

Accepted Manuscript

Complete Resolution of Post-Operative Hemiparesis following Carotid Endarterectomy with Therapeutic Hypothermia: A case study and literature review

Irina Usach, MHS, Andreas Sakopoulos, MD FACS, Hossein Razavi, MD FACP
FCCP



PII: S0890-5096(15)00404-5

DOI: [10.1016/j.avsg.2015.03.048](https://doi.org/10.1016/j.avsg.2015.03.048)

Reference: AVSG 2388

To appear in: *Annals of Vascular Surgery*

Received Date: 20 November 2014

Revised Date: 20 February 2015

Accepted Date: 2 March 2015

Please cite this article as: Usach I, Sakopoulos A, Razavi H, Complete Resolution of Post-Operative Hemiparesis following Carotid Endarterectomy with Therapeutic Hypothermia: A case study and literature review, *Annals of Vascular Surgery* (2015), doi: 10.1016/j.avsg.2015.03.048.

This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

1 Complete Resolution of Post-Operative Hemiparesis
2 following Carotid Endarterectomy with Therapeutic
3 Hypothermia: A case study and literature review

4

5 Irina Usach, MHS¹; Andreas Sakopoulos, MD FACS¹; Hossein Razavi, MD FACP
6 FCCP²

7

8

9 ¹Cardiothoracic and Endovascular Surgery
10 St. Helena Hospital, St. Helena, CA
11 10 Woodland Road, St. Helena, CA 94574

12

13 ²Pulmonary and Critical Care Medicine
14 St. Helena Hospital, St. Helena, CA
15 10 Woodland Road, St. Helena, CA 94574

16

17 Please address correspondence to:
18 Andreas Sakopoulos, MD FACS
19 Cardiothoracic and Endovascular Surgery
20 St. Helena Hospital
21 10 Woodland Road, St. Helena, CA 94574
22 Email: andreas.sakopoulos@ah.org
23 Phone number: 707-963-6315
24

1 **ABSTRACT**

2 Therapeutic hypothermia (TH) is indicated in a number of traumatic brain injuries as well
3 as for cardiovascular shock¹, but it has been limited in its application to acute ischemic
4 stroke. We present the case of a 65-year-old woman with a clinical cerebrovascular
5 accident (CVA) following a right carotid endarterectomy who was treated with a 24-hour
6 hypothermia protocol and had a full recovery. The hypothermia protocol utilized on this
7 patient and a review of the literature surrounding hypothermia in the setting of ischemic
8 stroke are presented.

9

10 **INTRODUCTION**

11 TH has been utilized in the treatment of traumatic brain injury and cardiogenic
12 shock, showing decreased cerebral and myocardial damage, improved post-ischemic
13 cardiac function and reduced end-organ damage due to hypoperfusion^{1,2}. Specifically, in
14 cardiogenic shock patients it has been shown that lowering brain temperature, even if
15 only by a few degrees, reduces ischemic damage^{2,3}. However, despite the underlying
16 similarities in the pathophysiology of injury, the benefits of TH have not been fully
17 explored in patients with acute ischemic stroke.

18 We present one case of acute ischemic stroke following right carotid
19 endarterectomy (CEA) that was treated with immediate TH, lasting 24 hours.

20

21 **CASE REPORT**

22 A 65-year-old woman with no prior history of CVA presented to clinic with
23 carotid duplex ultrasound findings of greater than 70% stenosis of her right internal
24 carotid artery. The patient underwent a standard right CEA with the use of a shunt with

1 Doppler, which demonstrated sustained blood flow throughout the procedure. The CEA
2 was completed with no apparent intraoperative complications. During awakening from
3 anesthesia and prior to extubation, the patient showed flaccid paralysis of the left upper
4 and lower extremities. This left-sided hemiparesis was clinically suggestive of an acute
5 CVA. Upon re-exploration, surface Doppler ultrasound demonstrated signal on the right
6 internal, external and common carotid arteries. The artery was opened and an
7 embolectomy catheter was advanced and pulled back, with no return of debris. Upon
8 closing, the patient was taken to radiology for an emergency computed tomography (CT)
9 as well as a computed tomographic angiography (CTA). The CT and CTA were both
10 unremarkable, showing no signs of hemorrhagic stroke and confirming presence of patent
11 cerebral vasculature throughout the right and left hemispheres (Figure I). However, these
12 findings did not rule out the possibility of ischemic stroke, and given the clinical severity
13 of the patient's symptoms, it was clear that the patient had suffered an ischemic stroke.
14 At this time, tissue plasminogen activator (tPA), the standard protocol for an ischemic
15 stroke within 4 hours of symptomatic onset, was contraindicated due to recent surgery.

16 The patient was then taken to the intensive care unit where a standard
17 hypothermic protocol was initiated. The patient was sedated with propofol, given
18 vecuronium as a paralytic, and cooled with IV saline and cooling blankets to 33°C,
19 maintaining that temperature for 24 hours. At that time, the patient was rewarmed,
20 extubated and a full neurological exam was performed. The patient was able to follow
21 commands; Cranial Nerves I-XII were intact to motion and sensory; strength was 5/5,
22 bilaterally in upper and lower extremities; deep tendon reflexes were +2/4, bilaterally in
23 upper and lower extremities; sensation to pain, vibration, light and deep touch were

1 intact, bilaterally in upper and lower extremities. The patient showed no signs of focal
2 neurological deficit and was discharged on post-operative day 4.

3

4 **DISCUSSION**

5 Despite evidence of the neuroprotection of TH in ischemic brain injury and
6 cardiopulmonary resuscitation, there has been very little data showing the benefit of TH
7 in acute ischemic stroke patients. In this case report we describe the presumed benefit of
8 TH in a patient who suffered an acute CVA immediately post-operatively and benefited
9 from this therapy. Although we cannot be certain that there is a true causal relationship
10 between TH and the resolution of our patient's hemiplegia, there is clearly a temporal
11 relationship. There is compelling evidence to support our theory that cooling neuronal
12 cells may ameliorate damage caused by ischemia and/or trauma.

13 In 2014, Xu et al. presented compelling data that demonstrated the
14 neuroprotective nature of TH in rat models that were exposed to global ischemia using an
15 in vitro model of oxygen glucose deprivation⁴. Xu et al. found that intermittent
16 hypothermia offered protection against ischemic injury on a cellular level altering
17 viability and inhibiting cellular death pathways⁴. That same year, Matsui et al. found that
18 hypothermia significantly decreases the release of Interleukin 17 and Granzyme B,
19 factors that mediate neuronal cell death, from T-cells following a model for toxic
20 neuronal cell injury ($P < 0.05$ when compared with normothermia)⁵. This finding
21 suggests that hypothermia plays an important role in neuroprotection as the immune
22 system recognizes, and responds to, acute brain injury.

1 In January 2015, Alonso-Alconada et al. used a piglet asphyxia model to prove
2 that cooling the brain to 33.5-35°C was protective in brain regions following ischemic
3 injury in an animal model⁶. Time has also been shown to be an important factor in the
4 effectiveness of TH. Yenari and Hemmen found that TH is most neuroprotective when it
5 is applied during, or even before, the onset of ischemia⁷. This is both applicable and
6 supportive of the application of immediate TH in the setting of CVA following CEA.

7 Despite the benefits of neuronal protection, TH does have potential adverse
8 effects to be aware of. It has been shown to provoke pneumonia⁸, coronary spasm and
9 life-threatening arrhythmias³ and should therefore be used with caution in patients with
10 pulmonary and/or cardiac comorbidities.

11 While this is clearly a single case report, and is limited in the scope of its
12 application, it may still be beneficial to consider a protocol whereby TH could be
13 considered as one of the therapeutic interventions available in the setting of ischemic
14 stroke. Other limitations include a lack of radiographic criteria to make a firm diagnosis
15 of CVA. However, clinically, our patient did have complete hemiparesis, which resolved
16 post-intervention. While, our patient's hemiparesis may have been transient, the temporal
17 relationship between the symptomatic resolution and TH is definitive enough to warrant
18 further research. Although narrow in its application, the use of TH in acute CVA can be
19 an important and effective therapeutic option immediately following CEA. Further
20 research must be directed at the effectiveness of TH in this setting.

21

22

23

¹ Warner, D. S., et al. "Translational Research in Acute Central Nervous System Injury: Lessons Learned and the Future." *JAMA Neurol* (2014).

² Stegman, B. M., et al. "Post-Myocardial Infarction Cardiogenic Shock Is a Systemic Illness in Need of Systemic Treatment: Is Therapeutic Hypothermia One Possibility?" *J Am Coll Cardiol* 59.7 (2012): 644-7.

³ Todaro, M. C., et al. "Hypothermia: A Double-Edged Sword." *Cardiology* 122.2 (2012): 126-8.

⁴ Xu, S. Y., et al. "Intermittent Hypothermia Is Neuroprotective in an in Vitro Model of Ischemic Stroke." *Int J Biol Sci* 10.8 (2014): 873-81.

⁵ Matsui, T., et al. "Hypothermia Reduces but Hyperthermia Augments T Cell-Derived Release of Interleukin-17 and Granzyme B That Mediate Neuronal Cell Death." *Neurocrit Care* (2014).

⁶ Alonso-Alconada, D., et al. "Brain Cell Death Is Reduced with Cooling by 3.5 Degrees C to 5 Degrees C but Increased with Cooling by 8.5 Degrees C in a Piglet Asphyxia Model." *Stroke* 46.1 (2015): 275-8.

⁷ Yenari, M. A., and T. M. Hemmen. "Therapeutic Hypothermia for Brain Ischemia: Where Have We Come and Where Do We Go?" *Stroke* 41.10 Suppl (2010): S72-4.

⁸ Nolan, J. P., et al. "Therapeutic Hypothermia after Cardiac Arrest. An Advisory Statement by the Advancement Life Support Task Force of the International Liaison Committee on Resuscitation." *Resuscitation* 57.3 (2003): 231-5.

FIGURE**Figure I: Post-operative CT Angiography: Sagittal section, 9° showing patent right internal carotid**