[5] or endovascular treatment. However, when the site of arterial injury is not well defined or easily accessible surgically, prompt imaging evaluation[5] such as computed tomographic angiography is pivotal in treatment planning and assessing complications.

Different endovascular treatment options can be used sequentially or in combination to achieve haemostasis, which comprise endovascular treatment such as stenting, embolisation, or coiling of a pseudoaneurysm using a percutaneous approach. Embolisation or coiling of a pseudoaneurysm may be performed if the pseudoaneurysm sac can be selectively cannulated, which may be technically challenging in the neck region especially if the injured feeding vessel is tortuous.

Endovascular Stenting

Covered stent graft deployment along the injured segment is helpful in preserving perfusion, with exclusion of the pseudoaneurysm from circulation (Figure 1). This is imperative if the injured artery must be preserved to supply organs or extremities.

In the literature, both balloons and self-expanding stents have been used in management of arterial injury.[6] Among self-expanding stents, Fluency (Bard Peripheral Vascular Inc, Tempe [AZ], US), Viabahn (WL Gore & Associates Inc, Newark [DE], US), Wallgraft (Boston Scientific, Natick [MA], US), and Cragg covered stents (Boston Scientific, Natick [MA], US) have all been used.[6] The covered stents available in the Hong Kong market include the Fluency self-expanding stent, the BeGraft peripheral balloon-mounted stent graft system (Bentley InnoMed, Hechingen, Germany), the iCover balloon-expandable stent (iVascular, Barcelona, Spain), and the recently available Advanta V12 balloon-expandable covered stent (Advanta, Getinge, Sweden).

Choice of stent graft should be based on device availability, the operator's experience, arterial diameter, distance of other vital branches from the subclavian artery

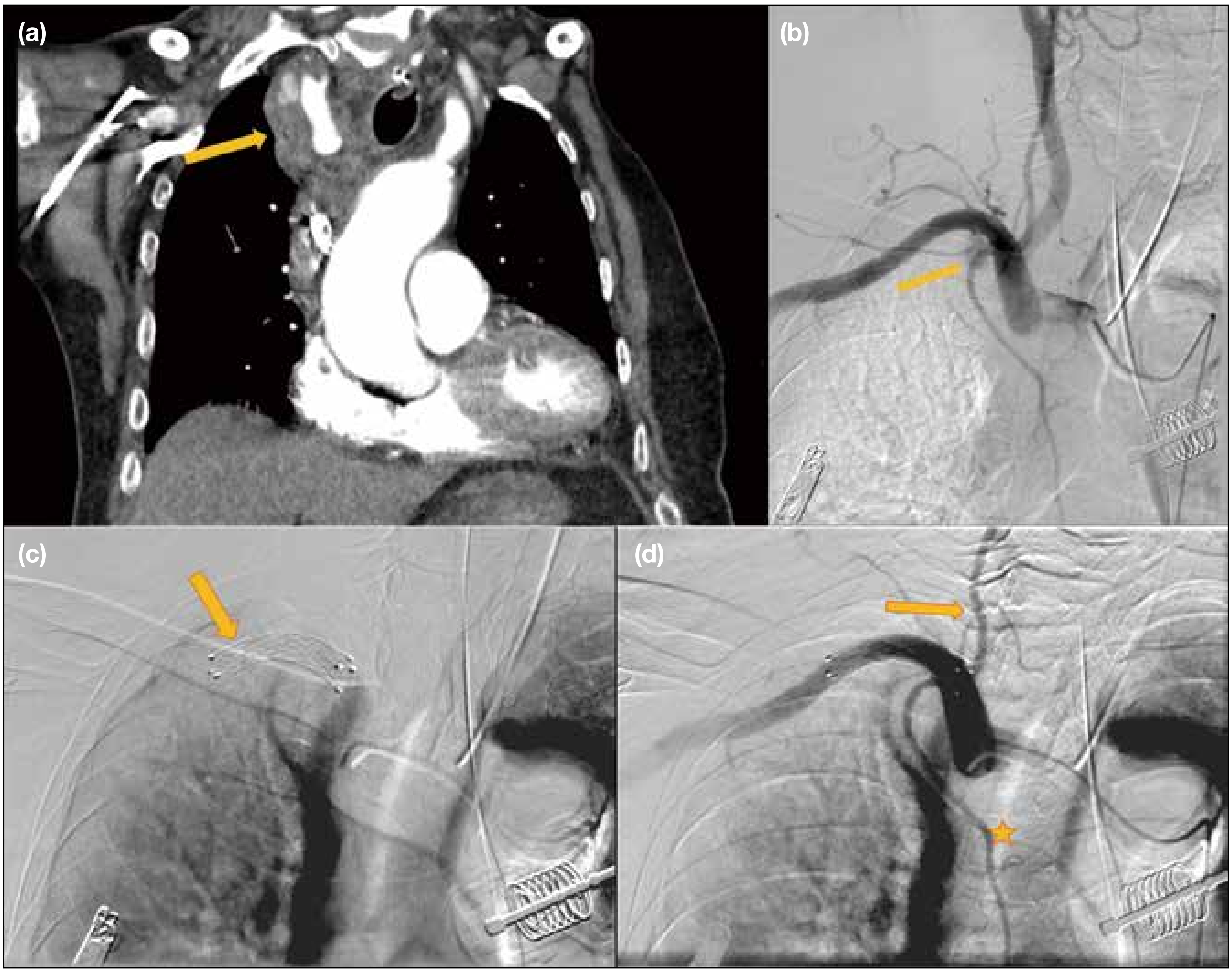

Figure 1. Case 1. Right subclavian artery perforation with pseudoaneurysm formation after attempted central venous catheterisation. (a) Contrast-enhanced computed tomographic angiography of the thorax and (b) digital subtraction angiography demonstrated a pseudoaneurysm (arrows) arising from the proximal right subclavian artery, with adjacent haematoma. (c) Using right femoral access, the right subclavian artery was cannulated with a 4-Fr H1 catheter (Cordis Corporation, Miami [FL], US) and a 0.035 inch × 150 cm Terumo guidewire (Terumo Medical Corporation, Somerset [NJ], US), followed by a guidewire exchange to a 0.035 inch × 260 cm Super Stiff Amplatz guidewire (Boston Scientific, Natick [MA], US). A 10 mm × 40 mm Fluency stent graft (Bard Peripheral Vascular, Tempe [AZ], US) [arrow] was deployed over the wire along the injured segment of the right subclavian artery, distal to the origin of the right vertebral artery. (d) Post-stenting angiography shows successful exclusion of the pseudoaneurysm with preservation of blood flow to the vertebral (arrow) and internal mammary arteries (star).

(especially the vertebral artery), and the availability of adequate landing zones. An ideal covered stent should have flexibility and conformability to the vessel, allowing for adaptation to vascular tortuosity.

Caution should be exercised if stent deployment potentially involves the vertebral artery origin, due to the risk of impairing posterior circulation, resulting in ischaemic stroke, especially if patients lack contralateral dominant vertebral artery supply.

To the best of authors' knowledge and experience, while there is no universal consensus or guideline regarding the use of antiplatelet drugs or anticoagulants after emergency stenting, the clinical decision regarding choice and timing of starting antiplatelet drugs and anticoagulants after stenting should be based on balancing the risks of rebleeding versus stent thrombosis, as well as contraindications for antiplatelet or anticoagulant use from patient co-morbidities (such as recent intracranial haemorrhage).

In the long term, the decision for lifelong antiplatelet treatment (e.g., lifelong aspirin 80 mg per oral daily) would be made on a case-by-case basis, balancing the risk of stent thrombosis versus the risk of long-term antiplatelet use.

Vascular Closure Devices

Suture-mediated vascular closure devices have emerged as an alternative treatment option and are particularly favoured in frail patients in averting major open surgical repair. Originally approved for percutaneous

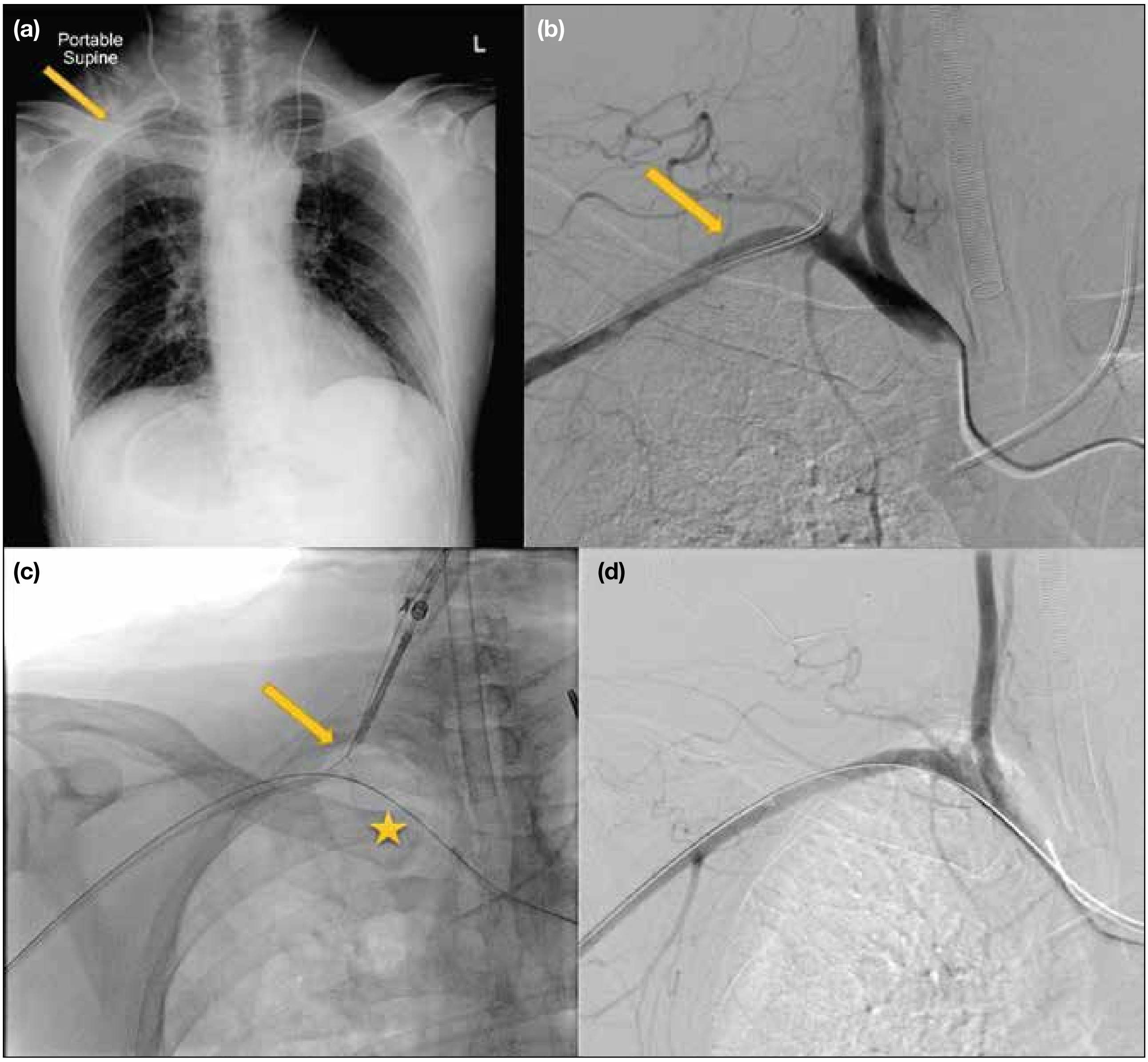

Figure 2. Case 2. A malpositioned triple lumen central venous catheter perforates into the right subclavian artery. Chest X-ray (a) demonstrates the abnormal course of the catheter with subclavian artery catheterisation and the tip (arrow) angulated towards the right axilla. Digital subtraction angiography (b) shows the course of catheter within the right subclavian artery (arrow), with the site of arterial entry distal to the origin of the vertebral artery and the tip in the right axillary artery. The interventional radiology team planned for removal of the catheter with arterial repair by a vascular closure device. (c) A safety guidewire (260-cm Amplatz Super Stiff guidewire; Boston Scientific, Natick [MA], US) was inserted via a right femoral artery sheath, coursing to the right brachial artery (star). Right lower neck dissection was performed by the vascular surgeons to facilitate access to the subclavian artery for deployment of the vascular closure device and repair of the internal jugular vein. The malpositioned catheter in the right subclavian artery was removed over a 0.035-inch Terumo guidewire (Terumo Medical Corporation, Somerset [NJ], US). The right subclavian artery was repaired by Perclose ProGlide (Abbott Vascular, Redwood City [CA], US) [arrow] deployed just adjacent to the subclavian artery at neck dissection. A subsequent right subclavian angiogram (d) reveals a patent subclavian artery without contrast extravasation. The safety guidewire was then removed with neck wound closure by surgery.

closure of femoral artery punctures, which are more superficial, suture-mediated closure devices such as Perclose ProGlide have been used off-label with reports of successful closure of the subclavian or innominate artery.[7,8] The minimal amount of intraluminal material used mitigates the risk of thromboembolism or device dislodgement. To facilitate deployment of the closure device as close to the vessel perforation site as possible in a relatively deep arterial perforation site along the subclavian or innominate artery, regional neck dissection by vascular surgery to gain adequate vessel exposure may be helpful (Figure 2).

Complications of suture-mediated closure devices include complete occlusion of the artery[9] and failed haemostasis. Therefore, placement of a safety guidewire into the injured artery prior to deploying the vascular closure device (Figure 2c) would facilitate rapid deployment of a balloon for temporary occlusion, or stenting as secondary haemostatic measures in case of failure of vascular closure device.

Pseudoaneurysm Treatment with Percutaneous Thrombin Injection

Percutaneous thrombin injection for pseudoaneurysms is a safe and effective treatment with a success rate of > 90%,[10,11] which is useful in the supraclavicular or retroclavicular region and is accessible with percutaneous needle puncture or when the injured artery is not accessible by endovascular catheterisation (Figures 3 and 4). Slow injection under real-time imaging guidance, with the needle tip directed away from the pseudoaneurysm sac, help minimise the risk of non-target embolisation. The advantages of this procedure include simplicity, speed and less discomfort compared with ultrasound-guided compression, as well as a low complication rate (< 1.3%).[11]

A small risk of iatrogenic thrombin embolisation into the parent artery resulting in arterial occlusion[11] exists, which may be minimised with injection distant from the pseudoaneurysm neck. Other risks include allergic rection and infection such as skin cellulitis or abscess formation.

RETRIEVAL OF BROKEN CATHETER FRAGMENTS

Mechanical failure of a long-term central venous catheter may result in catheter fragmentation, dislodgement, or embolisation. Imaging with plain radiographs such as chest X-ray is readily available for prompt screening of catheter integrity in clinical setting.

Computed tomography enables accurate localisation of dislodged catheter fragments, assessment of the relationship to adjacent vasculature, and detection of complications. Imaging can facilitate assessment of crucial factors in treatment planning, including the size, orientation and location of dislodged catheter fragments, the calibre of venous access routes, and the intended extraction route and vascular access site, which can guide the choice of type and size of retrieval device with reference to available institutional resources.

Establishment of venous access through a large calibre superficial vein such as the internal jugular or common femoral vein is beneficial in enabling convenient equipment deployment. Haemostasis in these superficial venous access sites can be more easily achieved with compression.[12] The relatively straightforward course from the right internal jugular vein or femoral veins to the vena cava with reduced angulation compared with the left side facilitates easier engagement and retrieval of retained catheter fragments in the vena cava. Commonly used retrieval tools include Amplatz Goose Neck snare (ev3 Inc, Plymouth [MN], US; Figure 5) or EN Snare (Merit Medical, West Jordan [UT], US; Figure 6).

FIBRIN SHEATH STRIPPING AROUND RETAINED CATHETER THROUGH TRANSFEMORAL VENOUS ACCESS

Fibrin sheath formation is a common complication with long-term indwelling catheter, leading to encasement of catheter tip or side hole impairing catheter patency, thrombus formation or infective complications.[13] Fibrin sheaths may also be adherent to the catheter and vessel wall, precluding catheter removal. While fibrin sheath detection from plain radiography or cross-sectional imaging is difficult given their thin appearance, fluoroscopy with contrast injection into the affected catheter is helpful in depicting fibrin sheath as filling defects, as well as contrast reflux along the proximal catheter with efflux from defects in the sleeve, or excessive ejection of contrast material from the side holes of the proximal port,[13] which may be secondary to blockage of catheter tip outflow by fibrin sheath.

In the event of adherent catheter to vessel wall due to fibrin sheath precluding catheter removal, fibrin sheath

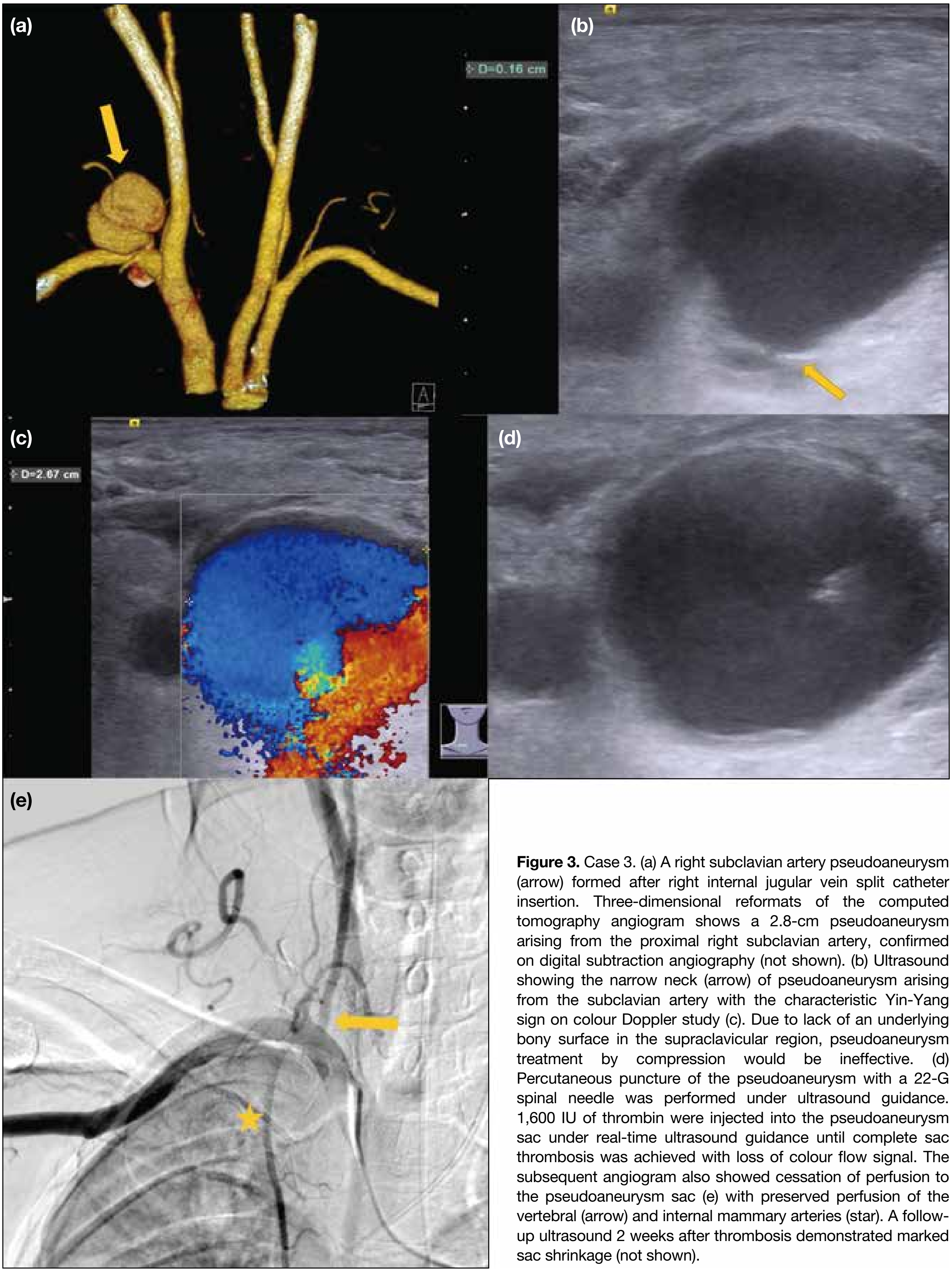

Figure 3. Case 3. (a) A right subclavian artery pseudoaneurysm (arrow) formed after right internal jugular vein split catheter insertion. Three-dimensional reformats of the computed tomography angiogram shows a 2.8-cm pseudoaneurysm arising from the proximal right subclavian artery, confirmed on digital subtraction angiography (not shown). (b) Ultrasound showing the narrow neck (arrow) of pseudoaneurysm arising from the subclavian artery with the characteristic Yin-Yang sign on colour Doppler study (c). Due to lack of an underlying bony surface in the supraclavicular region, pseudoaneurysm treatment by compression would be ineffective. (d) Percutaneous puncture of the pseudoaneurysm with a 22-G spinal needle was performed under ultrasound guidance. 1,600 IU of thrombin were injected into the pseudoaneurysm sac under real-time ultrasound guidance until complete sac thrombosis was achieved with loss of colour flow signal. The subsequent angiogram also showed cessation of perfusion to the pseudoaneurysm sac (e) with preserved perfusion of the vertebral (arrow) and internal mammary arteries (star). A follow-up ultrasound 2 weeks after thrombosis demonstrated marked sac shrinkage (not shown).

Figure 4. Case 4. Left thyrocervical trunk pseudoaneurysm after left internal jugular vein catheterisation. Digital subtraction angiography (a) shows a pseudoaneurysm (arrow) arising from the left thyrocervical trunk. A trial of endovascular catheterisation of the pseudoaneurysm for coiling was unsuccessful due to tortuous feeding vessels. (b, c) A percutaneous thrombin injection of 1,250 IU was performed under ultrasound guidance and real-time monitoring until complete sac thrombosis with loss of colour Doppler flow signal was carried out. (d) A subsequent left subclavian angiogram confirmed successful embolisation of the pseudoaneurysm.

stripping with snare-ride technique can be helpful in achieving release and successful removal of the catheter that was stuck to the vessel wall by adherent fibrin sheath (Figure 7).

CONCLUSION

In the unfortunate event of iatrogenic vascular injury during catheterisation, prompt assessment with computed tomographic angiography to delineate the intravascular course of the malpositioned catheter, its relationship to adjacent vital vasculature, and detection of complications is crucial for treatment planning. Careful planning of extraction routes and use of appropriate retrieval devices for retained catheter components are pivotal. Multidisciplinary collaboration, providing knowledge in different interventional radiological treatment options, can enable safe and effective intervention with reduced patient morbidity and enhanced recovery.

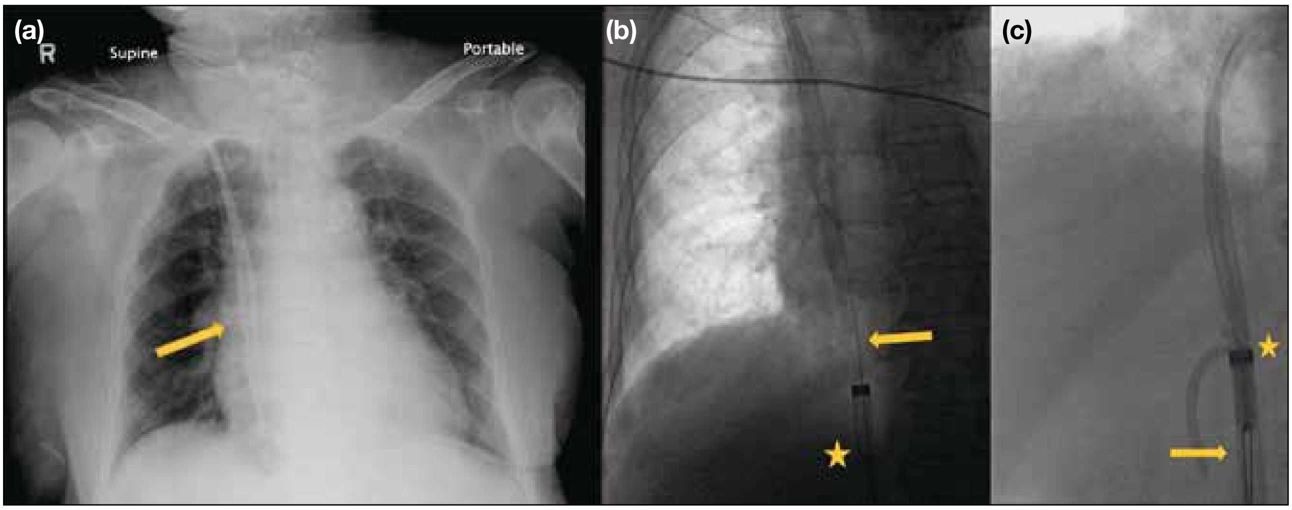

Figure 5. Case 5. Fragmented 10-Fr Ash Split Cath (Medcomp, Harleysville [PA], US) endovascular retrieval using transfemoral venous access. Chest X-ray (a) showing a segment of the catheter (arrow) dislodged into the superior vena cava and the right atrium. In view of the calibre of the catheter and the possibility of it doubling up during retrieval, a more sizable vascular sheath was employed to accommodate the retrieved catheter. Following ultrasound-guided puncture of right femoral vein with an 18-G needle and tract dilatation with a 10-Fr dilator, a 16-Fr vascular sheath (Performer introducer sheath; Cook Medical, Bloomington [IN], US) [stars] was inserted. The catheter was retrieved (b, c) using a 20-mm Amplatz Goose Neck snare kit (ev3 Inc, Plymouth [MN], US) [arrows] inserted into the vascular sheath (stars). Haemostasis at the femoral venous puncture site was achieved with manual compression.

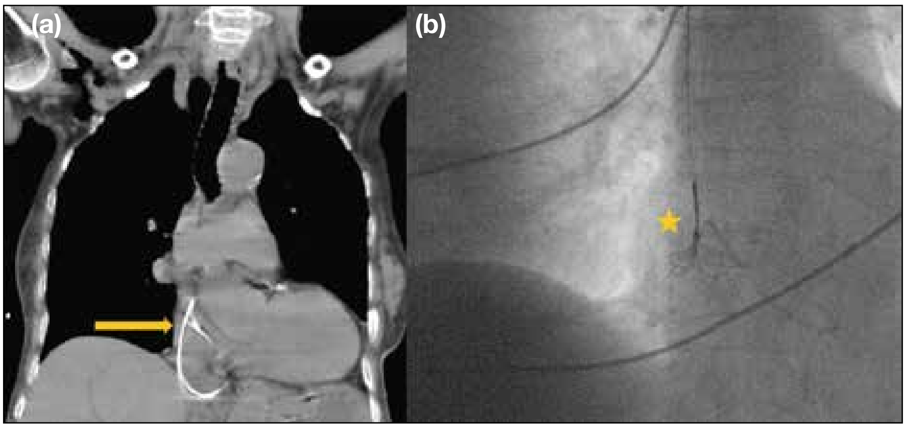

Figure 6. Case 6. Endovascular retrieval of a Hickman catheter fragment by transjugular venous access. (a) Computed tomography of the thorax demonstrates a Hickman catheter (arrow) fragment within the right atrium. (b) Via right internal jugular venous access (star), a 6-Fr EN Snare (Merit Medical, West Jordan [UT], US) was deployed with successful retrieval of the retained Hickman catheter fragment under fluoroscopic guidance.

REFERENCES

1. Saugel B, Scheeren TW, Teboul JL. Ultrasound-guided central venous catheter placement: a structured review and recommendations for clinical practice. Crit Care. 2017;21:225.
2. Ben Mrad I, Ben Fatma L, Ben Mrad M, Miri R, Mleyhi S, Mami I, et al. Endovascular management of a subclavian arterial injury during central venous catheter placement for hemodialysis. Open Access Emerg Med. 2021;13:273-7.
3. Pikwer A, Acosta S, Kölbel T, Malina M, Sonesson B, Akeson J. Management of inadvertent arterial catheterisation associated with central venous access procedures. Eur J Vasc Endovasc Surg. 2009;38:707-14.
4. Practice guidelines for central venous access 2020: an updated report by the American Society of Anesthesiologists Task Force on Central Venous Access [editorial]. Anesthesiology. 2020;132:8-43.
5. Guilbert MC, Elkouri S, Bracco D, Corriveau MM, Beaudoin N, Dubois MJ, et al. Arterial trauma during central venous catheter insertion: case series, review and proposed algorithm. J Vasc Surg. 2008;48:918-25; discussion 925.
6. Dornbos DL 3rd, Nimjee SM, Smith TP. Inadvertent arterial placement of central venous catheters: systematic review and guidelines for treatment. J Vasc Interv Radiol. 2019;30:1785-94.
7. Ng KT, Chau CM, Chan HF, Cheng LF, Ma KF, Chan KM.

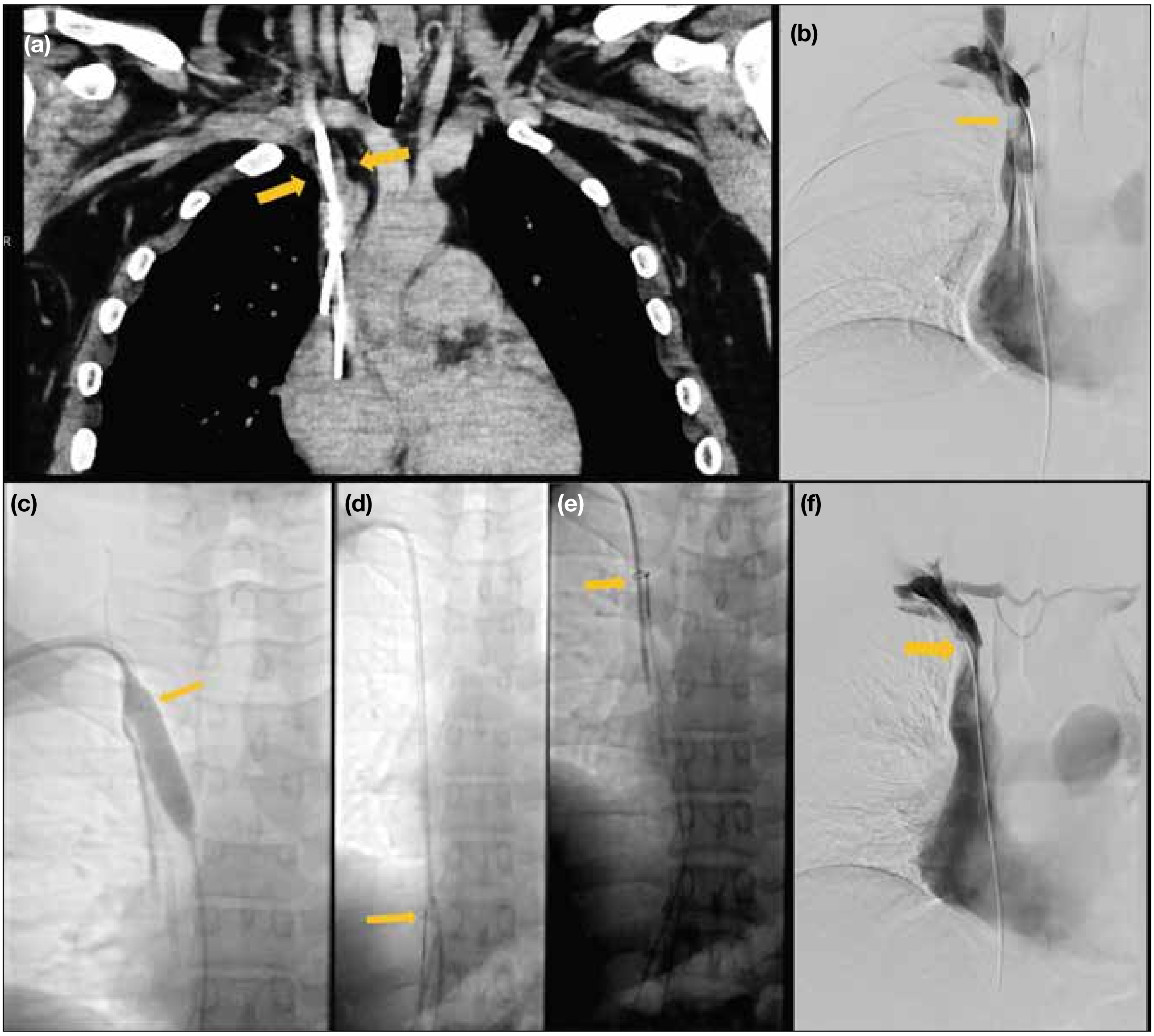

Figure 7. Case 7. Fibrin sheath stripping with snare-ride technique for removal of a right internal jugular Split Cath catheter with prior failed bedside removal. The catheter had been used for 18 months. Computed tomography of the thorax (a) reveals ill-defined bandlike pericatheter hypodensities (arrows) in the superior vena cava (SVC), with corresponding SVC stenosis demonstrated on catheter fluoroscopy (arrow in [b]), due to underlying fibrin sheath formation. Passage of a 0.035-inch Terumo guidewire down to the inferior vena cava (IVC) via the Split Cath catheter (Medcomp, Harleysville [PA], US) and a 4-Fr multipurpose catheter (Merit Medical, West Jordan [UT], US). (c) Right common femoral venous access followed by balloon venoplasty (arrow) along the stenotic SVC segment did not result in successful catheter removal. (d, e) Through-and-through wire access was established by passing the IVC guidewire downwards to the right femoral venous access. A gooseneck snare (Amplatz; ev3 Inc, Plymouth [MN], US) [arrows] was inserted via a right common femoral sheath along with the through-and-through wire to capture the split catheter by the snare-ride technique. Stripping of the fibrin sheath was performed with use of the gooseneck snare (note change in position of the snares as indicated by arrows in [d] and [e]), with successful removal of the catheter with part of the fibrin sheath from the jugular side. (f) Post-procedure angiogram shows mild residual SVC stenosis (arrow) which was patent without thrombus or extravasation.

Percutaneous repair of inadvertent brachiocephalic arterial puncture by closure device: a case report. Hong Kong J Radiol. 2020;23:134-8.
8. Lorenzo JF, Rey JV, Arquillo IL, Encisa de Sá JM. Off-label use of ProGlide percutaneous closure device in iatrogenic arterial catheterizations: our experience. Vascular. 2020;28:756-9.
9. Sharma M, Sakhuja R, Teitel D, Boyle A. Percutaneous arterial closure for inadvertent cannulation of the subclavian artery—a call for caution. J Invasive Cardiol. 2008;20:E229-32.
10. Sarioglu O, Capar AE, Belet U. Interventional treatment options in

pseudoaneurysms: different techniques in different localizations. Pol J Radiol. 2019;84:e319-27.
11. Lo AX, Hon TY, Luk WH, Loke TK, Lo SS, Chan JC. Ultrasound-guided thrombin injection for pseudoaneurysms: a case series at a local hospital. Hong Kong Med J. 2012;18:333-7.
12. Woodhouse JB, Uberoi R. Techniques for intravascular foreign body retrieval. Cardiovasc Intervent Radiol. 2013;36:888-97.
13. Faintuch S, Salazar GM. Malfunction of dialysis catheters: management of fibrin sheath and related problems. Tech Vasc Interv Radiol. 2008;11:195-200.