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# Central Diabetes Insipidus Following a Sports-Related Concussion: A Case Report

Cassidy M. Foley, DO,* and David H. Wang, MD, MS

A 24-year-old female swimmer presented to a sports medicine clinic with complaints of frequent urination and increased thirst. The patient admitted to progressive worsening of her symptoms over a 4-year period since suffering a concussion. A water deprivation test, antidiuretic hormone level, and diamino-8-D-arginine vasopressin challenge were completed, and the patient was diagnosed with persistent central diabetes insipidus. As concussion awareness increases, health care professionals will be faced with treatment of post-concussive patients more often. The aim of this case report is to increase awareness of possible pituitary dysfunction—specifically, central diabetes insipidus—following a concussion.

Keywords: concussion; diabetes insipidus; hypopituitarism; mild traumatic brain injury; sport

It is commonly reported that up to 3.8 million sports-related concussions occur every year in the United States.[7] The "Consensus Statement on Concussion in Sport" defined a concussion as "a complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces... [with] no abnormality on standard structural neuroimaging studies."[8] For this case report, we have applied the consensus statement's definition to our use of the words *concussion* and *mild traumatic brain injury*. However, the term *traumatic brain injury* indicates a more severe injury and is not used synonymously. We can expect that with increased awareness of concussions, more patients will present to health care providers seeking care and treatment for their injury and symptoms. Appropriate evaluation and management is essential to decrease long-term symptoms and prevent complications.[7]

Hypopituitarism is a form of neuroendocrine dysfunction that has been recognized as a complication of traumatic brain injuries.[1-3,9,11] The hypothalamic-pituitary communication system in the brain is responsible for secretion of homeostasis-regulating hormones.[11] Research has identified that traumatic brain injury commonly affects the levels of 7 pituitary hormones.[1-3,9,11] The anterior lobe synthesizes and secretes adrenocorticotropic hormone, thyroid-stimulating hormone, growth hormone, prolactin, and 2 gonadotropins: luteinizing hormone and follicle-stimulating hormone.[11] The posterior lobe stores and releases antidiuretic hormone (ADH).[3] Recent data have demonstrated that hypopituitarism can occur acutely in up to 56.5% of patients after the more severe diagnosis of traumatic brain injury.[11] Of the hormones affected, gonadotropic hormones and growth hormone have been identified as the most frequently deficient immediately following an injury.[9-11] Antidiuretic hormone is the only hormone from the posterior pituitary found to be affected.[10] Within a group of patients who suffered hypopituitarism acutely following a traumatic brain injury, deficiencies in ADH occurred slightly less often (50%) than gonadotropic hormones (61%) and growth hormone (56%).[10]

Antidiuretic hormone plays an important role in patients' ability to concentrate their urine, by assisting in the reabsorption of water from urine.[3] If patients lack secretion of ADH from the pituitary, they have central diabetes insipidus (DI).[3] Documented causes of central DI include direct damage to the pituitary by means of partial or complete transection of the stalk, vascular insults from thrombosis, hypotension or infarct, and pituitary swelling.[9] The function of the pituitary may also be compromised by cerebral edema surrounding the hypothalamic-pituitary region from skull fractures, intracranial bleeding, or operative mass evacuation.[3]

Past research has proved that traumatic brain injuries can result in acute central DI.[2,5,6,10,11] More often than not, the incidence of central DI decreases as patients move further out from the date of their injuries.[1,2] Acerini et al noted that the

From the Connecticut Children's Medical Center, Farmington, Connecticut

*Address correspondence to Cassidy M. Foley, DO, Connecticut Children's Medical Center, Elite Sports Medicine, 399 Farmington Avenue, 3rd Floor, Farmington, CT 06034 (e-mail: Tbeaulieu@ccmckids.org).

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Table 1. Water deprivation test results.[a]

| Time, h | Weight, kg | Urine Output, mL | Urine Osmolality, mmol/kg | Serum Osmolality, mmol/kg |
|---|---|---|---|---|
| 0 | 80.1 | 0 | 74 | 279 |
| 1 | 78.3 | 1000 | 53 | 289 |
| 2 | 77.9 | 840 | 66 | 288 |
| 3 | 77.4 | 450 | 188 | 288 |
| 4 | 77.2 | 100 | 613 | — |
| 5 | 77.2 | < 50 | 724 | — |

[a]3.5 hours: time at which diamino-8-D-arginine vasopressin was given, and the antidiuretic hormone level was drawn.

majority of cases resolved within several days to weeks after the traumatic brain injury.[1] Two other studies, which followed patients for 3 years and 1 year after their injuries, failed to identify any new cases of DI.[2,9] It also appears unlikely that patients experience delayed onset DI. However, it is possible for patients to experience persistent DI following a traumatic brain injury.[3]

## CASE REPORT

A 24-year-old elite swimmer from the Czech Republic presented with greater than a 4-year history of frequent urination and excessive thirst. She stated that she suffered from nocturia, which regularly awoke her 5 times a night, and she required fluids approximately every 1 to 2 hours. She admitted that her symptoms had been present for so long that she felt they were normal. She denied any other concerns, including diminished athletic performance. The patient described an event where she abruptly hit her head against the edge of the pool while she was swimming the backstroke. This mild traumatic brain injury, which occurred in the Czech Republic, did not result in a loss of consciousness but did require hospitalization for several days secondary to vomiting. The patient did not report abnormal imaging or laboratory values from her hospitalization. However, she identified that her increased urinary frequency and thirst presented shortly after the concussion. The patient described that over the past 3 years, her symptoms of nocturia and thirst had worsened to the point where her lifestyle had changed significantly to compensate.

Initial laboratory studies showed normal thyroid stimulating hormone level, serum glucose, and electrolytes. Her urine analysis showed no glucose, but her urine specific gravity was less than 1.005. DI was suspected, and a water deprivation test was performed (Table 1). The patient's urine osmolality was inappropriately dilute (< 300 mmol/kg) for a dehydrated state or for psychogenic DI.[3] Also, the patient's urine output was increased. She produced roughly 2500 mL of urine output during a 5-hour water deprivation test, making polyuria (> 3000 mL in 24 hours) likely in this patient.[2,3] The initial results of the water deprivation test indicated a lack of ADH from either the posterior pituitary or a nephrogenic insensitivity to the hormone. The patient's ADH level was < 1.2 pmol/L (0.9-4.6 pmol/L).

After the patient received diamino-8-D-arginine vasopressin,[6] her urine output decreased, and her urine osmolality rose to > 700 mmol/kg. The vasopressin test results indicated that the patient's symptoms were related to her lack of ADH production from the pituitary, also known as central DI.[2,3] Substantiating the diagnosis of central DI was the fact that the ADH level, when dehydrated, was inappropriately low (< 1.2 pmol/L) when it should have been elevated. A magnetic resonance image of the brain revealed normal results, indicating that the cause of this central DI was not structural. Because of the proximity of the concussion with the onset of symptoms and past medical research linking hypopituitarism to previous traumatic brain injury, the concussion may have initiated her symptoms.[1-3,5,6,9-11] The patient was initially treated with 10 µg of intranasal diamino-8-D-arginine vasopressin daily with a great improvement in her quality of life.

## DISCUSSION

As awareness and education surrounding concussions increase, more patients will present to their primary care providers seeking treatment. Sports-related concussions can result in a great array of symptoms whether they are behavioral, physical, cognitive, or emotional.[4] Concussions can also result in symptoms secondary to dysfunction of the hypothalamic-pituitary system. Research has identified that the incidence of traumatic brain injury "doubles between the age of 5 and 14 years and peaks in both males and females during adolescence."[1] Therefore, a large number of patients are prepubertal or pubertal and still have the potential for growth and maturation. Disruptions to the regulation of growth hormone, adrenocorticotropic hormone, or the gonadotropic hormones during childhood and adolescence can result in growth failure, delayed or arrested puberty, secondary amenorrhea, or reduced libido.[1] Hyperphagia, temperature instability, marked lethargy, and increased thirst and urination, as in our case, are markers for possible pituitary dysfunction.[1] This patient had symptoms associated with

hypopituitarism—specifically, reduced production of ADH—which may have occurred secondary to a concussion or mild traumatic brain injury.

DI has been identified as a result of traumatic brain injuries in past research.[1-3,5,6,9,10] One retrospective study conducted over a 4-year period found a 2.9% incidence of DI in traumatic brain injury patients.[5] Another study found that 26% of its population developed DI acutely following a computed tomography–documented brain injury.[2] These studies were conducted in an intensive care unit and a neurosurgical unit, respectively. The severity of the head injuries and the comorbidities were greater than those suffered by our patient. Past researchers concluded that DI is associated with more severe traumatic brain injury and lower Glasgow coma scale scores.[3]

When central DI occurs, it is often immediately following a traumatic brain injury.[10] Recovery of pituitary function is common, suggesting the presence of an effective repair mechanism.[11] Possible explanations include reabsorption of edema surrounding the hypothalamic-pituitary region or cessation of the release of inhibitory mediators.[3,11] Therefore, the symptoms associated with hypopituitarism also generally resolve over time. Agha et al found that 69% of the patients with DI following traumatic brain injury had recovered after 6 months and 77% recovered after 12 months.[2] Central DI may be persistent following a traumatic brain injury.[2,6] Agha et al noted that 6% to 6.9% of DI cases were persistent in patients with evidence of brain injury on magnetic resonance imaging or computed tomography.[2,3]

There is a high risk for pituitary dysfunction in children following traumatic brain injury.[3,9] Central DI can result in significant morbidity and mortality if not identified and treated. In a patient who has signs of an endocrine abnormality following a sport-related concussion, screening for pituitary dysfunction should be considered.

## REFERENCES


1. Acerini CL, Tasker RC, Bellone S, Bona G, Thompson CJ, Savage MO. Hypopituitarism in childhood and adolescence following traumatic brain injury: the case for prospective endocrine investigation. *Eur J Endocrinol.* 2006;155(5):663-669.
2. Agha A, Sherlock M, Phillips J, Tormey W, Thompson CJ. The natural history of post-traumatic neurohypophysial dysfunction. *Eur J Endocrinol.* 2005;152(3):371-377.
3. Agha A, Thornton E, O'Kelly P, Tormey W, Phillips J, Thompson CJ. Posterior pituitary dysfunction after traumatic brain injury. *J Clin Endocrinol Metab.* 2004;89(12):5987-5992.
4. Ayr LK, Yeates KO, Taylor HG, Browne M. Dimensions of postconcussive symptoms in children with mild traumatic brain injuries. *J Int Neuropsychol Soc.* 2009;15(1):19-30.
5. Boughey JC, Yost MJ, Bynoe RP. Diabetes insipidus in the head-injured patient. *Am Surg.* 2004;70(6):500-503.
6. Chou YC, Wang TY, Yang PY, Meng NH, Chou LW. Permanent central diabetes insipidus after mild traumatic brain injury. *Brain Inj.* 2009;23(13-14):1095-1098.
7. Halstead ME, Walter KD; American Academy of Pediatrics. Clinical report: sport-related concussion in children and adolescents. *Pediatrics.* 2010;126(3):597-615.
8. McCrory P, Meeuwisse W, Johnston K, et al. Concussion statement on concussion in sport: the 3rd International Conference on Concussion in Sport, held in Zurich, November 2008. *Clin J Sport Med.* 2009;19(3):185-200.
9. Niederland T, Makovi H, Gal V, Andreka B, Abraham CS, Kovacs J. Abnormalities of pituitary function after traumatic brain injury in children. *J Neurotrauma.* 2007;24(1):119-127.
10. Su DH, Chang YC, Chang CC. Post-traumatic anterior and posterior pituitary dysfunction. *J Formos Med Assoc.* 2005;104(7):463-467.
11. Tanriverdi F, Senyurek H, Unluhizarci K, Selcuklu A, Casanueva FF, Kelestimur F. High risk of hypopituitarism after traumatic brain injury: a prospective investigation of anterior pituitary function in the acute phase and 12 months after trauma. *J Clin Endocrinol Metab.* 2006;91(6):2105-2111.