Complications and Great Escapes: Equipment and Techniques

Rory McPherson, BHB, MBCHB, FRANZCR¹ Timothy Buckenham, MBCHB, FRANZCR¹

¹ Department of Interventional Radiology, Monash Health, Clayton, Victoria, Australia

Semin Intervent Radiol 2014;31:361–369

Address for correspondence Rory McPherson, BHB, MBCHB, FRANZCR, Department of Interventional Radiology, Monash Health, 246 Clayton Road, Clayton, Victoria 3146, Australia (e-mail: rorymcpherson@gmail.com).

Abstract

Keywords

- interventional radiology
- complications
- iliac arterial rupture
- iatrogenic arteriovenous fistula
- vascular snare
- distal embolization
- thrombolysis

All endovascular procedures have the potential for complications. The primary aims should always be avoidance of preventable complications and to minimize the impact of any complication. The core principles of an effective preventive strategy are: involving the interventional and clinical teams in a clear outline of the procedure and its potential adverse outcomes; ensuring an adequate inventory of required and backup equipment; the use of “time-out” to minimize wrong patient/wrong side adverse events; and an active audit program to identify areas of improvement. In the event of an adverse outcome there are many strategies that can be employed to rectify the situation or minimize the iatrogenic injury. This article provides a case-based discussion highlighting some of these techniques and how they can be used in a clinical setting.

Objectives: Upon completion of this article, the reader will be able to describe the methods used in the prevention and treatment of common complications occurring during endovascular procedures.

Accreditation: This activity has been planned and implemented in accordance with the Essential Areas and Policies of the Accreditation Council for Continuing Medical Education (ACCME) through the joint providership of Tufts University School of Medicine (TUSM) and Thieme Medical Publishers, New York. TUSM is accredited by the ACCME to provide continuing medical education for physicians.

Credit: Tufts University School of Medicine designates this journal-based CME activity for a maximum of **1 AMA PRA Category 1 Credit™**. Physicians should claim only the credit commensurate with the extent of their participation in the activity.

A wide spectrum of complications resulting from vascular interventional radiology procedures has been well documented. In any discussion regarding complications, prevention remains the key element. Nevertheless, some complications are unavoidable even for the most experienced operator. This article discusses the importance of a team approach to preven-

tion and early recognition of complications. A series of cases is presented illustrating the evolution of a variety of complications and the considerations that influence their management. The article will focus on technical insights and clinical advice important in the management of iatrogenic injuries.

Prevention of Complications

The following steps should be taken before a procedure to ensure the risk and consequence of any complication is minimized:

- High-risk patients should be thoroughly discussed with the appropriate clinical team, ensuring that they are aware of any potential adverse outcome that may require medical or surgical intervention. All discussions should be recorded in the patient notes. The best forum for discussion of complex elective cases is the multidisciplinary meeting.
- Patient factors, such as age, clinical status, comorbidities, and the disease process being treated, should be considered allowing the risk-benefit ratio of the proposed procedure to be evaluated. Correctable factors such as deranged coagulation should be attended before starting.

Issue Theme Peripheral Arterial Disease; Guest Editors, David Kessel, MB, BS, MA, MRCP, FRCR, EBIR and Iain Robertson, MD, MBChB, MRCP, FRCR, EBIR

Copyright © 2014 by Thieme Medical Publishers, Inc., 333 Seventh Avenue, New York, NY 10001, USA. Tel: +1(212) 584-4662.

DOI <http://dx.doi.org/10.1055/s-0034-1393973>. ISSN 0739-9529.

It is almost always safer to delay a case than to proceed with inadequate preparation.

- A review of the day's planned schedule should be performed at the start of each day to establish the order of cases and review any special considerations for each case. It is prudent to perform a review at the end of each day to ensure that any inventory issues are resolved, as these might have an impact on the "on call" cases or cases for the following day.
- A modified "safer surgery check" or "time-out" should be performed before every case. This should ensure that events such as wrong patient and wrong site treatments do not occur.
- The treatment plan should be presented to the entire team before commencement of the procedure. Patient-specific considerations should be reviewed and the likely consumables discussed. Every member of the team needs to understand the aims of the procedure, the approach, intended therapy, potential difficulties, and if necessary a backup plan. The plan should include a list of possible adverse outcomes and how they could be managed.
- Check that the appropriate equipment is available, including consumables required to treat anticipated complications (► **Table 1**). If any items are missing consider whether it is safe to proceed or whether the case should be rescheduled.
- Obtain an informed consent. Many operators favor the PARQ approach, ensuring that the discussion covers: procedure, alternatives, risks, and questions. The procedure should be discussed in general terms, including what the patient should expect to experience and the likely outcomes in terms of technical and clinical success, as well as the likelihood of any recurrence. Alternative treatment options should also be reviewed, including medical, surgical, different interventional approaches, and doing nothing. The risks and potential complications of the procedure must be discussed. This should include serious, but rare problems, in particular limb loss and death. When discussing the risk of uncommon but major complications, it is helpful if you can put such serious risk into perspective in terms that the patient can understand.

Table 1 Devices often used in the treatment of specific complication types

Complication	Device
Hemorrhage	Covered stents, occlusion balloons
Embolus	Aspiration catheters
Acute occlusion	Thrombolysis catheters
Maldeployment or migration of an implantable device	Vascular snares
Contrast reaction	Adrenaline, hydrocortisone, antihistamines
Pseudoaneurysm formation	Thrombin (bovine or human)

Preprocedure Clinical Evaluation

The preprocedural clinical state must be checked and documented. This gives a reference that is helpful when assessing the outcome of a procedure or the severity of a complication (e.g., distal embolization during an angioplasty procedure). An understanding of the classification allows comparison of the preprocedure to postprocedure state, facilitating clear communication between the involved clinicians. As examples, the Rutherford classification of acute and chronic limb ischemia is given in ► **Tables 2** and **3**.

Equipment

Interventional Inventory

► **Table 1** describes the basic equipment needed to manage complications; this list should be checked before starting the procedure.

Imaging and Monitoring Equipment

Standard monitoring equipment should include blood pressure monitoring, telemetry, and pulse oximetry. Preferably, this should be easily viewable by the operator, for example, on the main display monitor. High-quality ultrasound equipment facilitates safe vessel access, assessment of vessel patency, and imaging of suspected hematomas or false aneurysms.

What to Do When a Complication Has Occurred?

Once a complication has occurred, it is important to assess the situation quickly; it often helps to ask the following questions:

- Is there an immediate threat to the patient safety, and if so what immediate steps are required to manage this? Examples of life-threatening complications are hemorrhagic shock and cardiac tamponade.
- Are there any other treatments needed in the acute situation? Good examples are ensuring prompt and adequate analgesia, giving oxygen, and establishing appropriate intravenous access. The operator will often be in a suitable position to place a reassuringly large femoral vein sheath.

Once suitable steps have been taken to ensure patient safety and pain control, it is time to take stock of the situation by considering:

- *What is the nature and severity of the complication and what are the management alternatives?* Some complications are minor and do not require any specific treatment (e.g., a small hematoma), and can just be documented. More significant complications, such as flow-limiting dissection, may simply be managed by endovascular means, while others may require operative repair.
- *Do I need assistance?* For instance, additional nursing staff may be needed to monitor the patient and administer

Table 2 Rutherford classification of acute limb ischemia

Category	Description/prognosis	Findings	
		Sensory loss	Muscle weakness
I. Viable	Not immediately threatened	None	None
IIa. Marginally threatened	Salvageable if promptly treated	Minimal (toes) or none	None
IIb. Immediately threatened	Salvageable with immediate revascularization	More than toes, associated with rest pain	Mild, moderate
III. Irreversible	Major tissue loss or permanent nerve damage inevitable	Profound, anesthetic	Profound, paralysis (rigor)

Source: Adapted from Rutherford et al.¹

drugs. This is often the time to “phone a friend”—a more senior colleague, anesthesiologists, and surgeons—to inform them that there is a problem, discuss the options, and let them know that their assistance may be required.

What to Do in the Aftermath of a Complication?

It is always a good practice to make thorough, factual, and contemporaneous notes in the patient record. It is important to inform the patient what has happened and what the consequences may be and to make a record of this discussion in the notes. Patients will appreciate an apology if an adverse event occurs; this is not an admission of fault, but an open communication about what has happened and what can be done about it. If there has been a particularly severe complication it may be necessary to see the patient and their relatives on several occasions.

There should be a team debriefing. This should be sympathetic and open, remembering that team members may be distressed. The aim should be to learn from the event and improve future care. Consider what aspects of the management were done well and what could be improved upon; if the complication was preventable, consider what should be done in the future if faced with a similar situation. There may be important issues that require team training, and if so this should be put in place.

Table 3 Rutherford classification of chronic ischemia

Grade	Category	Clinical description
0	0	Asymptomatic: No hemodynamically significant occlusive disease
	1	Mild claudication
I	2	Moderate claudication
	3	Severe claudication
II	4	Ischemic rest pain
III	5	Minor tissue loss
	6	Major tissue loss

Source: Adapted from Rutherford et al.¹

Case-Based Discussion

Case 1

A 39-year-old man presented with rest pain in the right lower limb. The patient initially denied a history of claudication or acute deterioration. His medical history included lymphoma of the left hemipelvis treated with radiotherapy 10 years ago. He had a 20 pack-year smoking history. A diagnosis of antiphospholipid antibody syndrome, with an elevated dilute Russell viper venom of 1.9 (normal, 0.8–1.2), had been made 2 years ago. His medications included warfarin, discontinued 5 days before presentation. Preprocedure, clinical examination revealed an impalpable right femoral pulse. The soft tissues of the left pelvis were “woody” to palpation consistent with radiotherapy change, precluding pulse palpation and arterial puncture. Computed tomography (CT) angiogram showed the right common iliac artery (CIA) was occluded from flush with its origin to 1 cm proximal to the internal iliac artery. In addition, there was a short left popliteal artery occlusion and discontinuous left crural circulation.

After reviewing the preprocedure CT, the right common femoral artery (CFA) was punctured. Angiography confirmed right CIA occlusion. Minimal resistance was encountered when traversing the right CIA occlusion with a guide wire. Primary stenting with a self-expanding stent of the right CIA occlusion was performed. After deployment of the stent, the patient complained of severe left lower limb pain. Examination revealed a Rutherford acute classification IIb/III limb (pulseless, paresthetic, and paralyzed). Angiography revealed a large embolus in the left external iliac artery (EIA) and left CFA bifurcation (→Fig. 1A, B). The patient complained of severe pain, and was unable to remain immobile on the angiographic table.

What Is the Immediate Management Objective?

The immediate priority is to control the severe pain. Not only is this distressing but, due to restlessness, the patient is at a further risk of falling from the angiography table. Opiate analgesia and an antiemetic were given immediately, and the emergency anesthetic team was called for ongoing pain control that was eventually achieved with a ketamine infusion.

Figure 1 Embolism of the contralateral limb following stent placement. (A, B) Following stenting of the right CIA, there are large emboli in the left EIA (arrow), CFA (solid arrow), and profunda femoris (arrowhead) arteries. (C) Following restoration of flow in the left SFA, the left popliteal artery occlusion is confirmed (arrow). (D) Following overnight thrombolysis there is residual nonobstructive thrombus in the distal CFA and profunda femoris (arrow). CIA, common iliac artery; CFA, common femoral artery; EIA, external iliac artery; SFA, superficial femoral artery.

What Is the Next Priority?

The next priority is to revascularize the left lower limb; this must be achieved rapidly to enable limb salvage.

What Are the Options for Revascularizing the Leg?

Surgical embolectomy, thrombus aspiration, and thrombolysis are the options available for revascularization of the leg.

Embolectomy would normally be the first-choice therapy as there is a narrow therapeutic window. However, having previously discussed the case with the vascular surgical team, the authors were conscious of the significant difficulties involved with a surgical embolectomy due to the radiotherapy changes in the left groin.

Once the patient had adequate analgesia, thrombus was aspirated from the left CFA via a triaxial catheter system

(Chaperone; Terumo, Somerset, NJ) through a detachable hub sheath (Destination; Terumo). This was followed by high-dose thrombolysis with urokinase of the left EIA and left CFA. Within 30 minutes, brisk flow was restored down the left superficial femoral artery (SFA) to the preexisting popliteal artery occlusion (►Fig. 1C). Some residual thrombus was present at the left CFA bifurcation. The patient was transferred to the intensive care unit for further analgesia and ongoing thrombolysis. Systemic anticoagulation with heparin was commenced. The next day follow-up showed a clinical improvement with some persisting paresthesia (Rutherford classification IIA). Further angiography was performed, showing left EIA recanalization, but there was residual nonobstructive thrombus in the distal CFA and profunda femoris artery (►Fig. 1D). The popliteal occlusion was balloon dilated

but did not revascularize, and a noniatrogenic recent thrombosis was thought to be the most likely cause. The preprocedure status of the discontinuous crural vessels was unchanged. Thrombolysis was continued overnight, which resulted in recanalization of the popliteal artery. Due to his iatrogenic coagulopathy from the heparin and thrombolysis, the right CFA puncture was closed with a suture-mediated closure device. Numbness and pain initially resolved (Rutherford classification I), but at 8 months his rest pain had returned and duplex ultrasound showed recrudescence of his left popliteal occlusion.

Learning Points

- It is important to understand that although this was very severe ischemia there is a window of a few hours before the changes become irreversible, allowing for endovascular treatment. Typically with such severe ischemia the time delay to presentation renders the limb unsalvageable. Once the flow was restored, the severity of the ischemia decreased and allowed continued thrombolysis. Had this not occurred, then early surgical embolectomy would have been required.
- Peripheral vascular emboli can be thought of according to their composition, size, and the level of occlusion. Management strategy depends on etiology and symptomatology. In broad terms emboli can be removed from the circulation (embolectomy, aspiration, or thrombolysis) or trapped against the vessel wall. Macroemboli such as described above typically block named vessels and require some form of intervention if they result in symptomatic ischemia or a significant reduction in runoff. Smaller emboli in insignificant branch vessels do not usually require any therapy. True microemboli block the circulation at the arteriolar and capillary level and result in visceral infarction and “trash foot.” Macroemboli may be formed of fresh thrombus that will respond to aspiration and thrombolysis. Large atheromatous emboli are managed either by embolectomy or by trapping against the vessel wall with a stent.
- The effortless passage of the guide wire through the right CIA is suggestive of an acute thrombotic occlusion, increasing the risk of dislodging the fresh clot and producing an embolus.
- On further clinical interrogation of the patient after the procedure, a history of recent right-sided deterioration was obtained suggesting an acute occlusion, which is a contraindication to angioplasty and stenting. Had this been apparent, his Rutherford IIa ischemia would have been managed by thrombolysis rather than primary stenting. When there is a delay in presentation and the limb is not threatened, the thrombus can be left for 6 to 8 weeks to organize before stenting.
- Young patients presenting with arterial occlusive disease should be investigated for a coagulopathy, including antiphospholipid syndrome.
- There is an increased risk of acute thromboembolic events in thrombotic lesions, in long, complex occlusions, and in patients with a history of amputation.²
- Risk of acute thromboembolism can be reduced with careful technique and appropriate anticoagulation. Careful crossing of stenotic lesions, use of low-profile catheters and wires, and minimizing balloon inflations using long balloons can reduce the risk of emboli. Anticoagulation sufficient to maintain an activated clotting time < 250 seconds is recommended in those at high risk.

Case 2

A 21-year-old woman with an untreated aortic coarctation and a history of hypertension was referred for treatment. An echocardiogram suggested a significant gradient across the coarctation. Treatment was planned with endoluminal repair using a Cheatham-platinum (CP)–covered stent (Pfm Medical, Carlsbad, CA). The interventional radiology team was called when the proceduralists encountered difficulties. Initially, the cranial end of the stent had been partially expanded and the stent had migrated off the balloon (►Fig. 2A).

What Should Be Attempted?

If the stent is still on the wire an attempt should be made to recapture the stent on the balloon. First, the balloon can be fully deflated using a 50-mL syringe, and the balloon can gently be advanced or retracted back into the stent. Care should be exercised to make sure the guide wire remains inside the stent. Recapturing the stent is much less likely to succeed with high-profile balloons, such as the double balloon used with the CP.

In this case, this maneuver had been attempted without any success, and repeat balloon inflation led to the opening of the caudal end of the stent. The balloon was deflated and was passed through the stent in a further attempt to recapture the stent. When the balloon was retracted this resulted in the sheath becoming deeply impacted in the stent (►Fig. 2B).

What Can Be Done Now?

At this stage it was impossible to recapture or deploy the stent. The stent must be removed from over the sheath and either retracted into the sheath and removed or deployed in a safe site.

The left brachial artery was accessed with a 5F sheath. The balloon was exchanged for a catheter and wire to simplify snaring. The wire was captured and the snare tightened around the cephalic end of the stent, thereby closing the stent (►Fig. 2C). The sheath and stent were brought into the abdominal aorta to minimize manipulation at the site of the coarctation and within the aortic arch. The stent was held with the snare and the sheath pulled free. A further attempt was made to introduce the balloon through the stent, but despite the snare this could not be achieved. The left femoral artery was accessed and a snare was placed directly over the caudal end of the stent (►Fig. 2D). By providing countertraction with the snare, a new balloon could be placed within its lumen. The stent was uneventfully deployed in the infrarenal abdominal aorta, and the procedure was abandoned at this point.

Figure 2 Accidental stent malposition. (A) The balloon mounted CP stent herniated off the balloon (arrow), and the cephalic end partially expanded. (B) The delivery sheath is impacted in the inner lumen of the CP stent (open arrow), and the caudal end of the stent is now partially deployed (closed arrow). (C) A snare retrieval device (arrow) has been placed from the left upper limb around the partially opened cephalic end of the stent, and the cephalic end of the stent closed by the snare. (D) The stent and sheath have been pulled back into the abdominal aorta. A snare has been placed from the left common femoral artery (arrow) and is used to secure the stent in position for capture by a new balloon. CP, Cheatham platinum.

Learning Points

- In general terms, a balloon-mounted stent can be recaptured either on the original or a new balloon, and deployed at the original target site or a place of safety as described earlier. If this fails, an attempt should be made to snare it and remove it, which may require a large sheath (and which was not possible with the CP stent).
- The CP stent is deployed using a concentric double-balloon system. The inner balloon has a diameter 50% of the outer, and is 10 mm shorter. The operator inflates the inner balloon first to partly open the central portion of the stent; subsequently the outer balloon is inflated to fully deploy the stent. In this patient, the balloon had been “prepared” with an injection of contrast into the inner balloon before insertion into the sheath, which may have led to the stent becoming loose.
- Covered stents not infrequently displace from their balloon mounting site. This may occur during passage through the valve of the delivery sheath, and the relationship between the balloon and the stent must be checked before deployment.
- Preparation of the balloon may loosen the stent from the balloon; this maneuver should be performed with caution.
- The risk of stent migration can be reduced by placing a guiding sheath across the lesion; the stent graft is then subsequently positioned at the target site within the sheath. The guiding sheath is pulled back to expose the stent just before stent deployment.

- The guide wire should remain inside the stent at all costs, as this ensures that it is aligned with the sheath and the vessel wall. Occasionally, a stent may need to be removed via an arteriotomy.

Case 3

A frail 65-year-old woman presented with persistent rest pain for a few days following left CFA endarterectomy and patch. An ultrasound revealed a high-grade stenosis at the cephalic end of the CFA patch graft. The ipsilateral EIA had been treated with an 8-mm self-expanding stent some months ago. The

vascular surgical team felt that the endarterectomy had been extended just above the inguinal ligament and wished to avoid further surgery. The possibility of rupture during endovascular treatment was considered to be high in view of the recent surgery and discussed in advance of the procedure. However, on balance the favored option of the clinical group and the patient was an endovascular approach.

The right common femoral and EIA were severely diseased and ultrasound-guided access was required. A 30 cm 6F sheath was placed over the aortic bifurcation into the left CIA. Angiography confirmed the distal EIA stenosis (→Fig. 3A).

Figure 3 Rupture following angioplasty. (A) Preangioplasty angiography demonstrates a stenosis above the left CFA patch graft (arrow). (B) Angiography postangioplasty demonstrates contrast extravasation (arrow) consistent with CFA rupture. (C) Following deflation of the left EIA balloon, the contrast extravasation from the left CFA has ceased, but significant stenosis remains (arrow). (D) Completion angiography following deployment of an 8-mm covered stent (between arrows) demonstrates the resolution of the stenosis as well as the resolution of the contrast extravasation. CFA, common femoral artery; EIA, external iliac artery.

Figure 4 Iatrogenic arteriovenous fistula noted during recanalization procedure. (A) Postangioplasty angiogram demonstrating contrast extravasation (open black arrow), extra-arterial position of the distal catheter tip (solid black arrow); and persistent occlusion of the SFA (open white arrow), (B) poststenting angiogram demonstrates contrast-filling multiple venous structures of the leg (open black arrows) as well as visualization of the distal stent in a vein (solid white arrow). (C) Angiogram following coiling (arrows) of the stent to close the arteriovenous fistula.

The left CFA stenosis was dilated with a 6-mm diameter balloon; the patient complained of pain as soon as the balloon was deflated. Postangioplasty angiography demonstrated rupture of the left CFA (► **Fig. 3B**). The patient became hypotensive.

What Is the Immediate Priority?

This is a life-threatening situation, and the priority is to obtain hemostasis and then to control pain.

An 8-mm angioplasty balloon was inflated to 2 atmospheres in the left EIA stent, and the blood pressure immediately stabilized. Opiate analgesia was given to control the pain. The surgical team was called in case a combined procedure was necessary. The balloon was deflated after 10 minutes, and subsequent angiography showed no ongoing extravasation but did note a residual stenosis (► **Fig. 3C**). The 6F right CFA sheath was exchanged for an 8F sheath, and an 8-mm covered stent was deployed to treat the stenosis and ensure exclusion of the leak (► **Fig. 3D**).

If the Bleeding Had Not Ceased after Deflation of the Left EIA Balloon, What Would Be the Next Option?

The left EIA balloon should be reinflated to restore hemostasis. Additional vascular access should be obtained, in this case via the left brachial artery. A second occlusion balloon would be deployed in the proximal left iliac artery, and the right CFA sheath could then be exchanged, allowing placement of a covered stent in the left CFA.

If the SFA is patent, then infrainguinal access through the left SFA can be considered. This would not have been an option in this case due to the occluded left SFA.

Learning Points

- Rupture of the iliac arteries is a potentially catastrophic complication due to rapid exsanguination into the retro-

peritoneal space and peritoneal cavity. Proximal balloon control of the inflow artery is lifesaving and should be performed without delay. Stent grafting or surgical repair is the definitive treatment of anything other than trivial extravasation.

- The incidence of rupture following angioplasty is reported as less than 1%,³ however, any intervention in the iliac vessels should be performed with caution. Pain despite deflation of the balloon may be the first clue of rupture, however hemodynamic collapse may also be the first sign.

Case 4

A 60-year-old man presented with lifestyle-limiting intermittent claudication at 50 metres. Imaging showed a 5-cm mid-SFA occlusion. The occlusion was crossed with difficulty and some contrast extravasation was noted. The patient complained of severe pain during balloon dilation; postangioplasty angiography was performed (► **Fig. 4A**.)

What Does the Angiogram Show?

There are several abnormalities: there is evidence of contrast extravasation as previously noted; the catheter looks to lie outside the line of the distal SFA; the popliteal vein is opacifying in the arterial phase of contrast injection; and the occlusion persists.

In view of the suboptimal appearances a stent was placed. The patient complained of severe right foot pain, and examination revealed an acutely ischemic right foot, grade Rutherford IIb. An angiogram was performed shown in ► **Fig. 4B**.

What Does the Angiogram Show?

The angiogram shows an arteriovenous fistula with the distal end of the stent lying within a vein.

How Would You Proceed?

The reason the foot was ischemic was the preferential outflow into the low-pressure venous conduit, stealing flow through the iatrogenic fistula. Multiple coils were placed inside the stent to close the iatrogenic arteriovenous fistula (→Fig. 4C). As the status of the ischemic right foot did not improve, the patient proceeded to a femoral–distal surgical bypass.

How Else Could This Have Been Managed?

Surgery was clearly the best option for this patient, but if there was a major contraindication to surgery, following occlusion of the stent it might have been possible to cross the occlusion from a retrograde puncture of the popliteal artery. A covered stent could then be placed across the occlusion, but there would be a risk of this being compressed by the original stent.

Learning Point

- After crossing any lesion, intraluminal position should always be confirmed before angioplasty or stenting. The iatrogenic arteriovenous stenting described in this case could have been avoided if this had been performed.

Conclusion

Every complication is an opportunity for learning. The four cases discussed above are examples of the protean manifestations of iatrogenic injury that can occur during endovascular procedures. The fundamental principles of complication management are as follows:

1. **Preparedness:** This includes the principles elucidated above, in particular making the interventional team and clinical teams aware of potential complications, discussing potential adverse outcomes, and having the appropriate inventory on hand to treat such complications.
2. **Alertness:** Rapid identification of complications allows rapid remediation, improving outcomes. The operator

should be aware of the potential risks and should be monitoring the patient closely for signs of an adverse event. These signs may be related to patient physiology, such as repeated yawning, reduced level of consciousness, unremitting pain, or agitation, or they may be imaging findings such as displacement of the contrast-filled bladder suggesting retroperitoneal hematoma. Do not forget that all members of the team should be empowered to point out areas of concern, further alerting the operator to the potential of a complication.

3. **Assessment:** Identify and control life-threatening problems first, then calmly consider the management options.
4. **Response:** The first type of response can be thought of in terms of a technical response (i.e., an endovascular maneuver to correct the complication). Examples of this include deployment of a covered stent as in case three; the deployment of an uncovered stent for acute dissection; thromboaspiration in distal embolization; or the use of a goose neck snare to retrieve a maldeployed device such as in case two. The other type of “response” is the management of the patient by responding to their physiological disturbance. For instance, intravenous atropine for the management of a vasovagal episode, volume replacement in exsanguination, and recognizing the need for emergency assistance when the physiological situation moves beyond the management potential of the operator are all examples of patient-centered reactions and responses.

References

- 1 Working Party on Thrombolysis in the Management of Limb Ischemia. Thrombolysis in the management of lower limb peripheral arterial occlusion—a consensus document. *Am J Cardiol* 1998; 81(2):207–218
- 2 Davies MG, Bismuth J, Saad WE, et al. Implications of in situ thrombosis and distal embolization during superficial femoral artery endoluminal intervention. *Ann Vasc Surg* 2010;24(1): 14–22
- 3 Kondo Y, Dardik A, Muto A, Koizumi J, Nishibe M, Nishibe T. Primary stent placement for iliac artery chronic total occlusions. *Surg Today* 2010;40(5):433–439