Case Report

Therapeutic systemic hypothermia for a pediatric patient with an isolated cervical spinal cord injury

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Context: While uncommon, spinal cord injuries most frequently occur in adolescent and young adult males. Established treatment options are limited and focused on supportive care. Therapeutic systemic hypothermia is an emerging experimental treatment currently undergoing clinical trials in adults.

Findings: Here we report a case of a 13-year-old male with an American Spinal Injury Association Impairment Scale grade C traumatic cervical spinal cord injury treated with 48 hours of therapeutic systemic hypothermia who made a complete neurological recovery. To our knowledge, this is the youngest such case report.

Clinical relevance: This case suggests that consideration should be given to including pediatric patients in future clinical trials of therapeutic hypothermia for spinal cord injury.

Keywords: Spinal cord injuries, Hypothermia, Induced, Trauma, Nervous system, Cervical cord

Context

The incidence of spinal cord injury in the United States is estimated at over 10,000 cases per year.^{1,2} Injuries are most common between 15 and 30 years of age, and threefold more common in men than women.^{1,2} Motor vehicle accidents and falls are the leading causes of injury.^{1,2} Prognosis is variable based on age, spinal level, and initial severity of injury.^{3–5} The American Spinal Injury Association Impairment Scale (AIS) designates severity of injury based on the degree of sensory and motor impairment at presentation, with grade A representing a complete injury, and grade E representing a normal examination.⁶ Higher grades are associated with worse functional prognosis.³

Treatment options are extremely limited; the majority of therapy is directed at intensive supportive care and maintenance of adequate perfusion pressure. For those with cervical spine injuries, the American Association of Neurological Surgeons and Congress of Neurological Surgeons (AANS/CNS) recommend early closed

reduction of cervical spinal fractures or dislocation injuries to allow realignment of the cervical spine.⁷ The use of any specific pharmacotherapy to improve prognosis is controversial. Methylprednisolone has been used historically, however, the AANS/CNS recommended against this approach in their 2013 update.^{7,8}

Given the paucity of effective therapies, a variety of experimental treatments are in clinical or pre-clinical trials.⁹ Therapeutic systemic hypothermia has been under investigation in animal models of ischemic spinal cord injury since the 1940s, and in models of traumatic spinal cord injury since the 1990s.^{10–14} In these models, hypothermia has been shown to decrease CNS metabolic rate and inflammatory cell activation and is postulated to decrease the immune-mediated “secondary injury” that occurs following traumatic spinal cord injury.^{9,15,16} Enthusiasm built for potential human applicability following a case report of a professional football player who underwent systemic therapeutic hypothermia for a spinal cord injury with good clinical results.^{17,18} In the past decade, three publications have evaluated the use of therapeutic systemic hypothermia for spinal cord injury.^{19–21} The largest of these was a

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2012 case series of 35 patients by Dididze *et al.* examining the use of intravascular cooling for traumatic cervical spinal cord injury in AIS grade A patients.²¹ They reported an overall 42.9% conversion rate from AIS grade A compared to a historical control rate of 26.1%.²¹ The youngest patient included was 16 years old at the time of injury.²¹ A phase II/III clinical trial evaluating therapeutic hypothermia for spinal cord injury is currently in planning.²² To our knowledge, no publication has ever referenced the use of therapeutic hypothermia in a younger patient.

Findings

A 13-year-old male with no prior medical or surgical history presented to the emergency department via EMS following a fall resulting in paralysis. The patient reported that he was climbing a tree and fell approximately 10 feet, landing on his left side. Witnesses did not report a loss of consciousness, but the patient immediately complained of upper and lower extremity weakness. EMS was activated and he was transported in a cervical collar and long spine board. At the time of initial evaluation, his vital signs were: T 36.2°C, HR 73, BP 130/80, RR 20, and SpO₂ 98% on room air. The primary survey was remarkable for anisocoria with a right pupil at 6 cm and left at 4 cm, but both briskly reactive to light. Initial Glasgow Coma Scale was 15.

The secondary survey was remarkable for tenderness over C5-C6 in the posterior midline and several

neurologic abnormalities. Cranial nerves were intact except for anisocoria. Gaze was conjugate and extraocular movements were intact. Strength in the biceps was 4-/5 bilaterally, triceps 0/5 bilaterally, and intrinsic hand muscles 1/5 bilaterally. Left lower extremity strength was 0/5 in all muscle groups. Right lower extremity strength was 4/5 knee extension and 4+/5 ankle plantarflexion & dorsiflexion. The sensation was preserved in the bilateral upper extremities. Lower extremity sensation was only noted in the right great toe; the lower extremities were otherwise completely insensate. Initial head CT was negative. Cervical spine CT showed unstable C4 and C5 fractures (Fig. 1). CT of the chest, abdomen, and pelvis did not show additional injuries.

Neurosurgery consulted at the bedside and recommended cervical spine MRI. This re-demonstrated C4 and C5 vertebral fractures and elucidated a spinal cord contusion from C3 to C5 with cord edema and patchy hemorrhage (Fig. 2). There was a minimal epidural hematoma at C5 without spinal cord compression. Additionally, there was the destruction of the anterior longitudinal ligament at C3 and C4, the interspinous ligaments from C3-C6, and the ligamentum flavum from C3-C6, leading to unstable soft tissue injuries.

Figure 1 Non-contrast axial computed tomography of the cervical spine at the level of C4 showing a fracture through the vertebral body and the right lamina adjacent to the spinous process (arrows).

Figure 2 Sagittal T2-weighted MRI of the cervical spine demonstrating C4 and C5 vertebral fractures and elucidating a spinal cord contusion from C3 to C5 with cord edema and patchy hemorrhage (arrows).

Vertebral arteries were intact with no evidence of dissection.

Given an isolated spinal cord injury without evidence of traumatic brain injury, the patient was admitted to the pediatric intensive care unit. He was started on methylprednisolone 30 mg/kg, followed by 5.4 mg/kg per hour for 23 hours. Additionally, an extensive conversation was had with the family regarding the potential benefits and harms of therapeutic hypothermia. After shared decision-making, the family elected to initiate the institutional therapeutic hypothermia protocol. The patient was intubated and paralyzed to prevent shivering. An intravascular systemic cooling catheter was inserted (Icy Catheter, Zoll Medical), and the patient was cooled to a target temperature of 32°C. Target temperature was achieved within approximately 4 hours of injury. Following the induction of hypothermia, the patient experienced bradycardia to 30 beats per minute without associated hypotension. His core temperature was raised to a target of 33.5°C and maintained for 48 hours. He was re-warmed over 24 hours.

Following rewarming, the patient underwent an uncomplicated cervical corpectomy of C4-C5 with autologous bone graft and C3-C6 spinal fusion on hospital day 4. He recovered in the PICU and was extubated on hospital day 5. His course was complicated by approximately 36 hours of delirium treated with risperidone and lorazepam as needed. Otherwise, he had an expected post-operative recovery. He began physical and occupational therapy and had marked neurologic improvement during his admission. He remained hospitalized for 19 days, and at the time of discharge was noted to be cognitively normal, with improving motor function in all extremities, but persistent left leg weakness. He was discharged to an inpatient rehabilitation facility, where he received physical and occupational therapy. Subsequently, he received outpatient therapy through a local private company until he was assessed to have fulfilled his rehabilitation goals.

Following his injury, the patient has received health care in our system for the past 5 years. At his last well adolescent examination (at 18 years old), he had a normal complete neurologic examination, including gait, and had no residual lower extremity weakness. He was physically active, participating in aerobics several times per week. Socially, he was a senior in high school and doing well. He was also carrying a part-time job outside of the classroom.

Conclusion / clinical relevance

Here we report a case of a 13-year-old male with an AIS grade C traumatic cervical spinal cord injury treated

with 48 hours of therapeutic systemic hypothermia delivered via an intravascular cooling device and who made a complete neurologic recovery (AIS grade E on 5-year follow up). There were no apparent complications attributable to hypothermia or the intravascular cooling catheter, other than transient bradycardia which responded to increasing core temperature to 33.5°C. To our knowledge, this is the youngest case of therapeutic hypothermia application for spinal cord injury. As with any case report, caution must be exercised in attributing total causality for the patient's improvement to the hypothermia intervention; it is possible that he might have recovered spontaneously. However, this case suggests that consideration should be given to including pediatric patients in future clinical trials of therapeutic hypothermia for spinal cord injury.

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