Rare Presentation of Central Pontine Myelinosis Secondary to Hyperosmolar Hyperglycemia

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***Abstract*—Central pontine myelinolysis (CPM) is a rare demyelinating disorder typically linked to rapid correction of chronic hyponatremia, but can also occur in other settings of abrupt osmotic shifts. We report a case of a 62-year-old male with poorly controlled diabetes mellitus who presented with sudden onset of dysarthria, dysphagia, and gait instability. Despite being normonatremic throughout hospitalization, he exhibited severe hyperglycemia and elevated serum osmolality. Neurological examination revealed cranial nerve and cerebellar dysfunction, and MRI confirmed CPM. This case highlights hyperosmolar hyperglycemic state (HHS) as an uncommon yet important cause of CPM, emphasizing the need for careful management of fluid and glucose levels in diabetic emergencies to prevent serious neurological complications**

***Index Terms*—Central Pontine Myelinolysis (CPM), Diabetes Mellitus, Electrolyte Imbalance, Hyperosmolar Hyperglycemic State (HHS), Hyperglycemia, Demyelination, MRI, Neurological Complications, Osmotic Demyelination Syndrome.**

I. INTRODUCTION

Central pontine myelinolysis (CPM) is a form of osmotic demyelination syndrome (ODS)[1], a neurologic condition characterized by non-inflammatory demyelination, primarily affecting the central base of the pons. First described in 1959[1], CPM has traditionally been associated with the rapid correction of chronic hyponatremia, particularly in malnourished or alcoholic individuals. However, more recent evidence has expanded its etiologic spectrum to include other states[2,3] of rapid osmotic shifts, including hyperosmolar hyperglycemic state (HHS), liver transplantation, severe burns, and prolonged diuretic use.

The pathophysiology of CPM involves disruption of the blood-brain barrier[4,5] and osmotic injury to oligodendrocytes. In chronic hyponatremia, brain cells adapt by reducing intracellular osmolytes to prevent cerebral edema. If serum sodium is corrected too rapidly, the extracellular osmolality increases faster than the brain can reaccumulate osmolytes, leading to dehydration and shrinkage of brain cells, ultimately resulting in demyelination. In HHS, although sodium levels may be normal or even low, the rapid fall in plasma glucose and water shifts during insulin and fluid therapy can similarly increase plasma osmolality, precipitating CPM.

Clinical presentation can be variable. While some patients remain asymptomatic or recover fully, others develop serious neurological deficits, ranging from dysarthria, dysphagia, and quadriparesis to the devastating "locked-in" syndrome, where cognitive function is preserved but voluntary movement is almost entirely lost. MRI imaging, particularly T2-weighted and FLAIR sequences, typically reveals symmetric hyperintensities in the central pons without mass effect or enhancement.

Management is largely supportive, emphasizing prevention by ensuring gradual correction of metabolic derangements. Guidelines recommend limiting sodium correction to ≤8–10 mEq/L in the first 24 hours and ≤18 mEq/L in 48 hours[6]. In hyperosmolar states like HHS, clinicians should also correct plasma glucose and osmolality slowly to avoid iatrogenic injury.

This case illustrates a rare presentation of CPM in the setting of HHS, reinforcing the importance of recognizing hyperglycemia-induced osmotic injury as

a potential cause of pontine demyelination and underscores the need for careful monitoring and tailored correction of metabolic imbalances.

II. DESCRIPTON OF THE CASE

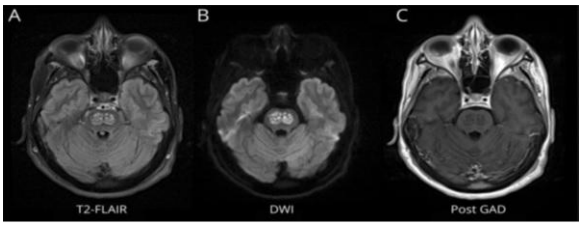
A 62-year-old male presented to the emergency department with a 10-day history of progressive neurological symptoms, including slurred speech (dysarthria), difficulty swallowing (dysphagia), nasal regurgitation, and unsteadiness of gait. His symptoms began insidiously and gradually worsened, notably affecting his ability to swallow liquids more than solids. There was no history of limb weakness, diplopia, sensory deficits, seizures, fever, or altered sensorium. His family reported no recent falls, trauma, or intoxication. The patient was known to have type 2 diabetes mellitus for 15 years, with poor glycemic control and irregular adherence to treatment. He denied alcohol use, liver disease, or recent illness.

On examination, the patient was hemodynamically stable (BP 120/80 mmHg, HR 82 bpm), afebrile, and fully conscious, oriented to time, place, and person. Cranial nerve examination revealed bilateral nystagmus, dysarthria, reduced palatal elevation with diminished gag reflex, and spastic bilateral tongue movements, indicating involvement of lower cranial nerves and corticobulbar tracts. Mild bilateral facial weakness was observed. No sensory or motor deficits were present in the limbs, but deep tendon reflexes were sluggish and plantars were bilaterally flexor. Cerebellar signs were positive with bilateral dysmetria and unsteady tandem gait, suggesting pontocerebellar involvement. The remainder of the systemic examination was unremarkable..

III. REPORTS

Laboratory investigations revealed marked hyperglycemia with a random blood glucose level of 538 mg/dL on admission. Serum sodium was within the normal range throughout hospitalization (133–138 mmol/L), potassium 3.58 mmol/L, chloride 100 mmol/L, and serum osmolality was elevated at 302 mOsm/kg, confirming a diagnosis of hyperosmolar hyperglycemic state (HHS). Notably, urine ketones were negative, ruling out diabetic ketoacidosis (DKA). Renal function was preserved (creatinine 1.37 mg/dL), and liver function tests were within normal limits. Inflammatory markers including ESR and leukocyte count were unremarkable

MRI of the brain revealed symmetric hyperintensity in the central pons on T2-weighted and FLAIR sequences, without contrast enhancement or mass effect—findings characteristic of central pontine myelinolysis. No other white matter or cortical lesions were identified. There was no evidence of ischemia, hemorrhage, or space-occupying lesions. The diagnosis of CPM secondary to rapid osmotic shifts during treatment of HHS was made.



In light of normonatremia, alternative etiologies such as brainstem infarction, Bickerstaff brainstem encephalitis, and multiple sclerosis were considered but ruled out based on imaging and clinical evolution. The absence of fever, CSF abnormalities (if done), or systemic signs also made infectious or parainfectious causes unlikely. The absence of alcohol use or liver dysfunction ruled out classic risk factors for CPM.

The patient was managed with cautious rehydration using isotonic saline and controlled insulin infusion, targeting a gradual reduction in serum glucose and osmolality. Electrolytes were monitored closely to avoid rapid shifts. Supportive care including speech therapy and aspiration precautions were initiated.

Over the following two weeks, his dysarthria and swallowing difficulty gradually improved, though gait ataxia persisted. He was discharged on subcutaneous insulin and scheduled for outpatient neurorehabilitation.

IV. DISCUSSION

Central Pontine Myelinolysis (CPM) is traditionally regarded as a neurologic complication of rapid correction of chronic hyponatremia, especially in individuals with predisposing risk factors such as

alcoholism, liver disease, malnutrition, or electrolyte imbalances. However, emerging evidence has broadened our understanding[2] of the condition's etiology, recognizing **osmotic stress per se**, irrespective of sodium levels, as the central pathogenic driver.

Our case is unique in that CPM occurred in a normonatremic patient, suggesting an alternative pathophysiological mechanism linked to hyperosmolar hyperglycemic state (HHS). This observation aligns with recent literature indicating that hyperosmolarity alone—especially when corrected rapidly—can induce myelinolysis. The central basis pontis is particularly susceptible to osmotic shifts due to its dense admixture of gray and white matter and its relatively limited capacity to adapt to rapid extracellular osmolality changes.

In HHS, plasma glucose levels often exceed 600 mg/dL[7], leading to increased serum osmolality (>320 mOsm/kg). Brain cells adapt by accumulating idiogenic osmoles; however, with rapid rehydration and insulin therapy, a sudden intracellular influx of water can cause endothelial dysfunction, disruption of the blood-brain barrier, and cellular edema, ultimately resulting in non-inflammatory demyelination. This pathogenesis mirrors that of hyponatremia correction, supporting the hypothesis that rate of osmotic change is more important than the absolute values of serum sodium or glucose.

A systematic review by Martin (2004)[1] and subsequent case reports (e.g., Singh et al., 2012; Dhanjal et al., 2015)[6] have documented instances of CPM following HHS, often in elderly patients with uncontrolled diabetes. In these cases, sodium was often normal or mildly elevated, reinforcing the concept that rapid shifts in effective osmolality during glucose correction are culpable. Our patient's sodium remained within 133–138 mmol/L during hospitalization, excluding classical ODS triggers and pointing toward HHS-induced injury.

From a diagnostic standpoint, clinical suspicion is essential. CPM may present subacutely, with symptoms including dysarthria, dysphagia, quadriparesis, pseudobulbar palsy, and ataxia. Notably, the classic "locked-in" syndrome, while feared, is relatively uncommon and reflects severe pontine involvement. In our patient, the combination of lower cranial nerve dysfunction, spastic tongue movements, and cerebellar ataxia warranted early neuroimaging. MRI remains the gold standard, with symmetric T2/FLAIR hyperintensities in the central pons and no contrast enhancement, diffusion restriction, or mass effect, which are key to differentiating CPM from brainstem infarction or infiltrative disorders.

Differential diagnoses in this context include ischemic stroke of the brainstem, Bickerstaff brainstem encephalitis, glioma, multiple sclerosis, and infectious brainstem syndromes (e.g., Listeria rhombencephalitis). However, the absence of fever, leukocytosis, CSF abnormalities, and the radiological pattern in our case argued against these conditions.

This case underlines the clinical imperative for gradual correction of metabolic derangements, not just hyponatremia. According to *Harrison's Principles of Internal Medicine*[2], sodium correction should not exceed 8–10 mmol/L in 24 hours, and similar caution should be applied in the management of hyperosmolar states. The American Diabetes Association also emphasizes[8] slow rehydration and reduction of glucose levels in HHS to prevent cerebral edema or demyelinating complications.

Importantly, there is no specific treatment for CPM. Management remains supportive, focused on preventing further osmotic insults and facilitating neurorehabilitation. Some reports have explored corticosteroids[5], plasmapheresis, and IVIG, but none are established therapies. Our patient showed partial recovery with supportive care, highlighting the potential for neurological improvement if diagnosed and managed early.

V. HELPFUL CLINICAL POINTS

- Normonatremia Does Not Exclude Osmotic Demyelination Syndrome (ODS): Although classical teaching emphasizes rapid correction of chronic hyponatremia as the predominant cause of CPM, it is now recognized

that any rapid change in serum osmolality—regardless of sodium level—can precipitate CPM. This case highlights that even patients with normonatremia are at risk if they experience rapid correction of hyperglycemia or plasma osmolality, as seen in hyperosmolar hyperglycemic state (HHS).

- Rate of Osmotic Correction Is More Crucial Than Absolute Values:
  The speed of change in effective osmolality, rather than the actual levels of serum sodium or glucose, is the primary pathogenic factor in osmotic demyelination. Guidelines recommend correcting serum sodium at a rate not exceeding 8–10 mmol/L in the first 24 hours, and similarly, glucose should be lowered gradually (50–75 mg/dL per hour) in HHS to avoid cerebral edema and demyelination. This reinforces the principle of "slow and steady" correction in metabolic emergencies.
- HHS Is an Underrecognized Precipitant of CPM:
  While hyponatremia remains the most cited risk factor, HHS is increasingly reported in case literature as a direct cause of CPM, especially in elderly patients with poorly controlled diabetes. Hyperglycemia alone, through mechanisms involving blood-brain barrier disruption, endothelial dysfunction, and osmotic imbalance, can create the setting for non-inflammatory demyelination in the central pons.
- Clinical Presentation May Be Subtle and Subacute:
  CPM does not always present with the dramatic "locked-in syndrome." Instead, as in our patient, bulbar symptoms such as dysarthria, dysphagia, nasal regurgitation, and gait ataxia may be the earliest and only signs. Recognizing this non-classical, slowly evolving presentation is critical for timely imaging and intervention.
- High Index of Suspicion in Vulnerable Populations:
  Patients with diabetes mellitus, especially those with poor glycemic control, advanced age, or co-morbidities (e.g., renal dysfunction, malnutrition), are at higher risk of ODS when exposed to osmotic shifts. Physicians should maintain a high clinical index of suspicion for CPM in such populations when neurological symptoms emerge during metabolic correction.
- MRI Is the Diagnostic Modality of Choice:
  MRI brain with T2-weighted, FLAIR, and DWI sequences is essential for diagnosing CPM, showing symmetric hyperintense lesions in the central pons without mass effect or enhancement. Early imaging is crucial in differentiating CPM from ischemic stroke, encephalitis, demyelinating disorders, or brainstem neoplasms, which may have overlapping symptoms but different radiologic signatures and treatment implications.
- No Definitive Treatment—Prevention Is Paramount:
  There is no established therapy for CPM once demyelination occurs. Management is largely supportive, emphasizing preventing further osmotic insults, ensuring adequate hydration, and initiating neurorehabilitation. Hence, prevention via controlled correction of metabolic parameters is the cornerstone of care.
- Functional Recovery Is Possible With Early Detection:
  Contrary to earlier beliefs that CPM always leads to permanent deficits, recent case series suggest that timely recognition and supportive care can result in partial or even full neurological recovery. This underscores the value of early diagnosis, clinical vigilance, and multidisciplinary rehabilitation strategies

VI. CONCLUSION

This case underscores an important and underrecognized cause of central pontine myelinolysis—hyperosmolar hyperglycemic state (HHS)—in the absence of hyponatremia. It highlights the fact that rapid correction of plasma osmolality, regardless of the serum sodium level, can precipitate serious neurological complications including CPM. Clinicians managing hyperglycemic crises must be vigilant not only about correcting hyperglycemia and dehydration but also about doing so at a controlled and gradual pace. Early identification of neurological symptoms, timely neuroimaging, and supportive care can significantly influence functional recovery. This case adds to the growing body of evidence that osmotic demyelination syndromes should be

considered in patients with unexplained neurological deficits during the management of metabolic emergencies—even in normonatremic individuals.

APPENDIX

Appendix A: Laboratory Results on Admission

Parameter	Result	Reference Range
Random Blood Sugar (RBS)	538 mg/dL	70–140 mg/dL
Serum Sodium (Na^+)	133 mmol/L	135–145 mmol/L
Serum Potassium (K^+)	3.58 mmol/L	3.5–5.0 mmol/L
Serum Chloride (Cl^-)	100 mmol/L	98–106 mmol/L
Serum Osmolality	302 mOsm/kg	275–295 mOsm/kg
Urea	33.9 mg/dL	10–50 mg/dL
Creatinine	1.37 mg/dL	0.7–1.3 mg/dL
Hemoglobin	13.2 g/dL	13–17 g/dL (Males)
Total Leukocyte Count	7700 /mm³	4000–11000 /mm³
Platelet Count	2.46 lakh/mm³	1.5–4.0 lakh/mm³
ESR	10 mm/hr	<20 mm/hr
Urine Ketones	Negative	—
SGOT/SGPT	13 / 10 IU/L	<40 IU/L
Alkaline Phosphatase	126 IU/L	40–129 IU/L
Serum Bilirubin (T/D)	0.3 / 0.1 mg/dL	<1.2 / <0.3 mg/dL

Appendix B: Imaging Summary

- MRI Brain (T2-FLAIR and DWI): Symmetric hyperintensity in the central pontine region without contrast enhancement, diffusion restriction, or mass effect—findings consistent with central pontine myelinolysis.

Appendix C: Hospital Course Summary

- Day 1: Admission with HHS; initiated controlled fluid resuscitation and insulin therapy.
- Days 2–5: Neurological symptoms stabilized; supportive care continued; electrolytes monitored.
- Day 6: MRI confirmed CPM.
- Day 10+: Clinical improvement in dysphagia and dysarthria; gait instability persisted.
- Discharged with follow-up plan for rehabilitation and glycemic control.

Appendix D: Consent for Publication

Written informed consent was obtained from the patient for the publication of this case report and accompanying clinical details and imaging. A copy of the signed consent is available for review by the journal's editorial office upon request.

Appendix E: Abbreviations Used

Abbreviation	Full Form
CPM	Central Pontine Myelinolysis
HHS	Hyperosmolar Hyperglycemic State
MRI	Magnetic Resonance Imaging
RBS	Random Blood Sugar
DTRs	Deep Tendon Reflexes
ESR	Erythrocyte Sedimentation Rate
DWI	Diffusion-Weighted Imaging
T2-FLAIR	T2-weighted Fluid-Attenuated Inversion Recovery

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