INTRODUCTION

Indwelling arterial catheters are used routinely for continuous hemodynamic monitoring and for obtaining repetitive blood samples during major surgery and in critically ill patients. The radial artery is the most common site for catheterization. Major complications such as ischemic insult, sepsis, and pseudoaneurysm formation are rare, occurring in fewer than 1% of cases. We describe two cases of patients undergoing major surgical and endovascular interventions in which arterial catheterization was associated with acute radial arterial thrombosis and radial ischemic neuropathy.

CASE PRESENTATION—PATIENT 1

An 88-year-old female was scheduled for a low anterior resection and end-colostomy formation for a high-grade invasive recto-sigmoid adenocarcinoma. She had suffered an acute kidney injury attributable to the mass effect of the tumor involving the bladder that required a rigid cystoscopy and stent insertion prior to laparotomy. Her past medical history included low body mass index, shingles, recurrent urinary tract infection, uterine prolapse, and a single functioning kidney. Prior to her admission, she lived at home alone and was fully independent. She did not take any regular medications and had no known drug allergies. Her preoperative bloods results demonstrated an iron-deficiency anemia (hemoglobin 10g/dL), acute kidney injury, and raised inflammatory markers consistent with a contained colonic perforation. Coagulation studies were normal. She had been receiving a daily prophylactic dose of enoxaparin (20mg) in the preoperative period.

Prior to induction of anesthesia, a 20G arterial catheter (Arterial Leader Cath (PE), Vygon Ref 115.090, 3Fr- L.8 cm-0.9 mm-24 mL/min) was inserted in the left radial artery using the Seldinger technique. The first attempt was successful, and the arterial catheter was introduced without resistance. Blood could be withdrawn, and a normal pulse tracing was shown on the monitor. No discoloration of the hand was noted. General anesthesia was initiated uneventfully, and the patient was positioned on the surgical table in lithotomy with all necessary padding and safety straps applied. All pressure areas including venous and arterial lines were padded and protected. There were no intraoperative issues with the arterial catheter. The surgery concluded after approximately five hours without any complications and minimal estimated blood loss.

At the end of the procedure, progressive dampening of the arterial line trace was noted on the monitor and blood could not be aspirated through it. On removal of the surgical drapes, the left hand was noted to be cold and pale with a prolonged
capillary refill time of five seconds. The arterial catheter was disconnected from the transducer tubing, and there was evidence of thrombus lodged in the catheter. The catheter was promptly removed, and the hand was actively warmed. The patient was extubated and transferred to the recovery room where an urgent consultation with a vascular surgeon was obtained. On further examination, sensation and motor function in the left hand were intact. Doppler ultrasound examination was unable to detect radial, ulnar, or palmar arch pulsations adequately. The brachial pulse was detectable.

Following on immediate advice from vascular and colorectal surgical colleagues, treatment with a heparin infusion was not favored following major abdominal surgery. CT angiography was contraindicated due to her acute kidney injury. Surgical intervention was deemed infeasible. After obtaining consent from the patient, a left-sided stellate ganglion block was performed by an experienced pain specialist. After 2 hours, the patient’s hand color and temperature improved with a commensurate reduction in capillary refill time. The patient was transferred to the high dependency unit for ongoing postsurgical observation and was reviewed by the vascular team on a daily basis thereafter.

Within 24 hours, Doppler signals in the left radial and ulnar branches were detectable. The fourth and fifth digits remained cold to touch, with intact sensation, for a further 48 hours. Subsequently, there was full resolution of symptoms with no requirement for further intervention.

3 | CASE PRESENTATION—PATIENT 2

A 66-year-old female was scheduled for an elective endovascular coiling of her right posterior communicating artery aneurysm in the interventional radiology suite. This was an incidental finding during investigation of recurrent headaches. Her medical history included emphysema, ischemic heart disease, dyslipidemia, hypertension, and osteoporosis. She was a current smoker with a 40-pack year history. She was a current smoker with a 40-pack year history. heart disease, dyslipidemia, hypertension, and osteoporosis.

An ultrasound scan of her left upper limb demonstrated patent left brachial and ulnar arteries, and greater than 50% stenosis of the left radial artery. The patient experienced progressive purple-blush discoloration of the left index finger with increasing tenderness. After consultation with vascular surgery, she received a loading dose of 5000 IU of intravenous Heparin and 100 mcg of Iloprost. She continued on their respective infusions (dosing as per local guidelines) as well as oral dual anti-platelet therapies, aspirin 75 mg and clopidogrel 75 mg, once daily. Topical glyceryl trinitrate ointment was applied to the affected fingers for analgesic and vasodilatory purposes. Complete resolution of her symptoms was observed after eight days of treatment, and she was discharged for follow-up in vascular outpatient service.

4 | DISCUSSION

Easy access and low complication rates have resulted in the radial artery being the most popular site for arterial cannulation. The most common reported complication is temporary arterial occlusion with a mean incidence of 19.7%. Serious ischemic injury resulting from permanent occlusion is, however, rare (mean incidence 0.09%) but the potential consequences of necrosis and finger amputation are significant.

The benefits of monitoring with arterial catheterization are obvious but must be balanced against the associated risks and should outweigh the potential harms. It has been shown that the incidence of radial artery occlusion increases linearly with the ratio of outer diameter of the arterial catheter to vessel lumen diameter. This may explain the higher incidence in females and the preference for using narrow lumen catheters. Other risk factors include low body mass index, advanced age, vascular disease, prolonged peri-procedural hypotension and/or hypertension, vasopressor use, catheter composition, prolonged catheter placement, and excess trauma from multiple attempts at the same site. It is possible that risk factors, such as low body mass index, advanced age, vascular disease, and female gender, may have contributed to the temporary occlusion in both patients outlined above.

Radial artery occlusion (RAO) is the most frequent post-procedural complication of transradial access in cardiac catheterization. This can have significant clinical implications, such as precluding the use of the ipsilateral radial artery for future procedures and as a conduit for coronary artery bypass grafting or for arteriovenous fistula creation in patients requiring hemodialysis. Therefore, prevention is of upmost clinical importance. During radial hemostasis, complete cessation of blood flow with “occlusive” compression promotes thrombus formation and is a strong predictor of RAO. In the PROPHET trial, the “patent” or nonocclusive hemostasis protocol was compared with to conventional pressure application for hemostasis after transradial diagnostic coronary
angiography. The patent hemostasis technique was associated with a significant decrease in early (<24 hours) RAO rates from 12% to 5% and late RAO rates (30 days) from 7% to 1.8%. Similarly, in the RACOMAP trial, patent hemostasis was performed with a pneumatic compression device in which compression was guided by mean arterial pressure (maintaining thereby flow within the radial artery during hemostasis), demonstrating also a significant decrease in RAO rates from 12.0% to 1.1%. Despite being simple and inexpensive nonpharmacological method of preventing RAO, it requires significant involvement of the nursing staff due to the need for repeated oximetry-plethysmographic evaluation of radial flow and frequent adaptation of the hemostatic pressure to ensure ongoing vessel patency. As such, there is still limited adoption of the technique worldwide.

The consequences of RAO are generally benign when managed appropriately in a timely manner. A cold, pale hand, or fingers with reduced motor function, sensory deficit, or pain following radial artery cannulation should be immediately investigated. Management options include medical and/or surgical intervention. If ischemia is suspected, the catheter should be removed immediately and the affected limb elevated and warmed. Anticoagulant, thrombolytic, and vasodilator therapy may be indicated if there is a perceived risk of progressive ischemia following these conservative measures. Some cardiology data suggest that immediate treatment with 5000 IU intravenous heparin combined with compression of the ipsilateral ulnar artery for 1 hour or, alternatively, body-weight-adjusted therapeutic dosing of enoxaparin or fondaparinux for 4 weeks may help recanalize the radial artery. Some case reports have described successful recanalization of the occluded radial artery with angioplasty. In certain cases, thrombectomy, surgical bypass, or cervical sympathetic blockage should be considered. However, surgical intervention in the setting of iatrogenic radial arterial thrombosis is uncommon.

There is strong evidence for the use of ultrasound guidance in radial artery catheterization in both adult and pediatric populations. Ultrasound guidance significantly increases first-attempt success rate, which subsequently results in a significant reduction in the number of attempts. The early use of ultrasound can be a valuable adjunct in radial arterial catheterization and should be considered, especially in predicted difficult cases.

The Allen’s test or modified Allen’s test are bedside tests that can be performed in patients undergoing radial artery puncture. The hand is perfused by both the radial and ulnar arteries with extensive collateral flow between the two. However, some patients have incomplete palmar arches, which may diminish collateral perfusion, possibly leading to hand ischemia in the presence of RAO. Although rarely performed in practice, identifying collateral flow to the region supplied by the artery can be useful prior to puncture. While limited studies have found variable accuracy associated with such evaluations, it is believed that patients, and in particular high-risk patients, undergoing radial artery puncture should have the collateral flow to the vessel evaluated. Finger pulse plethysmography, Doppler flow measurements, and measurement of the arterial systolic pressure of the thumb have been described but are not routinely used.

Clinical guidelines for the prevention, diagnosis, and management of radial arterial occlusion are lacking in the current literature. Safe vascular access is integral to anesthetic and critical care practice. The Association of Anesthetists of Great Britain and Ireland Safe Vascular Access 2016 guidelines is a consensus document which provides practical advice on the safe insertion and removal of vascular access devices. In relation to arterial access, it is advised that compression of radial and ulnar arteries to assess collateral perfusion (Allen’s test) is unreliable and that ultrasound can be used to assess vessel patency and size. However, the significance of potential complications is poorly described and there is a paucity of clear, evidence-based, guidance on the prevention and management of radial arterial occlusion.

5 CONCLUSION

Radial arterial occlusion resulting in compromised circulation to the hand/fingers during the placement of an indwelling arterial catheter at the time of surgery is a rare phenomenon but has significant potential consequences. Consideration should be given to utilizing a reliable test to establish patency of the palmar arch. Furthermore, all patients should be examined for radial artery patency before discharge. Novel studies and techniques are needed to improve strategies that minimize the incidence of this major complication of radial access. We describe two such cases in which timely recognition of this complication contributed to successful management, with both patients making a full recovery.

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CONFLICT OF INTEREST

There are no conflicts of interest to declare. There exists no financial interest or connection, direct or indirect, or other situation that might raise the question of bias in this work reported or the conclusions, implications, or opinions stated—including pertinent commercial or other sources of funding for the individual author(s) or for the associated...
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AUTHOR CONTRIBUTIONS
AD: involved in substantial contribution to the acquisition, analysis, and interpretation of data, involved in drafting the manuscript, agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. TO’N: involved in substantial contribution to the acquisition, analysis, and interpretation of data, involved in drafting the manuscript, gave final approval of the version to be published, agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. DR: involved in substantial contribution to the analysis of data, involved in drafting the manuscript, gave final approval of the version to be published, agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. JD: involved in substantial contribution to the acquisition, analysis, and interpretation of data, involved in drafting the manuscript, gave final approval of the version to be published, agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

ETHICS APPROVAL
All persons gave their informed consent prior to their inclusion in this article. Patient anonymity was preserved wherever possible.

DATA AVAILABILITY STATEMENT
The data that support the findings of this case report are available on request from the corresponding author. The data are not publicly available due to privacy and/or ethical restrictions.

ORCID
Alison Deasy https://orcid.org/0000-0002-9915-6122

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