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Water & electrolyte disturbances

Copotoiu Ruxandra

Total body water TBW

- **60% men, if 70kg TBW = 600ml/l = 42kg**
- **50% women**
- **Age dependent**


Men
Women
Adipose
and lipid
Misc.
tissue
Total
body water
(kg)
(kg)
80
70
60
50
40
30
20
10
0
Young
Older
Young
Older

Shigechyo Izumi born June 1965, lived 120 years + 237 days

- **Worked until 105 yars**
- **Drank sake**
- **started to smoke at 70yrs**

TBW age dependent

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Growing old

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TBW compartments

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- **Intracellular 2/3 total water = 40% total body weight**
- **Extracellular 1/3 = 20%total body weight**

  - **Intravascular 5% total body weight**
  - **Interstitial fluid 15% total body weight**

  Transcellular – part of extracellular 1-10l

  Plasma + red cells = blood volume = 7% total body weight

Osmolarity = tonicity = nr of particles in solution = 280-295mOsm/l

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Osmolality = mOsm/kg

Measured osmometers

- **Depression of the freezing point**
- **Vaporization**

Calculated

$2xNa^+ + BUN/2.8 + glicemia/18 = 280-295$

Urine osmolality

50 – 1200mOsm/kg

Hel imbalances

- **Compartment volume – regulated by aldosteron**
- **Fluid concentration– regulated by ADH**

Tonicity regulation

AVP arginine vasopressin = ADH

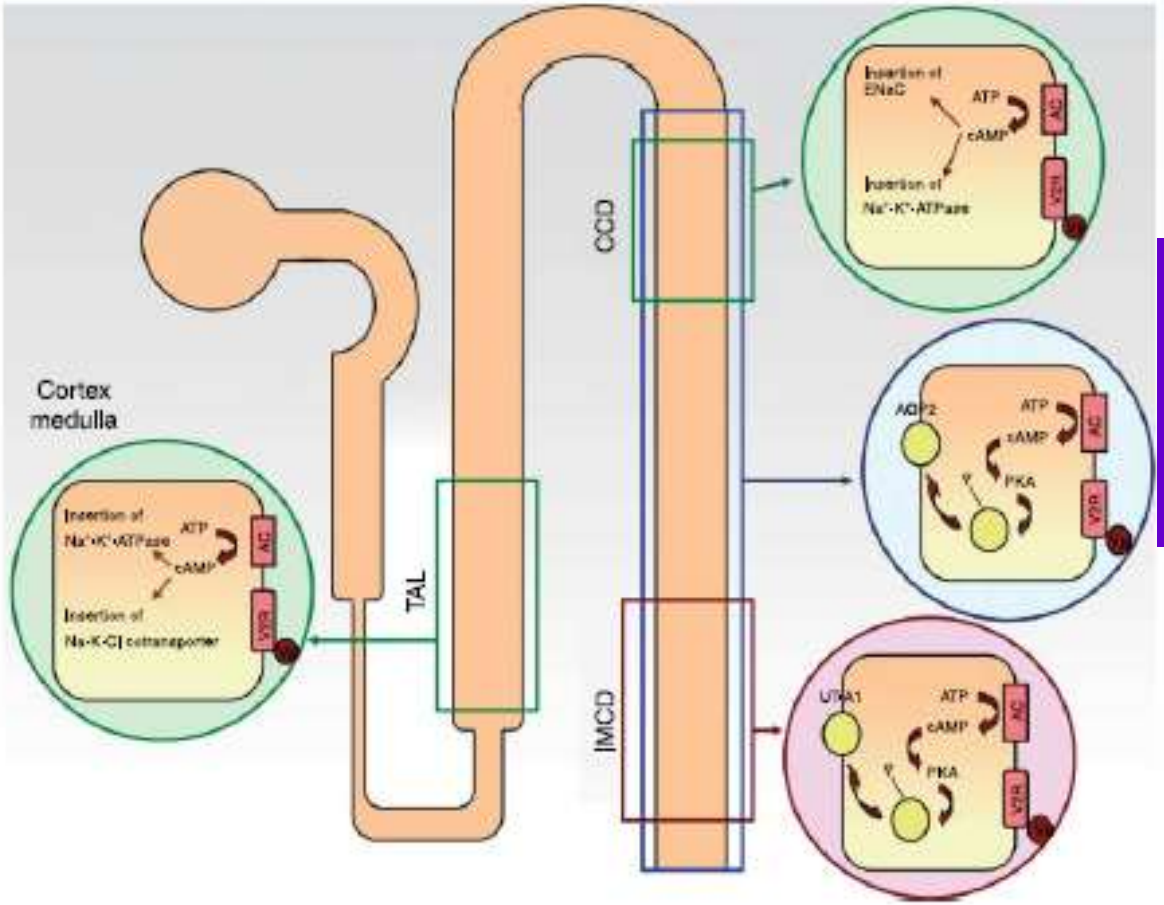
Dependency:

- Water intake
- Hormone output
  - **Small changes of osmolality 1-2% osmorecceptors ant hypothalamus**
  - **Mean BP/blood volume baroreceptors – Ao arch, carotid bodies**

Vasopressin-independent mechanisms in controlling water homeostasis

Carrie Y Y Cheng*, Jessica Y S Chu* and Billy K C Chow

School of Biological Sciences, The University of Hong Kong, Pokfulam, Hong Kong SAR, People's Republic of China



ADH→↑AQP-2channels:

- **Free water reabsorbtion**
- **antidiuresis**

Secretin & oxytocine contribution to water regulation

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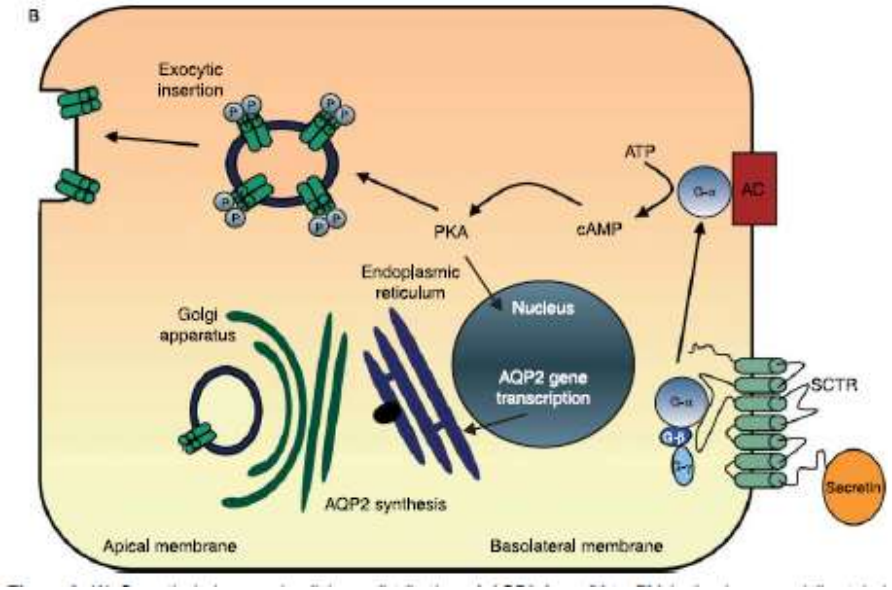

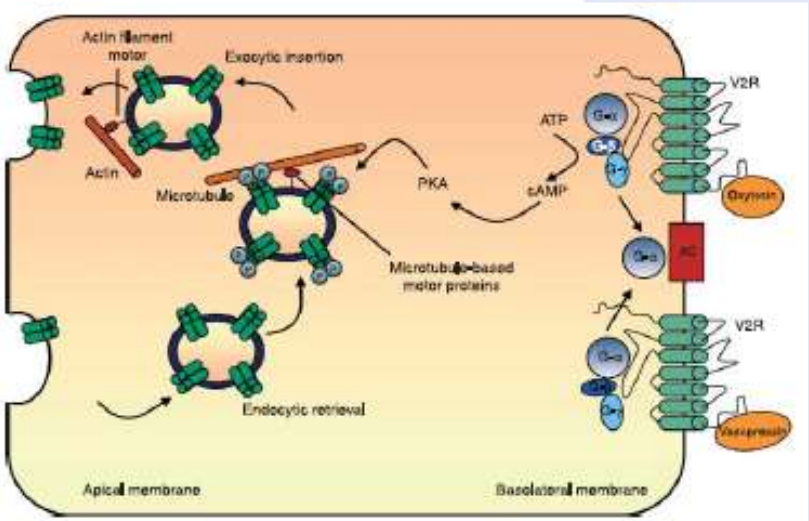

ICF concentration of solutes # ECF concentration of solutes
70kg adult, masculine, TBW = 42l

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Compartment	water	Cations & anions
ICF	28l (40% x 70)	Na+ 10; K 150+; Ma 2+ 40; Fosfates 107; proteins 40; sulfates 43
ECF	Circulating BV = 4.9 (7% x 70kg)	Na+ 142; K+ 4; Ca2+ 5 ; Mg2+ 3; Cl 103; NaHCO3 27
	14l (20% x 70)	Na+

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If the IC stores of solutes are depleted, one needs large amounts of certain electrolytes to replete small serum changes.

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As today, we are unable to assess intracellular electrolytes at the bedside.

Fluid flux between intravascular compartment and interstitium Q

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Plasma proteins/interstitial fluid proteins 16/1 = oncotic pressure difference.

$$Q = Kf \{(Pc-Pi) - \sigma(\pi c - \pi i)\}$$

Q = net flux

Pc-Pi = hydrostatic pressure capillary/interstitium

$\pi c - \pi i$ = oncotic pressure difference

Kf membrane filtration coefficient ml/min/mmHg (capillary surface area x capillary hydraulic conductance)

σ = permeability factor (0 = completely permeable, 1=impermeable)

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σ Explains why in capillary leak (shock, ARDS), colloids cannot mainaitn the oncotic pressure difference and leak into the interstitium.

Principles of fluid resuscitation

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- **Intravascular hypovolemia should be replaced with isotonic fluids which tend to distribute in the ECF (3:1) intravascular: interstitium.**
- **Hipotonic fluids will distribute evenly between all body compartments.**

- **The endpoint of fluid resuscitation !?**
  - **Surrogate markers: BP, HR, urine output, parameters of perfusion and cardiac function.**

Hyponatremia ser Na^+<135mE/l

Water>>>/Na

Clinical signs: Cerebral edema

Mild: 130-135 - asimptomatic

Moderate: 125-130: fatigue, malaise, nausea, usteadiness

Severe: 115-120 headache, restleness, obtundation, lethargy, seisures, coma, brainstem herniation, respiratory arrest, death

Truisms about Na

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- **Na is a relative fixed solute 136-140**
  - **K follows…should be closely monitored and replaced or opposed**
- **Disturbances in serum Na reflect disorders in water balance**

- **Administration of water to a patient with impaired water excretion can lead to hyponatremia.**

Water intake and excretion/regulation

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Hyper Na	Thirst stimulated → ↑water intake ADH release↑ → Concentrated urine	Free water retention
Normo Na		Free water intake = free water excretion
Hypo Na	ADH supressed → Dilute urine	Free water excretion

States of impaired water excretion in the ICU leading to Hyponatremia

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Volume depleted states

- Volume depletion
- Diuretics

Normal volume states

- SIADH
- Pain
- Postoperative state
- Nausea
- Hypothyroidism

Volume-expanded states

- Congestive heart failure
- Renal failure
- Cirrhosis

Hypo-osmolar hyponatremia

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ECV

Hypovolemic

- **Simultaneous loss of solute & water →↓ECV→nonosmotoc release of ADH. If water intake →hNa**
- **Cerebral salt-wasting syndrome**

Isovolemic

- **SIADH ser Osm<275, Urine>100mOsm/l**
- **Adrenal insufficiency – nonosmotic ADH release due to cortizol deficiency**
- **Pregnancy - chorionic GDT ↑**

Hypervolemic

- **Congestive heart failure**
- **Cirrhosis**
- **Chronic kidney disease**

Dehidration

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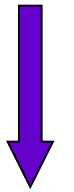
- Dehidration – ambiguous term, uable to differentiate between simple water loss and Na loss
- A simple water deficit proportionally reduces ECF and ICF
- A NaCl deficit always reduces ECF

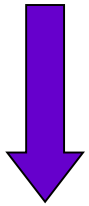
Water deficit (l) = 0,6 x G x Na plasmatic / (140 – 1)

Hyperosmolar Hyponatremia

↑↑osmotically active particles in plasma



Water efflux from ICS→ECS



hNa^{+} & Hyperosmolality

Hyperosmolar Hyponatremia

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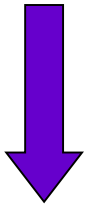

hNa^{+} & Hyperosmolality

Hyperglycemia, mannitol, glycerol, ethanol, sorbitol infusions

Iso-osmolar hNa

- ↑↑ECS by isotonic non-Na containing fluid
- ↑↑ serum proteins & lipids

Hypernatremia >145mmol/l

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- **Brain shrinked, collapsed→vascular damage + intracerebral or SAH**

- **Osmotic myelinosis = late, but following rapid hNa correction:**

  Lethargy, muscle weakness, nausea, hyperreflexia, seizures, coma

HNa

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Diabetes insipidus

- **Central diabetes = ADH deficiency: TBI, pituitary surgery, brain death, aneurismal SAH, autoimmmune**

- **Nephrogenic**

  renal resistance to ADH

- **Osmotic diuresis – excess nonresorbable urinary solute**
  - **Hyperglycemia, mannitol, ↑↑serurea, hypertonic medication**

HNa

- **Sea water ingestion**
- **Use of hypertonic saline for cerebral edema**
- **Use of NaHCO3 iv**
- **Overdose of tricyclic antidepressants**

K^+

- 98% IC = 3 000mEq 140-150mmol/l
- EC <2% 60ml ser 3.5-4.5mEq/l
- Cellular access ; active Na+, K^+-ATP ase
- Cellular exit: passive diffusion

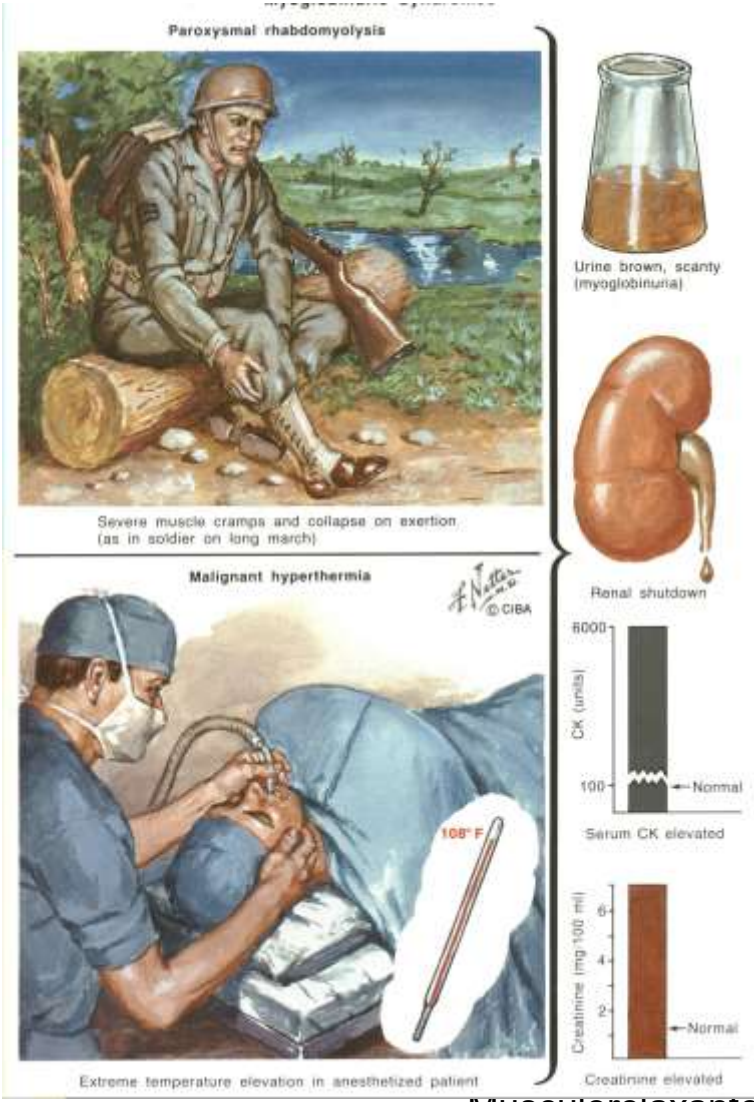
hK <3.5

- ↓ K intake
- ↑renal losses
- Redistribution ECS → ICS

HK+>5.0

- Exogenous
- Endogenous

Myoglobinuria sindromes



- Paroxistic rhabdomyolisis: severe muscle pain, exericise collaps
- Malignant hyperthermia
- Rhamdomiolysis due to heroin overdose

(Kumar, BJA 1999;83:496-498)

PPF periodic familial paralysis

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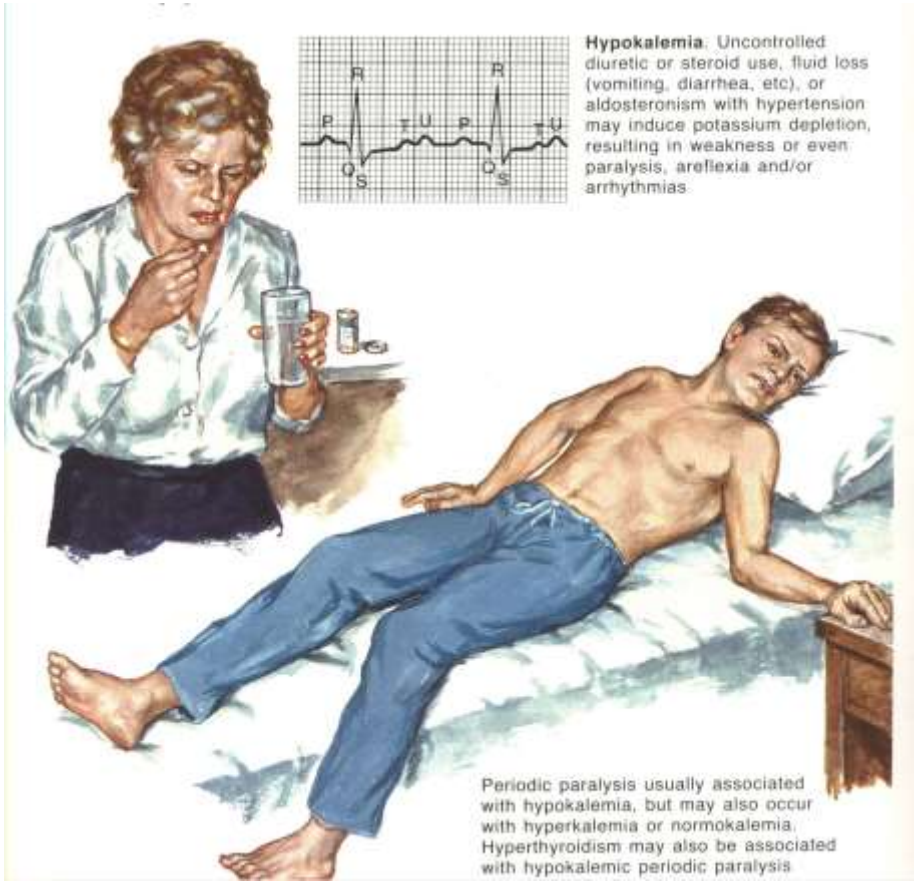

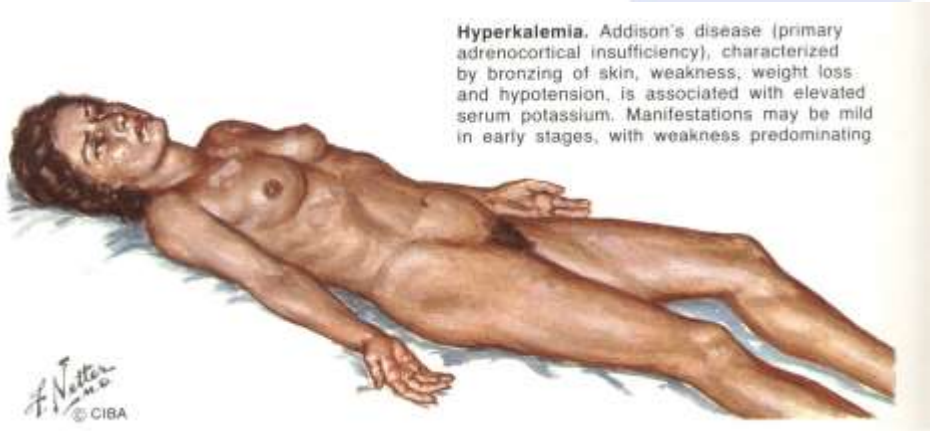

HEL status assessment

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Volemia assessment

- BP supine + sitting
- HR
- Mucosal Humidity
- Skin fold
- Urinary output

Assessment of plasmatic concentration

- Na serum
- serum osmolality

Assessment of electrolyte composition

Serum electrolites, BUN, glycemia, ABG, pH