neurocritical care society Neurocrit Care (2015) 23:72–77
DOI 10.1007/s12028-014-0069-6

ORIGINAL ARTICLE

Inferior Vena Cava Thrombosis Related to Hypothermia Catheter: Report of 20 Consecutive Cases

Andres Reccius · Pablo Mercado · Patricio Vargas · Claudio Canals · Jose Montes

Published online: 24 December 2014

Abstract
Background Temperature management using endovascular catheters is an established therapy in neurointensive care. Nonetheless, several case series have reported a high rate of thrombosis related to the use of endovascular hypothermia catheters.
Methods As a result of a pulmonary embolism that developed in a patient after removing an inferior vena cava hypothermia catheter, we designed a clinical protocol for managing and removing these devices. First, an invasive cavography was performed before the removal of the catheter. If there was a thrombus, a cava vein filter was inserted through jugular access. After that, the catheter was removed.
Results The venography found inferior vena cava thrombi in 18 of 20 consecutive patients. A concomitant ultrasonography study showed vena cava thrombosis in only three patients. A vena cava filter was inserted in all patients where thrombi were found, without any significant complication. Anticoagulation was started in all patients. No symptomatic pulmonary embolism was diagnosed until the time of discharge.
Conclusions The frequency of thrombosis related to temperature management catheters is extremely high (90 %). Furthermore, ultrasonography has a very low sensibility to detect cava vein thrombosis (16.7 %). The real meaning of our findings is unknown, but other temperature control systems could be a safer option. More studies are needed to confirm our findings.

Keywords Therapeutic hypothermia · Cardiac arrest · CoolGard · Neurocritical care · Venous thrombosis · Cava vein thrombosis · Catheter related thrombosis

Introduction

Temperature control is an established therapy in neurointensive care [1]. Therapeutic hypothermia decreases intracranial pressure in several catastrophic neurologic diseases, including traumatic brain injury [2], intracerebral hemorrhage [3], subarachnoid hemorrhage [4], ischemic stroke [5], and hepatic encephalopathy [6].Until recently, therapeutic hypothermia was a standard of care in out-of-hospital cardiac arrest patients with shockable rhythms [7, 8]; however, the recent TTM trial [9] did not show any difference in outcome if the patients were treated using active temperature control systems at 33 or 36 °C. Fever has been consistently related to poor outcome in patients with acute severe neurological diseases [10]. Consequently, active control of body temperature may be a reasonable therapeutic option for several diseases.

Temperature management can be performed using pharmacotherapy or physical methods. Pharmacological strategies have not been demonstrated to be a satisfactory control of body temperature [11, 12]. Physical methods, particularly endovascular cooling, have been demonstrated to be safe, relatively simple, and effective in controlling body temperature [13].

A. Reccius · P. Mercado · C. Canals · J. Montes (✉)
Department of Critical Care, Clinica Alemana de Santiago, Universidad del Desarrollo, Vitacura 5951, Santiago, Chile
e-mail: jmontes@alemana.cl

A. Reccius
e-mail: areccius@alemana.cl

P. Vargas
Interventional Radiology Unit, Department of Diagnostics Imaging, Clinica Alemana de Santiago, Universidad del Desarrollo, Vitacura 5951, Santiago, Chile

Nevertheless, endovascular temperature control has several potential complications related to temperature management as well as the use of endovascular catheters [14]. Thrombosis is a well-described complication of "traditional" endovascular central venous catheters. One study showed a thrombosis rate of 21.5 % [15] for "traditional" central venous catheters. Because the use of endovascular temperature control catheters is relatively recent and limited, this factor implies that there are little data published concerning the use of these devices and that the data are largely restricted to a small number of case reports [16–18]. Simosa et al., in a small case series, found a thrombosis rate of 50 % with the use of endovascular temperature control catheters, employing ultrasound as a diagnostic method [19].

The aim of our study was to report the rate of thrombosis associated with endovascular temperature control catheters in a series of 20 patients, using simultaneous ultrasonography and cavography as diagnostic methods.

Methods

At our institution, we use the CoolGard 3000® system (Zoll Medical, Chelmsford, MA, USA) for endovascular temperature control. We use the Icy® catheter at 34 °C for endovascular therapeutic hypothermia in cardiac arrest patients and also to control intracranial hypertension in several patients with catastrophic neurological diseases. The Cool Line® catheter is used for vascular-induced normothermia at 36.5 °C in neurocritical patients who experience fever that is not well controlled using pharmacological therapy.

A protocol for removing these temperature control catheters was developed at our institution after a patient, who previously had a normal venous ultrasound, suffered a severe pulmonary embolism immediately after the removal of a femoral Icy® catheter. This protocol includes venous cavography using digital subtraction angiography immediately before catheter removal. The protocol details are described below.

From January 2009 to June 2012, we studied all of the patients who underwent temperature control using the CoolGard 3000® system during their stay in the ICU. The decision regarding the use of an endovascular temperature control system was left to the discretion of the attending physician. Either an Icy® or Cool Line® catheter was inserted into the inferior vena cava through a femoral venous access under ultrasound guidance.

All of the patients had elastic stockings and intermittent pneumatic compression for venous thrombosis prophylaxis during their ICU stay. The pharmacological DVT prophylaxis using enoxaparin was initiated based on the discretion of the attending physician.

Duplex ultrasonography of the vena cava and lower limbs was performed in all of the patients by an independent radiologist before the removal of the endovascular temperature control catheters. Vena cava thrombosis was defined as an echogenic intracaval material. Shortly after the ultrasonography was conducted, a digital subtraction venography of the inferior vena cava was performed by manually injecting 20 ml of contrast fluid through the femoral venous access, using a new vascular sheath inserted according to the Seldinger technique. The inferior vena cava thrombosis was subsequently defined as an intra-luminal filling defect within the vascular lumen. These filling defects were considered thrombus only if they were far from the renal or hepatic venous confluence, in order to dismiss pitfalls of flow-related phenomena. If the venography showed a caval thrombus, the interventional radiologist inserted a Celect® vena cava filter (VCF) (Cook Medical, Bloomington, IN, USA) through a jugular access. The temperature control catheter would be subsequently removed through the common femoral vein access after the VCF insertion. In those patients with no caval thrombus, the temperature control catheters were simply removed.

The pharmacological treatment for venous thrombosis was prescribed by the attending physician.

The following data were recorded: patient's age, sex, diagnosis, indication for active temperature control, duration and model of the catheter, insertion site, pharmacological venous thrombosis prophylaxis, temperature target, clinical signs of venous thrombosis, and venous thrombosis documented by venous duplex ultrasonography or caval venography.

Results

During the study period, 20 patients underwent endovascular temperature control (Tables 1 & 2). The mean age was 41 years (18–75 years), and 5 patients (25 %) were female. A total of 17 patients (85 %) used the Icy® catheter for hypothermia and 3 patients (15 %) used the Cool Line® catheter for normothermia. Of the 20 patients, 8 patients (40 %) had severe traumatic brain injury, 6 patients (30 %) had cardiac arrest, 4 patients (20 %) had intracerebral hemorrhage, 1 patient (5 %) had an acute ischemic stroke, and 1 patient (5 %) had an aneurysmal subarachnoid hemorrhage. The average catheter duration was 4.8 days (range, 2–8 days). Two patients required the endovascular temperature system for more than 7 days; hence, the first catheter was removed according to our protocol and another catheter was inserted for 4 and 5 days, respectively. Because these two patients were diagnosed with venous thrombosis when the first catheter was removed, a VCF was inserted; for the removal of the second catheter, no cavography was performed (Table 1).

Table 1 Patients

Age (years)	Sex	Diagnosis	Temperature control indication	Duration of catheter (days)	Catheter model	Temperature target (°C)	Presence of vena cava thrombosis	Pharmacologic DVT/PE prophylaxis	Pharmacologic DVT treatment
33	F	TBI	ICP	8	Icy	34	Yes	No	No
75	M	ICH	Fever	8 + 4	Cool Line	36.5	Yes	No	No
27	M	TBI	ICP	7 + 5	Icy	35	Yes	Enoxaparin 40 mg QD started on day 8	Continued enoxaparin 40 mg QD
21	M	TBI	ICP	6	Icy	35	Yes	No	Enoxaparin 40 mg QD
28	M	TBI	Fever	3	Cool Line	36.5	Yes	No	No
52	M	ICH	ICP	6	Icy	35	Yes	No	Enoxaparin 40 mg QD 7 days after diagnosis
27	M	Cardiac arrest	Cardiac arrest	3	Icy	34	Yes	Enoxaparin 40 mg QD started on day 1	Continued enoxaparin 40 mg QD
65	M	ICH	ICP	6	Icy	36.5	Yes	No	No
19	F	TBI	ICP	6	Icy	34	Yes	Enoxaparin 40 mg QD started on day 3	Continued enoxaparin 40 mg QD
18	M	Cardiac arrest	Cardiac arrest	4	Icy	34	Yes	Enoxaparin 40 mg QD started on day 1	Continued enoxaparin 40 mg QD
47	F	Cardiac arrest	Cardiac arrest	3	Icy	34	Yes	Enoxaparin 40 mg QD started on day 1	Enoxaparin 60 mg BID
24	M	Cardiac arrest	Cardiac arrest	4	Icy	34	Yes	No	Enoxaparin 60 mg BID
24	M	TBI	ICP	4	Icy	34	Yes	No	Enoxaparin 20 mg QD
57	M	TBI	ICP	4	Icy	35	Yes	Enoxaparin 40 mg QD started on day 2	Enoxaparin 40 mg QD
43	F	IS	ICP	7	Icy	34	Yes	Enoxaparin 40 mg QD started one day prior catheter insertion	Continued enoxaparin 40 mg QD
61	F	SAH	Fever	4	Cool Line	36.5	Yes	Enoxaparin 40 mg QD started seven days prior catheter insertion	Enoxaparin 60 mg BID
32	M	TBI	ICP	4	Icy	34	Yes	Enoxaparin 40 mg QD started on day 2	Enoxaparin 80 mg BID
68	M	Cardiac arrest	Cardiac arrest	2	Icy	34	No	Enoxaparin 40 mg QD started on day 1	Continued enoxaparin 40 mg QD
35	M	ICH	ICP	5	Icy	34	Yes	Enoxaparin 40 mg QD started on day 4	Continued enoxaparin 40 mg QD
72	M	Cardiac arrest	Cardiac arrest	2	Icy	34	No	Enoxaparin 40 mg QD started on day 1	Enoxaparin 40 mg QD started on day 1

TBI Traumatic brain injury, *ICH* Intracerebral hemorrhage, *IS* Ischemic stroke *ICP* Intracranial pressure, *IPC* Intermittent pneumatic compression, *ES* Elastic stockings, *QD* once a day, *BID* twice a day

Cavography showed thrombosis related to the temperature control catheter in 18 of 20 patients (90 %) (Table 3; Fig. 1). The thrombus originated in the femoral vein in four patients; in the other patients, the thrombus started in the common iliac vein. The thrombus proximal extension was up to the initial segment of the inferior vena cava in 13

Table 2 Patient characteristics

Mean Age	41.2 (18–75)
Sex	
Male	15 (75 %)
Female	5 (25 %)
Diagnosis	
TBI	8 (40 %)
Cardiac Arrest	6 (30 %)
ICH	4 (20 %)
Ischemic Stroke	1 (5 %)
SAH	1 (5 %)

TBI Traumatic injury, *ICH* Intracerebral hemorrhage, *SAH* Subarachnoid hemorrhage

Table 3 Vena cava thrombosis characteristics

Vena cava thrombosis	
Present	18 (90 %)
Absent	2 (10 %)
Thrombus distal extension	
Femoral	4 (22 %)
Common iliac	14 (78 %)
Thrombus proximal extension	
Initial caval	13 (72 %)
Infrarenal vena cava	5 (28 %)
Thrombus attachment	
Vessel wall	14 (78 %)
Catheter	4 (22 %)

patients, and in five patients, the thrombus proximal extension was up to the infrarenal segment. In 14 of the 18 patients, the thrombus was attached to the wall vessel; in the other four patients, the thrombus was attached only to the catheter; after the catheter was removed, the thrombus floated free in the vena cava. None of the thrombi produced stenosis with significant hemodynamic effect.

Only 3 of the 20 patients (15 %) presented a positive ultrasonography for venous thrombosis. None of the patients had clinical signs of DVT.

In accordance with our protocol, after the diagnosis of venous thrombosis, a VCF was inserted into the 18 patients who had been diagnosed with vena cava thrombosis. In five patients, the VCF was inserted in an infrarenal position because of the extension of the cava thrombus just below that point.

In total, 12 patients received enoxaparin as a DVT prophylaxis before the removal of the catheter (Table 1). Moreover, after vena cava thrombosis was diagnosed, 16 of these 18 patients received pharmacologic treatment. As previously mentioned, 12 patients received enoxaparin as DVT prophylactic doses (20 or 40 mg per day); and 4 patients received enoxaparin as anticoagulation doses (60

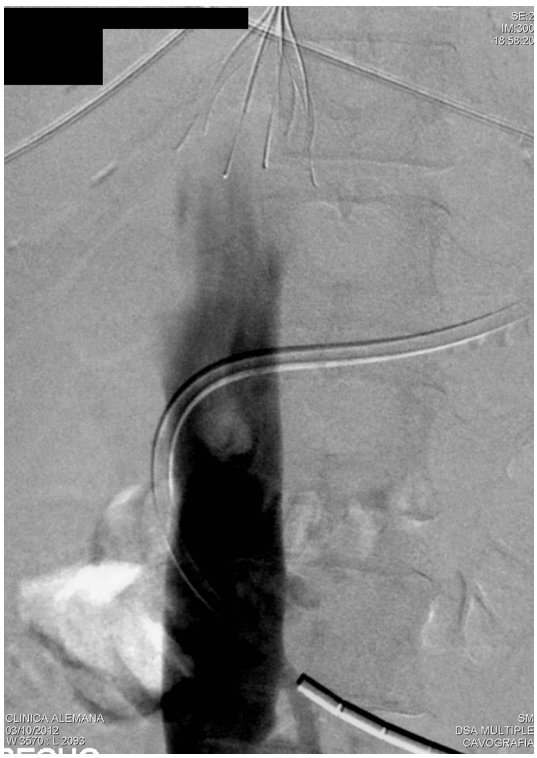

Fig. 1 Example of a patient with a cava vein thrombosis, visualized as a contrast fluid filling defect

or 80 mg twice a day). No patients developed symptomatic pulmonary embolism until hospital discharge (mean, 49 days). There were no complications related to the insertion of the VCF.

Discussion

To the best of our knowledge, this is the first report that prospectively and systematically examines the rate of thrombotic complications related to an endovascular temperature control system, using angiographic cavography.

Our results demonstrate a significantly higher rate of catheter-related thrombosis compared to the previously published studies on temperature control catheters. Taylor et al. [20], using the CoolGard® system for rewarming trauma patients, found that 1 of 11 patients had a femoral vein thrombosis related to the catheter. Simosa et al. [19], studying patients with traumatic brain injury using ultrasound after the removal of the Icy® catheter, found that 50 % had catheter-related thrombus. In the study by Simosa et al., the rate was time dependent, ranging from a 34 % rate if the catheter was used for 4 days or less, to a rate of 75 % if the catheter was used for more than 4 days.

Our higher rate of catheter-related thrombosis could be explained by the following reasons:

First, the diagnostic method we use for vena cava thrombosis is the gold standard. Compared to ultrasound, angiographic cavography has a higher positive predictive value [21]. Nonetheless, there could be false positives, especially in relation to the flow of non-opacified blood at the confluence of renal and hepatic veins [22, 23]. Because of this likelihood, we defined vena cava thrombosis as an intraluminal filling defect within the vascular lumen of the vena cava far from the renal or hepatic venous confluence, so that the likelihood of having false positives in our series was small.

We left the catheter in for a longer period of time because several patients had severe brain injuries and required hypothermia for intracranial pressure control. As mentioned, Simosa et al. demonstrated that the longer the catheter is left in, the higher is the likelihood of thrombosis. However, in our patients, we found catheter-related thrombosis even in patients who had catheters for only 2 days.

Another likely reason for having this high occurrence of catheter-related thrombosis is that we started pharmacological DVT prophylaxis late. Many of our patients had hemorrhagic strokes or traumatic brain injuries, which would have contraindicated an early pharmacological DVT prophylaxis. Nevertheless, even in patients in whom we started enoxaparin early, we still found vena cava thrombosis. Notably, all of our patients had intermittent pneumatic compression and elastic stockings from the time of their admission to the ICU.

Hypothermia catheters may have more thrombotic complications than "traditional" central venous catheters. Merrer et al. [15] studied in a general critical care population the use of "traditional" central venous catheters using ultrasound and found that the occurrence of thrombosis at femoral access was 21.5 %. As previously mentioned, Simosa et al. [19], using the same diagnostic tool as Merrer et al., reported a 50 % catheter-related thrombosis in patients with endovascular temperature control catheters; we found a 90 % thrombosis related to the temperature control catheter using cavography. It is likely that the shape of the catheter (with two or three balloons) and the timing of pharmacological DVT prophylaxis could explain this higher incidence in our study. Moreover, it has been reported that neurocritical patients may exhibit more likelihood of DVT [24, 25].

Our study has several limitations. First, it shows the experience of one single center, and we do not know whether we can extrapolate these results to a different patient population. Additionally, the DVT prophylaxis was indicated according to the discretion of the attending physician, and therapy was not guided by a predetermined protocol. Finally, to better understand our results, it would have been interesting to have performed pulmonary artery imaging to note if these patients would have developed asymptomatic pulmonary embolism.

What do our findings mean? They are, at least, a warning sign. Other temperature control systems could most likely be a better option for patients who need temperature control for long periods of time or in whom the pharmacological DVT prophylaxis is contraindicated. This is especially true after the publication of the TTM trial, which showed that there is no difference in outcome if the patients were actively treated with the temperature targeted at 33 or 36 °C.

Finally, because ultrasound has a low positive predictive value, we suggest that an angiographic cavography should be performed before removing the hypothermia catheter; if there are signs of thrombosis, a VCF should be inserted. Additional studies are warranted to confirm these recommendations.

References

1. Badjatia N. Hyperthermia and fever control in brain injury. Crit Care Med. 2009;37(Suppl 7):S250–7.
2. Schreckinger M, Marion DW. Contemporary management of traumatic intracranial hypertension: is there a role for therapeutic hypothermia? Neurocrit Care. 2009;11:427–36.
3. Kollmar R, Staykov D, Dorfler A, Schellinger PD, Schwab S, Bardutzky J. Hypothermia reduces perihemorrhagic edema after intracerebral hemorrhage. Stroke. 2010;41:1684–9.
4. Torok E, Klopotowski M, Trabold R, Thal SC, Plesnila N, Scholler K. Mild hypothermia (33 degrees C) reduces intracranial hypertension and improves functional outcome after subarachnoid hemorrhage in rats. Neurosurgery. 2009;65:352–9; discussion 359.
5. Kollmar R, Schwab S. Hypothermia and ischemic stroke. Curr Treat Options Neurol. 2012;14:188–96.
6. Stravitz RT, Larsen FS. Therapeutic hypothermia for acute liver failure. Crit Care Med. 2009;37:S258–64.
7. Bernard SA, Gray TW, Buist MD, Jones BM, Silvester W, Gutteridge G, Smith K. Treatment of comatose survivors of out-of-hospital cardiac arrest with induced hypothermia. N Eng J Med. 2002;346:557–63.
8. Group HaCAS. Mild therapeutic hypothermia to improve the neurologic outcome after cardiac arrest. N Eng J Med. 2002;346:549–56.
9. Nielsen N, Wetterslev J, Cronberg T, et al. Targeted temperature management at 33°C versus 36°C after cardiac arrest. N Engl J Med. 2013;369:2197–206.
10. Badjatia N. Fever control in the neuro-ICU: why, who, and when? Curr Opin Crit Care. 2009;15:79–82.
11. Sulter G, Elting JW, Maurits N, Luijckx GJ, De Keyser J. Acetylsalicylic acid and acetaminophen to combat elevated body temperature in acute ischemic stroke. Cerebrovasc Dis. 2004;17:118–22.
12. Kasner SE, Wein T, Piriyawat P, Villar-Cordova CE, Chalela JA, Krieger DW, Morgenstern LB, Kimmel SE, Grotta JC. Acetaminophen for altering body temperature in acute stroke: a randomized clinical trial. Stroke. 2002;33:130–4.
13. Schwab S, Kollmar R. Rise of the machines: controlling the body temperature of critically ill patients by endovascular catheters. Neurocrit Care. 2004;1:127–30.
14. Polderman KH, Herold I. Therapeutic hypothermia and controlled normothermia in the intensive care unit: practical considerations, side effects, and cooling methods. Crit Care Med. 2009;37:1101–20.

15. Merrer J, De Jonghe B, Golliot F, Lefrant JY, Raffy B, Barre E, Rigaud JP, Casciani D, Misset B, Bosquet C, et al. Complications of femoral and subclavian venous catheterization in critically ill patients: a randomized controlled trial. JAMA. 2001;286:700–7.
16. Lau E, Bajzer C, Menon V. Inferior vena cava thrombus associated with intravascular cooling catheter. Resuscitation. 2010;81:1457–8.
17. Prunet B, Lacroix G, Bordes J, Poyet R, D'Aranda E, Goutorbe P. Catheter related venous thrombosis with cooling and warming catheters: two case reports. Cases J. 2009;2:8857.
18. Retamal J, Bachler J, Mejia R, Concha O, Andresen M. Venous thrombosis secondary to catheter insertion for hypothermia after cardiac arrest. Report of one case. Rev Med Chil. 2011;139:1201–5.
19. Simosa HF, Petersen DJ, Agarwal SK, Burke PA, Hirsch EF. Increased risk of deep venous thrombosis with endovascular cooling in patients with traumatic head injury. Am Surg. 2007;73:461–4.
20. Taylor EE, Carroll JP, Lovitt MA, Petrey LB, Gray PE, Mastropieri CJ, Foreman ML. Active intravascular rewarming for hypothermia associated with traumatic injury: early experience with a new technique. Proc (Bayl Univ Med Cent). 2008;21:120–6.
21. Park JH, Lee JB, Han MC, Choi BI, Im CK, Yeon KM, Kim CW. Sonographic evaluation of inferior vena caval obstruction: correlative study with vena cavography. AJR Am J Roentgenol. 1985;145:757–62.
22. Bates SM, Jaeschke R, Stevens SM, Goodacre S, Wells PS, Stevenson MD, Kearon C, Schunemann HJ, Crowther M, Pauker SG, et al. Diagnosis of DVT: antithrombotic therapy and prevention of thrombosis, 9th ed: American College of Chest Physicians evidence-based clinical practice guidelines. Chest. 2012;141:e351S–418S.
23. Andrews RT. Contrast peripheral phlebography and pulmonary angiography for diagnosis of thromboembolism. Circulation. 2004;109(12 suppl 1):I22–7.
24. Knudson MM, Ikossi DG, Khaw L, Morabito D, Speetzen LS. Thromboembolism after trauma: an analysis of 1602 episodes from the American College of Surgeons National Trauma Data Bank. Ann Surg. 2004;240:490–6; discussion 496–498.
25. Gregory PC, Kuhlemeier KV. Prevalence of venous thromboembolism in acute hemorrhagic and thromboembolic stroke. Am J Phys Med Rehabil. 2003;82:364–9.