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*Case Report*

# Acute hyponatremia post craniotomy resulting in a unilateral fixed and dilated pupil: A case study on diagnosis and management

David J. Caldwell, Justin K. Scheer, Gray Umbach, Manish K. Aghi

Department of Neurological Surgery, University of California San Francisco, San Francisco, California, United States.

E-mail: *David J Caldwell - david.caldwell@ucsf.edu; Justin K. Scheer - jks2243@cumc.columbia.edu; Gray Umbach - gray.umbach@ucsf.edu; Manish K Aghi - manish.aghi@ucsf.edu

***Corresponding author:**
David J. Caldwell,
Department of Neurological Surgery, University of California San Francisco, San Francisco, California, United States.

david.caldwell@ucsf.edu

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## ABSTRACT

**Background:** Postoperative hyponatremia is a known complication of intracranial surgery, which can present with depressed mental status. Hyponatremia resulting in focal neurologic deficits is less frequently described.

**Case Description:** We describe a patient who, after a bifrontal craniotomy for olfactory groove meningioma, developed acute hyponatremia overnight with a decline in mental status from Glasgow coma scale (GCS) score 15 to GCS 7 and a unilateral fixed dilated pupil. Head computed tomography showed expected postoperative changes without new acute or localizing findings, such as unilateral uncal herniation. The patient's mental status and pupil immediately improved with the administration of mannitol; however, there was a subsequent decline in mental status with a preserved pupil later that morning. Hypertonic saline reversed the neurologic change, and the patient was eventually discharged without a neurologic deficit. Focal neurologic deficits need not always arise following a craniotomy from a postoperative hematoma, stroke, or other finding with radiographic correlate.

**Conclusion:** Post-craniotomy hyponatremia should now be seen as a postoperative complication that can result in both a general neurologic decline in mental status, as well as with focal neurologic signs such as a fixed, dilated pupil, which can be reversed with hyperosmolar therapy and correction of the hyponatremia.

**Keywords:** Craniotomy, Hyponatremia, Meningioma

## INTRODUCTION

Intracranial surgery can result in a variety of postoperative complications, one of which is postoperative hyponatremia. This is a well-described phenomenon which often presents with depressed mental status and lethargy[16,17] and can progress to seizures and death. Hyponatremia can occur after surgery for lesions in the sellar and suprasellar region,[10] in the setting of patients with aneurysmal subarachnoid hemorrhage,[1] as well as after craniotomies for other supratentorial lesions.[6]

Postoperative hyponatremia can be due to several factors, which include water retention,[16,17] as well as the inability of kidneys to retain sodium and subsequent blood volume depletion.[12] These causes exist on a spectrum[12], from the syndrome of inappropriate antidiuretic hormone[6] (SIADH) to cerebral salt wasting (CSW), which are treated differently, with fluid restriction

and with fluid administration and hypertonic solutions, respectively.[7] Here, we discuss the case of a patient with an olfactory groove meningioma who developed acute hyponatremia following an uncomplicated bifrontal craniotomy and had an acute neurologic decline with a focal neurologic deficit of a fixed, dilated pupil. After correction of her hyponatremia, she was eventually discharged neurologically intact.

## CASE REPORT

The patient was a 50-year-old female who presented initially with anosmia and headaches. Computed tomography (CT) and magnetic resonance imaging (MRI) revealed an enhancing extra-axial 4.1 × 4.3 × 3.6-centimeter mass originating from the cribriform plate with extension into the planum sphenoidale. She had no other focal neurologic deficits preoperatively. Her preoperative sodium was 138 millimoles/liter (mmol/L). On the day of surgery, she underwent an elective uncomplicated bifrontal craniotomy for tumor resection that took 4 h and 9 min. 63 g of mannitol was given intraoperatively. On her postoperative examination, she was alert and oriented ×3 but with perseverative speech. She was full strength on motor examination without any pronator drift and did not have any observable cranial nerve deficits. She was admitted to the neurologic intensive care unit (ICU) postoperatively with intravenous fluids (normal saline) running at 125 milliliters (mL)/hour (h). Her postoperative sodium was 139 mmol/L at 1 h postoperatively with a lactate of 5.1 mmol/L that was down-trending from a peak of 7.7 mmol intraoperatively. She had 5.1 liters (L) of total urine output (UOP) by 2 h postoperatively and an additional 2.5 L by 14 h postoperatively (an average of 206 mL/h for the 12 h in between). Her net fluid balance was −185 cc at the 14-h postoperative time point, and she had received 2 L of additional NS boluses overnight. Her evening sodium 7 h postoperatively was 132 mmol/L with preserved mental status. At this point, every 6-h sodium laboratory checks were begun, and urine studies were sent. Her urine specific gravity was 1.018, her urine osmolality was 698, and her urine sodium was 263. at this time, her serum sodium was 132, her serum creatinine 0.38, and her serum urea nitrogen 10. Her sodium decreased to 129 mmol/L 14 h postoperatively, and 3% was started at 30 mL/h. Shortly after, the patient had an acute decline in neurologic status after feeling nauseous and receiving prochlorperazine. On examination, her Glasgow coma scale (GCS) was GCS7 (E1V1M5), with localization in her bilateral upper extremities. Her right neurologic pupil index (NPI) was 0, with a size of 5.44 mm, and her left NPI was 3.2, with a size of 2.0 mm. She was protecting her airway. The decision was made to administer hyperosmolar therapy and obtain a CT due to the concern for a new mass lesion, such as postoperative hematoma causing her acute decline in GCS and a focal neurologic deficit. 25 g of mannitol was given at 15 h postoperatively, and her imaging was obtained shortly after [Figure 1]. Although the brain appears full, this was the case pre-operatively as well. There were no obvious abnormalities on the head CT, and the final read stated expected postsurgical changes and no new hypodensities. On returning to the ICU and after receiving mannitol, her examination had improved rapidly to GCS 14 (E4V4M6), with a right NPI of 4.5 and size of 2.65 mm, and a left NPI of 4.6 with size of 2.12 mm. Given the brisk response to hyperosmolar therapy and no focal lesion seen on imaging, the findings were thought to be most likely from acute cerebral edema from hyponatremia. Her sodium at this 15 h time point was 126. Later in the morning, she had a subsequent decrease in alertness with preserved pupils and was given 30 mL of 23.4% hypertonic sodium chloride with immediate improvement 18 h postoperatively. Her sodium had increased to 137 mmol/L 22 h postoperatively, and the hypertonic saline infusion was discontinued. To help maintain her sodium level (subsequently maintained between 134 and 142), it was restarted at 10 mL/h titrated up to 20 mL/h, and tapered back to 10 mL/h. It was eventually discontinued completely on postoperative day 4. Her sodium was 136 on postoperative day 5, and she was discharged neurologically intact. Postoperative MRI acquired on postoperative day 2 showed gross total resection of the mass with expected postoperative changes [Figure 2], with no lesions that would have explained the unilateral pupillary findings.

## DISCUSSION

Although previously known, acute hyponatremia can occur immediately postoperatively following a craniotomy, even without subarachnoid hemorrhage or disruption of the sellar region. The incidence of postoperative hyponatremia in the first 24 h appears rare, as a study looking at elective craniotomies for brain tumor surgeries looking at 188 patients demonstrated only one patient having diabetes insipidus and none having dysnatremia.[9] Similarly, another study looking at postoperative complications and 30-day readmissions in 243 patients undergoing craniectomy or craniotomy did not specifically identify any patients with sodium abnormalities as either a complication or reason for readmission.[5] Another study looking at 207 consecutive patients undergoing a 1st-time craniotomy for an intra-axial tumor demonstrated only one patient with an electrolyte imbalance.[2]

Although hyponatremia is generally thought to result in an overall decline in mental status and lethargy, we show here an acute focal cranial nerve deficit without mass lesion on CT that reversed rapidly with correction of the hyponatremia using hyperosmolar therapy and sodium correction. Given an improvement in symptoms with the administration of

mannitol, one possible mechanism of this change is cerebral edema secondary to hyponatremia that resulted in transient compression of the 3rd nerve; however, there was no imaging correlate seen. Of note, the patient was receiving mannitol before the CT scanner, so it is possible that there was a local mass effect that resolved by the time of imaging or was not well visualized on CT. A previous case study in a child with aneurysm subarachnoid hemorrhage demonstrated acute hyponatremia (Na 128) leading to a decline in GCS and evidence of transtentorial herniation on CT imaging, although the authors did not describe any focal cranial nerve deficit.[3]

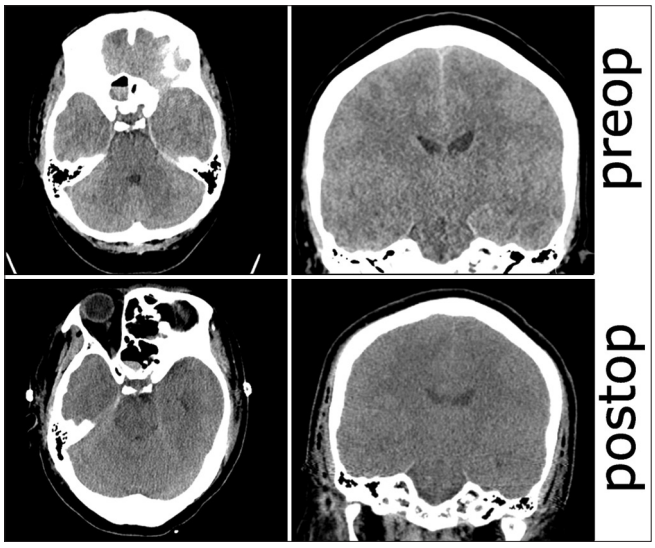


**Figure 1:** Pre- and post-operative day 1 computed tomography scans. The postoperative scan was acquired shortly after the patient developed a depressed neurologic status and focal neurologic deficit and minutes after mannitol had been started. Postoperative changes, but no focal mass lesions or postoperative complications were seen on the final read. Of note, the brain appears full both pre-and post-operatively.

The post-craniotomy neurologic decline can have several causes, including the mass effect (which can be secondary to a focal lesion such as a hematoma or, more in general, edema) and seizure. In one of the prior studies looking at 188 patients undergoing craniotomy, they reported ten patients who had a neurologic deterioration in the first 24 hours, with intracranial hematoma being found in 3.[9] Postoperative edema (or swelling) has been noted to occur and can result in postoperative transient neurologic worsening, as shown in 16 patients out of the 207 studied.[2] In this case, the authors documented the postoperative edema was seen on a CT scan and was treated with steroids, which is different from in our patient.

As for the origin of the hyponatremia, possible mechanisms for hyponatremia include SIADH and CSW. The patient had an elevated urine osmolality and urine sodium,[7] which can be seen in both, but given the patient was net negative (−185 cc at the 14 h time point) and had a markedly elevated urine osmolality and sodium, this most closely resembles CSW. The hyponatremia resolved with fluids and sodium administration rather than fluid restriction, more

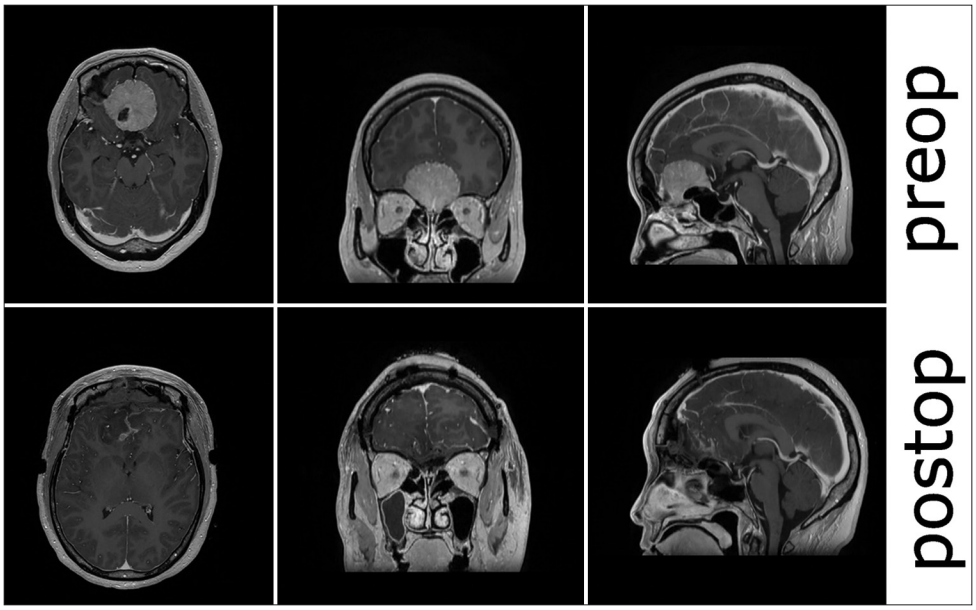


**Figure 2:** Post contrast pre- and postoperative day 2 magnetic resonance imaging scans. Of note is a gross total resection with expected postoperative changes and no evidence of a lesion that would have explained a focal cranial nerve deficit.

consistent with CSW. The previous literature noted that aneurysmal subarachnoid hemorrhage patients frequently had CSW, whereas the control group of brain tumor patients undergoing craniotomy did not have increased UOP and urinary sodium excretion.[1] Of note, in this study, hyponatremia was not observed in either group. Another less likely possibility is transient hyponatremia secondary to mannitol, as it has been previously noted in the literature that mannitol given in preparation for a craniotomy can result in acute intraoperative hyponatremia.[8] However, in that case, the hyponatremia resolved after adequate diuresis and the hyponatremia was thought to be secondary to temporary blood dilution. In the present study, the hyponatremia occurred after significant diuresis from the intraoperative mannitol had already occurred, and the hyponatremia was noted while the patient was in the ICU, not intraoperatively. Interestingly, several hours later, after the first episode, the patient had another episode of depressed mental status that reversed quickly with hypertonic saline, pointing to the source of the deficit likely as hyponatremia with subsequent cerebral edema. Hyponatremia secondary to CSW is treated with fluid administration and replacement of sodium, rather than fluid restriction.[7,13] One limitation of our study is that we did not measure the serum osmolality in the period of acute hyponatremia, and we did not track uric acid, albumin, or 24-hour urine excretion, which can further interrogate the function of the kidneys and fluid balance.[7,13] Even with a severe decline in GCS and focal deficit, the patient recovered quickly and was discharged without a neurologic deficit, highlighting the importance of vigilance and prompt correction of imbalances in post-craniotomy electrolyte disorders. Hyponatremia resulting in the development of cranial nerve palsy has been rarely described in the case of series before.[15] However, in the previously published case, the patient had pituitary apoplexy, was not postoperative, had more severe hyponatremia (~110 mmol/L) than in our patient's case, and the etiology was most likely secondary to SIADH.

As for the mechanism of hyponatremia causing brain edema, aquaporin 4 channels within astrocytes control water movement, and regulatory mechanisms in brain cells cause the immediate efflux of ions and, subsequently water to restore normal volume in the setting of hypotonicity.[4] The rate of osmolality change influences the degree to which neurologic symptoms emerge, and despite protective mechanisms in the brain, the brain is sensitive to shifts in tonicity. Edema is classically considered to be classified as cytotoxic or vasogenic, with cytotoxic edema secondary to an increase in intracellular fluid and vasogenic edema secondary to disruption of the blood-brain barrier and an increase in extracellular fluid.[11] Other authors classify additional types or subtypes of edema, including osmotic edema resulting from osmotic imbalances and interstitial edema as a consequence of disorders in cerebrospinal fluid movement.[14] Although not seen in our case, patients with hyponatremia can sometimes have brain swelling and edema seen on CT scans.[3]

## CONCLUSION

We describe a focal cranial nerve deficit acutely resulting after a craniotomy for a meningioma, most likely secondary to cerebral edema from craniotomy-related hyponatremia, with rapid recovery of neurologic function with hyperosmolar therapy and sodium correction. No imaging correlate explained the focal deficit. These findings are limited by the number of subjects ($n$ = 1), as well as the fact that our postoperative imaging during the episode of hyponatremia was limited to a CT, restricting our ability to assess for specific MRI findings such as edema better seen on a T2 sequence, cranial nerves, or the extent of residual tumor. Despite our limitations, these findings are relevant broadly to cranial neurosurgery, as sodium imbalance is a common postoperative problem and can have significant morbidity and mortality if not identified and managed. Not all focal neurologic signs need to be secondary to a postoperative hemorrhage or a mass lesion and may be a sign of worsened cerebral edema secondary to electrolyte disturbances requiring swift correction.

### Ethical approval

The Institutional Review Board approval is not required.

### Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent.

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### Conflicts of interest

There are no conflicts of interest.

### Use of artificial intelligence (AI)-assisted technology for manuscript preparation

The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

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