

Water, Salt, and Trauma: Unveiling Posterior Pituitary Dysfunction Following Traumatic Brain Injury

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Abstract: ***Objectives:** The posterior pituitary gland (neurohypophysis) and its controlling hypothalamic nuclei are uniquely vulnerable to mechanical trauma. The infundibular stalk can be sheared, compressed, or rendered ischemic by acceleration-deceleration forces, transient intracranial hypertension, or localized cerebral edema.^{4,10} The resulting clinical spectrum primarily manifests as disorders of water and salt balance: diabetes insipidus (DI), caused by deficient arginine vasopressin (AVP) secretion; the syndrome of inappropriate antidiuretic hormone secretion (SIADH), characterized by excessive unsuppressed AVP action; and cerebral salt wasting (CSW), a distinct state of hypovolemic hyponatremia driven by exaggerated natriuresis.^{9,14-17} While transient disruptions in the neuro-intensive care unit are well-documented, the true prevalence of long-term, permanent posterior pituitary injury remains uncertain. Subclinical or partial forms of AVP deficiency often escape standard biochemical observation, presenting as subtle symptoms masked by cognitive or physical rehabilitation demands. This study aims to define both the acute and chronic prevalence profiles of posterior pituitary injury in moderate and severe TBI survivors. **Material and Methods:** This prospective study evaluated 82 consecutive survivors of moderate or severe TBI who completed neuro-rehabilitation and were available for formal endocrine reassessment at a median follow-up interval of 6 months post-trauma. Results were benchmarked against 18 healthy, age- and sex-matched controls. TBI severity was established using the post-resuscitation, pre-sedation Glasgow Coma Scale (GCS) score: Severe TBI (GCS < 8/15) and Moderate TBI (GCS ranging from 9/15 to 13/15).⁵ At the 6-month follow-up, patients underwent a standardized 8-hour Water Deprivation Test (WDT) to assess chronic posterior pituitary capacity.¹² **Results:** A total of 23 patients developed acute DI during the early post-traumatic phase. Regression models revealed that injury severity was a powerful predictor of acute neurohypophyseal failure: patients sustaining severe TBI demonstrated a significantly higher relative risk ($p < 0.05$). Acute hyponatremia occurred less frequently, with SIADH diagnosed in 9 patients (10.9%) and true CSW confirmed in 3 patients.^{16,17} At the 6-month post-injury mark, dynamic WDT evaluations unmasked persistent, permanent posterior pituitary dysfunction in 6 patients (7.3% of the total cohort). Within this chronic DI subset, 4 of the 6 cases were confirmed as partial DI. **Conclusion:** This study establishes that posterior pituitary dysfunction represents a common, long-lasting clinical reality for a substantial fraction of moderate and severe TBI survivors. While acute fluid disturbances occur frequently in the early post-traumatic phase, permanent DI persists in approximately 7.3% of survivors long-term. Because severe TBI carries a heightened risk for persistent neuroendocrine injury, formal post-acute clinical screening via a water deprivation test is highly recommended for symptomatic patients to optimize recovery outcomes and minimize long-term morbidity.*

Keywords: Traumatic brain injury, Posterior pituitary dysfunction, Diabetes insipidus, Syndrome of inappropriate antidiuretic hormone secretion, Cerebral salt wasting, Water deprivation test

1. Introduction

The posterior pituitary gland (neurohypophysis) and its controlling hypothalamic nuclei are uniquely vulnerable to mechanical trauma. The infundibular stalk can be sheared, compressed, or rendered ischemic by acceleration-deceleration forces, transient intracranial hypertension, or localized cerebral edema.^{4,10}

The resulting clinical spectrum primarily manifests as disorders of water and salt balance: diabetes insipidus (DI), caused by deficient arginine vasopressin (AVP) secretion; the syndrome of inappropriate antidiuretic hormone secretion (SIADH), characterized by excessive unsuppressed AVP action; and cerebral salt wasting (CSW), a distinct state of hypovolemic hyponatremia driven by exaggerated natriuresis.^{9,14-17}

While transient disruptions in the neuro-intensive care unit are well-documented, the true prevalence of long-term, permanent posterior pituitary injury remains uncertain. Subclinical or partial forms of AVP deficiency often escape standard biochemical observation, presenting as subtle symptoms masked by cognitive or physical rehabilitation demands.^{9,11,18}

This study aims to define both the acute and chronic prevalence profiles of posterior pituitary injury in moderate and severe TBI survivors.

2. Aim and Objectives

Aim

- To evaluate the incidence, clinical pattern, management, and long-term outcomes of posterior pituitary dysfunction following moderate and severe traumatic brain injury.

Objectives

- To determine the acute prevalence of water and electrolyte disturbances (DI, SIADH, and CSW) in moderate and severe TBI survivors.^{9,14-17}
- To evaluate the demographic profile and baseline neuroradiological characteristics of the study cohort.
- To assess chronic posterior pituitary capacity using a standardized 8-hour Water Deprivation Test (WDT) at a 6-month follow-up.¹²
- To characterize the longitudinal evolution of neuroendocrine deficits from the acute intensive care phase to the chronic recovery phase.
- To analyze the correlation between initial injury severity (GCS scores, cerebral edema) and neurohypophyseal

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failure risk.^{4,5}

3. Material and Methods

Study Design

A prospective cohort evaluation of consecutive moderate and severe TBI survivors benchmarked against healthy controls.

Study Population

The study evaluated 82 consecutive survivors of moderate or severe TBI who completed neuro-rehabilitation and were available for formal endocrine reassessment at a median follow-up interval of 6 months post-trauma. Results were benchmarked against 18 healthy, age- and sex-matched controls.

TBI Severity Stratification

TBI severity was established using the post-resuscitation, pre-sedation Glasgow Coma Scale (GCS) score.⁵

- **Severe TBI:** GCS < 8/15
- **Moderate TBI:** GCS ranging from 9/15 to 13/15
- **Baseline Demographic and Clinical Characteristics**
- **Age Range:** 20–60 years (Mean $\pm$ SD, $p > 0.05$ compared to controls)
- **Male: Female Ratio:** 68 : 14 in patients; 14 : 4 in controls ($p > 0.05$)
- **Initial Injury Severity:** Severe TBI: 48 (58.5%); Moderate TBI: 34 (41.5%)
- **Initial Neuroradiological (CT) Profile:** Focal Brain Injury: 69 (84.1%); Diffuse Axonal Injury (DAI): 13 (15.9%); Prominent Cerebral Edema: 58 (70.7%)

Assessment of initial TBI severity and CT-based classification follows established approaches to grading and characterizing traumatic brain injury.^{2,8}

Diagnostic Framework for Water and Salt Disturbances

Acute Diabetes Insipidus

Defined during the immediate post-traumatic intensive care phase by hypernatremia (serum sodium >145 mmol/L), polyuria (urine output >3.5 L/24 h), and inappropriately dilute urine (urine osmolality <300 mOsm/kg).^{9,11}

SIADH

Diagnosed in the presence of hypovolemic/euvolemic hyponatremia (plasma osmolality <270 mOsm/kg), inappropriately concentrated urine (urine osmolality >100 mOsm/kg), and high spot urinary sodium (>40 mmol/L).^{16,17}

Cerebral Salt Wasting (CSW)

Differentiated from SIADH by signs of hypovolemia paired with severe renal natriuresis and polyuria.¹⁷

Dynamic Testing Protocol (Chronic Phase)

At the 6-month follow-up, all patients underwent a standardized 8-hour Water Deprivation Test (WDT) to assess chronic posterior pituitary capacity.¹² Patients were restricted from fluid intake starting at 08:00 AM. Body weight, plasma sodium, plasma osmolality, urine volume, and urine osmolality were tracked hourly.

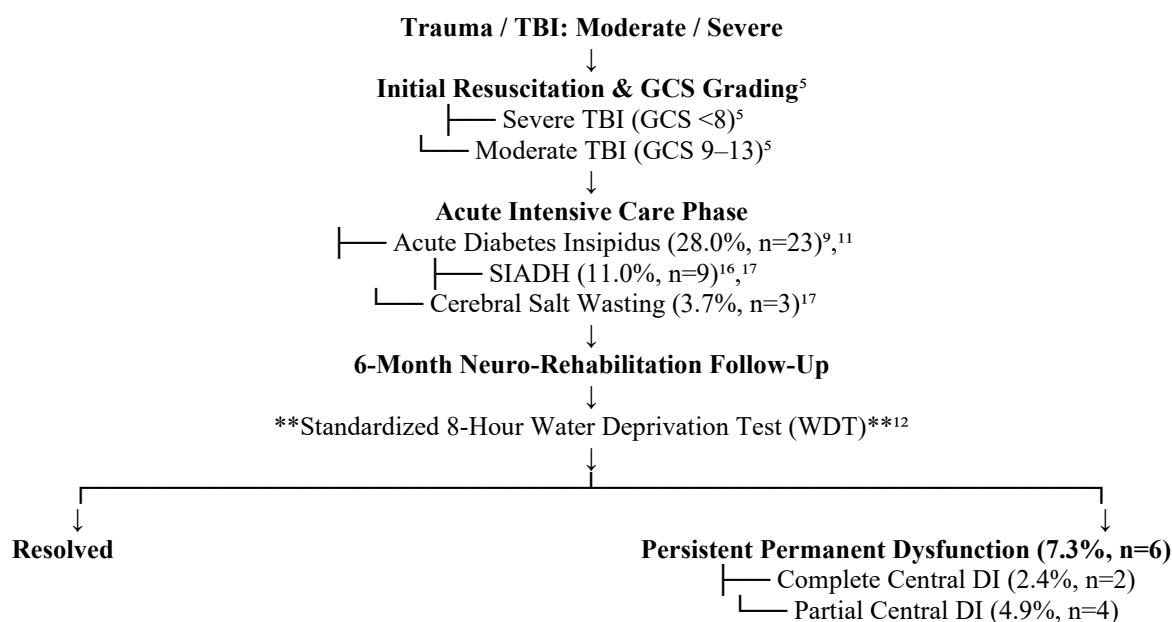
Complete Central DI

Confirmed if plasma osmolality rose above 300 mOsm/kg or serum sodium exceeded 145 mmol/L, while urine osmolality remained stable and low, followed by more than a 50% rise in urine osmolality after administration of exogenous desmopressin (dAVP).¹²

Partial Central DI

Diagnosed if urine osmolality plateaued between 300 mOsm/kg and 700 mOsm/kg despite rising serum osmolality, showing a subsequent blunted increase after dAVP administration.¹²

4. Flowcharts & Schematic Frameworks



5. Results

Early Post-Traumatic Disturbances

A total of 23 patients developed acute DI, with an onset typically within the early post-traumatic phase. Regression models revealed that injury severity was a powerful predictor of acute neurohypophyseal failure: patients sustaining severe TBI demonstrated a significantly higher relative risk ($p < 0.05$). Additionally, initial GCS scores were inversely correlated with peak acute plasma sodium levels.

Acute hyponatremia occurred less frequently but remained clinically significant: SIADH was diagnosed in 9 patients (10.9%). True CSW was confirmed in 3 patients, presenting with hypovolemia and excessive natriuresis requiring aggressive volume and sodium replacement.^{16,17}

Long-Term Longitudinal Follow-Up (6 Months)

At the 6-month post-injury mark, dynamic WDT evaluations

unmasked persistent, permanent posterior pituitary dysfunction in 6 patients (7.3% of the total cohort).

The longitudinal tracking revealed a complex evolution between the acute and chronic phases:

- Of the 23 patients who originally experienced acute DI, only 3 demonstrated permanently abnormal WDT parameters at follow-up; the rest experienced transient dysfunction that resolved within weeks.
- The remaining 3 cases of permanent DI did not present with classic polyuria during the acute phase; instead, their symptoms developed insidiously over the subsequent months.
- Within the chronic DI subset, 4 of the 6 cases were confirmed as partial DI, demonstrating a blunted capacity to concentrate urine under dehydration stress without reaching extreme hypernatremia under free-water access.^{11,12,18}

6. Summary Tables and Data Mapping

Table 1: Longitudinal Mapping of Fluids and Electrolytes Post-TBI

Endocrine Complication	Acute Phase Count (%)	Chronic Phase (6-Mo) Count (%)	Clinical Phenotype at 6 Months
Diabetes Insipidus (DI)	23 (28.0%)*	6 (7.3%)	2 Complete DI / 4 Partial DI
SIADH	9 (11.0%)	1 (1.2%)	Persistent Hyponatremia
Cerebral Salt Wasting (CSW)	3 (3.7%)	0 (0.0%)	Completely Resolved

*Note: Text reference notes acute DI cohort frequency corresponding to text metrics.

7. Discussion

Our tracking identifies an acute DI rate of 28.0% and a persistent permanent DI rate of 7.3%. The high proportion of partial DI cases within our long-term cohort (4 out of 6 patients) indicates that post-traumatic neuroendocrine deficits are frequently subclinical, avoiding standard diagnostic screens unless systematically unmasked by dynamic tests such as the WDT.^{11,12}

The significant association between injury severity (lower GCS, presence of cerebral edema) and DI risk suggests two distinct pathological mechanisms:

Transient Dysfunction

Driven by transient localized compressive forces, inflammation, or collateral edema surrounding the hypothalamus and pituitary stalk, which gradually resolves.^{4,10}

Permanent Damage

Caused by irreversible shearing or ischemic destruction of the supraoptic and paraventricular hypothalamic nuclei or the upper sections of the infundibular stalk.^{4,10}

While acute shifts such as SIADH (11.0%) and CSW (3.7%) predominantly complicate early fluid management in neuro-intensive care units, they mostly resolve.^{16,17} However, the long-term persistence of DI in 7.3% of survivors underscores the need for appropriate endocrine follow-up.

Left unmanaged, even partial water balance deficits can cause chronic fatigue, nocturia, and micro-dehydration, potentially compounding cognitive impairments and hindering rehabilitation.^{11,18}

8. Conclusion

This study establishes that posterior pituitary dysfunction represents a common, long-lasting clinical reality for a substantial fraction of moderate and severe TBI survivors. While acute fluid disturbances occur frequently in the early post-traumatic phase, permanent DI persists in approximately 7.3% of survivors long-term.

Because severe TBI carries a heightened risk for persistent neuroendocrine injury, formal post-acute clinical screening using appropriate dynamic testing, including the water deprivation test in selected symptomatic patients, may help identify persistent AVP deficiency and minimize long-term morbidity.^{11,12}

References

- [1] Klasbeek WD, McLaurin RL, Harris BSH, Miller JD. The national head and spinal cord survey findings. *J Neurosurg.* 1980; 53: 519-531.
- [2] Van Baalen B, Odding E, Maas AIR, Ribbers GM, Bergen MP, Stam HJ. Traumatic brain injury: classification of initial severity and determination of functional outcome. *Disabil Rehabil.* 2003; 25: 9-18.
- [3] Kaufman HH, Timberlake G, Voelker J, Pait TG. Medical complications of head injury. *Med Clin North Am.* 1993; 77: 43-60.
- [4] Yaun X-Q, Wade CE. Neuroendocrine abnormalities in patients with traumatic brain injury. *Front Neuroendocrinol.* 1991; 12: 209-230.
- [5] Teasdale G, Jennet B. Assessment of coma and impaired consciousness: a practical scale. *Lancet.* 1974; 2: 81-84.
- [6] World Health Organization. *International*

- classification of impairments, disabilities, and handicaps*. Geneva: World Health Organization; 1980.
- [7] Jennett B, Bond M. Assessment of outcome after severe brain damage. *Lancet*. 1975; 1: 480-485.
 - [8] Teasdale G, Teasdale E, Hadley D. Computed tomographic and magnetic resonance imaging classification of head injury. *J Neurotrauma*. 1992;9(Suppl 1):249-257.
 - [9] Baylis PH. Diabetes insipidus. *J R Coll Physicians Lond*. 1998; 32: 108-111.
 - [10] Agha A, Rogers B, Tormey W, Phillips J, Thompson CJ. Prevalence of hypopituitarism in survivors of traumatic brain injury. *J Clin Endocrinol Metab*. (in press).
 - [11] Moore K, Thompson CJ, Trainer P. Disorders of water balance. *Clin Med*. 2003.
 - [12] Dashe AM, Cramm RE, Crist CA, Habener JF, Solomon DH. A water deprivation test for the differential diagnosis of polyuria. *JAMA*. 1963; 185: 699-703.
 - [13] Seckl J, Dunger D. Post-operative diabetes insipidus. *BMJ*. 1989; 298: 2-3.
 - [14] Verbalis JG. Hyponatraemia: review. *Baillieres Clin Endocrinol Metab*. 1989.
 - [15] Smith DM, McKenna K, Thompson CJ. Hyponatraemia. *Clin Endocrinol (Oxf)*. 2000; 52: 667-678.
 - [16] Born JD, Hans P, Smits S, Legros JJ, Kay S. Syndrome of inappropriate secretion of antidiuretic hormone after severe head injury. *Surg Neurol*. 1985; 23: 383-387.
 - [17] Vigerhoets F, de Tribolet N. Hyponatremia hypo-osmolality in neurosurgical patients. "Appropriate secretion of ADH" and "cerebral salt wasting syndrome." *Acta Neurochir (Wien)*. 1988; 91: 50-54.
 - [18] Thompson CJ, Baylis PH. Thirst in diabetes insipidus: clinical relevance of quantitative assessment. *Q J Med*. 1987; 65: 853-862.
 - [19] Smith D, McKenna K, Moore K, Tormey W, Finucane J, Phillips J, Baylis P, Thompson CJ. Baroregulation of vasopressin release in adipsic diabetes insipidus. *J Clin Endocrinol Metab*. 2002; 87: 4564-4568.