

Sodium in the ICU

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GIVITI - Gruppo italiano per la Valutazione
degli Interventi in Terapia Intensiva

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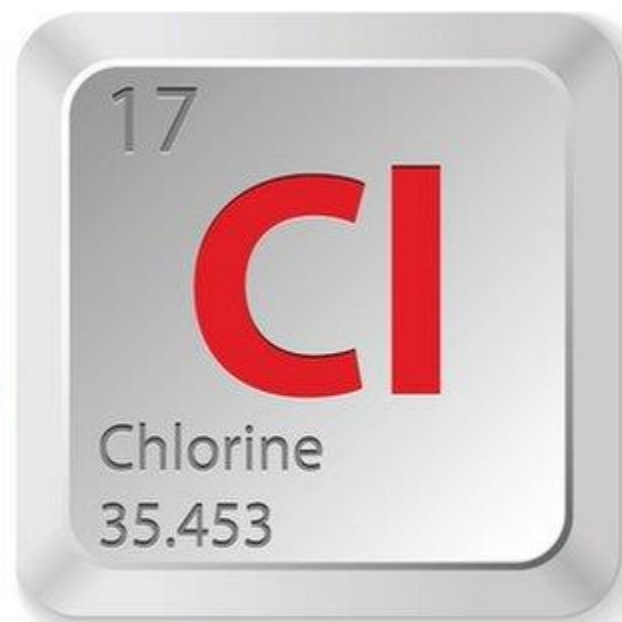
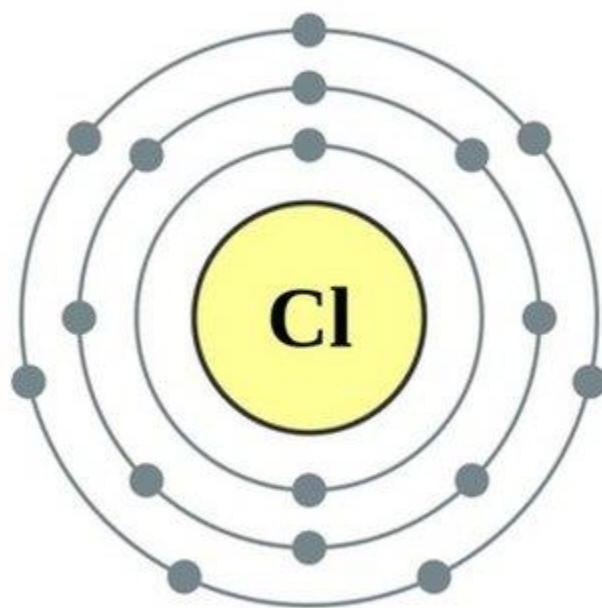
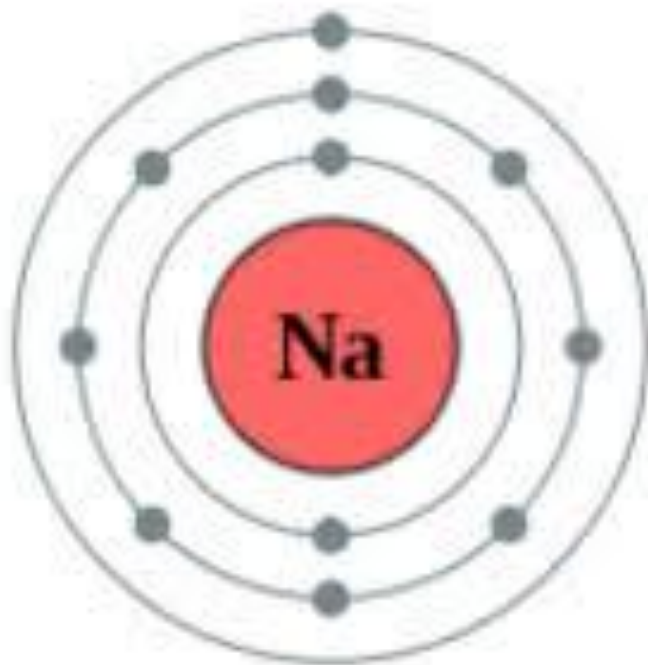
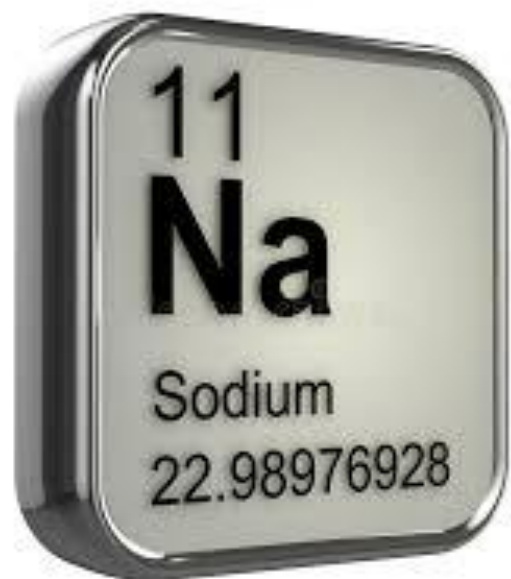


Agenda

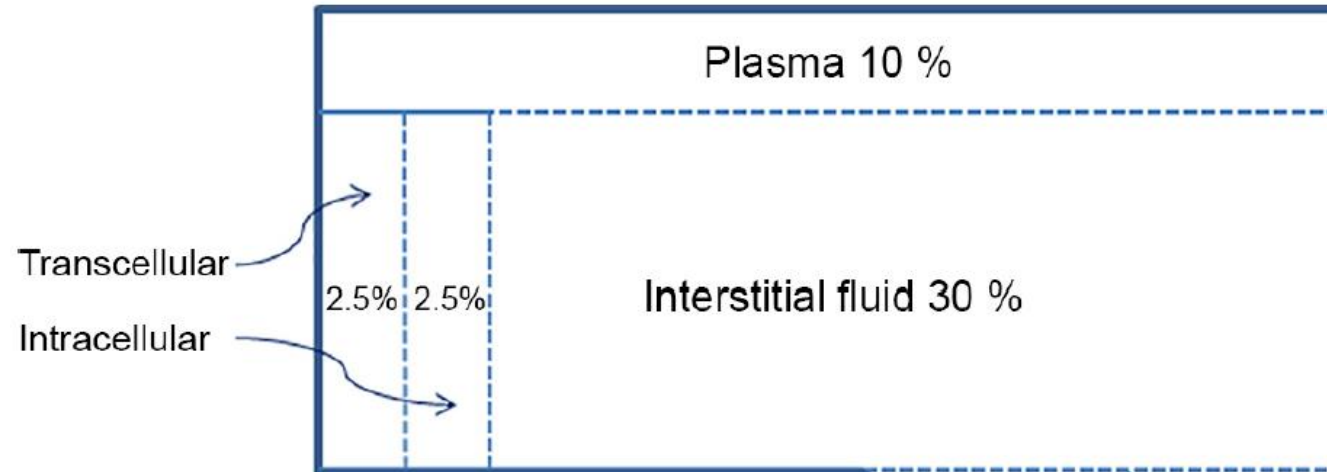
- Sodium homeostasis — The Basics
- The hospital — A sodium-rich environment
- Strategies — Correct fluids & cut the creep!
- Hyponatremia — The Black Beast

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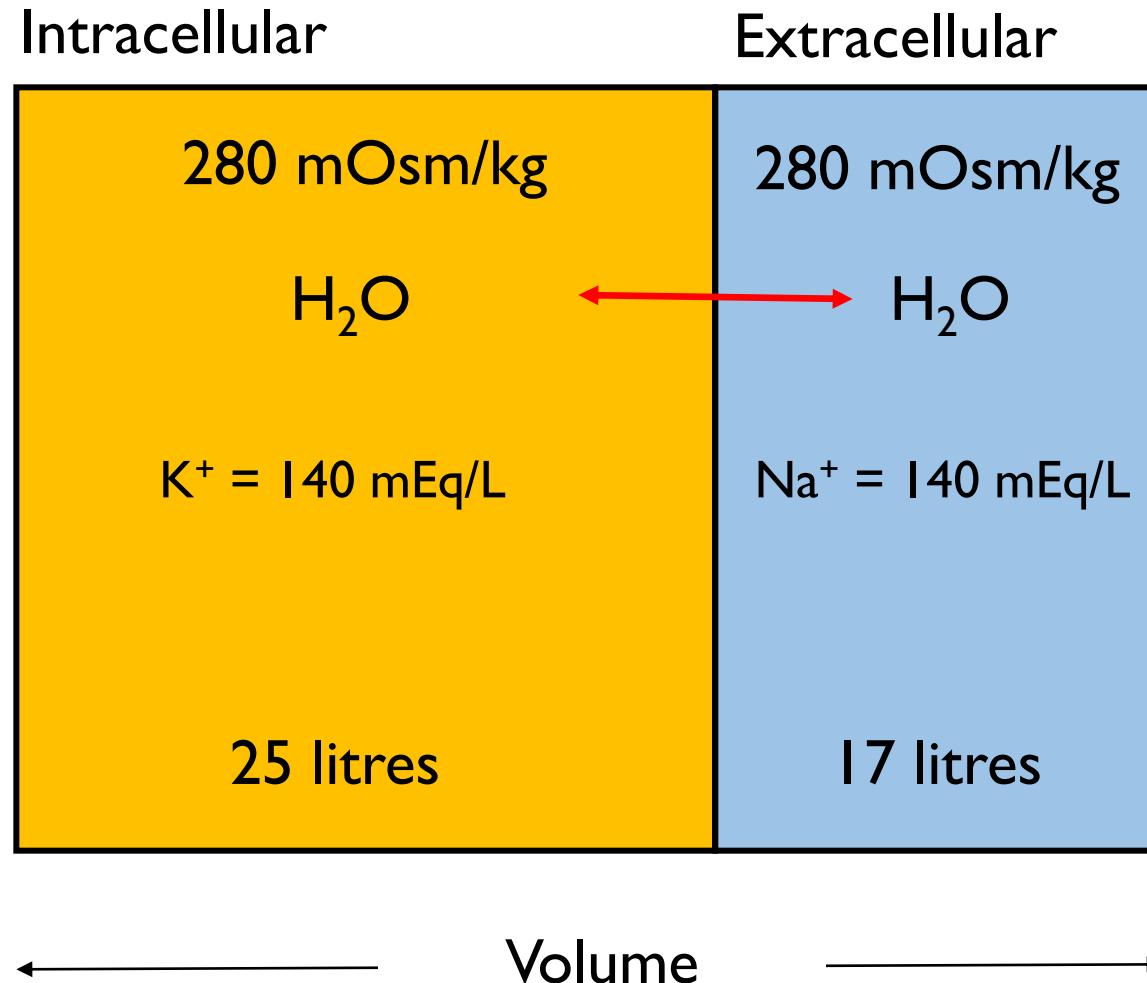
Total body sodium



≈4200 mmol

≈95 g

Water, osmolarity and osmolar equilibrium



Plasma osmolarity

$$\text{POSM} = 2 \times [\text{Na}^+] + \frac{\text{Gluc}}{18} + \frac{\text{Urea}}{6}$$

$$\text{POSM} = 280 + 5 + 5 = 290$$

Na = 140

Gluc = 90

Urea = 30

BUN (mg/dl) = Urea (mg/dl)/2.1428
Urea (mmol/L) = BUN (mg/dl) x 0.357

Plasma tonicity

$$\begin{array}{ccccccc} \text{POSM} & = & 2 \times [\text{Na}^+] & + & \frac{\text{Gluc}}{18} & + & \frac{\text{Urea}}{6} \\ \\ \text{POSM} & = & 280 & + & 5 & + & 5 & = & 285 \end{array}$$

E.G. Na = 140
Gluc = 90
Urea = 30

BUN (mg/dl) = Urea (mg/dl)/2.1428
Urea (mmol/L) = BUN (mg/dl) x 0.357

Water, osmolarity and osmotic equilibrium

$$\text{POSM} = \frac{2 \text{ Na}_e}{\text{ECF}} \quad \text{!} \quad \text{ICOSM} = \frac{2 \text{ K}_e}{\text{ICF}}$$

$$\text{POSM} = \text{ICOSM} = \frac{2 (\text{Na}_e + \text{K}_e)}{\text{TBW}}$$

Sodium balance

Input

Diet

0.02 to 6-8 mmol/kg/day

!

=

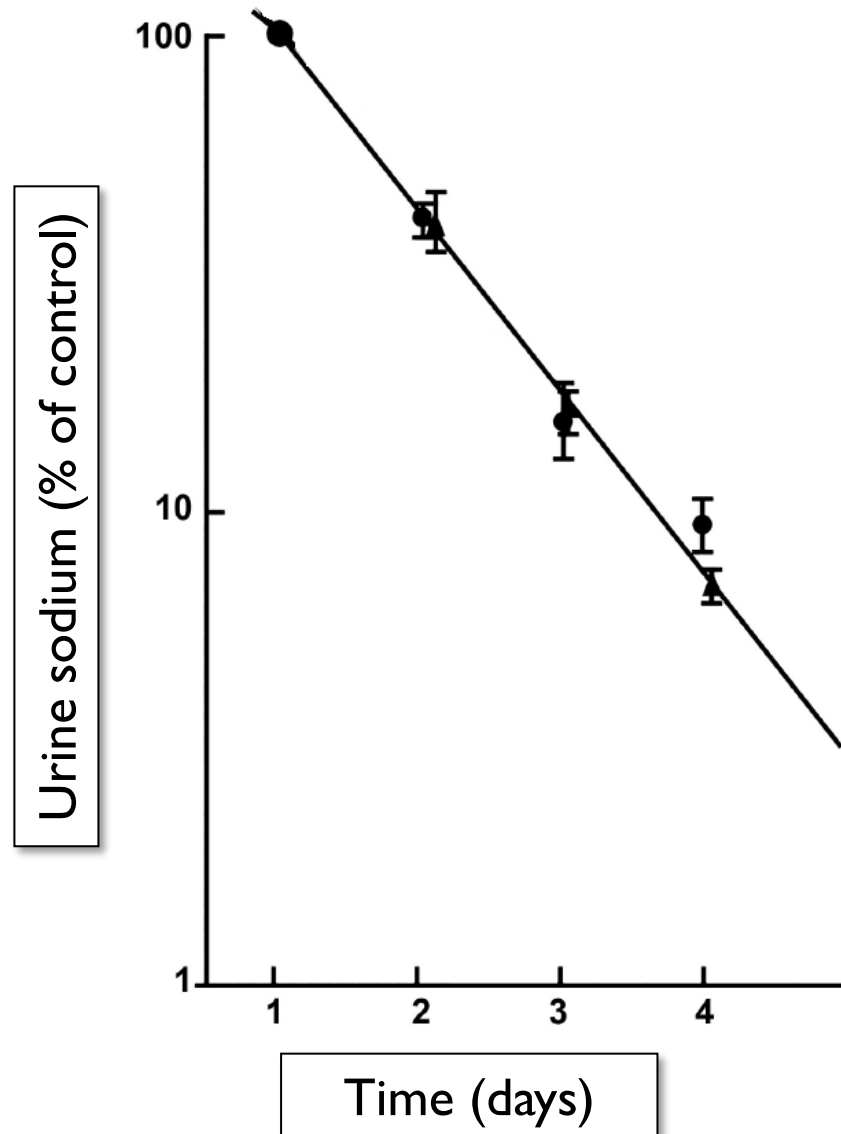
Output

Urine

Stool

Skin

Renal adaptation to sodium restriction

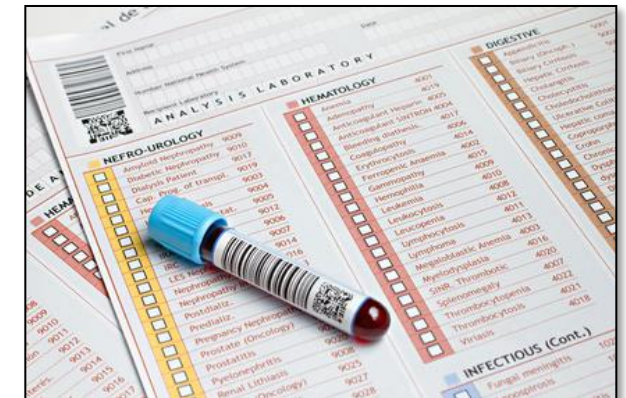
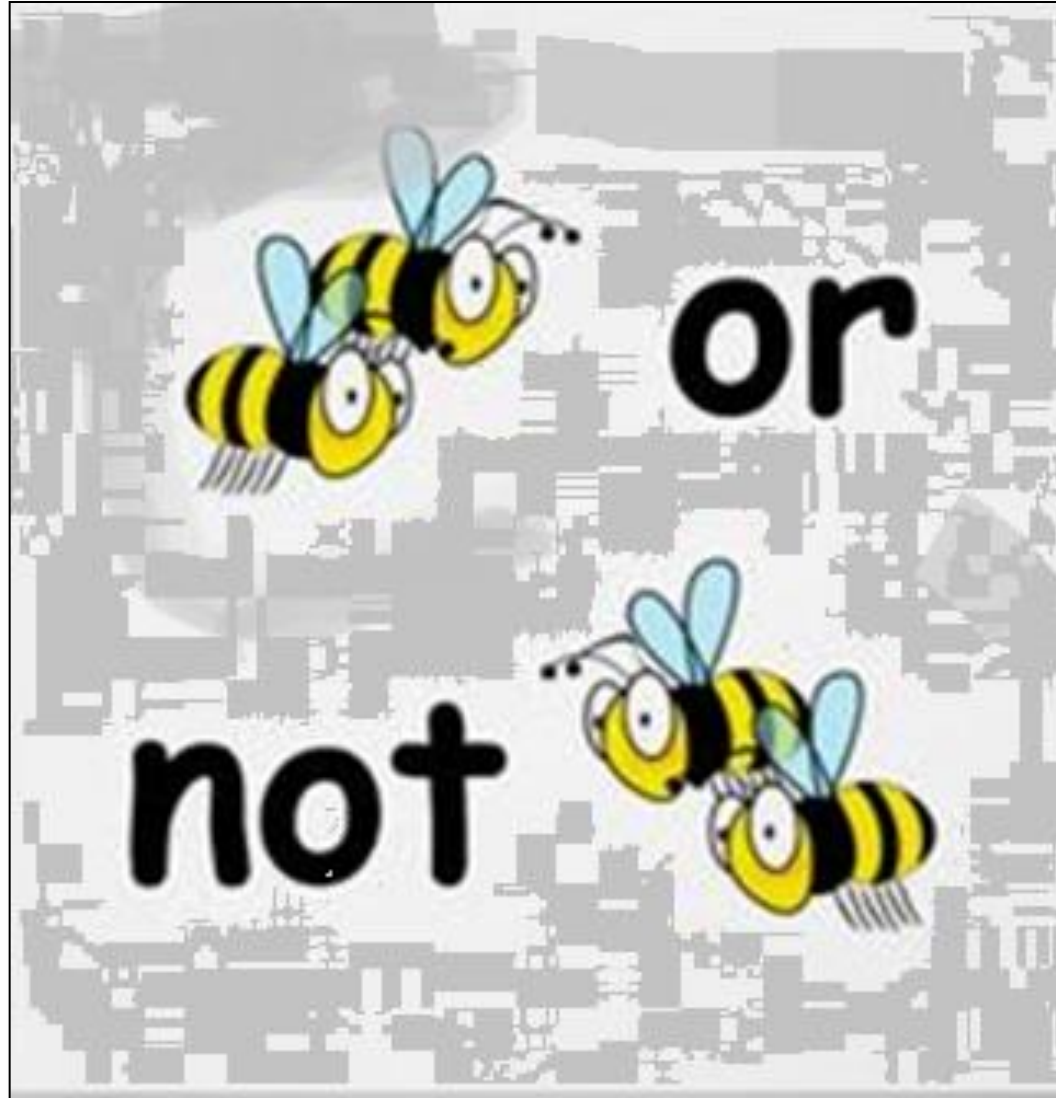


Renin

Aldosterone

< 1 mEq/day

Do I really know sodium concentration?



Ion Selective Electrodes

```
graph TD; A[Ion Selective Electrodes] --> B[Direct]; A --> C[Indirect];
```

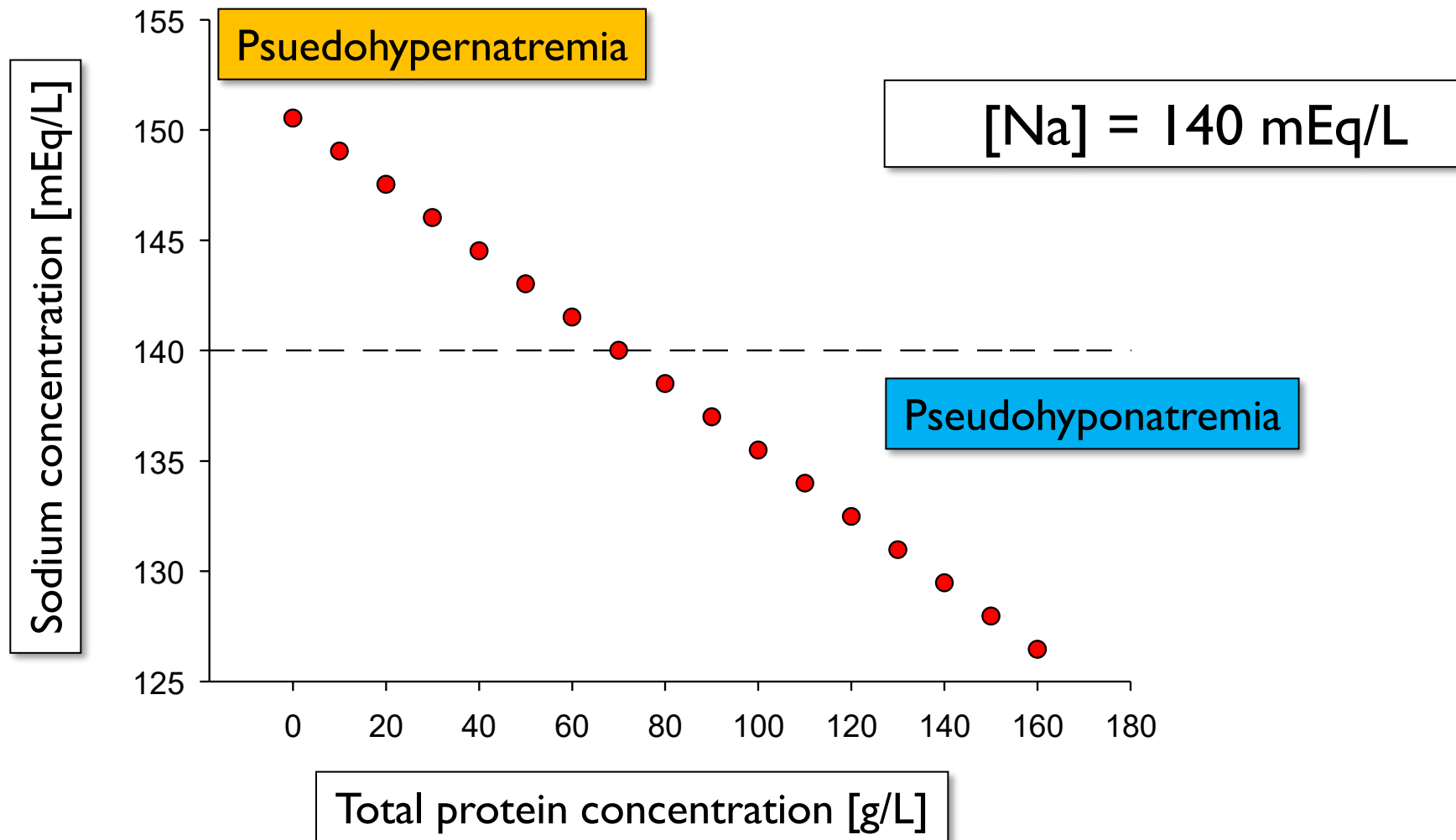
Direct

- Typical point-of-care
- **Whole** blood
- No Pre-dilution

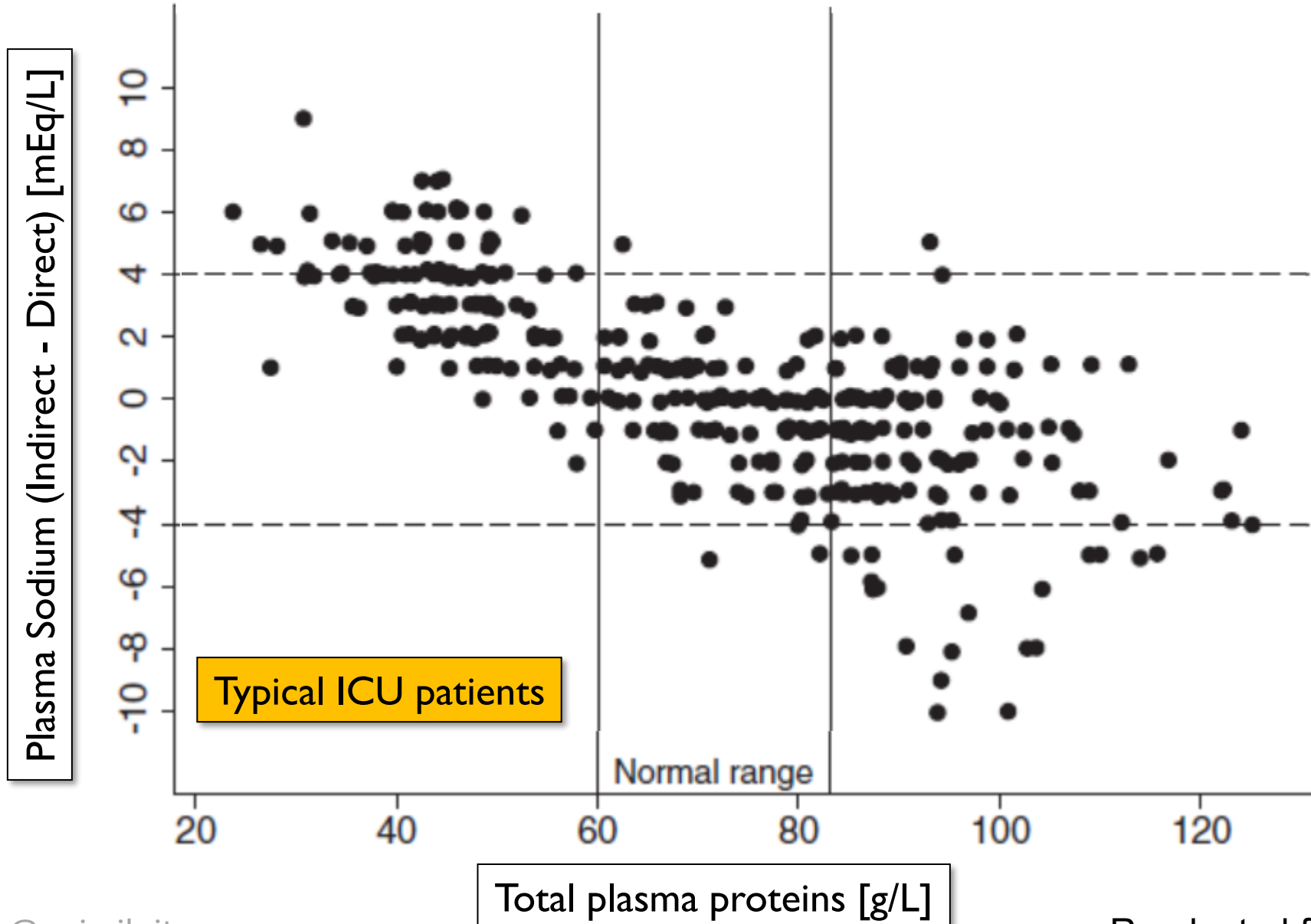
Indirect

- Typical Lab
- **Plasma**
- Premixed with a diluent (buffer)
- 1:**20** to 1:**34**
- Assumes **70** g/L of proteins

Protein concentration and sodium - indirect ISE -

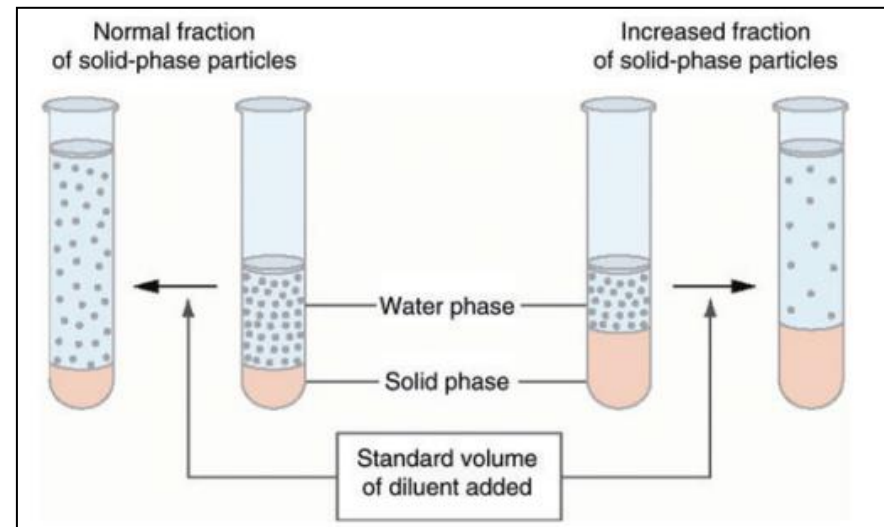


«Pseudo-natremiae»



Clinical Practice Guideline

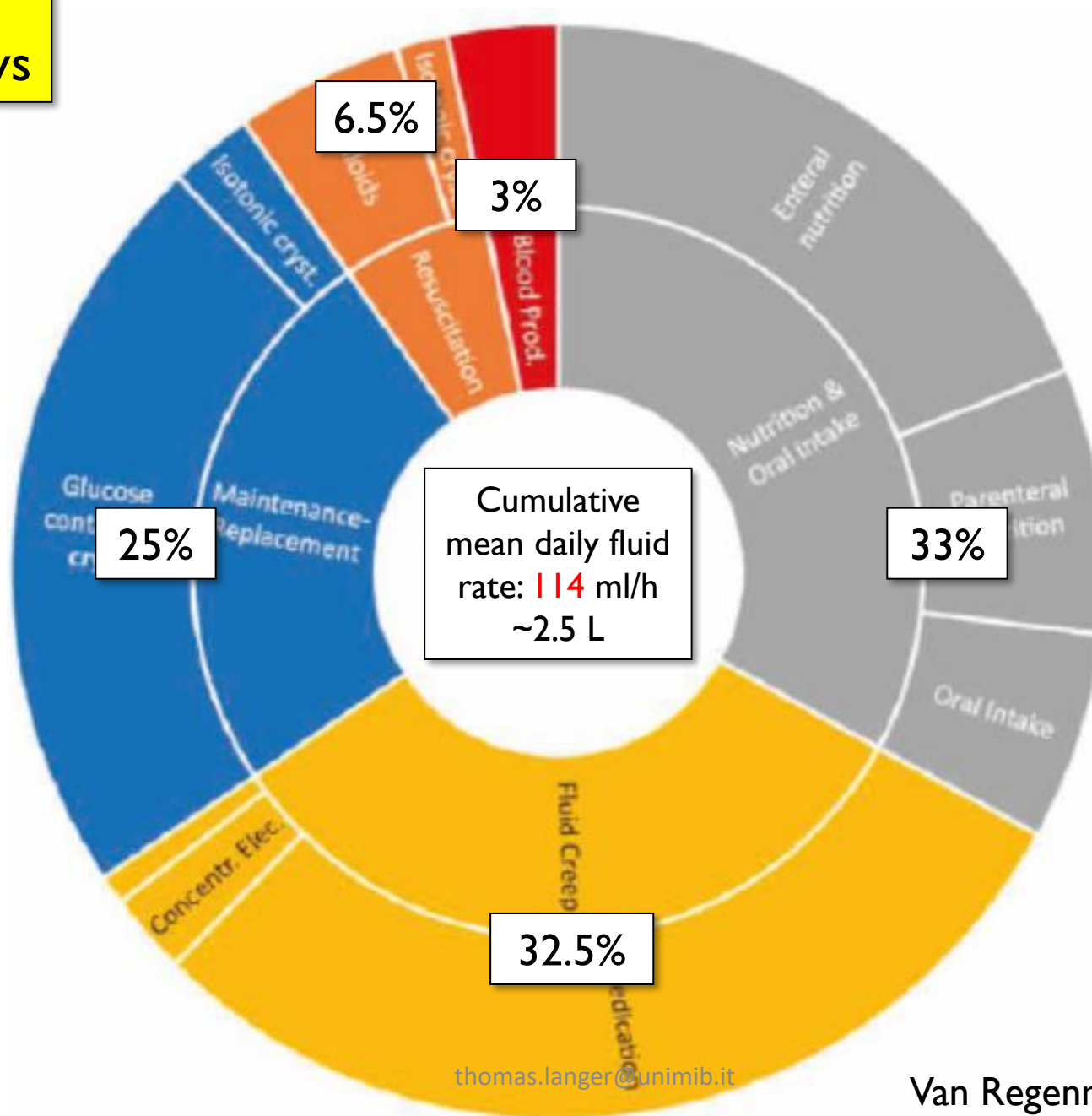
Clinical practice guideline on diagnosis and treatment of hyponatraemia



Agenda

- Sodium homeostasis — The Basics
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14654 pts
103098 ICU days



Characteristics of some crystalloids

[] in mEq/L

	NaCl 0.9%	Lactated Ringer's	Hartmann's	Rehydrating III	Plasma Lyte	Sterofundin ISO
Na ⁺	154	130	131	140	140	145
K ⁺	0	4	5	10	5	4
Ca ²⁺	0	3	4	5	0	5
Mg ²⁺	0	0	0	3	3	2
Cl ⁻	154	109	111	103	98	127

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Maintenance fluids

Provide water and electrolytes in hemodynamically stable patients that are not able/allowed to drink water

I.

Do I really need maintenance fluids?

Consider enteral feed: >80% is water!

Consider fluid creep!

Consider addition of enteral water!

Maintenance fluids

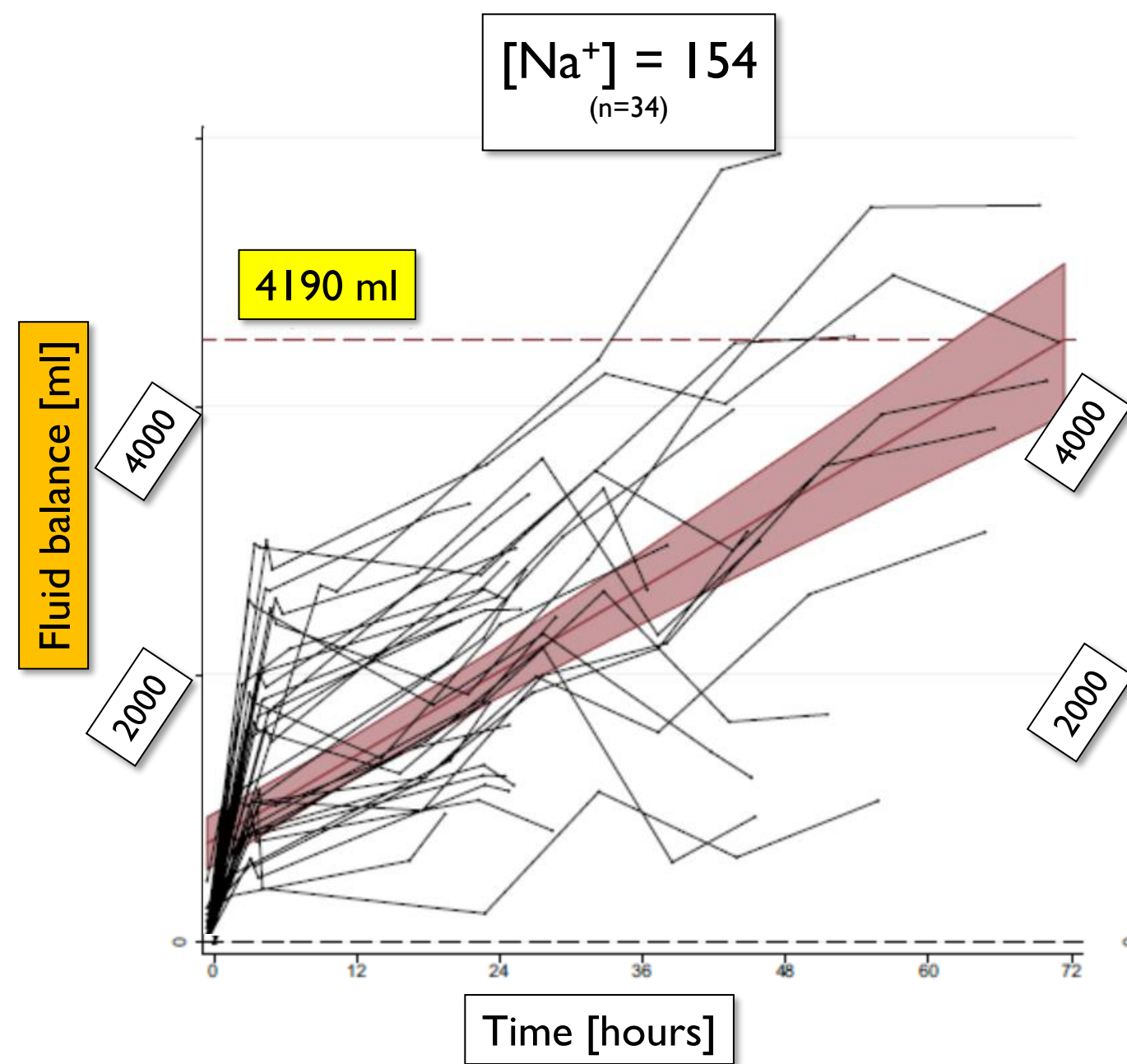
2.

If really needed:

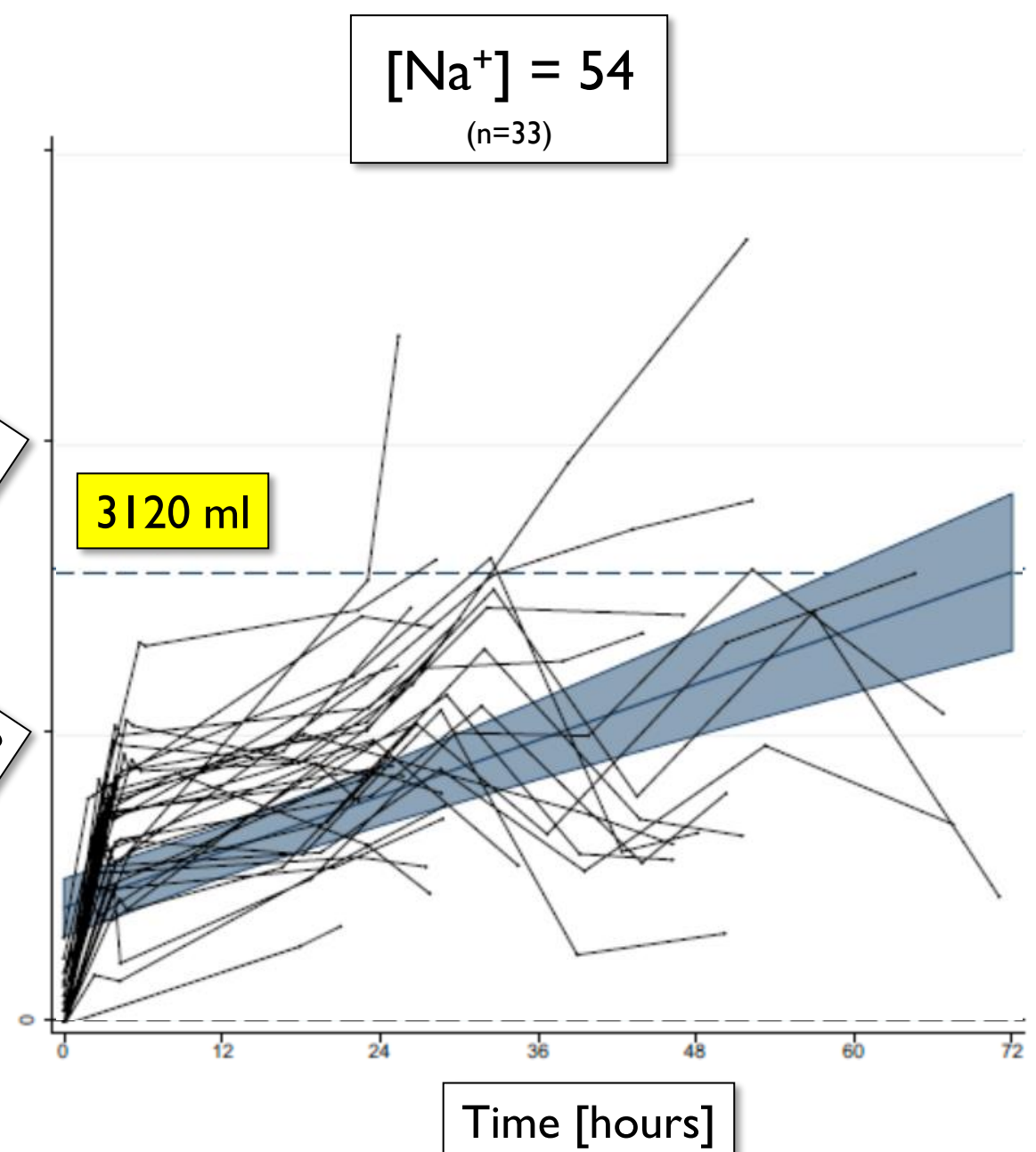
Use **hypotonic fluids!**

Lower sodium load

Low risks of hyponatremia in adult ICU patients



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Characteristics of hypotonic crystalloids

										[] in mEq/L	

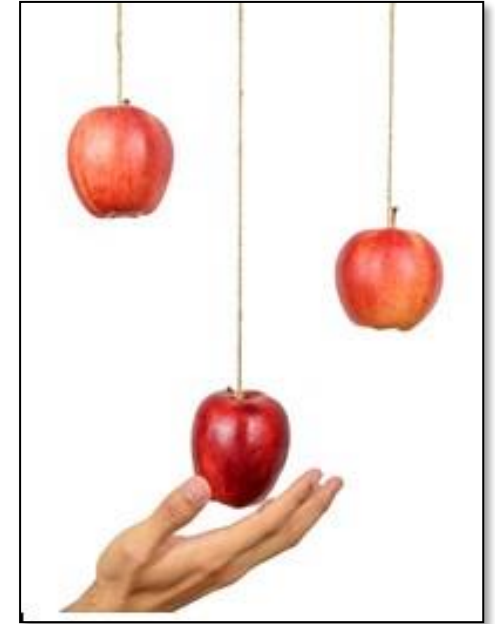
[] in mEq/L

Cut the creep!

Oral drugs whenever possible

Concentrate more!

Use Dex 5% instead of NaCl 0.9%



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Clinical case

Man, 62 years

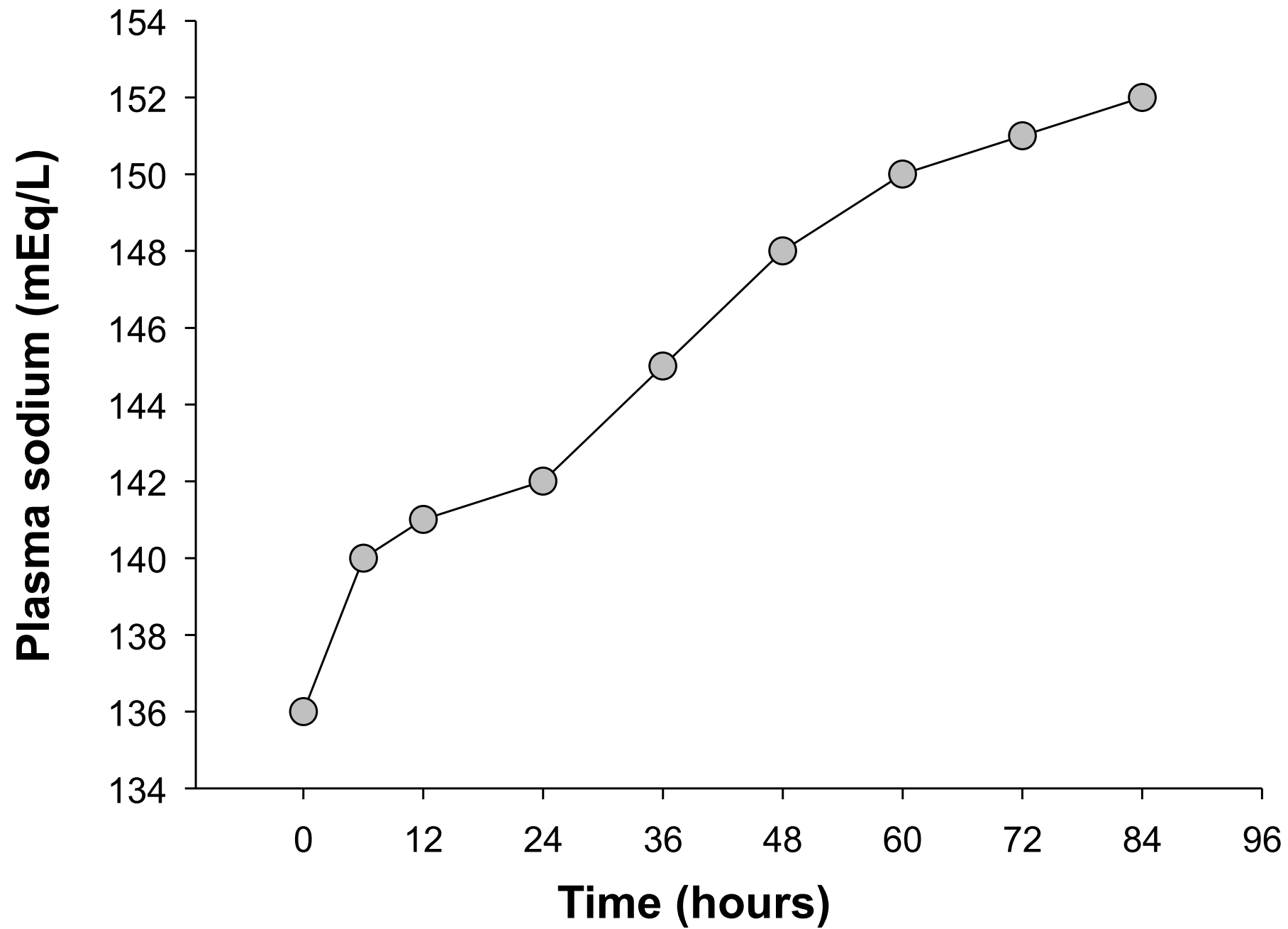
1.75 m, 75 kg, BSA 1.9 m², PBW 71 kg

PMH: Smoker, benign prostatic hypertrophy

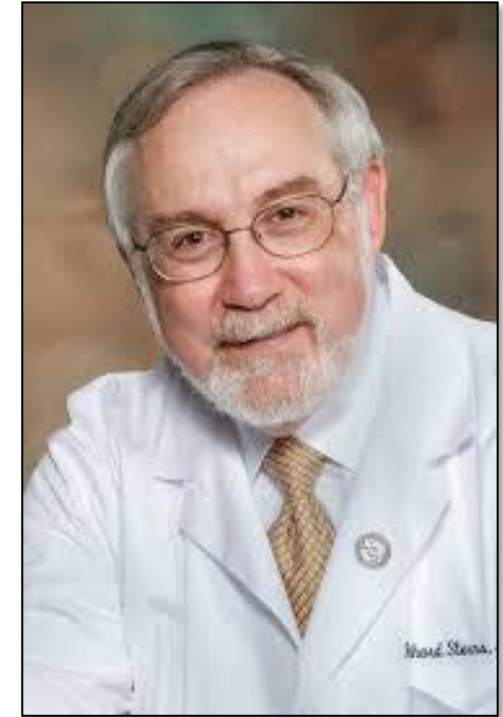
CMH: In the ED, AP 75/52/40 mmHg, HR 115r oliguric, lactate 6 mmol/L, BE -12 mmol/L → Septic shock

Clinical course: ATB, AKI, no CRRT, weaned from pressors, difficult to wean from ventilator
Agitated, delirium





Of all fluid and electrolyte disturbances, hypernatremia is the easiest to evaluate and treat.

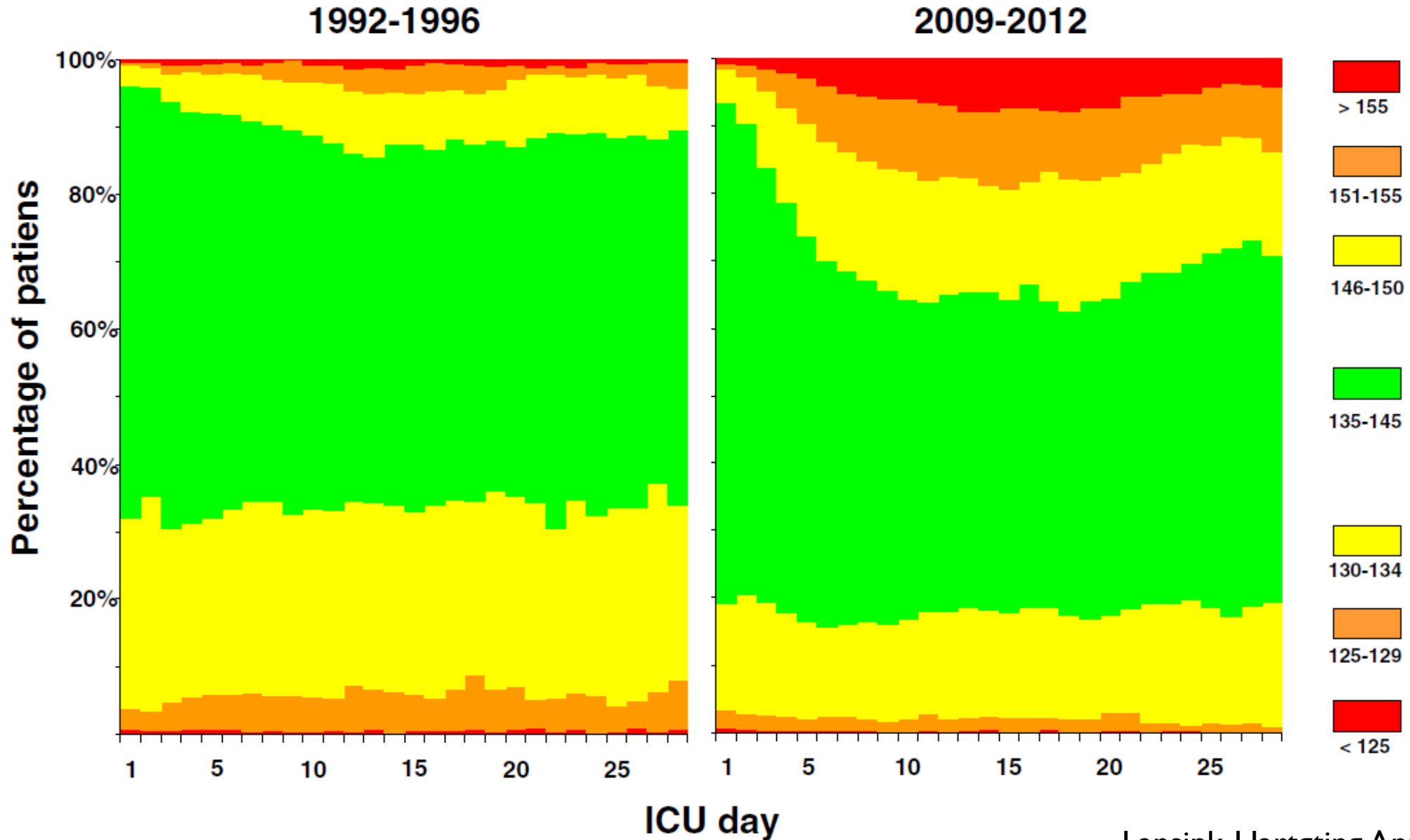


Richard Sterns, Critical Care Medicine 1999; 27 (6): 1041-42

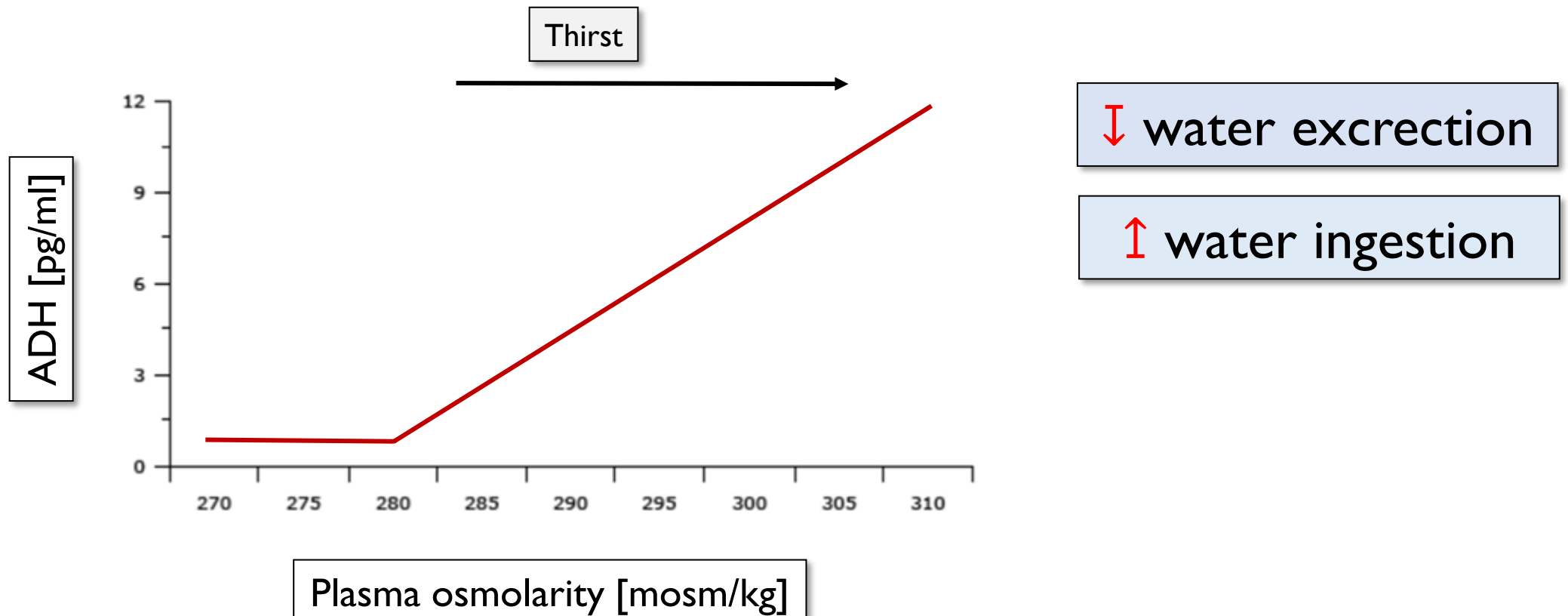
Hypotonic = Hyponatremia ≠ Non - Hypotonic

Hypernatremia = Hypertonic

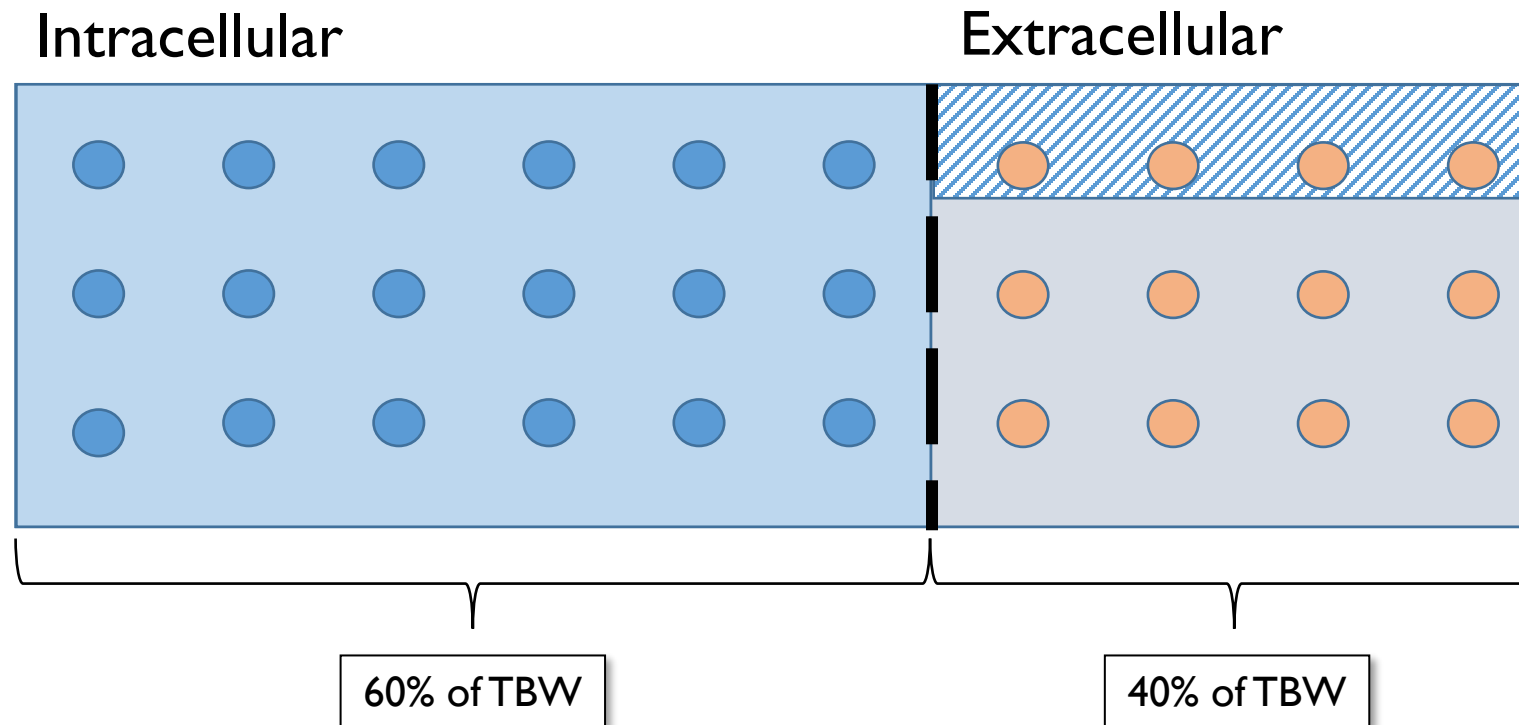
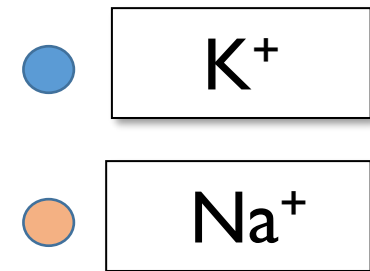
Dysnatremia over time



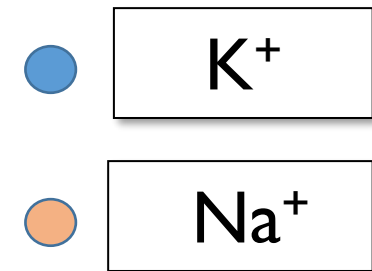
Normal response to hyperosmolarity



Normal condition

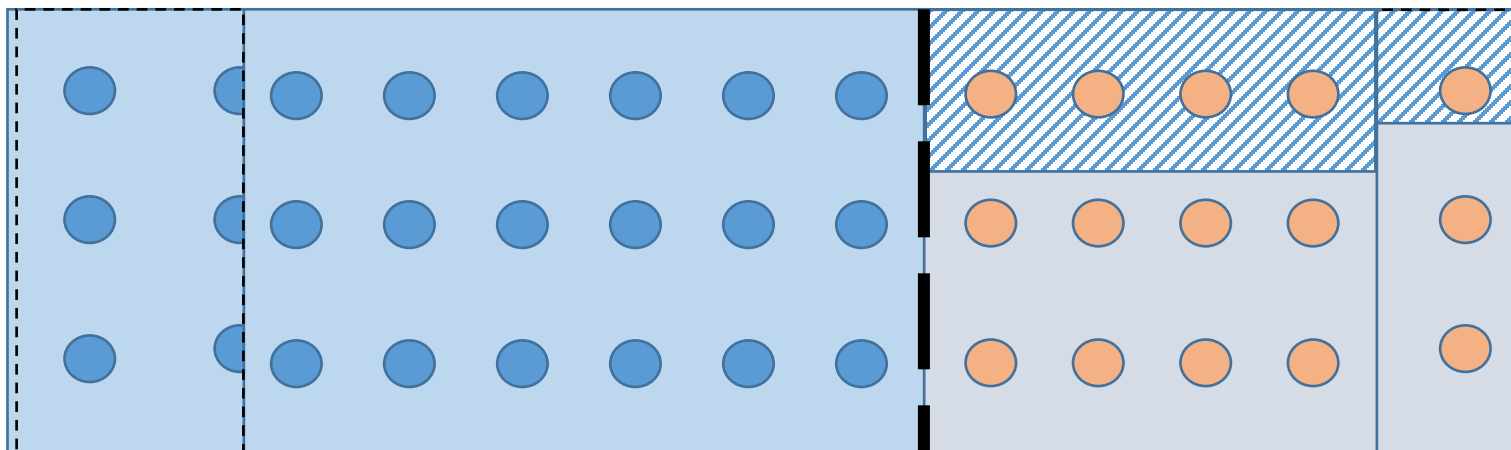


Pure water deficit



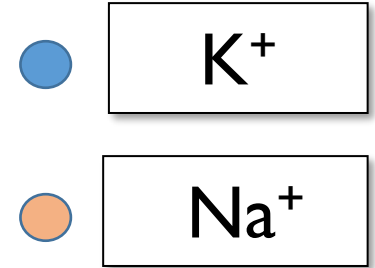
Intracellular

Extracellular



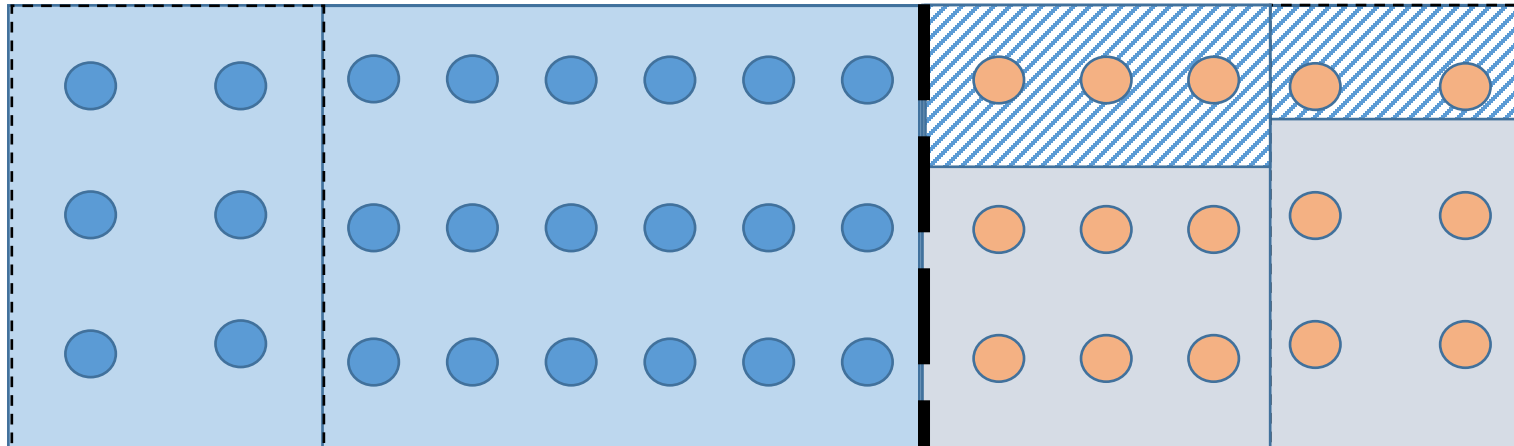
Diabetes insipidus

Hypotonic sodium loss



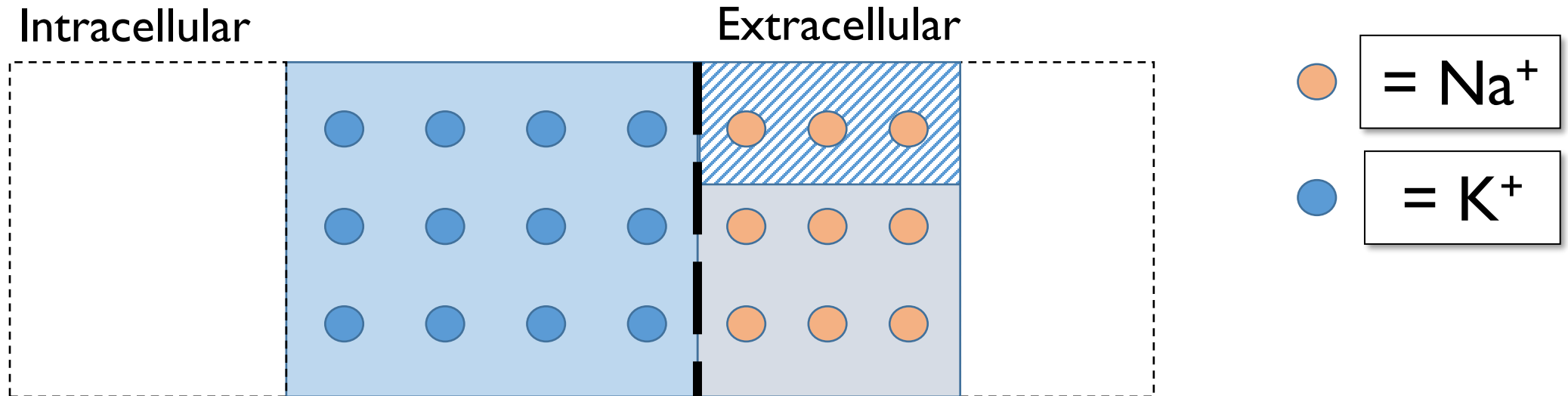
Intracellular

Extracellular



Vomiting

Hypotonic sodium and potassium loss



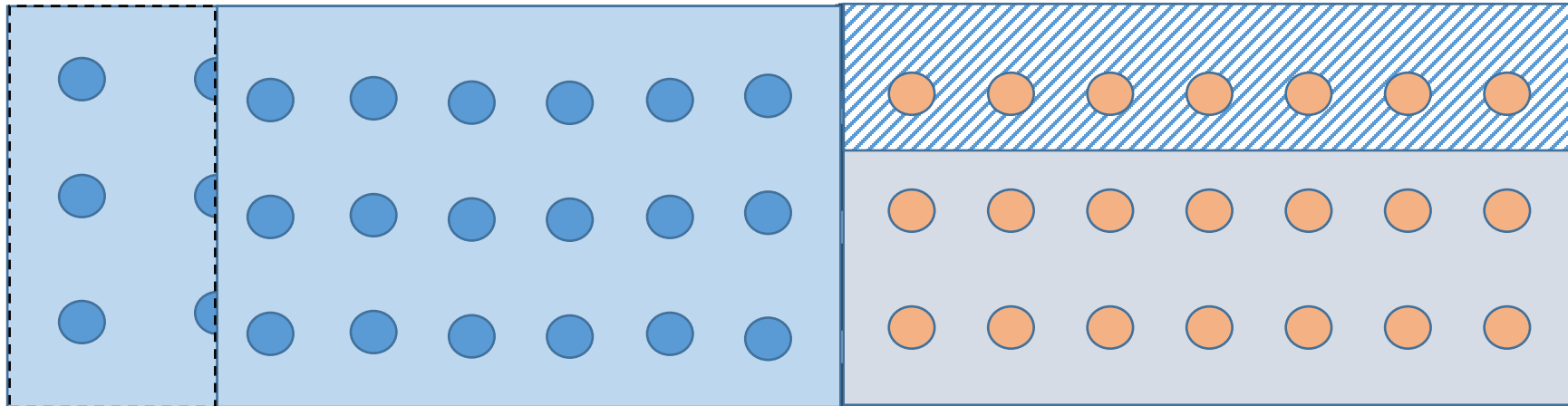
Osmotic or pharm diuresis

Glucose, urea, mannitol, furosemide

Hypertonic sodium gain

● = Na^+

● = K^+



Hypertonic NaHCO_3 , NaCl

Diagnostic workup

History

Plasma

Sodium (Point of care), glycemia, urea

Urine

Measured osmolarity + sodium + potassium

Hypernatremia

Urinary osmolarity [mOsm/kg]

<300

- Diabetes Insipidus

300 - 800

- Partial DI
- Osmotic diuresis

>800

- Insensible/gastro. water loss
- Too little water intake
- Na⁺ overload

Urinary osmolarity

50 – 1200 mOsm/kg

Treatment

Acute

vs.

Chronic

Instant quality: just add water R Sterns Crit Care Med 2009

Caveat

Avoid overcorrection!

STOP

• $\Delta\text{Na} = 10 - 12 \text{ mEq/L}$

Water deficit (theory)

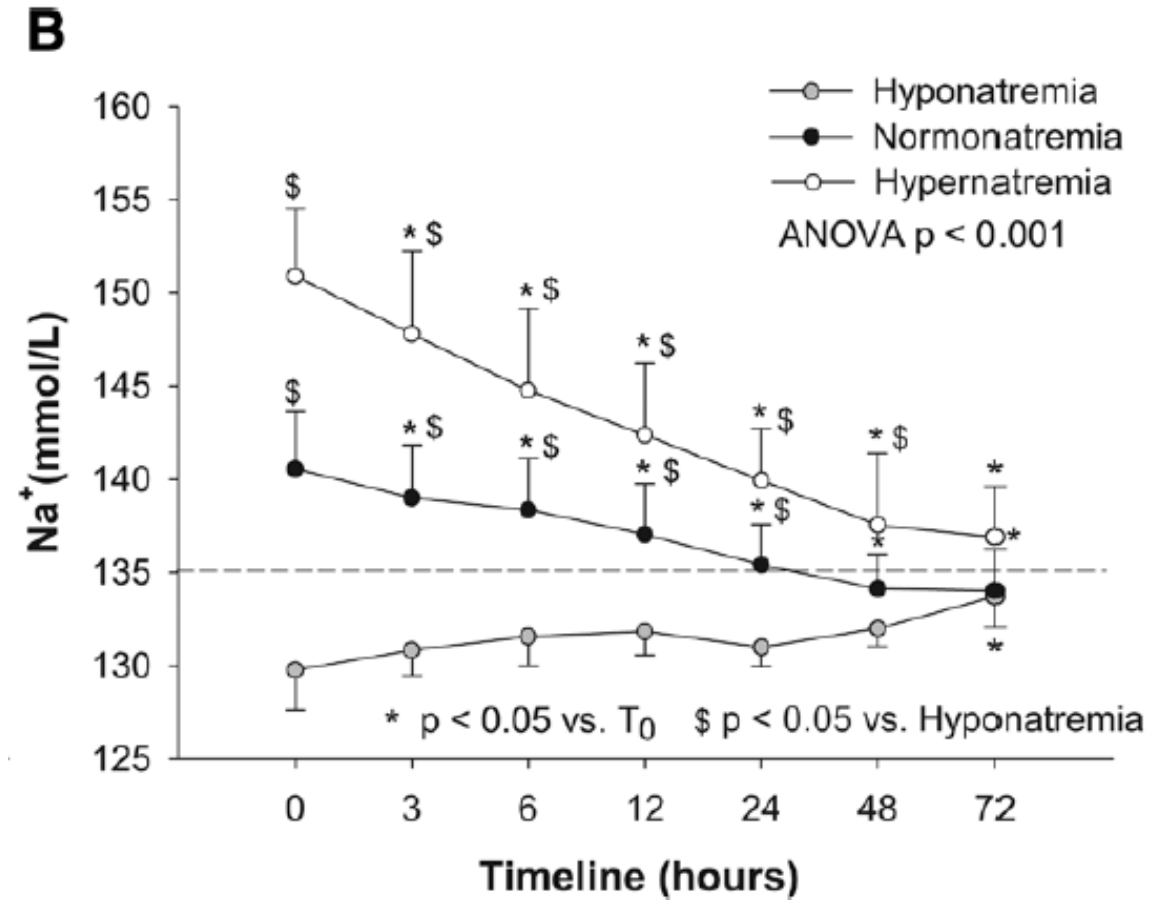
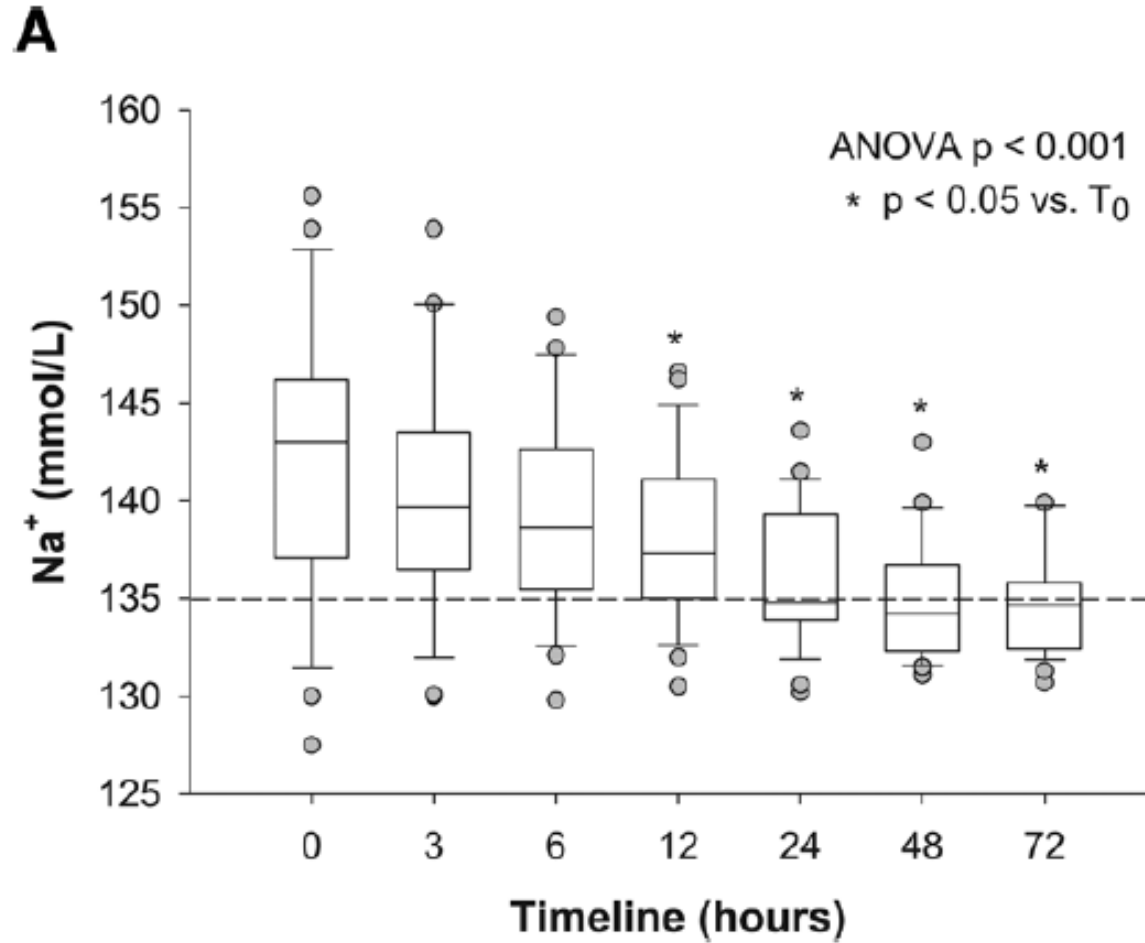
$$\text{H}_2\text{O deficit} = 0.6 \times \text{Lean bw} \times \frac{[\text{Na}^+]_{\text{pl}} - 140}{140}$$

e.g. 70 kg ♂ with $\text{Na}^+ = 150$

3 L

Consider ongoing losses!

Treatment with CRRT



Conclusions

Sodium key electrolyte for electroneutrality and osmolarity

What's in a number: sodium measurement

Hospital/ICU: a sodium-rich environment

Hypernatremia is very common and preventable

Water? Still, sparking? Just free water, thank you!

Water, water, everywhere. Nor any drop to drink!

