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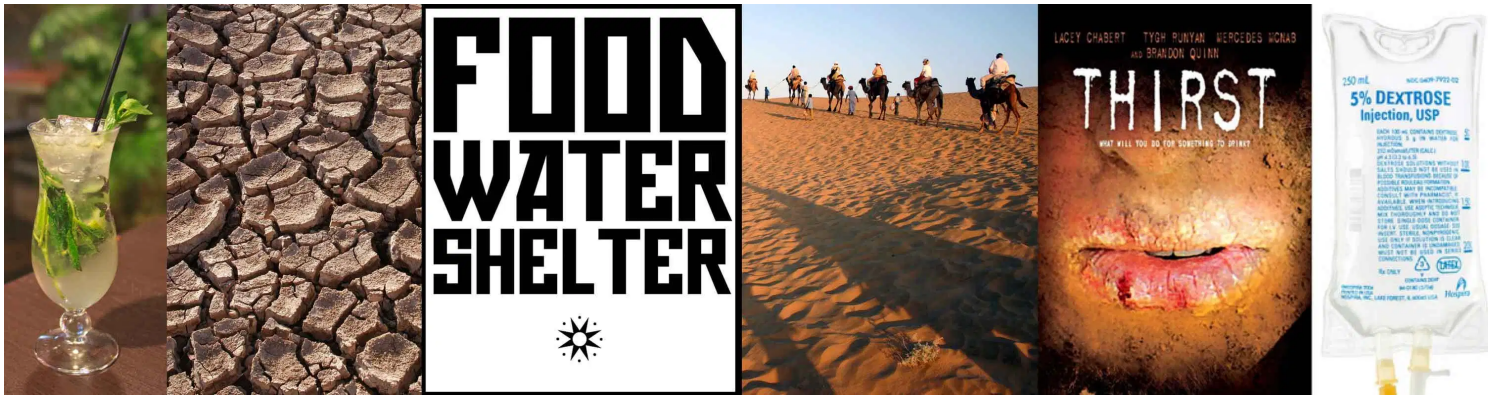
Hypernatremia & dehydration in the ICU

November 2, 2016 by Josh Farkas



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why hypernatremia is important in the ICU

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- Hypernatremia is very common in the ICU.[1] It often develops during ICU admission due to inadequate free water administration.
- Hypernatremia is *not* benign:
  - Hypernatremia causes profound *thirst*. Particularly among intubated patients, this may cause misery and *agitation* (which may be inappropriately treated with sedatives or antipsychotics).
  - Hypernatremia may cause delirium, thereby increasing the length of ventilation and ICU stay.
- Hypernatremia should always be corrected promptly.
  - Untreated hypernatremia is a hallmark of low-quality, amateur ICU care.[2]
  - Hypernatremia usually won't improve on its own (it requires active management).

- Even mild hypernatremia (e.g. sodium 146-148 mEq/L) may cause discomfort and shouldn't be ignored.

Crit Care Med. 1999 Jun;27(6):1105-8.

Hypernatremia in the intensive care unit: an indicator of quality of care?

Polderman KH[1], Schreuder WO, Strack van Schijndel RJ, Thijs LG.

CONCLUSIONS: Despite frequent measurement of sodium levels in patients in the ICU, hypernatremia is a relatively common occurrence. Initial treatment of hypernatremia is often inadequate, and sometimes treatment is delayed. The development of hypernatremia is associated with adverse outcomes for patients developing hypernatremia in the ICU. Hypernatremia could potentially be used as an indicator of quality of care in the medical ICU.

20 years later, we are still having the same exact problem!

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common causes of hypernatremia

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inadequate free water intake

- Everyone requires ~1 liter/day of water (more if febrile, tachypneic).
- Common causes of inadequate intake:
  - Inability to access and drink water (e.g. debilitated or delirious patients).
  - Failure to provide adequate free water to ventilated patients.

increased gastrointestinal water loss

- Most forms of diarrhea
- Vomiting or other gastrointestinal output (e.g., nasogastric tube, fistula)

renal water loss

- Loop diuretics
- Osmotic diuresis: Hyperglycemia, mannitol
- Renal dysfunction with inability to retain free water
  - Post-ATN or post-obstructive polyuria
  - Chronic renal insufficiency
- Central diabetes insipidus
  - Intracranial hemorrhage
  - Meningitis
  - Herniation, brain death
- Nephrogenic diabetes insipidus
  - Chronic lithium use
  - Amphotercin
  - Hypercalcemia, hypokalemia

sodium poisoning (uncommon)

- Administration of numerous ampules of hypertonic bicarbonate during a code
- Excessive use of hypertonic saline for neurocritically ill patients
- Drinking soy sauce or ocean water

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evaluation of cause

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chart review or H&P can usually reveal cause

- Review inputs/outputs: High urine or gastrointestinal output?
- Is the patient being provided with adequate free water?

- Are there medications that cause hypernatremia? (e.g. lactulose, mannitol, ampules of bicarbonate)
- Are there specific disease states that cause hypernatremia? (e.g. marked hyperglycemia, brain death)
- Has the patient been chronically exposed to lithium in the past? Some patients have *chronic partial diabetes insipidus*, which they *compensate* for at home by drinking lots of water. If they are intubated, they will lose this compensation and become hypernatremic.

labs

- May occasionally help establish a diagnosis of diabetes insipidus
  - Normal response to hypernatremia is to conserve water and produce concentrated urine (e.g. >300 mOsm).
  - Failure to concentrate urine indicates diabetes insipidus (e.g., urine osmolality <300 mOsm, or urine specific gravity <1.010).

treatment: addressing specific causes

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The treatment of most causes of hypernatremia consists of general treatment of the underlying disorder and supportive care (e.g. replacement of lost water and electrolytes). The following situations require more advanced management.

central diabetes insipidus

- The simplest treatment might be desmopressin (DDAVP) 2 micrograms IV q8 hours. This is effective in causing the kidneys to retain free water. Note, however, that if excessive fluid is provided, the patient will develop hyponatremia.
- Alternative treatment: vasopressin infusion 0.001-0.01 units/minute, titrated until the urine output decreases to a relatively normal rate. This has the advantage that it is titratable, so that it can be stopped if hyponatremia occurs. However, it requires a central line and the dosing can be tricky.

nephrogenic diabetes insipidus

- Patients may have chronically elevated free water requirements (e.g. chronic nephrogenic diabetes insipidus from lithium). The most important component of management is simply providing enough free water to keep up with losses.
- Thiazide diuretics may be helpful by causing mild hypovolemia which stimulates increased water reabsorption in the proximal tubule.

treatment: optimal rate of sodium reduction

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josh farkas 💊
@PulmCrit

EBM nerd challenge: is there any evidence that rapid correction of hypernatremia is dangerous in adults over ~50 years old?

10 9:58 AM - Feb 9, 2019

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Hillel Sternlicht, MD @ConceptsInHTN · Feb 9, 2019
@drjosflynn Based in lit review sev months ago, believe no. Extrapolated from newborn- toddler data. Dr Flynn of peds nephro could comment twitter.com/PulmCrit/statu…

> **josh farkas** 💊 @PulmCrit
> EBM nerd challenge: is there any evidence that rapid correction of hypernatremia is dangerous in adults over ~50 years old?

Joseph Flynn
@drjosflynn

Right - reports of cerebral hemorrhage w/rapid correction in neonates. Adult data sparse. Came across this paper which might help @PulmCrit ncbi.nlm.nih.gov/pubmed?term=24…

2 12:55 PM - Feb 9, 2019

See Joseph Flynn's other Tweets

chronic hypernatremia

- Brain tissue will adapt to hypernatremia over about two days. Rapidly dropping the sodium concentration could *theoretically* cause cerebral edema and herniation.
- Traditional teaching is to target a sodium decrease of 12 mEq/L per day (0.5 mEq/L/hr). However, some authors recommend *twice* this rate (1 mEq/L/hr).[3] Both choices appear to be equally arbitrary.
- Among adults over ~40 years old there is no solid evidence that rapid correction of sodium causes harm.
  - Retrospective studies actually correlate *slower* correction of sodium with worse outcomes.[3,4]
  - There don't seem to be case studies of patients who developed herniation due to over-aggressive sodium correction (unlike over-correction of *hyponatremia*, wherein scores of case studies document harm). One case study described a patient whose sodium was dropped by 20 mEq/L in *two hours hour* by dialysis, without any problems.[5]
- Patients who may be at increased risk for cerebral edema:
  - Younger patients (especially premenopausal women) who have very little empty space in their brains.
  - Patients with active neurologic disease and pre-existing cerebral edema.
- Bottom line?
  - **Shoot for 12 mEq/L daily drop** in most patients with chronic hypernatremia.
  - Don't be terrified of overshooting this. By far the most common problem is dropping the sodium too slowly.

acute hypernatremia

- Hypernatremia which is known to have developed in <<48 hours should be treated rapidly (the brain tissue won't have time to adapt to hypernatremia, so there is no risk of cerebral edema).
- The precise rate of change which is safe is *unknown*. For patients with neurologic deterioration due to acute hypernatremia, very rapid correction is probably *safer* than the alternative (leaving the patient with an elevated sodium for a prolonged period could create a risk of osmotic demyelination!).
  - In one epic case, a 19-year-old man drank a quart of soy sauce and developed acute hypernatremia with sodium 196 mM, seizures, and coma. He was treated with *six liters* of free water over 30 minutes and recovered well.[6]
- For patients with acute hypernatremia and oliguria, hemodialysis may be needed to rapidly correct the sodium (without obligating the patient to receive a large volume of free water).

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treatment: free water replacement

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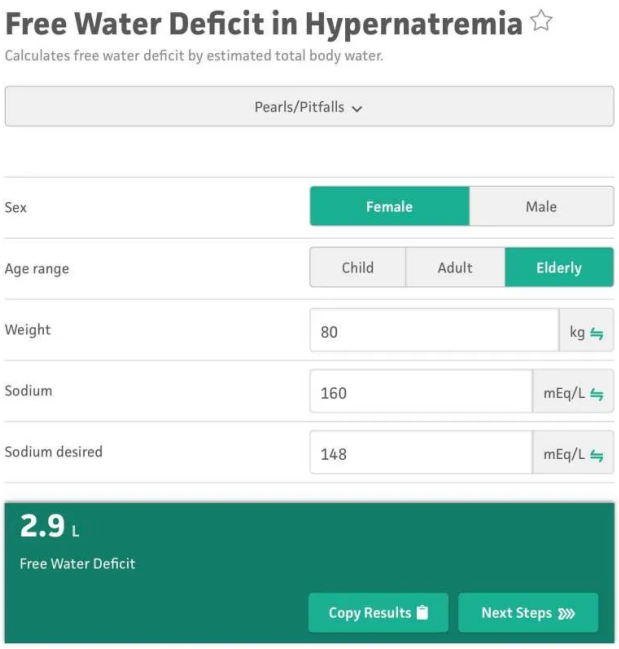
ad librium vs. goal-directed therapy

- The cornerstone of hypernatremia treatment is free water replacement. There are two general strategies to achieve this:
  - *Ad librium* strategy: For alert patients with *mild-moderate* hypernatremia who are thirsty and able to drink, the best treatment is to simply provide them with free access to water. This is easy and effective.
  - Goal-directed strategy: For comatose patients or patients with severe hypernatremia, calculation of water needs and monitoring is needed. The remainder of this chapter describes how to do this.

calculate the amount of free water required over 24 hours

- (1) Calculate the amount of free water required to drop from the patient's current sodium to your target sodium over the next day.
  - You are *not* trying to calculate the *total* free water deficit here, only what you need to give them in the next 24 hours. For example, the image below shows how to calculate the amount of water required to drop a patient's sodium from 160 mEq/L to 148 mEq/L (using MDCalc (https://www.mdcalc.com/free-water-deficit-hypernatremia)).
- (2) Add about one liter in addition to the calculated amount of water, to account for ongoing free water losses.
  - For example, in this case illustrated below, we would add 1 liter to 2.9 liters: the patient needs 3.9 liters of water over the next 24 hours.



administer free water

- The best route of free water administration is generally the gut. However, this may be limited in some cases by ileus or NPO status.
- If the enteral route is unavailable, free water should be given as D5W intravenously.
  - It would be preferable to provide either pure water via central line or D2.5W peripherally, to avoid hyperglycemia.[1] However, most hospitals lack either of these options (or, practically speaking, they would cause your pharmacy staff to go nuts).
- Don't try to provide free water by giving 1/2 NS or other sodium-containing fluids:
  - This is a highly inefficient strategy to provide free water.
  - Give free water as either water per NGT or D5W.
  - If the patient needs additional volume resuscitation, then provide that *separately* (e.g. simultaneous administration of Lactated Ringers). Using two infusions allows for separate titration of the amount of water and volume you are providing.

add diuretics if the patient is volume overloaded

- It's not uncommon to encounter a patient who is *both* volume overloaded *and* hypernatremic. When this occurs, *both* problems must be simultaneously and aggressively treated as follows:
  - (1) Free water should be administered as described above.
  - (2) Diuretics should be given to promote sodium excretion (natriuresis) and maintain a negative fluid balance. If only furosemide is used, this will stimulate production of a *dilute* urine which will hamstring the ability to treat hypernatremia. Thus, a *combination* of furosemide plus a high-dose thiazide diuretic must be used (e.g. indapamide or metolazone). Diuretics should be up-titrated as necessary to maintain a negative fluid balance.
  - (3) Cycle electrolytes frequently. Potassium supplementation will typically be required. Additional free water may be needed as well, to overcome renal losses.
- This isn't easy. It generally requires a lot of free water, fairly high doses of diuretics, and a lot of potassium supplementation. However, it is generally achievable over time (otherwise dialysis may be required). Active management is important, because these problems generally won't resolve on their own.
  - A common misconception is that volume overload plus hypernatremia cannot be treated; this is entirely false.

- If the patient is slightly net positive during administration of free water, that's OK. Since water is distributed into both the intracellular and extracellular spaces, it tends to cause less edema generation than an isotonic solution (which distributes purely into the *extracellular* fluid).

monitor therapy and adjust as needed

- Electrolytes should be monitored (e.g. q8-q12hr).
- Unlike hyponatremia, significant *over-correction* of hypernatremia is rarely a problem (more on this below).
- Under-correction will occur if there is ongoing free water loss.
  - This is frequently seen in patients remaining on lactulose for the treatment of hepatic encephalopathy.
  - Up-titrate the free water as needed to achieve your target sodium. Don't be afraid – if you overshoot slightly it will be fine.

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is ICU admission required for elderly patients with severe hypernatremia?

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The most common cause of severe hypernatremia in the emergency department is an elderly patient with dementia who has difficulty eating and drinking. These patients may gradually develop profound hypernatremia (e.g. sodium >170 mEq/L). This will trigger panic and a desire to admit the patient to the ICU. However, ICU admission is generally not needed for these patients for the following reasons.

(1) over-correction of hypernatremia is extremely unlikely

- Hypernatremia in this situation represents a *free water deficit*.
- Since humans are incapable of generating water, it is unlikely that the patient will suddenly overcorrect (and abruptly drop their sodium level).
  - The only way that over-correction could occur is if the patient abruptly woke up and started drinking lots of water.
- Sodium over-correction is generally seen in *hyponatremia,* due to rapid excretion of free water. This mechanism cannot occur in patients with hypernatremia due to a water deficit.

(2) over-correction would be safe

- If over-correction did occur (e.g. sodium levels falling >12 mEq/L) this would probably be safe.
- As discussed above, there is no evidence that rapid falls in sodium are dangerous in older adults. This is likely to be especially true among the elderly, who often have decreased brain size and thus greater room in which to swell (should edema occur).

reasonable treatment strategy:

- (1) Calculate the appropriate volume of free water to achieve a 12 mEq/day drop in sodium (as described above). In severe hypernatremia, the safest way to provide this is either as a continuous infusion of D5W or via gastric tube.
- (2) Check the serum sodium q6-q8 hours and adjust the free water intake appropriately.
- (3) Restrict the patient's intentional water intake to <1 liter per day, to avoid abrupt shifts in sodium.

consider palliative care

- Dehydration is sometimes a mechanism of natural, painless death in an elderly person with severe dementia.
- Prior to resuscitation with water, consider the patient's wishes and baseline quality of life.

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podcast

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(https://i1.wp.com/emcrit.org/wp-content/uploads/2016/11/apps.40518.14127333176902609.7be7b901-15fe-4c27-863c-7c0dbfc26c5c.5c278f58-912b-4af9-88f8-a65fff2da477.jpg)

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questions & discussion

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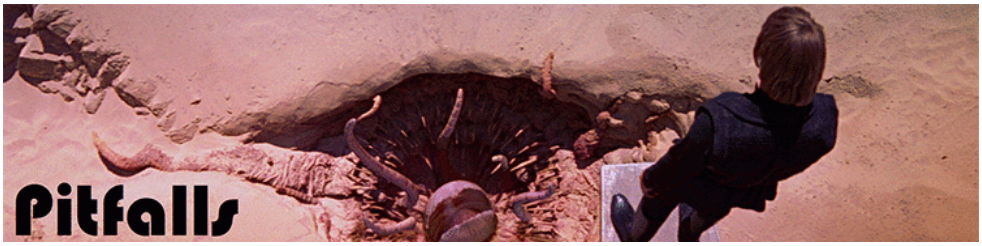
To keep this page small and fast, questions & discussion about this post can be found on another page ***here*** (https://emcrit.org/pulmcrit/hypernatremia-2/) .



(https://i1.wp.com/emcrit.org/wp-content/uploads/2016/11/pitfalls2.gif)

- Hypernatremia causes ICU patients to be delirious, thirsty, agitated, and miserable. It requires prompt, precise, and definitive management. This is a core competency for anyone managing critically ill patients.
- Hypernatremia should be approached with the same degree of urgency that we would use when treating hyperkalemia.
- If you see a patient's sodium gradually trending upwards, don't wait until it is severely elevated. Free water should be given in anticipation of worsening free water deficiency, to *prevent* hypernatremia.
  - If ignored, hypernatremia almost never gets better, but instead will generally get worse.
- Failure to calculate the free water requirement will usually cause inadequate amounts of water to be delivered. Free water needs are often surprisingly high.
- Routinely providing patients with adequate amounts of free water enterally along with their tube feeds may avoid problems with hypernatremia.
- If a patient with brain injury starts producing large volumes of pale, dilute urine, don't ignore this – check electrolytes and consider the possibility of central diabetes insipidus.

Going further:

- Hypernatremia (https://emcrit.org/emcrit/hypernatremia/) (EMCrit)
- Overcoming occult diuretic resistance: Achieving diuresis without dehydration (https://emcrit.org/pulmcrit/occult-diuretic-resistance/) (PulmCrit)
- Hypernatremia (https://lifeinthefastlane.com/investigations/hypernatraemia/) (Mike Cadogan, LITFL)

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The Internet Book of Critical Care is an online textbook written by Josh Farkas (@PulmCrit), an associate professor of Pulmonary and Critical Care Medicine at the University of Vermont.
