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INTERVENTIONAL RADIOLOGY
TECHNICAL NOTE

A warning for warming catheters: interventional radiology's role

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ABSTRACT
Concerns have been raised in the literature, regarding the risk of venous thromboembolic events associated with the use of thermoregulatory catheters. Inferior vena cava (IVC) filters are commonly used to prevent venous thromboembolic events. We demonstrate the usefulness of IVC filter placement prior to the removal of thermoregulatory warming catheters. The management of thermoregulatory warming catheter associated venous thromboembolism is outlined through a retrospective case series of three patients. In one case IVC thrombus was incidentally detected at ultrasonography one-week post removal. The second case describes the occurrence of pulseless electrical activity arrest secondary to massive pulmonary embolism immediately post removal of the thermoregulatory catheter, and subsequent interventional radiology management including pulmonary thrombectomy and caval filter placement. The third case is of a patient in whom the removal of the warming catheter was performed in the angiography suite, with placement of IVC filter prior to removal. Venography displayed a large thrombus burden within the IVC filter. There is limited data in the literature regarding the use of IVC filters as prophylaxis in patients with thermoregulatory catheters, particularly warming catheters. We advocate the placement of an IVC filter prior to the removal of warming catheters. We raise awareness regarding the potential risks of venous thromboembolism in this population and the key role interventional radiology has in the management of these patients.

Thermoregulatory catheters were developed with the intention to provide endovascular therapeutic hypo- or hyperthermia in certain clinical circumstances. Thermoregulatory catheters are used in the management of patients with burns, during surgical procedures and in critically unwell patients where thermoregulation is required (1). Concerns have been raised regarding the risk of the venous thrombosis and thromboembolism with the use of temperature regulation catheters (2, 3).

Inferior vena cava (IVC) filters have been shown to be useful in preventing pulmonary emboli in the short term (4). We add to the literature, and raise awareness in the interventional radiology community, regarding the risks of thermoregulatory catheters and the prophylactic use of IVC filtration prior to removal of these catheters. In this case both infra and suprarenal IVC filters were used as a short-term solution to prevent embolic events.

Technique

Case 1: A 31-year-old female was admitted following 30% total body surface area flash flame burns and an inhalation injury, after smoking next to a gas cylinder which exploded. There was no significant past medical history and the patient was not taking any medications. An Alsius Thermoguard Intravascular Temperature re-warming catheter (Zoll Medical Corporation) was inserted into the IVC via the right femoral vein on arrival. It was removed 3 days later. Eight days post admission, (5 days post catheter removal) an ultrasound performed for investigation of deranged liver enzymes detected thrombus in the IVC (Fig. 1). She was placed on oral anticoagulant rivaroxaban 20 mg daily for 6 months, during which time repeat ultrasound documented resolution of the thrombus. The patient remained asymptomatic with no clinical evidence of embolism at 6-month follow-up, thus anticoagulation was ceased.

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Case 2: A 52-year-old female was admitted with 35% total body surface area burns following a house fire. Past medical history included schizoaffective disorder but the patient was not taking any regular medications. An Alsius Thermoguard Intravascular Temperature re-warming catheter (Zoll Medical Corporation) was inserted into the IVC via the right femoral vein on the day of presentation. It was removed 3 days later when no longer clinically necessary. Immediately upon removal, the patient suffered a pulseless electrical activity arrest. The patient underwent successful cardiopulmonary resuscitation including intubation and sinus rhythm was restored. Blood pressure was maintained on an adrenalin infusion; however, echocardiography demonstrated acute globally reduced right ventricular function, and a saddle pulmonary embolus was confirmed on computed tomography pulmonary angiography (Fig. 2a). The patient was transferred emergently to the interventional radiology suite for pulmonary embolectomy. Aspiration and Angiojet (Boston Scientific) thrombolysis/thrombectomy was performed (Fig. 2b, 2c). Pulmonary embolectomy was successful and an IVC filter was placed. The patient was managed in intensive care, including therapeutic anticoagulation with low molecular weight heparin (enoxaparin 1.5 mg/kg daily) for a number of days prior to transfer to the burns unit, and subsequent discharge home on 5 mg of apixiban daily. At 6-month follow-up, the patient reported no symptoms of lower limb thrombosis or pulmonary emboli, and the IVC filter was retrieved uneventfully, with a plan to cease anticoagulation in the future.

Case 3: A 57-year-old male was brought in by helicopter to the emergency department following a suicide attempt from a bridge into a creek. On recovery he was hypothermic, had unrecordable blood pressure and Glasgow coma scale (GCS) of 8.

Main points

- We describe three incidences of deep venous thromboses +/- embolus in the setting of thermoregulatory catheter use.
- We advocate judicious use of thermoregulatory catheters.
- We advocate removal of thermoregulatory catheters with fluoroscopy guidance and the prophylactic use of an IVC filter prior to the removal of warming catheters.

Figure 1. Thrombus in the IVC *(white arrow)* documented in Case 1, 8 days post admission and insertion of a thermoregulatory catheter.

On arrival to emergency, his primary examination revealed a self-maintained airway with oxygen saturations of 98%, heart rate 110 beats/min, blood pressure 50–70 mmHg systolic and a GCS of 5. His core temperature was 27 degrees recorded from a thermometer containing urinary catheter. Active rewarming was undertaken immediately, and a left femoral venous approach Alsius Thermoguard Intravascular Temperature re-warming catheter (Zoll Medical Corporation) was inserted by the intensive care team. The patient was admitted to the Intensive Care Unit and subsequently underwent operative management of his other significant injuries, which included facial lacerations and a right tibial fracture.

Twenty hours post warming catheter insertion, the patient's core temperature normalized and a decision was made to remove the femoral warming catheter. Due to the prior experience with warming catheters and the risk of associated thrombus, it was agreed that an IVC filter would be placed at the time of removal, venography performed to assess for thrombus, and the catheter removed under fluoroscopic guidance.

Access was achieved via the right femoral vein. An 11 F sheath was advanced over a wire into the infrarenal IVC and cavogram performed. An IVC filter was inserted caudal to the warming catheter, and the catheter balloon was subsequently deflated. Cavogram demonstrated a moderate volume filling defect at the level of the warming catheter, some of which extended through the struts of the filter at the level of the right renal vein (Fig. 3a). As it was unclear if this was thrombus or persistent balloon inflation, a second suprarenal filter was placed via a right internal jugular approach. This would thus protect the suprarenal viscera if the filling defect identified was indeed thrombus, and had the potential to migrate. The warming catheter was then removed and final venography confirmed a moderate thrombus burden at the infrarenal IVC filter, with small volume extending above the struts (Fig. 3b).

Subsequently the patient underwent further management of other injuries and extensive rehabilitation. He was treated with a heparin infusion initially as per hospital protocol (target activated partial thromboplastin time, 60–80 s) and switched to low molecular weight heparin after 8 days (enoxaparin 1.5 mg/kg daily). At 6-month follow-up, the patient reported no symptoms of lower limb post-thrombotic syndrome. The patient subsequently attended for filter retrieval, angiography at the time of filter retrieval demonstrated no thrombus.

Discussion

The standard approach to temperature control in the emergency department population is by preventing further loss of heat by removal of wet clothes and dressings with the

Figure 2. a–c. Saddle pulmonary embolus *(arrow)* was confirmed on CT pulmonary angiography **(a)** immediately post thermoregulatory catheter removal in case 2. Conventional pulmonary angiography demonstrates embolus in the right and left main pulmonary arteries (**b,** *black arrows*), and following successful thrombectomy **(c)**.

Figure 3. a, b. Cavogram demonstrated moderate volume filling defect at the level of the warming catheter (**a,** *black arrow)*, some of which extended through the struts of the infrarenal filter at the level of the right renal vein. The warming catheter was removed subsequent to suprarenal filter placement and final venography (**b)** confirmed thrombus at the level of the infrarenal IVC filter, with small volume extending above the struts *(white arrow)*.

commencement of passive external warming with devices including heating blankets as well as minimally invasive techniques such as warmed intravenous fluids. Further techniques that are less frequently utilized in the severely hypothermic population include body cavity lavage, and more recently extracorporeal membrane oxygenation (5). Core temperature regulation using thermoregulatory catheters has been shown to be effective in managing labile body temperatures which occur in patients with severe burns (1).

In our case series, a decision was made to use the Alsius Thermoguard intravascular temperature re-warming catheter. Subsequent to the initial two cases, institutional policy changed to involve the Interventional Radiology service for on table cavography with or without IVC filter placement prior to balloon deflation and catheter removal. This resulted in a controlled removal and good outcome for the third patient.

There is limited data in the literature regarding the use of IVC filters as prophylaxis in patients with thermoregulatory catheters, particularly warming catheters. Gierman et al. (3) reported an increased incidence of caval thrombus with the use of thermoregulatory catheters and recommended ultrasound to assess for thrombus in patients with a history of prior deep vein thrombosis. The risks and benefits need to be carefully considered prior to the use of thermoregulatory catheters given the results presented in this case series. IVC filters have been used by other clinicians in the management of these catheters (6, 7).

A suprarenal IVC filter may be employed in situations where thrombus is present in the juxtarenal or suprarenal IVC, where an infrarenal filter will not allay the risk of embolism. In Case 3 described above, the infrarenal filter has been employed to reduce the risk of renal embolization, and the suprarenal filter to protect against embolus of the juxtarenal thrombus.

This is a retrospective case series, limited by these factors. Patients in this series all had severe injuries, including trauma or burn injuries, which can increase the risk of thromboembolic events while in hospital, and may have been a contributing

factor in these cases (8). As thermoregulatory catheters are frequently employed in patients who have other risk factors for venous thromboembolism, such as trauma or major surgery, this may be a confounding factor contributing to the formation of venous thromboembolism. However, the occurrence of thrombosis or thromboembolism in the presence of thermoregulatory catheters may be contributed to by the potential alteration in flow dynamics in the vessel, increasing turbulence and stasis in the vessel, affecting Virchow's triad and thus contributing to thrombosis.

There is little data on the risk of embolic events due to removal of a thermoregulatory catheter. Further robust investigation into the risk of venous thromboembolism associated with warming catheters is necessary. We advocate caution with the use of warming catheters and recommend the placement of IVC filter for prevention of embolic events prior to removal.

Conflict of interest disclosure

The authors declared no conflicts of interest.

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