Hyponatremia: Approach & Management

By

Ahad Alhassan , MBBS

King Saud University

Objectives

- Define Hyponatremia
- 6 step approach and management of Hyponatremia
- Complications of Hyponatremia
- What to do if you over-correct Na?

What is Hyponatremia?

- Most common electrolyte disorder
- Occurs in about 20% of all Hospital admissions
- 30% of ICU admissions
- Levels <135 is directly associated with ↑ed in Hospital mortality (acute>chronic)

Hyponatremia

- **Mild:** 130 – 135 mmol/L
- **Moderate:** 125 – 129 mmol/L
- **Severe:** < 125 mmol/L

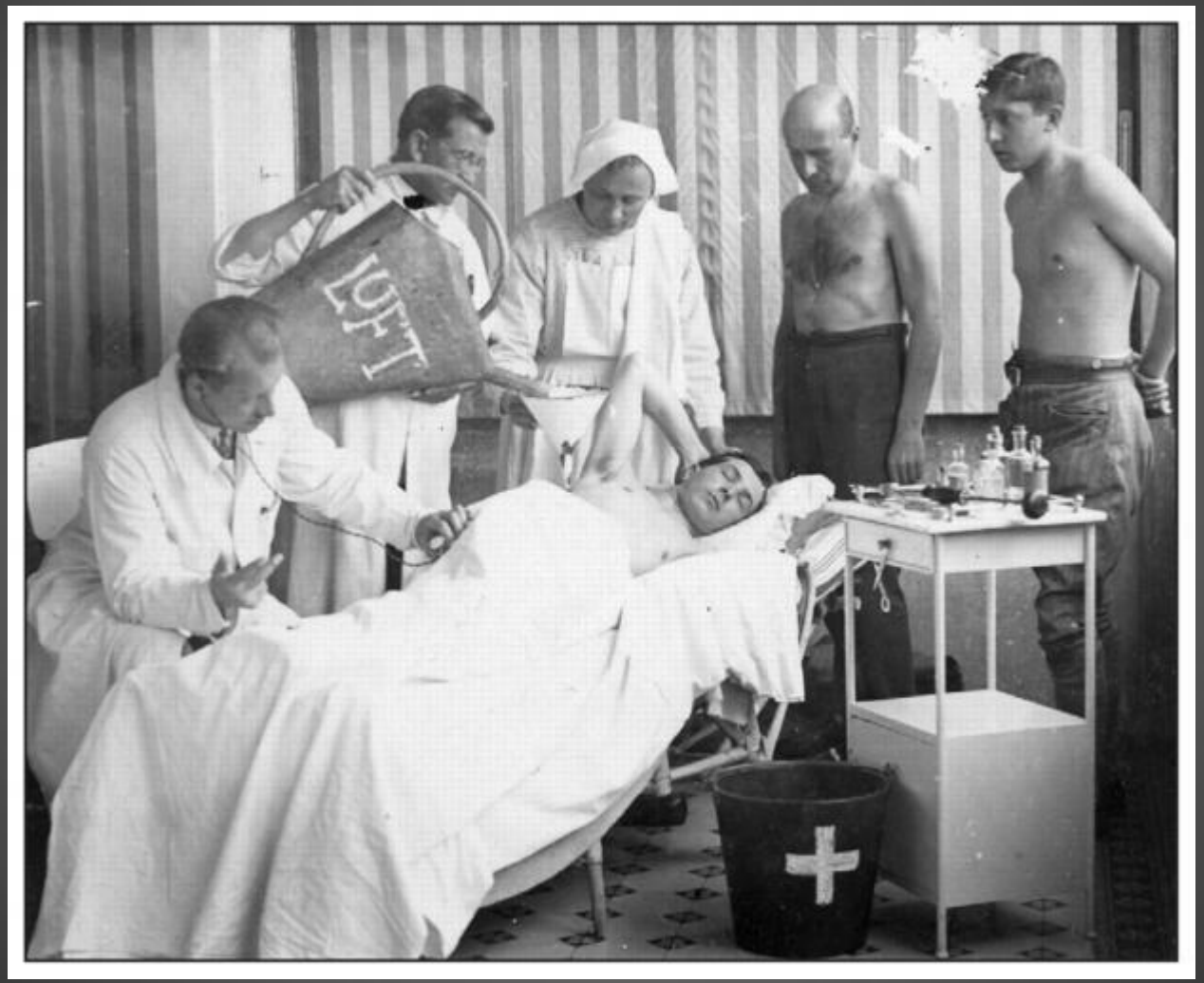
Hyponatremia

- Acute (<48 hrs) vs Chronic

- By Symptoms:

Severity	Symptom
Moderately severe	Nausea without vomiting
	Confusion
	Headache
Severe	Vomiting
	Cardiorespiratory distress
	Abnormal and deep somnolence
	Seizures
	Coma (Glasgow Coma Scale ≤8)

The Traditional Approach



$$p = n_e KT + n_i KT - KT\left[\frac{\kappa^3}{24\pi} + 2\pi\left[n_e n_e \lambda_{ee}^3\left[K_\circ(\xi_{ee}) - \frac{\xi_{ee}^3}{6}(\ln\kappa\lambda_{ee})\right]\right.\right.$$

$$\left.\left. + n_i n_i \lambda_{ii}^3\left[K_\circ(\xi_{ii}) - \frac{\xi_{ii}^3}{6}(\ln\kappa\lambda_{ii})\right] + 2n_e n_i \lambda_{ei}^3\left[K_\circ(\xi_{ei}) - \frac{\xi_{ei}^3}{6}(\ln\kappa\lambda_{ei})\right]\right]\right.$$

$$+\frac{\kappa^3}{24\pi}\left[3(\kappa\lambda_{ee})^2 + 3(\kappa\lambda_{ii})^2 + 6(\kappa\lambda_{ei})^2 - \frac{9}{2\sqrt{2}}\frac{n_e\Lambda_e^3}{2s_e+1} - \frac{9}{2\sqrt{2}}\frac{n_i\Lambda_i^3}{2s_i+1}\right.$$

$$\left. + \frac{27}{4(2s_e+1)(2s_e+1)}(\kappa\lambda_{ee})^2 + \frac{54}{4(2s_e+1)(2s_i+1)}(\kappa\lambda_{ei})^2 + \frac{27}{4(2s_i+1)(2s_i+1)}(\kappa\lambda_{ii})^2\right]$$

$$+6\pi n_e^2 n_i\ \lambda_{ee}^6\lambda_{ii}\left[K_\circ(\xi_{ei}) - \frac{\xi_{ei}^3}{6}(\ln\kappa\lambda_{ei})\right] + 6\pi n_e^2 n_i\ \lambda_{ii}^6\lambda_{ee}\left[K_\circ(\xi_{ei}) - \frac{\xi_{ei}^3}{6}(\ln\kappa\lambda_{ei})\right]$$

$$+2\pi n_e^3\lambda_{ee}^6\left[K_\circ(\xi_{ee}) - \frac{\xi_{ee}^3}{6}(\ln\kappa\lambda_{ee})\right] + 2\pi n_i^3\lambda_{ii}^6\left[K_\circ(\xi_{ii}) - \frac{\xi_{ii}^3}{6}(\ln\kappa\lambda_{ii})\right]$$

$$-\frac{27\Lambda^6}{4096\,\pi^6\sqrt{\pi}}\kappa^6\beta\left[\frac{1}{2} - \frac{11}{12\sqrt{2}}\frac{n_e\Lambda^2}{2s_e+1} + \left(\frac{\sqrt{3}+1}{6\sqrt{3}}\right)\frac{n_e n_i\Lambda^4}{(2s_e+1)(2s_i+1)} - \frac{\sqrt{2}}{9\sqrt{3}}\frac{n_e n_e n_e\Lambda^6}{(2s_e+1)(2s_e+1)(2s_e+1)}\right.$$

$$\left. - \frac{\sqrt{2}}{9\sqrt{3}}\frac{n_i n_i n_i\Lambda^6}{(2s_i+1)(2s_i+1)(2s_i+1)} - \frac{\sqrt{2}}{9\sqrt{3}}\frac{3n_e^2 n_i\Lambda^6}{(2s_e+1)(2s_e+1)(2s_i+1)} - \frac{\sqrt{2}}{9\sqrt{3}}\frac{3n_i^2 n_e\Lambda^6}{(2s_i+1)(2s_i+1)(2s_e+1)}\right]$$

$$\left. - \frac{1728\,\pi}{(4\pi)^3}\kappa^6 KT\left[\frac{23\sqrt{\pi}}{480} - \frac{397\pi\sqrt{3}}{38400}(\kappa\lambda_{ee})^2 - \frac{397\pi\sqrt{3}}{38400}(\kappa\lambda_{ei})^2 - \frac{397\pi\sqrt{3}}{38400}(\kappa\lambda_{ii})^2\right]\right].$$

$$[Na^+]_{2\ plasma} = \frac{([Na^+]_{1\ plasma} + y_1)TBW_1 + 1.03 \times E_{MB}}{TBW_1 + V_{MB}} - y_2$$

where

$[E] = [Na^+ + K^+]$

$E_{MB} = (Na^+ + K^+)_{input-output}$ = mass balance of $Na^+ + K^+$ in a chosen duration of time.

$= [E]_{IVF} \times V_{IVF} + [E]_{oral} \times V_{oral} + [E]_{tube\ feed} \times V_{tube\ feed} + [E]_{TPN} \times V_{TPN}$

$- [E]_{urine} \times V_{urine} - [E]_{GI} \times V_{GI} - [E]_{sweat} \times V_{sweat}$

$V_{MB} = V_{input} - V_{output}$ = mass balance of H_2O in a chosen duration of time.

$= V_{IVF} + V_{oral} + V_{tube\ feed} + V_{TPN} + V_{oxidation} - V_{urine} - V_{GI}$

$- V_{sweat} - V_{insensible}$

$y = 23.8 + (1.6/100)([G] - 120)$ where $[G]$ = plasma glucose concentration.

In patients with euglycemia, $y_1 = y_2 = 23.8$ for the sake of simplification.

The Traditional Approach

- Calculations… Calculations… & Calculations:
  - Estimated osmolality
  - Corrected Na & glucose
  - Corrected Na & lipids
  - Corrected Na & protein
  - Expected change in Na deficit… & many more ☹

$$\text{Corrected serum } (Na^+) = \text{measured } (Na^+) + 2.4 \times \frac{(\text{glucose (mg/dl)} - 100\ \text{(mg/dl)})}{100\ \text{mg/dl}}$$

$$\text{Change in plasma } [Na^+] = \frac{\text{Infusate } [Na^+] - \text{plasma } [Na^+]}{\text{Total body water} + 1}$$

$$\text{Change in plasma } [Na^+] = \frac{\text{Infusate } [Na^+] + \text{infusate } [K^+] - \text{plasma } [Na^+]}{\text{Total body water} + 1}$$

New Hip Simple Approach

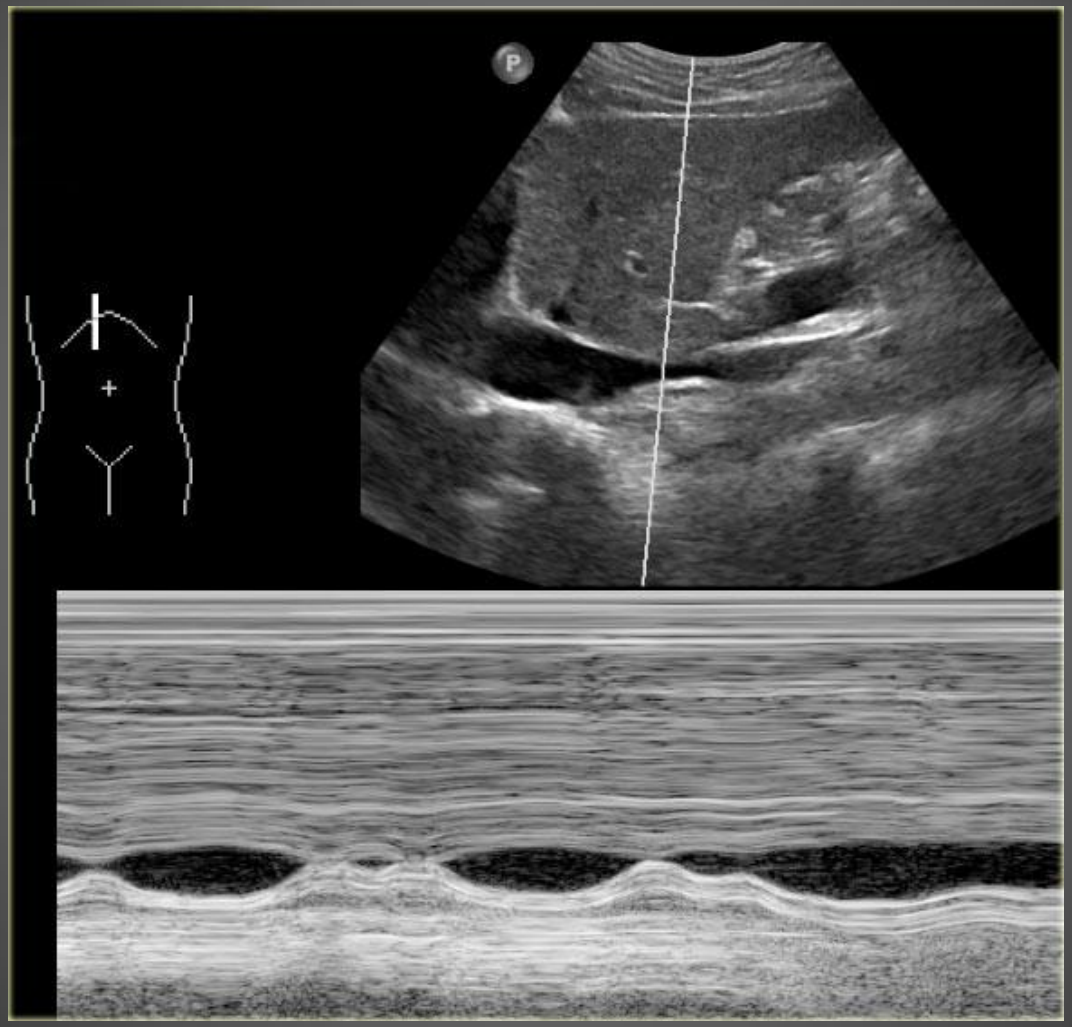
6 Steps to Approach Hyponatremia

1) Start with ABCs (priority)
2) Immediately Treat Neurological Emergencies (Seizures, coma or cerebral herniation/oedema)
   - Administer 3% hypertonic saline 100-150cc IV over 5-10min
   - repeat a second bolus if no improvement
   - Stop all fluids after the second bolus (don't over-correct)

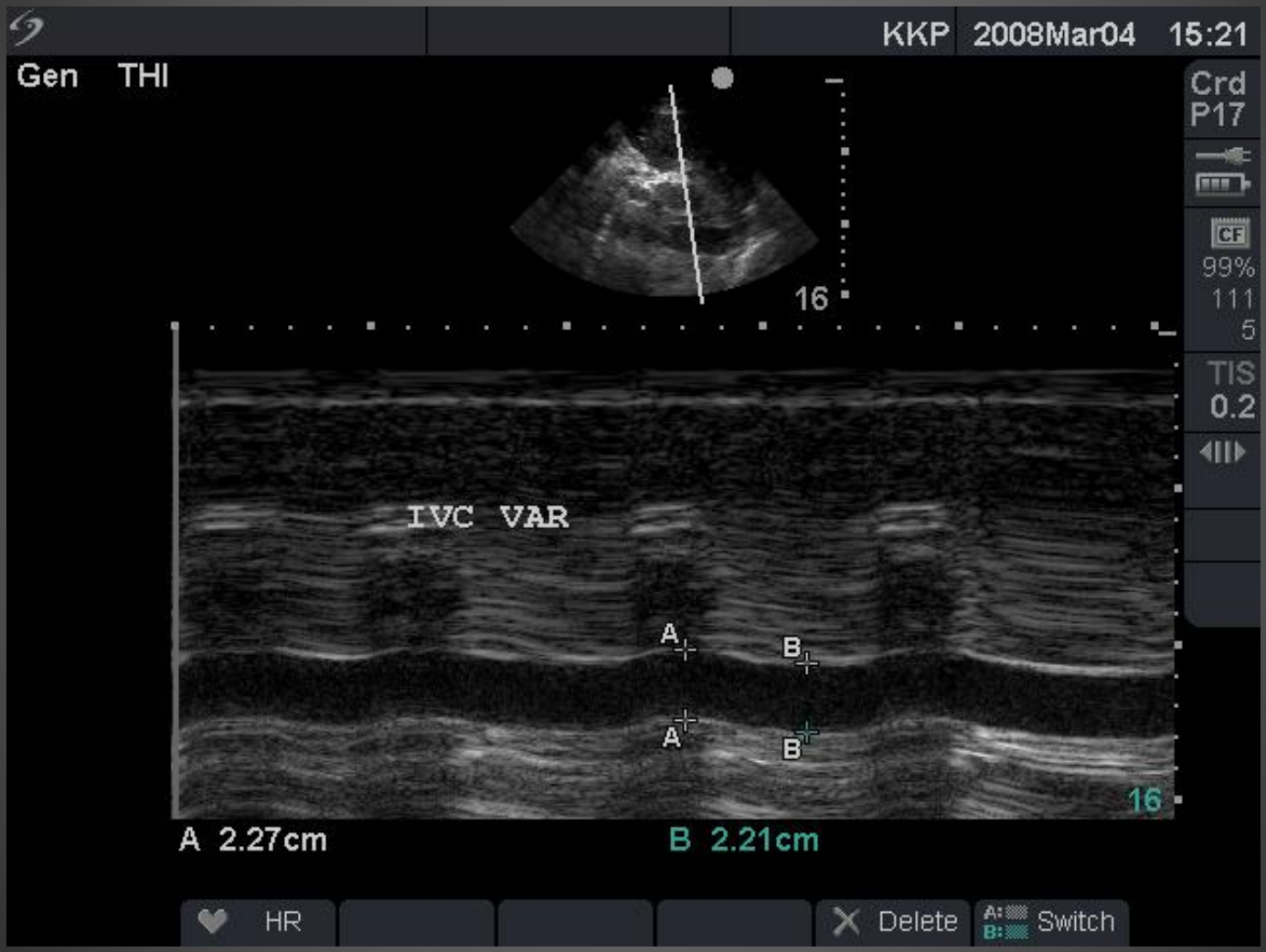
6 Steps

3) Intravascular Volume: Assess & Address
   - ***Hypovolemic:*** priority is to *restore adequate circulating volume*
   - ***Euvolemic:*** volume status normal, no treatment
   - ***Hypervolemic:*** sodium restriction, water restriction and diuretics

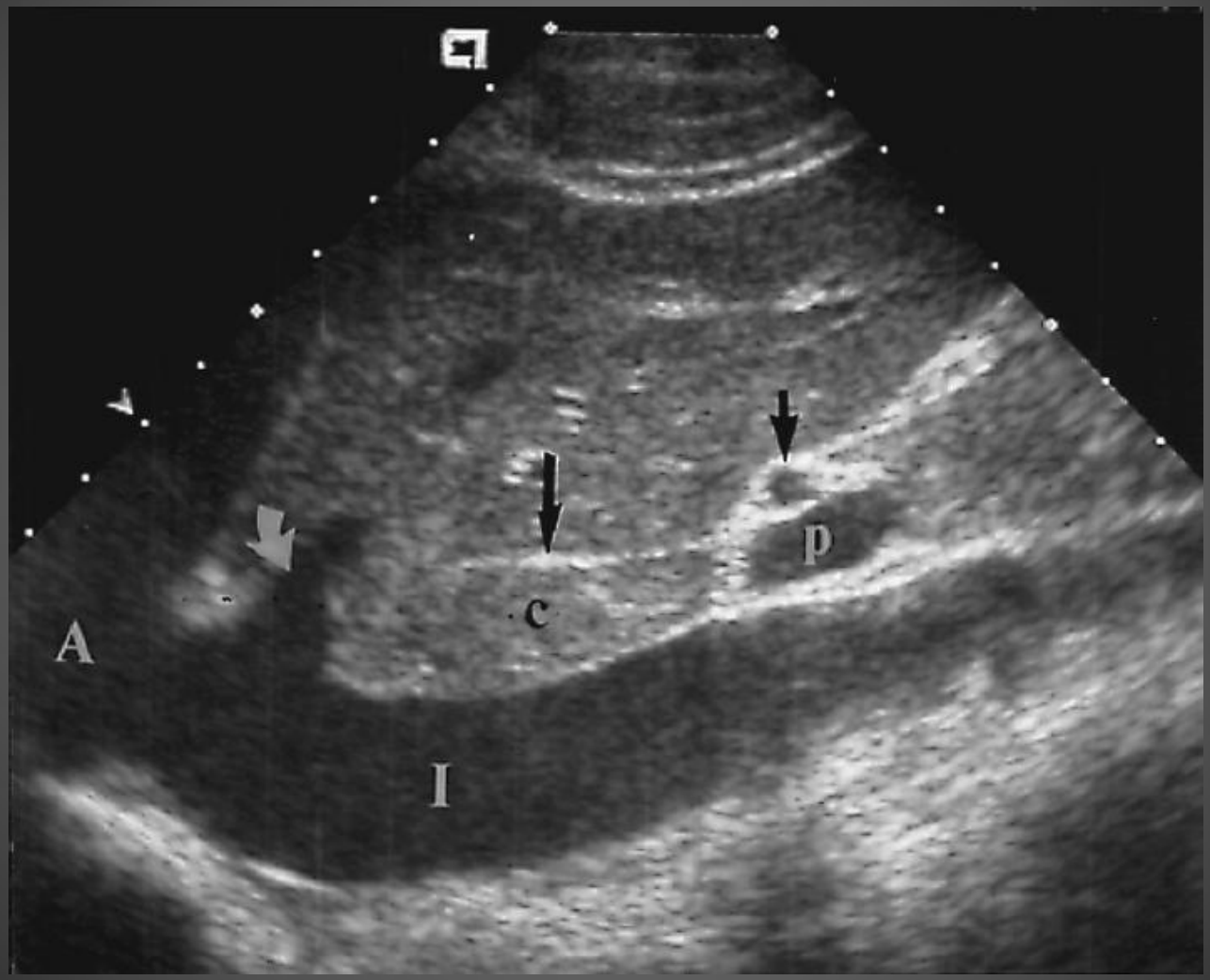
Hypovolemia



Euvolemic


KKP 2008Mar04 15:21
Gen THI
Crd P17
CF
99%
111
5
TIS 0.2
16
IVC VAR
A
B
A
B
16
A 2.27cm
B 2.21cm
HR
Delete
A:
B:
Switch

Hypervolemic



6 Steps

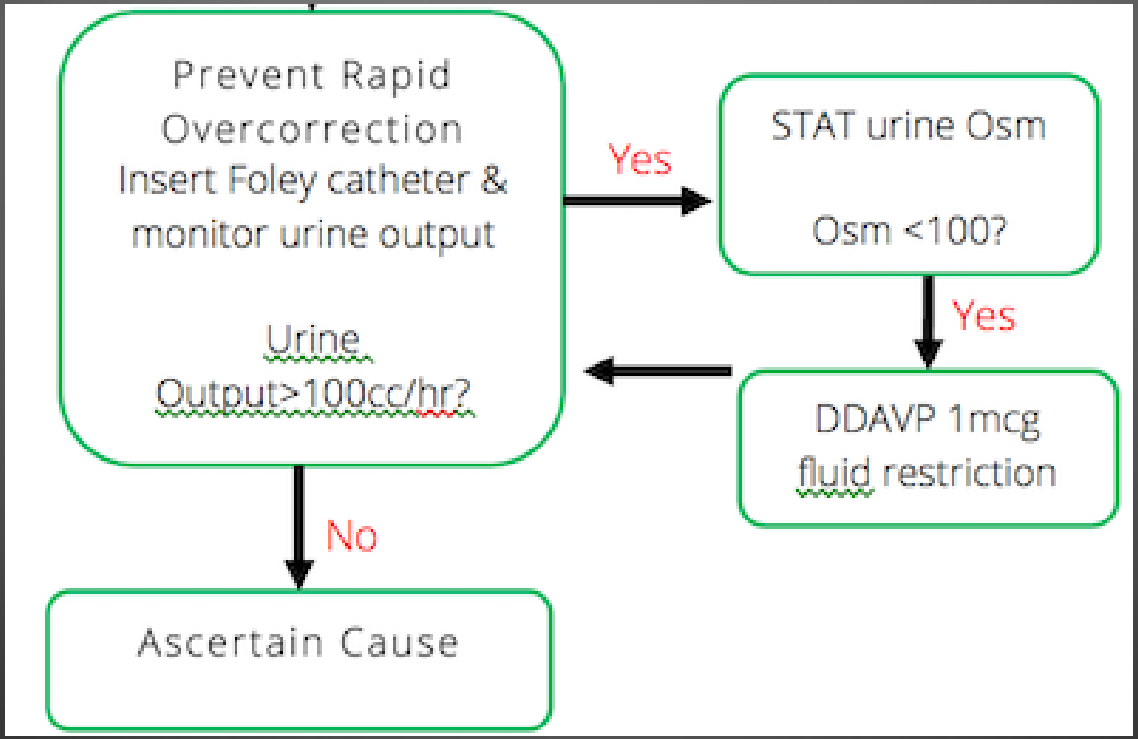
4) Prevent further Hyponatremia
   - *strict fluid restriction*
   - *saline locking the IV* Cannula (NO FLUIDS)
   - It is extremely important to tell the patient, his family and healthcare team ***"Water can literally kill you!"***

6 Steps

5) Prevent Over-Correction “Rule of 100s” & “Rule of 6s”
   - Rule of 6s:
     - ***“Six in six hours for severe symptoms, then stop.***
     - ***Six a day makes sense for safety.”***

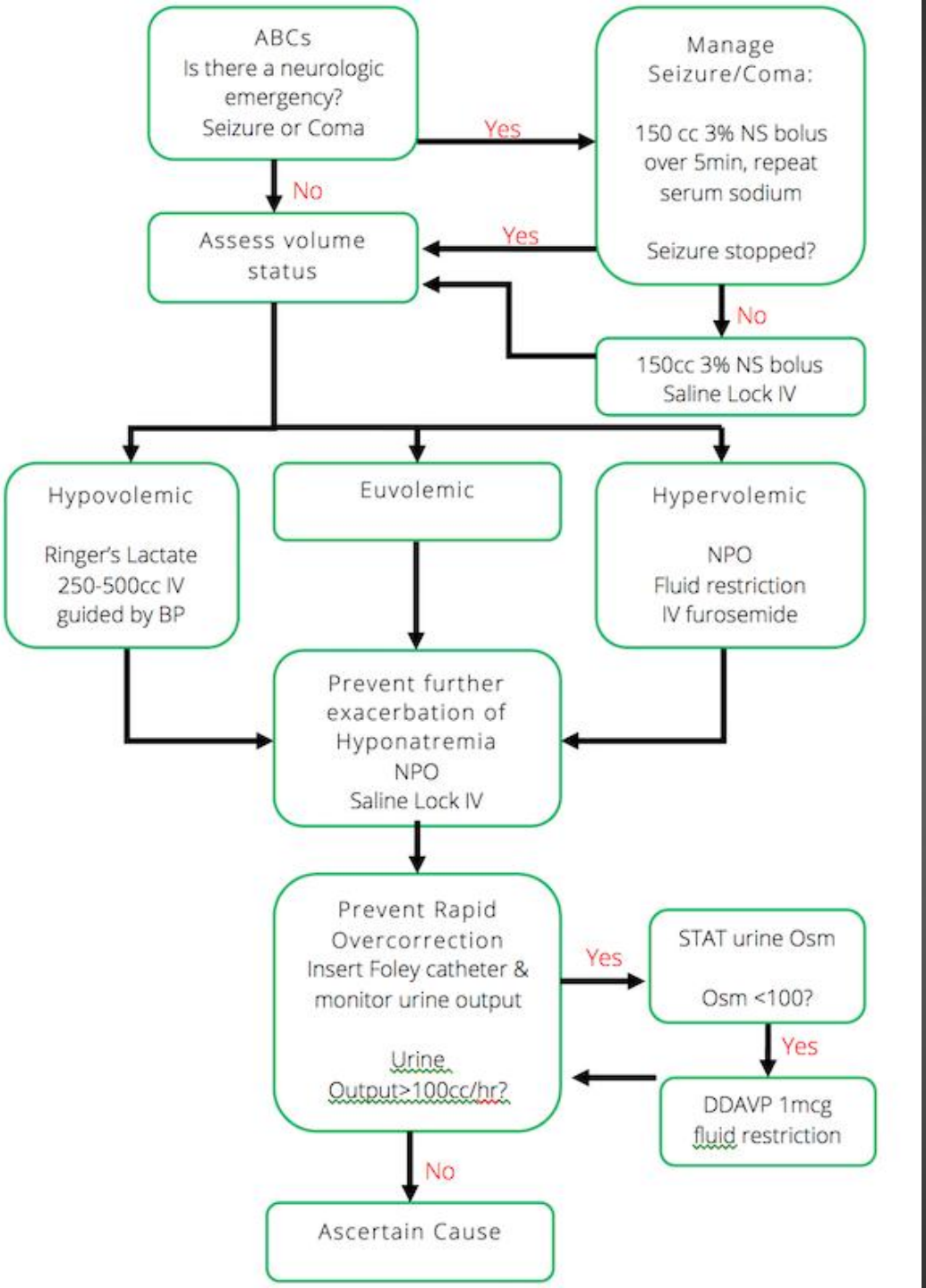
6 Steps

5) Prevent Over-Correction “Rule of 100s” & “Rule of 6s”
   - **Rule of 100s:**



6 Steps

6) Find out the Cause of Hyponatremia
   - Look at chief complaint: vomiting, diarrhea, pain or altered level of awareness
   - Review Medication List: causes of SIADH (thiazide diuretics and SSRIs), chronic steroids (adrenal imp)
   - Evaluate PMHx: Hx of end organ failure (CHF, liver failure and renal failure) or cancers
   - Lab work: hyperglycemia, potassium (hyperkalemia → adrenal insufficiency), TSH (hypothyroidism)


ABCs
Is there a neurologic emergency?
Seizure or Coma
Yes
Manage Seizure/Coma:
150 cc 3% NS bolus over 5min, repeat serum sodium
Seizure stopped?
No
Assess volume status
Yes
No
150cc 3% NS bolus
Saline Lock IV
Hypovolemic
Ringer's Lactate
250-500cc IV
guided by BP
Euvolemic
Hypervolemic
NPO
Fluid restriction
IV furosemide
Prevent further exacerbation of Hyponatremia
NPO
Saline Lock IV
Prevent Rapid Overcorrection
Insert Foley catheter & monitor urine output
Urine Output>100cc/hr?
Yes
STAT urine Osm
Osm <100?
Yes
DDAVP 1mcg
fluid restriction
No
Ascertain Cause

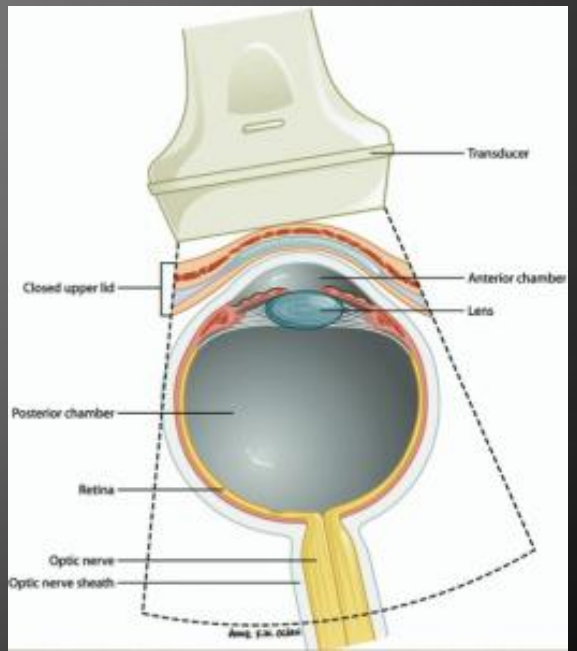
Complications of Hyponatremia

1) Cerebral Edema:

Severe Hyponatremia

Rapid Hyponatremia

+Altered level of consciousness



Complications of Hyponatremia

2) Osmotic Demyelination Syndrome (ODS)
   - Formerly known as Central Pontine Myelinolysis
   - Affects pons, cerebellum and basal ganglia
   - Occurs with Over-Correction of Hyponatremia
   - Clinical Dx (ataxia, quadriplegia, cranial nerve palsies, and the 'locked-in' syndrome)
   - Presents up to 7 days after rapid correction of Na

Complications of Hyponatremia

2) Osmotic Demyelination Syndrome (ODS)

- Risk Factors:
  - Elderly
  - Malnourished
  - Chronic Hyponatremia
  - Hyperkalemia

What to do in Over-Correction?

- repeat serum sodium ↑↑↑↑ dramatically higher than expected
- Over-Correction approach:
  1. Assess & correct intravascular volume
  2. Prevent ↑ in Na:
     A. Fluid restriction: make the patient NPO and stop IV fluids
     B. Give DDAVP 1 microgram IV
  3. Consult Nephrology

Thank you!