Tzu Chi Medical Journal 28 (2016) 180–182

Contents lists available at ScienceDirect

Tzu Chi Medical Journal

journal homepage: www.tzuchimedjnl.com

Case Report

Therapeutic hypothermia brings favorable neurologic outcomes in children with near drowning

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ARTICLE INFO

Article history:
Received 14 January 2016
Received in revised form
29 January 2016
Accepted 21 July 2016
Available online 15 September 2016

Keywords:
Children
Drowning
Hypothermia therapy
Near-drowning
Therapeutic hypothermia

ABSTRACT

A 1-year-10-month-old boy was admitted to our pediatric intensive care unit due to near drowning with pulmonary edema. A conventional ventilator with 100% oxygen supplementation was used initially, but was shifted to high frequency oscillatory ventilation as his oxygen saturation was around 84–88%. Therapeutic hypothermia was applied due to hypoxic ischemic encephalopathy with severe acidosis. His respiratory condition improved and he was extubated successfully on the 6th hospital day. The patient had no obvious neurological defects and he was discharged in a stable condition after 17 days of hospitalization. Our case report demonstrates the advantages of therapeutic hypothermia on survival and neurological outcomes in treating pediatric near drowning patients.

1. Introduction

Based on the new definition by the First World Congress on Drowning and the World Health Organization, drowning is the process of experiencing respiratory impairment from submersion or immersion in a liquid [1]. Drowning is a worldwide public health problem among toddlers and adolescents. According to the Ministry of Health and Welfare of Taiwan, 54,604 people drowned between 1971 and 2011, with an average of 1300 deaths annually. Of these, 51.2% were 0–24 years old and 34.4% were students. Lu et al [2] reported that drowning was the leading cause of death among Taiwanese adolescents aged between 10 years and 19 years from 1965 to 1975. Although it was the second leading cause of death from 1976 to 1994, it was still the main cause of death among males aged between 10 years and 14 years from 1965 to 1990. On average, 350 Taiwanese adolescents died annually due to drowning during this period [2].

Because of its neuroprotective effects, therapeutic hypothermia has been widely applied in adults with cardiac arrest and severe traumatic brain injury and in neonates with perinatal asphyxia [3–5]. Hypothermia therapy had been applied in near drowning in adults and with good neurological outcomes [3,6]. However, the effect of hypothermia therapy in near drowning in children is still unknown. Recently, the International Liaison Committee on Resuscitation recommended hypothermia to 32–34°C for 12–24 hours in children who remain comatose after resuscitation for cardiac arrest [7]. Here, we report a 1-year-10-month-old boy who nearly drowned who received hypothermia therapy with a favorable neurological outcome after discharge.

2. Case Report

A 1-year-10-month-old healthy boy was admitted to our pediatric intensive care unit (PICU) due to near drowning. He was found floating in a pool without any movement. After he was removed from the pool, the patient had a cold body temperature, cyanotic lips, and motions of trying to breathe. Cardiopulmonary resuscitation was performed immediately for 5 minutes and the patient had regained a pulse when emergency medical technicians arrived. In the ambulance, automated external defibrillation was used and

Conflicts of interest: none.

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http://dx.doi.org/10.1016/j.tcmj.2016.07.003

no shockable rhythm was found after analysis. The patient was transferred to our hospital within 20 minutes.

Pediatric advanced life support was performed in the emergency department with endotracheal intubation. He was still unconscious with a Glasgow Coma Scale score of E1VTM1 after resuscitation. His pupils were pinpoint with a sluggish light reflex bilaterally and his breath sounds revealed bilateral crackles. A chest radiograph revealed pulmonary edema with a diffuse reticular pattern bilaterally. He was admitted to our PICU under the impression of near drowning with pulmonary edema.

Severe respiratory and metabolic acidosis (pH 6.942, pCO_2 51.6 mmHg, HCO_3 10.9 mmol/L) was noted in the PICU. A conventional ventilator with 100% oxygen supplementation was used initially, but his oxygen saturation was only around 84–88%, therefore, we applied high frequency oscillatory ventilation (HFOV) and kept his oxygen saturation above 93%. A continuous midazolam (1~6 μg/kg/min) infusion was given for sedation. Because of hypoxic ischemic encephalopathy (HIE) with severe acidosis, hypothermia therapy was initiated according to the standard protocol reported by Topjian et al [4] in 2011. In brief, surface cooling was applied to our patient through an external cooling blanket to a goal rectal temperature of 32–34°C within 6 hours, and maintained at 32–34°C for 24 hours after cooling initiation, with rewarming to 36.5°C in the next 24 hours. Neuromuscular blocking and sedative agents were also used to avoid chilling during therapeutic hypothermia. An empirical antibiotic, intravenous amoxicillin/clavulanate 360 mg Q6H was prescribed for aspiration pneumonia with an elevated C-reactive protein (CRP) level (12.69 mg/dL) and fever up to 39.3°C. Some foamy sputum was suctioned from the endotracheal tube and the chest radiograph revealed pulmonary congestion and bilateral pulmonary perihilar infiltrations with suspected pulmonary edema. Furosemide was given immediately.

After hypothermia therapy for 24 hours, the rewarming program was started gradually (<0.5°C/h). The chest radiograph on the 2nd hospital day (HD) revealed improving pulmonary edema. We discontinued furosemide and HFOV was shifted to the conventional ventilator with synchronized intermittent mandatory ventilation mode. His respiratory condition improved gradually, so he was extubated on the 4th HD. However, progressively labored breathing with stridor and desaturation were noted, even after epinephrine inhalation therapy and use of bilevel positive airway pressure. He was reintubated and his respiratory condition stabilized. He was extubated successfully on the 6th HD. The patient's clinical condition improved gradually and he was transferred to our general ward on the 9th HD.

We discontinued antibiotics after 14 days as the pneumonia had resolved and the CRP level had decreased to 0.25 mg/dL. The patient received rehabilitation after discharge and evaluation showed no obvious neurological defect. He was discharged after 17 days of hospitalization in a stable condition. We used the pediatric cerebral performance categories scale (PCPCs) after discharge to evaluate the neurologic outcome according to the Pediatric Utstein Guidelines [8]. The PCPCs is a six point scale as follows: 1, normal performance; 2, mild disability; 3, moderate disability; 4, severe disability; 5, coma or persistent vegetative state; and 6, brain death [9]. His PCPCs score was 1 (normal age-appropriate performance).

3. Discussion

Previous study showed promising neurological outcomes in patients receiving hypothermia therapy after cardiac arrest [3,6]. Our patient survived and exhibited a favorable neurological outcome (PCPCs 1) after hypothermia therapy. Therefore, this therapy may reduce the mortality rate and attenuate HIE in drowning patients. Moreover, no obvious side effects of therapeutic hypothermia were observed in our patient, except for infection with a prolonged fever and elevated CRP level. The long-term survival outcomes of drowning patients depend mainly on the severity of the initial ischemic brain insult [10]. HIE is the most common cause of death of hospitalized drowning patients. A neuroprotective effect of active hypothermia has been shown after global brain ischemia, such as after cardiac arrest and neonatal asphyxia, and in case reports of good recoveries after near drowning in cold water [5,11–13]. In 2005, the International Liaison Committee on Resuscitation recommended induction of hypothermia (32–34°C) for 12–24 hours in comatose children after resuscitation from cardiac arrest [7]. The neuroprotective effect of active hypothermia in combination with its intracranial pressure reducing effects was also noted in pediatric patients in recent studies [14].

Brain metabolism decreases about 5–7% per °C reduction in core temperature [15]. Intracranial pressure reduction by therapeutic hypothermia can be due to cerebral vasoconstriction caused by a reduced metabolic rate, resulting in reduced intracranial blood volume. Furthermore, a reduced brain metabolic rate may cause a more favorable balance between cerebral oxygen and glucose supplies and requirements [16]. Other possible protective factors of hypothermia therapy include reduced free radicals, decreased toxic metabolites and excitatory substances, attenuation of proinflammatory cytokines, prevention of reperfusion injury and apoptosis, preservation of high energy phosphates, reduced mitochondrial dysfunction, and a reduction in oxidative stress [17–19]. In addition to the protective effects on the brain, after ischemic brain injury, mild hypothermia is also effective for lung injury or acute respiratory distress syndrome treatment which is the most common etiology of early mortality in submersion injury [20]. HFOV therapy in children with respiratory failure may improve the $PaCO_2$ and PaO_2/FiO_2 [21]. Our report showed that when conventional ventilator therapy was not effective in our patient, HFOV therapy effectively reversed his critical respiratory condition. In addition, extracorporeal membrane oxygenation may provide another chance for survival in children with severe acute respiratory distress syndrome, even those with pneumonia, who are not responding to conventional treatment [22].

In conclusion, our case report demonstrates the advantages of therapeutic hypothermia on survival and neurological outcomes when treating pediatric near drowning patients. Further prospective randomized controlled studies are needed to confirm the effects of therapeutic hypothermia in this population.

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