Central Diabetes Insipidus Complicating Near-Drowning

Melvin K.S. Leow, Dessmon Y.H. Tai, Gilbert K.F. Lau

Abstract

Central diabetes insipidus (DI) is a very rare sequela of near-drowning. We report this case to add to the limited existing knowledge of this highly unusual complication in this group of patients. A young female rescued from fresh water submersion developed polyuria associated with hypernatremia 4 days after the accident. Desmopressin (DDAVP) was used to control the inappropriate diuresis and stabilize her intravascular volume and tonicity. Despite satisfactory response to DDAVP, she remained in a comatose state and cardiac arrest supervened 18 days after the accident. Central DI should be considered in near-drowning patients with polyuria, and needs to be treated even in those with a dismal prognosis as this would facilitate the diagnosis of brain death. This might be of relevance to communities and medical institutions where the lawful procurement of human organs in optimal conditions for transplantation is a clinical priority.

Introduction

Despite the high incidence of drowning and near-drowning accidents (~10-43 per 100,000 annually) [1], fluid and electrolytes disorders occurring in such conditions are rare [2]. Among the spectrum of electrolyte and fluid derangement encountered in near-drowning, the syndrome of inappropriate antidiuretic hormone secretion (SIADH) predominates as a consequence to the hypoxic brain insult of underwater submersion. Strangely, central diabetes insipidus (DI) is an extremely rare sequela of near-drowning patients despite being a relatively common complication of hypoxic brain injury occurring in other contexts such as head trauma. A literature search using the Medline over the last 34 years did not reveal any case reports/series of central DI secondary to near-drowning. We describe a young near-drowning victim who developed central DI, which required desmopressin for control.

Case Report

A 10-year-old girl with a history of bronchial asthma was rescued after being submerged for about 5 minutes in a fresh water swimming pool on the 4 July 1999. As she was found to be pulseless and cyanosed, cardiopulmonary resuscitation was initiated by her father immediately and continued uninterrupted for 20 minutes by a doctor from a private clinic nearby before being managed by the ambulance paramedical team. The total time elapsed between her extrication from the pool to the arrival at the emergency department of a local hospital was approximately 30 minutes. She was intubated and ventilated. The cardiac monitor revealed ventricular fibrillation. Sinus rhythm was eventually restored after electrical defibrillation. She was then transferred to the intensive care unit after stabilizing her hemodynamically with inotrope support.

Clinically, she was comatose (Glasgow coma scale, GCS = 3/15) and her pupils were fixed and dilated. Oculocephalic, corneal and gag reflexes were absent, and she exhibited no response to nociceptive external stimuli. She was profoundly hypothermic at 32.9° C. Her blood pressure was 95/45 mm Hg while on dopamine infusion and she had sinus rhythm of 80/ min. Chest examination revealed dual heart sounds and bilateral widespread coarse crepitations. There was no evidence of cephalohematoma or signs of external in-
jury anywhere. Laboratory results showed metabolic acidosis, elevated transaminases associated with deranged coagulation profile (Table 1). Toxicological analysis of her blood and urine samples was negative. She was empirically treated with intravenous ceftriaxone and cloxacillin. Famotidine was added for stress ulcer prophylaxis. Intravenous vitamin K was administered to correct her coagulopathy.

On the 4th day of hospitalization, she was noted to have polyuria (~ 4 L/day) and severe hypernatremia (serum sodium 180 mmol/L). The serum osmolality was 367 mOsm/kg and urine osmolality was inappropriately dilute at 148 mOsm/kg. She was given an intravenous bolus of desamino-D-arginine vasoressin (DDAVP), which resulted in a prompt response with a reduction in her urine output. This confirmed central DI. Maintenance DDAVP was given intranasally at 12 hourly intervals. As DI broke through again, the intranasal route of administration was stopped 2 days later and switched to intravenous DDAVP 1 mg 12 hourly which reversed her fluid and electrolyte balance favorably by the 10th day of hospitalization (Table 2). However, she did not improve neurologically. The patient was diagnosed to be brain dead on the 14th day of hospitalization according to the 7 established criteria for brain death. Her parents were approached by a transplant coordinator for permission to harvest her kidneys, liver and corneas for transplantation, in accordance with existing legislation (the Medical Therapy, Education and Research Act). The parents rejected the request. They also wanted continuation of life support in view of her young age and the unexpected incident. Her condition deteriorated as bradycardia and hypotension supervened, terminating in asystolic cardiac arrest 18 days after the accident.

A coroner’s autopsy conducted the next day showed evidence of bilateral bronchopneumonia, with patchy consolidation of both lungs, particularly of the lower lobes; this being associated with moderate, acute pulmonary edema and congestion. As expected, the brain showed features consistent with brain death, comprising diffuse cortical discoloration and advanced autolysis, with extremely friable, liquefying parenchyma, particularly of the brain-stem and cerebellum. The pituitary gland was also partially autolyzed. Death was attributed to bronchopneumonia following near-drowning.

### Table 1. Laboratory investigations on admission

<table>
<thead>
<tr>
<th>Hematology</th>
<th>Arterial Blood Gases*</th>
<th>Serum Electrolytes</th>
<th>Liver Biochemistry</th>
</tr>
</thead>
<tbody>
<tr>
<td>WBC 9.200/µL</td>
<td>H 7.24</td>
<td>Na 140 mmol/L</td>
<td>Alb 35 g/L</td>
</tr>
<tr>
<td>Hb 11.5 g/Dl</td>
<td>PaCO₂ 38.5 mmHg</td>
<td>K 3.9 mmol/L</td>
<td>Bil 9 µmol/L</td>
</tr>
<tr>
<td>Plt 267,000/µL</td>
<td>PaO₂ 104 mmHg</td>
<td>Cl 121 mmol/L</td>
<td>ALP 246 U/L</td>
</tr>
<tr>
<td>PT 21.6 s</td>
<td>HCO₃⁻ 16.3 mmol/L</td>
<td>Urea 3.2 mmol/L</td>
<td>ALT 229 U/L</td>
</tr>
<tr>
<td>PTT 191.2 s</td>
<td>SaO₂ 96.9 %</td>
<td>Creat 71 mmol/L</td>
<td>AST 714 U/L</td>
</tr>
</tbody>
</table>

WBC: white blood count; Hb: hemoglobin; Plt: platelet; PT: prothrombin time; PTT: activated partial thromboplastin time; PaCO₂: arterial carbon dioxide tension; PaO₂: arterial oxygen tension; HCO₃⁻: bicarbonate; SaO₂: arterial oxygen saturation; Na: sodium; K:potassium; Cl: chloride; Creat: creatinine; Alb: albumin; Bil: bilirubin; ALP: alkaline phosphatase; ALT: alanine aminotransferase; AST: aspartate aminotransferase

* Ventilatory settings: synchronized intermittent mandatory ventilation

| FiO₂ | 1.0 |
| PEEP | 5 cm H₂O |

### Table 2. Serum electrolytes trend

<table>
<thead>
<tr>
<th>Days of hospitalization</th>
<th>Na (mmol/L)</th>
<th>K (mmol/L)</th>
<th>Cl (mmol/L)</th>
<th>Urea (mmol/L)</th>
<th>Creat (mmol/L)</th>
<th>s.Osm (mOsm/L)</th>
<th>u.Osm (mOsm/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5th</td>
<td>182</td>
<td>3.3</td>
<td>154</td>
<td>3.1</td>
<td>67</td>
<td>359</td>
<td>110</td>
</tr>
<tr>
<td>10th</td>
<td>133</td>
<td>4.2</td>
<td>99</td>
<td>1.9</td>
<td>36</td>
<td>253</td>
<td>242</td>
</tr>
</tbody>
</table>

s.Osm: serum osmolality; u.Osm: urine osmolality
Discussion

In the literature worldwide, there is a paucity of papers on central DI (otherwise called cranial DI) as an occurrence in near-drowning patients. We believe this represents one of exceptionally few documented reports of central DI complicating the clinical course of near-drowning. Among the known causes of central DI, traumatic brain injury, hypophysectomy, neoplasms of the pituitary or brain, meningitis and vascular malformations rank as commoner etiologies [3].

Many near-drowned victims suffer from hypotension and profound cerebral hypoxia that can result in cerebral edema and hypoxic brain damage [4]. Hypoxic brain injury can potentially lead to SIADH due to uncontrolled leakage of arginine vasopressin (AVP) from injured neurons. In direct contrast to SIADH, it is equally conceivable that prolonged hypoxia from near-drowning can destroy the AVP-synthesizing neurons and cause central DI through AVP deficiency. The possible pathogenetic mechanisms of central DI in this patient were hypothalamic or posterior pituitary infarction, with or without stalk transection by pressure of an edematous pituitary stalk against the free edge of the diaphragma sellae. AVP release is an active process triggered by neurotransmitter-induced depolarization activating voltage-sensitive calcium channels via propagation of sodium-dependent action potentials over the hypothalamic neurons. Consequently, we postulate that central DI occurred in this patient instead of SIADH due to hypoxic injury-induced neuronal shock, during which no AVP was released from lack of adenine triphosphate (ATP). It is also possible that neuronal damage at the level of the hypothalamus and proximal neurohypophysis under hypoxic, ATP-depleted conditions led to release of predominantly biologically inactive precursors rather than metabolically active AVP, since bio-inactive pre-pro-vasopressin is localized to the magnocellular neuron ribosomes before its active transport down to the posterior pituitary as inactive neurosecretory granules where the peptides are then cleaved during their passage to the neurohypophysis into AVP and neurophysin (Figure 1).

Interestingly, there are documented reports of brain death causing central DI [5,6]. This is probably due to disruption of the hypothalmo-hypophyseal axis when brain death supervenes [7]. It is however mandatory to correct any severe fluid and electrolyte imbalances if these are present in order to satisfy the pre-requisites necessary for the diagnosis of brain-stem death. Ironi-
It is essential to treat central DI for the following reasons. Firstly, even if the patient has a grave prognosis, the severe hypernatremia resulting from dehydration would act as a confounding factor that precludes the diagnosis of brain-stem death. Secondly, when such patients have been declared to be brain dead and possibly considered suitable candidates for organ donation, it is necessary that severe electrolyte disturbances including hypernatremia due to DI be corrected in order to preserve the functional and structural integrity of the organs [18].

Finally, severe hypernatremia and hyperosmolality from dehydration due to DI can be detrimental to the brain and these should always be corrected in order to maximize the chances of recovery of such patients, especially in those with a better prognosis.

In retrospect, our patient’s abysmal prognosis was not totally unexpected as she fulfilled 3 out of 5 criteria of the Orlowski’s scoring system: age above 3 years, arterial pH lower than 7.10 and comatose state on arrival at the emergency department. The GCS itself should not be relied upon as the sole prognostic indicator as several investigators have found that between 15% to 29% of patients recovered well from near-drowning despite an initial GCS of 3 out of 15 [19]. In conclusion, central DI is a rare complication of near-drowning. Before the formal process of brain death certification can be performed, one prerequisite is normalization of plasma electrolytes. The accompanying fluid and electrolyte disturbances need to be corrected by DDAVP to maintain the organs in optimal condi-

**Figure 1.** Proposed pathogenesis of central diabetes insipidus following hypoxic injury subsequent to near-drowning.

Abbreviations used in the figure illustration:

- AVP – Arginine vasopressin
- SON – Supraoptic nucleus of hypothalamus
- PVN – Paraventricular nucleus of hypothalamus
- DI – Diabetes insipidus
- ATP – Adenosine triphosphate
- VSCC – Voltage-sensitive calcium channel
- Pit – Pituitary gland
tion to ensure better chances of patient recovery, or in the case of brain dead patients, for lawful organ procurement.

Conclusions

Central DI is a rare complication of near drowning and portends a grave prognosis. Clinicians, especially those in intensive care settings, should be alerted to this aftermath of near drowning. The accompanying fluid and electrolyte disturbances need to be treated by DDAVP to maintain the organs in optimal conditions to ensure better chances of patient recovery, or in the case of brain dead patients, for organ procurement for transplantation. Normalization of electrolytes is also one of the prerequisites before the formal process of brain death certification can be performed.

References