MEDICINE

432 Team

19 Electrolytes Imbalance I (sodium & Water)

Done By:
Mona Almofarej

Reviewed By:
Raghad Al mutlaq

جامعة الملك سعود
King Saud University

COLOR GUIDE: • Females' Notes • Males' Notes • Important • Additional

Objectives

1. Recognize the systems that control body Na and H_2O contents
2. Understand the difference between body Na content (volume status) and serum Na concentration.
3. Recognize the different types of IV fluids used at bedside.
4. Know the workup for Hyponatremia
5. Know how to calculate the water deficit in Hypernatremia

structure:

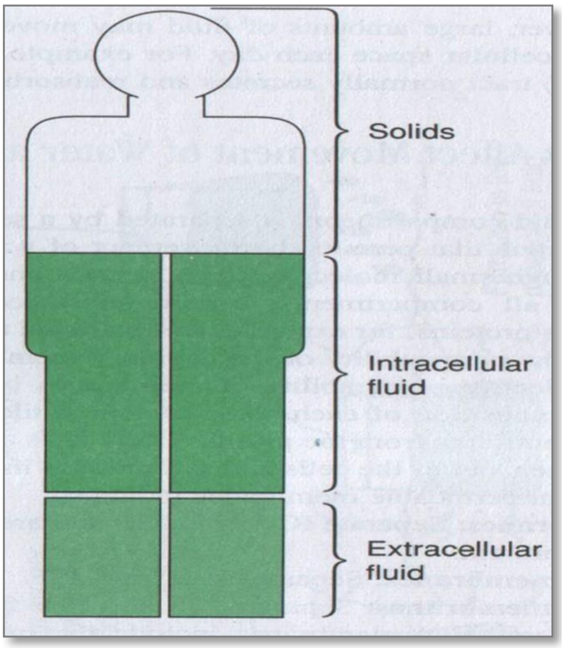
1. *Composition of the fluid compartments*
2. *Mechanisms which regulate fluid and Sodium balance*
3. *Disorders of water balance*
4. *Disorders of Sodium balance*

Note: please do NOT skip the pictures, especially the ones caontain graphs

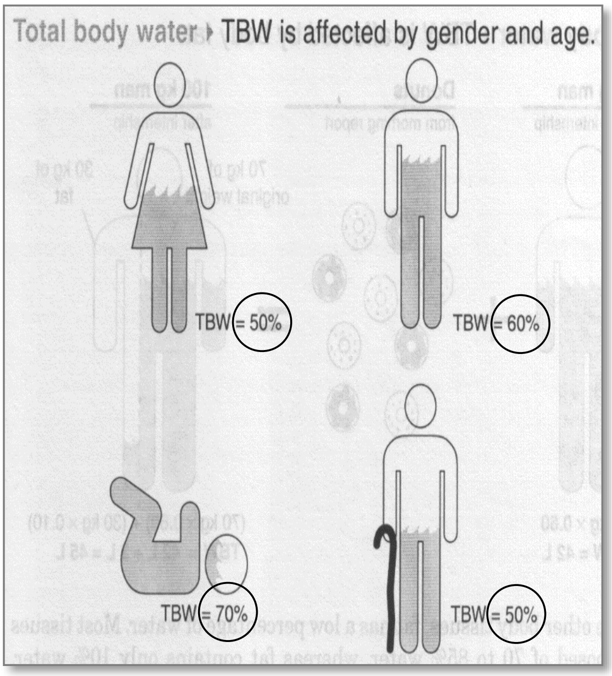
Homeostasis

A relative constancy in the internal environment of the body, naturally maintained by adaptive responses that promote cell function and survival (the body must maintain the level of fluid and electrolytes otherwise it will affect the metabolism.)

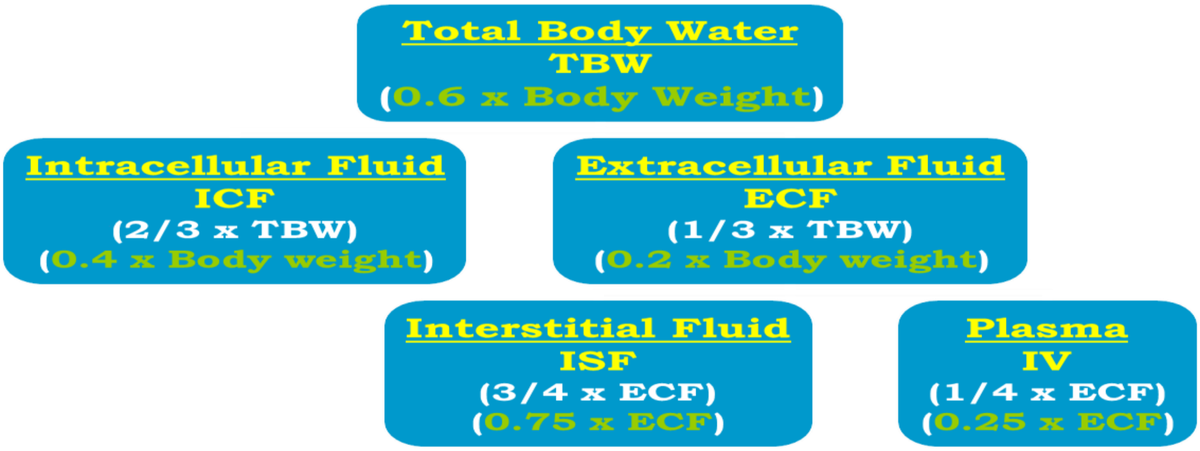
Total Body Fluid:



Normally, We have 60% of our body weight made of fluids



There are considerable variations in body water percentage based on a number of factors like age, health, weight, and gender. (It's important to know the percentages for IV fluid prescription)



Body Fluid Compartments:

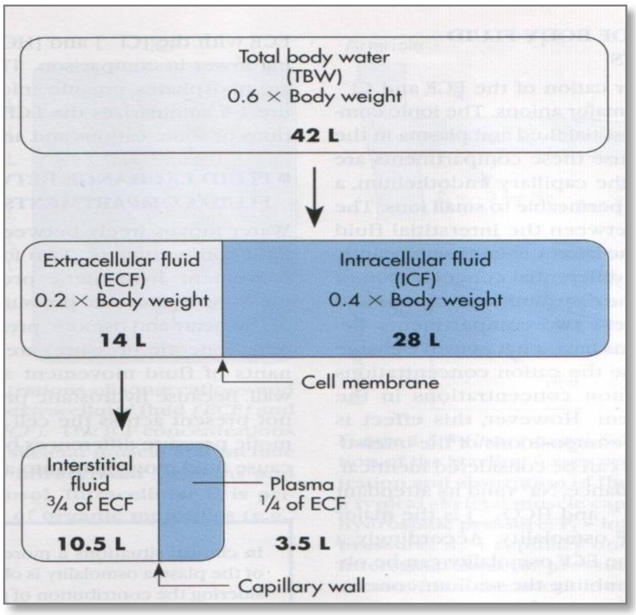
Fluid compartments are separated by thin *semi-permeable membranes* with pores to allow fluid movement and molecules of a specific size to pass while preventing larger heavier molecules from passing

The bodies fluid is composed of water and dissolved substances known as *solutes* (electrolyte or non-electrolytes)

Electrolytes are substances dissolved in solution dissociated into particles called *ions*

Cations: Positively charged ions

Anions: Negatively charged ions



This calculation for 30 y.old Caucasian male, his weight 70 kg.

60-40-20 rule:
- TBW is 60% of body weight.
- ICF is 40% of body weight
-ECF is 20% of body weight (interstitial fluid 15% and plasma 5%)

Definitions

Osmosis: movement of water (from low osmotic area to high osmotic area)

Diffusion: movement of solutes

Filtration: movement of both solutes and water

Osmolality:

- Osmoles in solution: mOsm/kg water
- Calculate plasma osmolality *-Posm-* = (2 x serum Na^+) + blood urea + glucose

(The serum sodium is multiplied by two to account for accompanying anions (chloride and bicarbonate)

- For Na+, K+ and Cl-: 1 mEq = 1 mOsm
- Normal osmolality of body fluids: 283-292 mOsm/kg water

Note(s):

Urea doesn't affect the water shift because it freely cross the cellular membrane exept in dialysis patient . If patient starts hemodialysis that will drop urea quickly so that will lead to water shift.

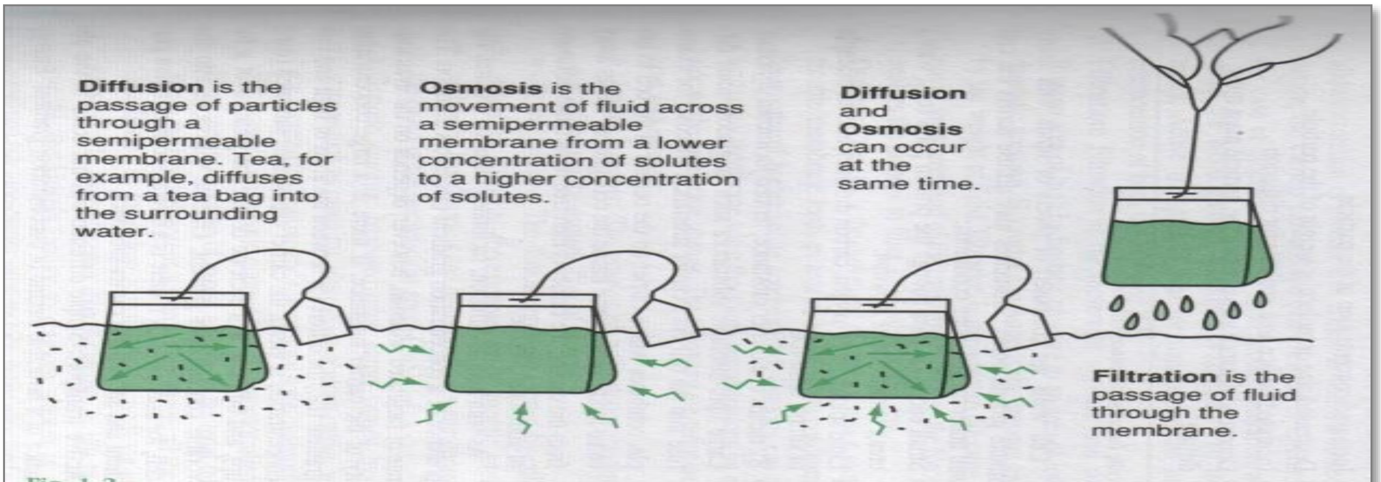


Fig. 1-2
Transport processes.

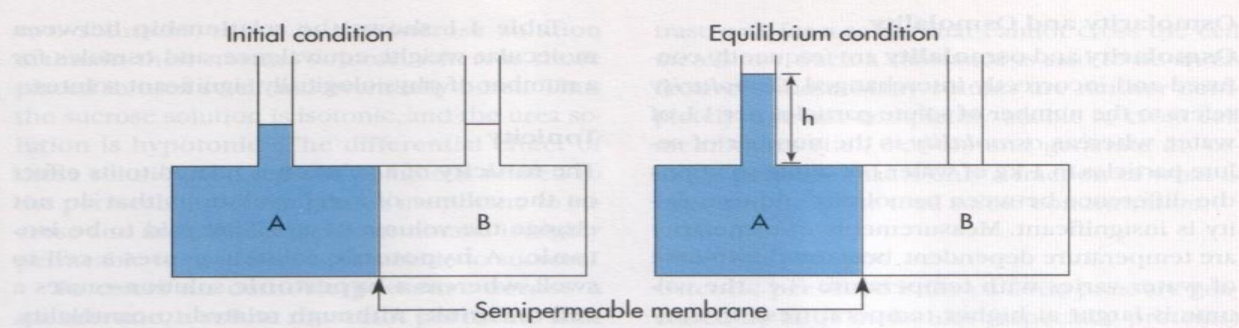
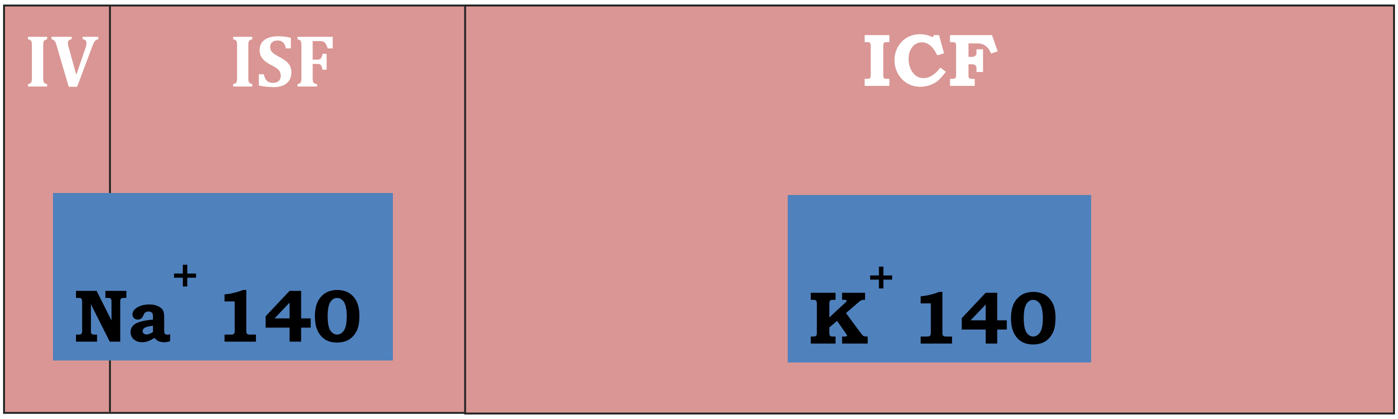


Figure 1-1 ■ **Schematic representation of osmotic water movement and the generation of an osmotic pressure. The solute particles in compartment *A* cause water to move by osmosis from compartment *B* across the semipermeable membrane into compartment *A*. The water column in compartment A will rise until the hydrostatic pressure generated by the water column (*b*) stops the flow of water from compartment *B* into compartment *A*. This hydrostatic pressure is equal to the osmotic pressure generated by the solution in compartment *A*.**

Body Fluid compartments:

- ECF and ICF are in *osmotic equilibrium*
- **ICFosm = ECFosm = Posm**



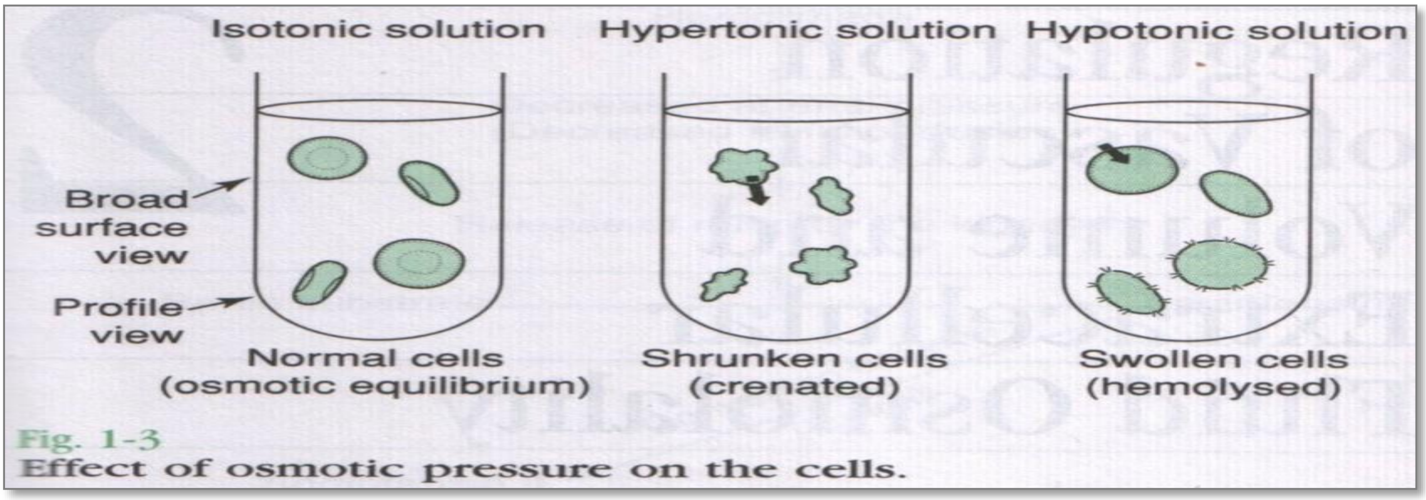


Fig. 1-3
Effect of osmotic pressure on the cells.

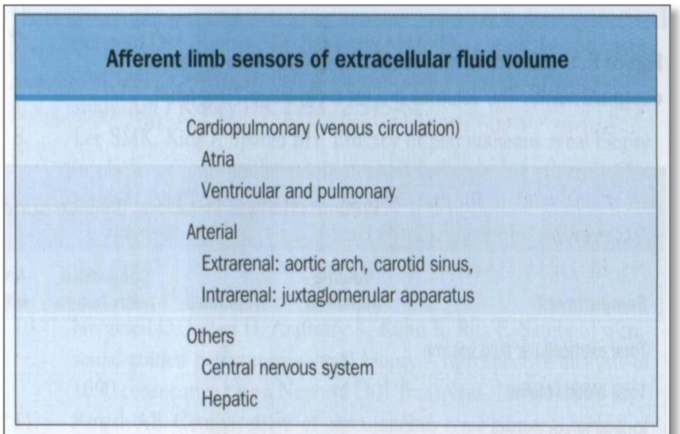
Regulation Mechanisms of Fluid and Electrolytes:

- Regulation of (both) osmolality and volume is achieved through thirst and the osmoreceptor-antidiuretic hormone system (vasopressin)
- Volume is more important than osmolality
- The regulation of volume (without osmolality) also occurs through neurological and renal mechanisms
    - The stretch receptors (baroreceptors)
    - The Renin-Angiotension-Aldosterone System

  } Hold Na so the water back to circulation

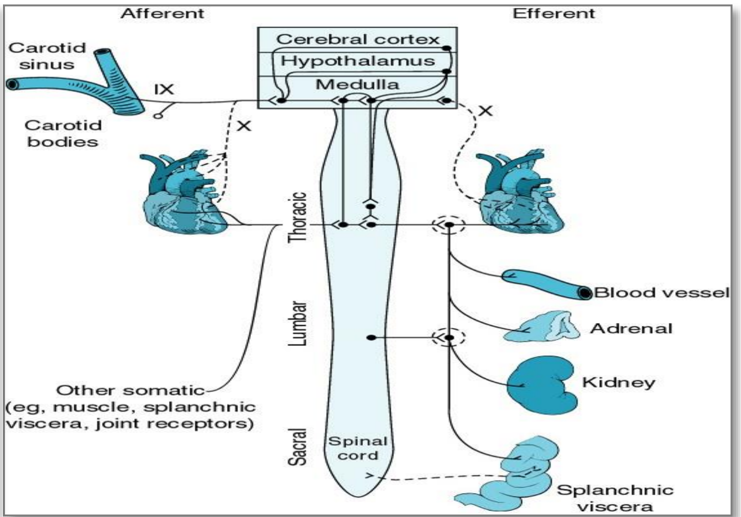
    - The Natriuretic peptides
    - Kinins & Prostaglandins

  } Push Na in the urine

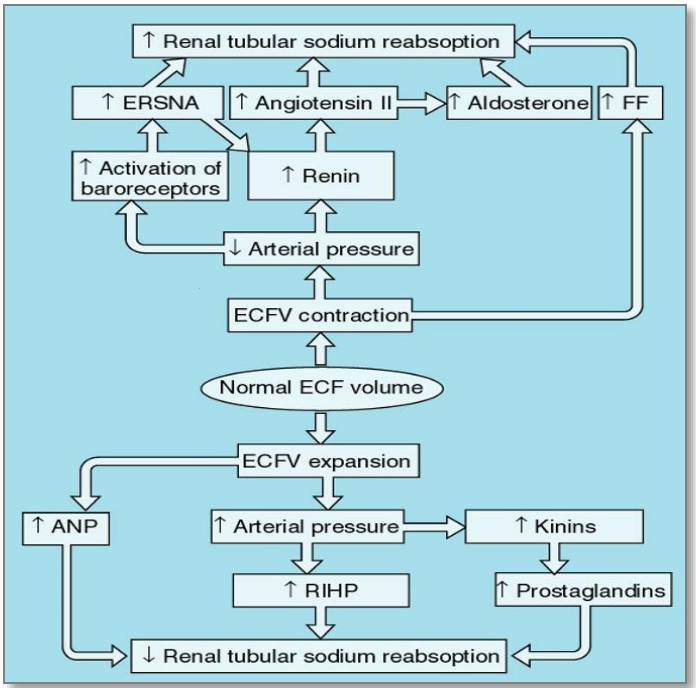


Afferent limb sensors of extracellular fluid volume
Cardiopulmonary (venous circulation)
Atria
Ventricular and pulmonary
Arterial
Extrarenal: aortic arch, carotid sinus,
Intrarenal: juxtaglomerular apparatus
Others
Central nervous system
Hepatic

Figure 8.4 The afferent limb (volume sensors) of the integrated homeostatic response system for extracellular volume.



Controlled by autonomic NS. Receptors exist on Afferent pathway ,e.g.Aortic Arch& heart & other organs.
Efferent controls Cardiac output, Renin system,
And Kidney absorption.



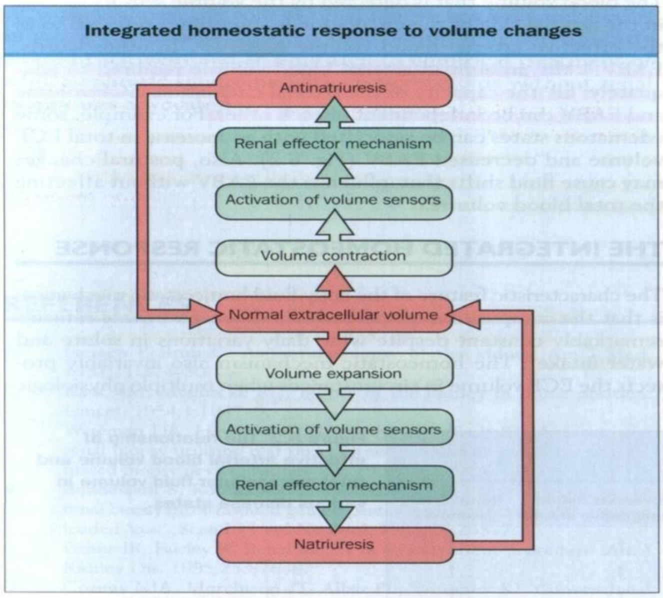
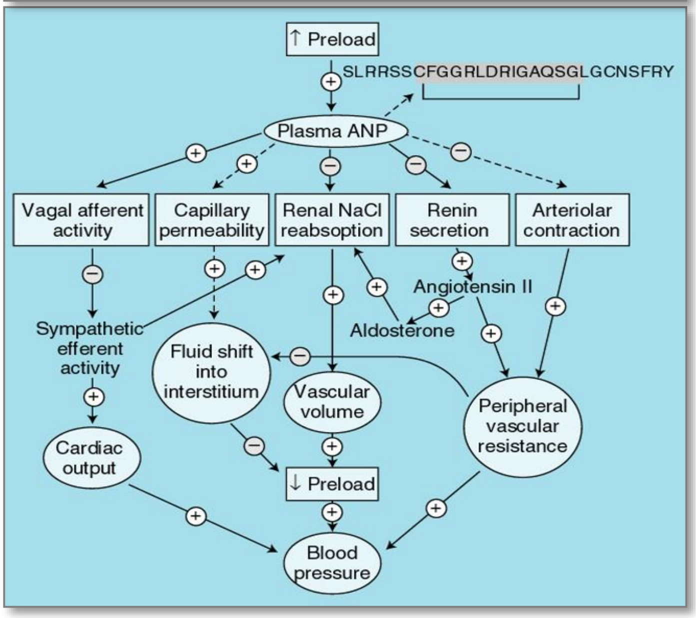
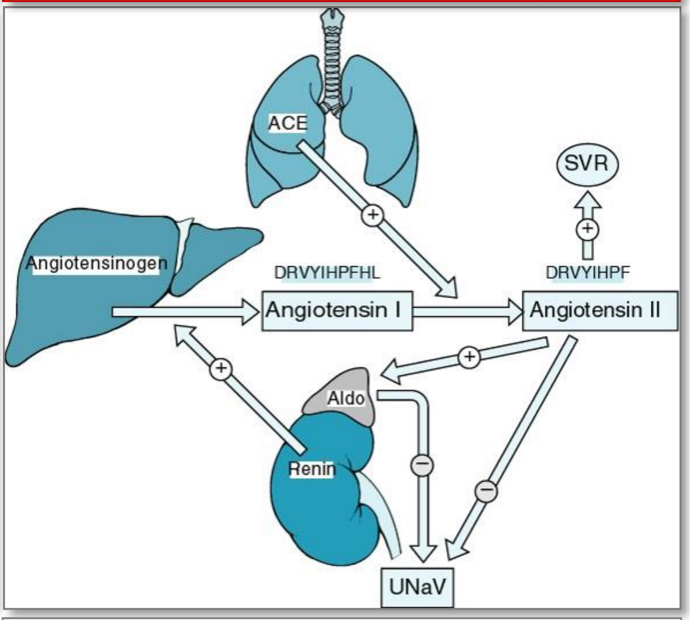


Figure 8.3 A general overview of the integrated homeostatic response system regulating extracellular fluid volume during volume contraction and expansion.





Helpful video:
http://www.youtube.com/watch?v=bY6IWVgFCrQ

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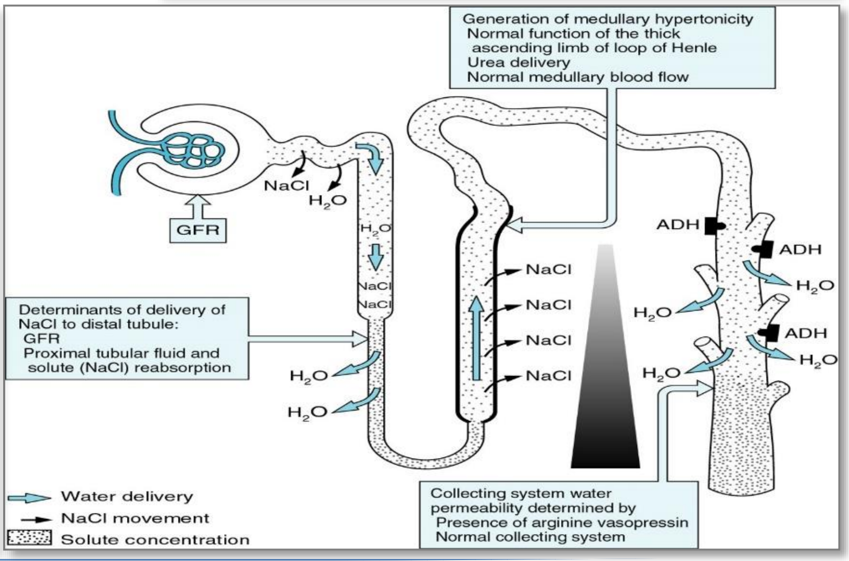
http://www.youtube.com/watch?v=vNvZaGcLzEo

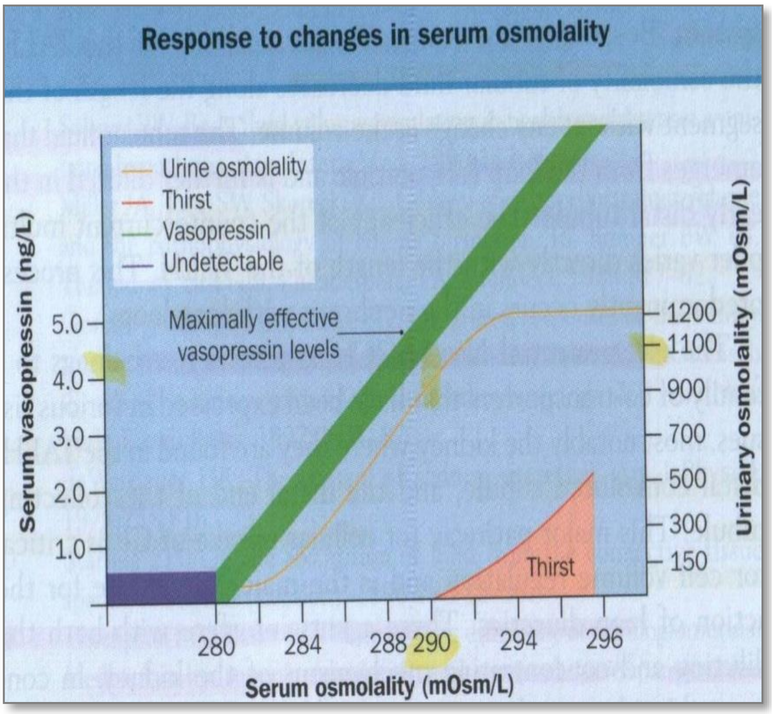


If there is an increase in serum osmolality, ADH will be released and thirst will be stimulated.
Range of urine osmo:
50-1200 mmol
1200 m0sm\L = maximum concentration of urine

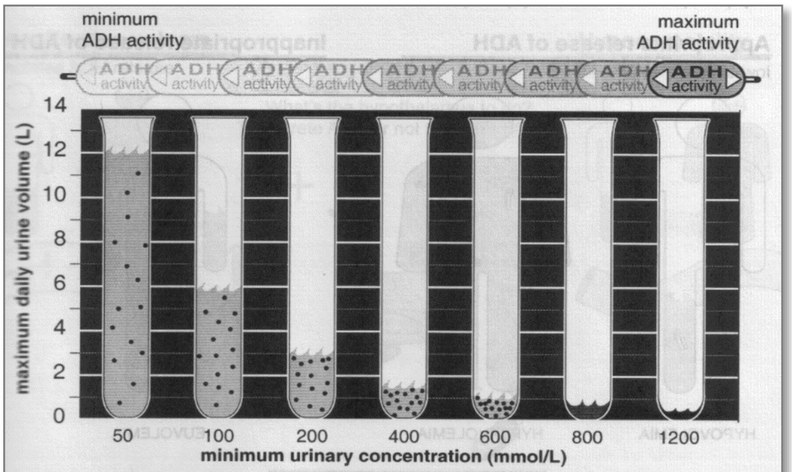
When the osmolality less than 280 m0sm\L the Vasopressin will be suppressed exept if there's low volume. (because volum is more important than osmolality)

If the osmolality above 280 m0sm\L the Vasopressin will be secreted.

The thirst begins when the osmolality above 290 m0sm\L and the kidney can't hold the water so, you need external supply for water.



Urine Output & Daily Solute Load:



The graph shows the maximum daily urine volume for several values of the minimum urinary concentration (50 to 1200 mmol/L), assuming a daily solute load of 600 mmol/day.

The Linear Relationship between Urine Specific Gravity and Urin osmolality *–Uosm* :

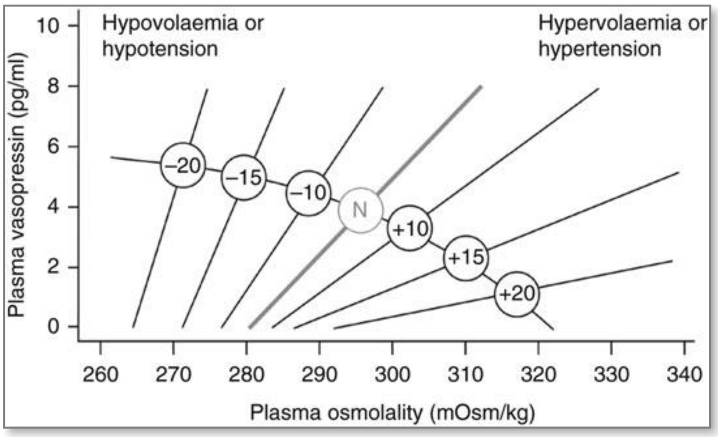
Laboratory investigations might take time to check on urine osmolality, so we estimate it by using a urine dipstick to know the specific gravity.
(Below 1.010 is very diluted urine, and above 1.010 is very concentrated urine)

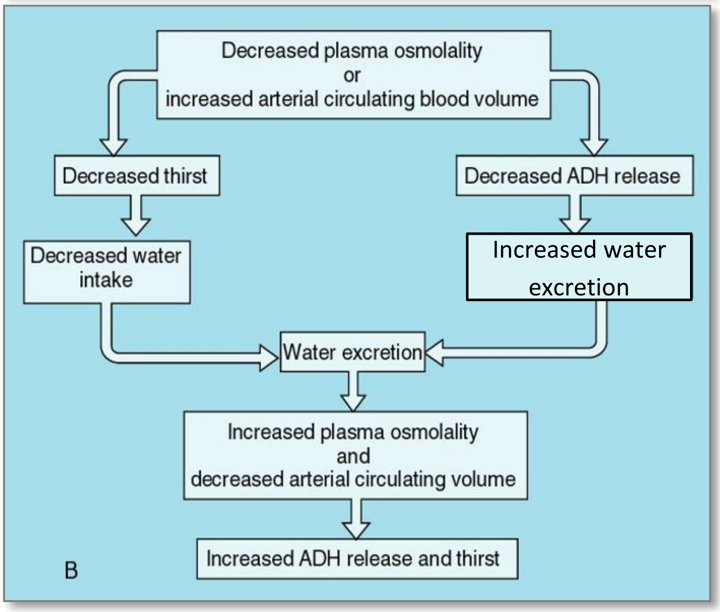
Specific Gravity	Osmolality (mOsm/Kg H_2O)
1.010 (Isotonic urine)	300 – 400
1.020	700 – 800
1.030	1000 – 1200

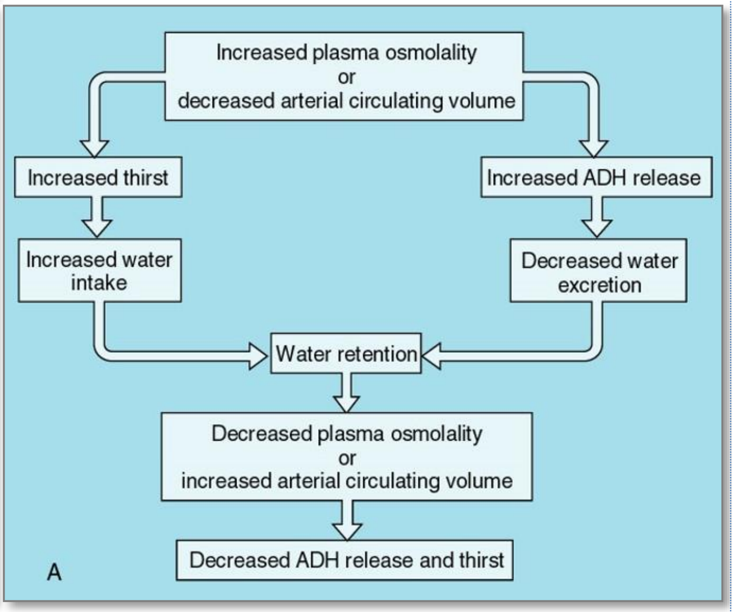
Plasma SG ~ 1.008

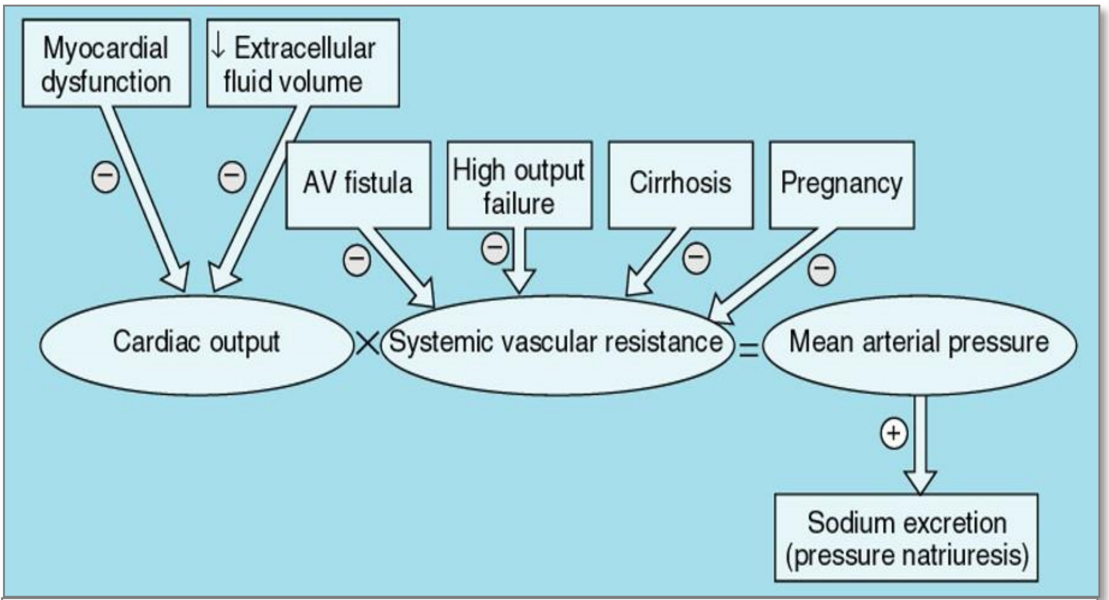
(specific gravity: how dense the solution compared to pure water.
Plasma is 1.008 , since it contains solutes it is heavier than pure water.)

Effect of Hypovolemia on Osmoreceptor Gain:









In case of decrease in the blood pressure the kidneys will start to reserve Sodium which causes an increase in Sodium and water levels beyond what we need leading to edema. Seen in CHF,and cirrhosis

Effective Arterial Blood Volume (EABV):

Although the absolute volume of the intravascular space is an important component of circulatory "fullness", *the adequacy of the circulation* (more commonly called the effective arterial blood volume or EABV) also is determined by cardiac output -CO- and systemic vascular resistance -SVR-.

- **↓ EABV:**
  - ↑ CO
  - ↑ SVR
  - ↑ Renal Na retention
- **↑ EABV:**
  - ↓ CO
  - ↓ SVR
  - ↓ Renal Na retention

Note(s):

Doctor said that you need to differentiate between EABV and Intravascular volume depletion.

Intravascular volume depletion:
Takes place when fluid is lost from extracellular space at a rate exceeding net intake. Acute hemorrhage is the leading cause of acute life-threatening intravascular volume loss requiring aggressive fluid resacititation to maintain tissue perfusion until the underlying cause can be corrected. Other intravascular volume deoletions may result from gastrointestinal (GI) disorders (e.g., vomiting, diarrhea or ascites), burns, environmental exposure, or renal salt wasting . volume depletion may also result from acute sequestration in the body in a "third space" that's not in equilibrium with the intracellular fluid, as seen in septic shock. *–medscape*

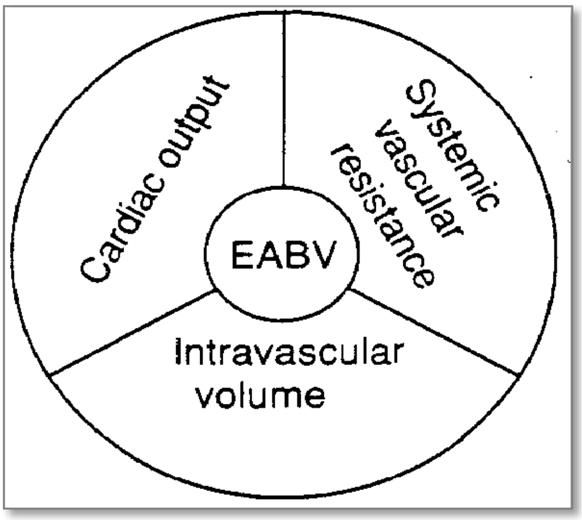
The fractional excretion of sodium (FENa) is the percentage of the sodium filtired by the kidney which is excreted in the urine "normally below 1%" *–wikipedia*

Sodium concentration is an expression of the relative numbers of sodium molecules to water molecules, irrespective of the total numbers *–veterinary medicine*
Sodium content represents the total number of sodium molecules present in the extracellular fluid compartment (ECF) *–veterinary medicine*

- **EABV is the amount of arterial blood volume required to adequately 'fill' the capacity of the arterial circulation**

(How much blood we have in the arterial side to tell the brain we have enough fullness, enough volume filling that part of the circulation.)

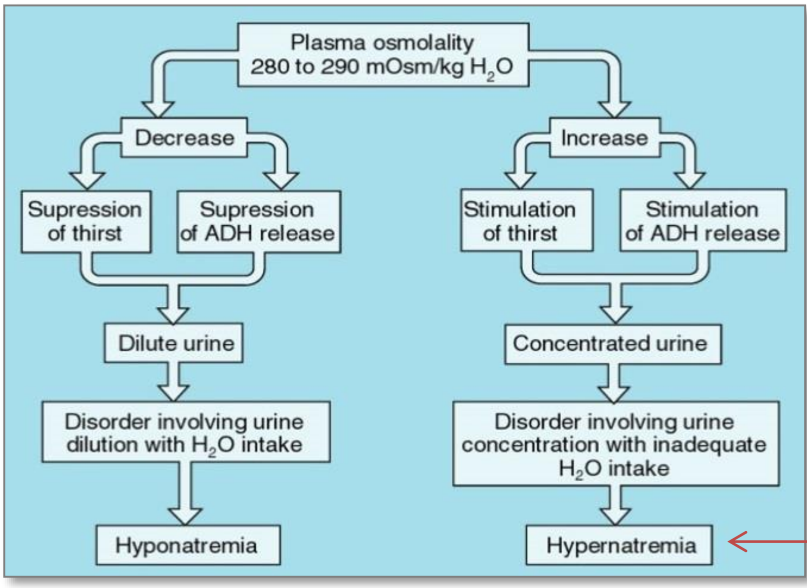
- ECF volume and EABV (means how much inside the arterial tree) can be independent of each other
- Edematous states: increase in total ECF volume and decreased EABV (Heart failure, cirrhosis, nephrotic syndrome)
- Postural changes may cause shifts that influence the EABV without affecting the total blood volume



Clinical features of Hypovolemia & Hypervolemia:

(no single sign will lead to a definitive diagnosis)

	Hypovolemia	Hypervolemia
Symptoms	Thirst	Ankle swelling
	Dizziness on standing	Abdominal swelling
	Weakness	Breathlessness
Signs	Low JVP	Raised JVP
	Postural hypotension	Peripheral edema
	Tachycardia	Pulmonary crepitations
	Dry mouth	Pleural effusion
	Reduced skin turgor	Ascites
	Reduced urine output	Hypertension (sometimes)
	Weight loss	Weight gain
	Confusion, stupor	



Serum concentration of Na not Na content

Sodium and Water:

- ECF volume= ***absolute*** amounts of Sodium and water
- Plasma Na^+ = ***ratio*** between the amounts of Sodium and water (Concentration)
- **Hyponatremia** = Water Excess
- **Hypernatremia** = Water Deficit

Water disorders, (causes a disturbance in Na concentration, not amount)

- **Hypervolemia** = Sodium Excess
  - "Edema"
- **Hypovolemia** = Sodium Deficit
  - "Dehydration"

	Hyponatremia (Water Excess)	***Hypernatremia (Water Deficit)***
Hypovolemia (Sodium Deficit) → Dehydration	Hemorrhagic Shock with good oral water intake	Diarrhea in Children and Seniors
Hypervolemia (Sodium Excess) → Edema	Advanced Congestive Heart Failure	Hemodialysis Patient after 3% Saline infusion

Tonicity:

- To compare the osmolality of a solution to that of another solution (body fluid compartments)
- Used to compare the osmolality of intravenous solutions to that of the serum:
    - ISOTONIC
    - HYPOTONIC
    - HYPERTONIC

Hypotonic	**Isotonic**	**Hypertonic**
Solutions have more water than solutes comparing to ECF	Solutions have the same solute concentration as the ECF	Solutions have more solutes than water comparing to ECF
Water will move from ECF into ICF	It will remain in the ECF (so not change the osmolality)	Water will move from ICF to ECF
Distilled Water 0.45% NaCl (1/2) 0.33% NaCl (1/3)	NS (0.9% NaCl) Ringers Lactate 2/3 DW-1/3 NS 5% Dextrose in Water (D5W)	3% NaCl 10%-50% Dextrose D5W-1/2 NS D5NS Amino acid solution

Intravenous Solutions

- Crystalloids vs Colloids (both have the same effect on decreasing mortality)
- Crystalloids are intravenous solutions that contain solutes that readily cross the capillary membrane
  - Dextrose and electrolyte solutions
- Colloids are intravenous solutions that DO NOT readily cross the capillary membrane (faster volume expansion, since it stays only inside blood vessel)
  - Blood, albumin, plasma

Solution	*Gluc*	*Na^+*	*K^+*	*Ca^{+2}*	*Cl^-*	*Lact*	*mOsm/L*
D_5W	50	0	0	0	0	0	278
$D_{10}W$	100	0	0	0	0	0	556
NS	0	154	0	0	154	0	308
½ NS	0	77	0	0	77	0	154
D_5 NS	50	154	0	0	154	0	293
D_5 ½ NS	50	77	0	0	77	0	216
2/3-1/3	33	50	0	0	50	0	285
Ringer's Lactate	0	130	4	3	109	28	274

Lytes: mEq/L

Gluc: g/L

D5W: 5 g Dextrose/100 mL of Water (50 g/L)

D10W: 10 g Dextrose/100 mL of Water (100 g/L)

NS *–normal saline–* (0.90% NS): 0.90 g NaCl/100 mL (9 g/L)

½ NS (0.45% NS): 0.45 g NaCl/100 mL (4.5 g/L)

2/3-1/3: 2/3 D5W (33 g/L) + 1/3 NS (0.33 g NaCl/100mL or 3.3 g NaCl/L)

D_5W: It's isotonic initially, but the glucose will be metabolite and the osmolality will be ZERO (become hypotonic)

$D_{10}W$: for the patient with hypoglycemia. It's hypertonic initially, but, after awhile it will become hypotonic because of glucose metabolism.

NS: It's isotonic contain 1\2 Cl and 1\2 Na. If it's given through IV it will stay in ESF.

½ NS: It's hypotonic.

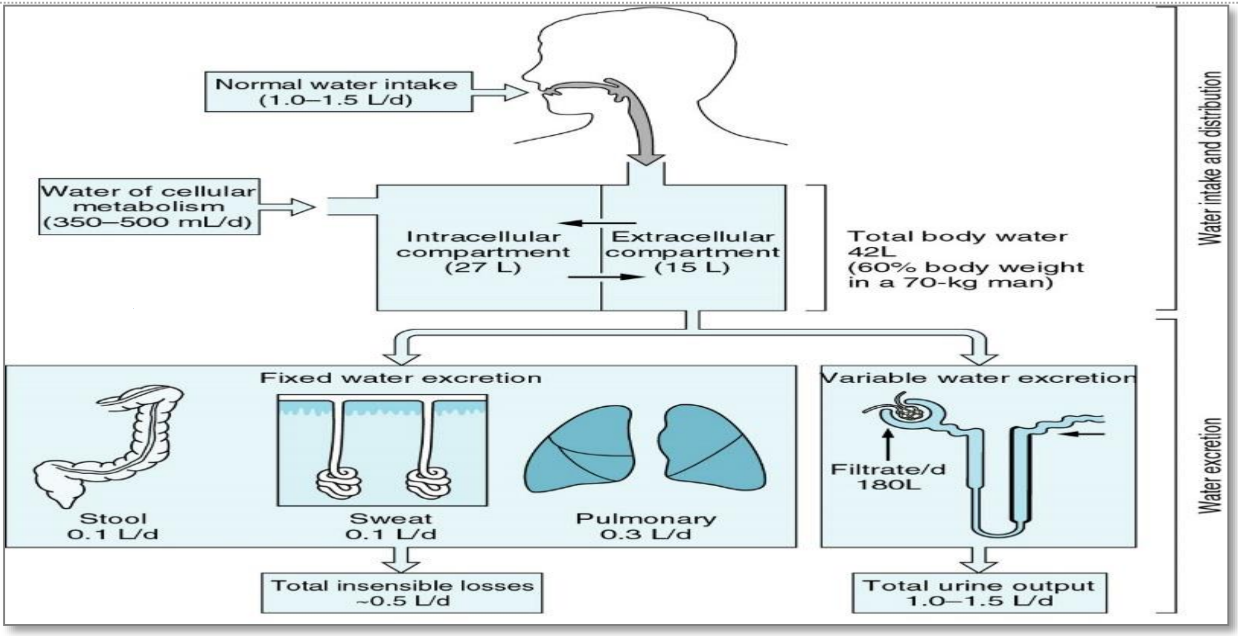
D_5 NS: It's hypertonic initially (2 isotonic D5+NS) but, 293 is the osmolality after burning the sugar so, it will become isotonic.

D_5 ½ NS: It's hypotonic after burning the glucose.

2/3-1/3: It's isotonic.

Ringer's Lactate: It's isotonic. It has Ca, less Na "similar to the serum Na" , lactate which metabolites into bicarbonate, K but there is a risk of hyperkalemia in case of decrease the urine output (renal failure).

Parental Fluid	ECF (1/3 TBW)		ICF (2/3 TBW)
	IV (1/4 ECF)	ISF (3/4 ECF)	
1000 ml D_5W	80 ml	250 ml	670 ml
1000 ml NS "will stay in ESF"	250 ml	750 ml	---
Colloids (PRBC) "in IV only because it can't cross the capillary wall"	300 ml	---	---
1000 ml ½ NS:			
(500 ml NS)	125 ml	375 ml	---
(500ml water)	40 ml	125 ml	335 ml
Total	165 ml	500 ml	335 ml
1000 ml D_5 ½NS "similar to 1000 ml 1\2 NS because this after metabolism"	165 ml	500 ml	335 ml
1000 ml $D_{10}W$	80 ml	250 ml	670 ml
1000 ml D_5NS	250 ml	750 ml	---



Saline is the best option for flow resuscitation.

Basal Requirements:

- Basal Water:

1st (10 kg × 4) ml/kg/h + 2nd (10 kg × 2) ml/kg/h + (10 kg × 1) ml/kg/h + (10 kg × 1) ml/kg/h (10 kg × 1) ml/kg/h .... Till it's done

It's a calculation method. E.g., 70 kg male. How much fluid does he require per hour?

you devide 70 to 7 parts, each = 10kg

1st 10 kg × 4 → **40ml**

2nd 10 kg ×2 → **20ml**

5 parts left (each = 10 kg) follow the rule: 1 × 10 kg → 10ml for each part → **50ml** *(for the 5 parts together)*

Simple summation: 40+20+50= 110ml/hour

- Insensible water loss:
  - Stool, breath, sweat: 800 ml/day *(ml/d)*
  - Increases by 100-150 ml/d for each degree above 37 C (changes with fever)

(IV prescription, for maintenance not resuscitation)

- Electrolytes:
  - Na: 50-150 mmol/d (NaCl) average = 100
  - Cl: 50-150 mmol/d (NaCl) average = 100
  - K: 20-60 mmol/d (KCl) average = 40

- Carbohydrates:
  - Dextrose: 100-150 g/d (enough for ketogenesis suppression not for nutritional use)
  - IV Dextrose minimizes protein catabolism and prevents ketoacidosis

  D_5 ½ NS: it will suppress the ketogensis and maintain the euvolemic and normal Na.

Hyponatremia:

Plasma Na < 135 mmol/L, is a common electrolyte abnormality, often asymptomatic can also be associated with disturbances of cerebral function. The likelihood of symptoms occurring is related more to the *speed* at which electrolyte abnormalities develop rather than their severity. When plasma osmolality falls **rapidly**, water flows into cerebral cells, which become swollen and ischaemic. However, when hyponatraemia develops **gradually**, cerebral neurons have time to respond by reducing intracellular osmolality, through excreting potassium and reducing synthesis of intracellular organic osmolytes.
It can be defined as disturbances in body water balance, in the absence of changes in sodium balance, alter plasma sodium concentration and hence plasma osmolality. When ECF osmolality changes abruptly, water flows rapidly across cell membranes with resultant cell swelling (during hypo-osmolality) or shrinkage (during hyperosmolality). Cerebral function is very sensitive to such volume changes, particularly brain swelling during hypo-osmolality, which can lead to an increase in intracerebral pressure and reduced cerebral perfusion.

–Davidson

Classified as: isotonic hyponatremia (***Na concentration*** *is normal*) hypotonic hyponatremia (***Na concentration*** *is low*) There are htpertonic situation in which body sense it as hypotonic because of low effect of the high volume.

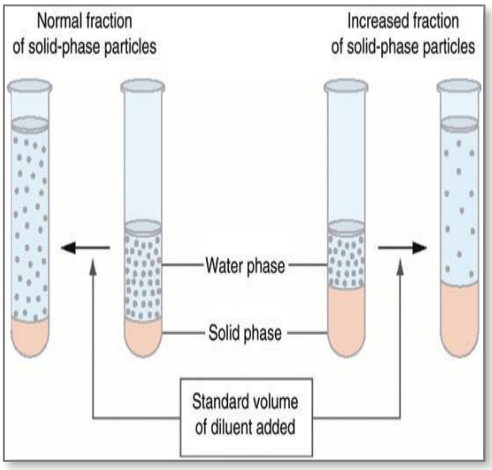
A. Normotonic or Isotonic Hyponatremia: no change in the osmolality because of increase in another solute

- Factitious Hyponatremia massive increase in blood triglysride levels –*wikipedia*
- Pseudohyponatremia
- Results from laboratory artifact due to high concentrations of proteins or lipids

It's a lab issue! Normally, plasma has aqueous "water" phase (93%) and solid phase (7%) and has extra-protein and extra cholesterol, so solid phase will go up and water phase will go down. The machine will measure the Na concentration in water phase and factor it to the whole plasma)

Pseudohyponatremia:

- Flame photometric or Indirect potentiometry
- measurement of PNa+
- Normal Measured PNa+ = 153 mmol/L of Plasma Water
- Normal Plasma Water Phase = 93% of One liter of Plasma
- Reported Plasma Na+ = 153 x 0.93 = 142 mmol/L of Plasma



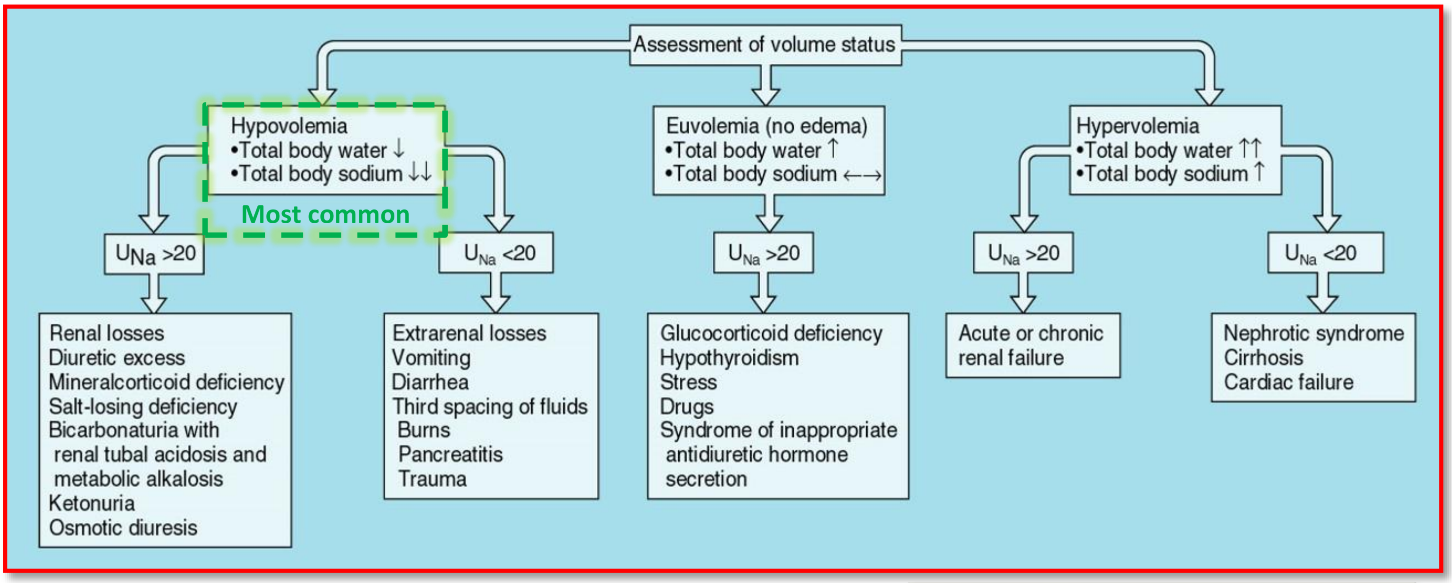
B. Hypertonic Hyponatremia:

1. Translocational Hyponatremia
2. Results from non-Na osmoles in serum (often glucose or mannitol) drawing Na-free H2O from cells
3. [Na+] declines by ~2.4 mEq/L for each 100 mg/dL [*5.5 mmol/L*] increase in serum glucose

Spasovski et al. Clinical practice guideline on diagnosis and treatment of hyponatraemia. Nephrol Dial Transplant (2014) 0: 1–39

Also called: *Transient hyponatraemia,* may occur due to osmotic shifts of water out of cells during hyperosmolar states caused by acute hyperglycaemia or by mannitol infusion –*Davidson*

C. Hypotonic Hyponatremia: *(explanation of the pic is in next page)*



The causes of hypotonic hyponatraemia are best categorised according to any associated changes in the ECF volume (hypovolemic hyponatremia, isotonic hyponatremia & hypervolemic hyponatremia) In all cases, there is retention of water relative to sodium, and it is clinical examination rather than the biochemical results that gives a clue to the underlying cause. –*Davidson*

You can't say it's hypotonic or hypertonic hyponateremia based on signs and symptoms. Best way to check volume: urine Na concentration.

Serum Na + urine Na are important in hyponatrimic pt.

Davidson:

With hypovolemia: Patients who have hyponatraemia in association with a sodium deficit ('depletional hyponatraemia') have clinical features of hypovolaemia and supportive laboratory findings, including low urinary sodium concentration (< 30 mmol/L) and elevated plasma renin activity.

With euvolaemia: Patients in this group (dilutional hyponatraemia) have no major disturbance of body sodium content and are clinically euvolaemic. Excess body water may be the result of abnormally high intake, either orally (primary polydipsia) or as a result of medically infused fluids (as intravenous dextrose solutions, or by absorption of sodium-free bladder irrigation fluid after prostatectomy). Water retention also occurs in the syndrome of inappropriate secretion of ADH (SIADH). In this condition, an endogenous source of ADH (either cerebral or tumour-derived) promotes water retention by the kidney. The clinical diagnosis requires the patient to be euvolaemic, with no evidence of *cardiac, renal or hepatic* disease potentially associated with hyponatraemia. Other non-osmotic stimuli that cause release of ADH (pain, stress, nausea) should also be excluded. Supportive laboratory findings are shown picture. In this situation, plasma concentrations of sodium, chloride, urea and uric acid are low with a correspondingly reduced osmolality. Urine osmolality, which should physiologically be maximally dilute (approximately 50 mmol/kg) in the face of low plasma osmolality, is higher than at least 100 mmol/kg and indeed is typically higher than the plasma osmolality. The urine sodium concentration is typically high (> 30 mmol/L), consistent with euvolaemia and lack of compensatory factors promoting sodium retention.

Diagnosis
- Low plasma sodium concentration (typically < 130 mmol/L)
- Low plasma osmolality (< 270 mmol/kg)
- Urine osmolality not minimally low (typically > 150 mmol/kg)
- Urine sodium concentration not minimally low (> 30 mmol/L)
- Low-normal plasma urea, creatinine, uric acid
- Exclusion of other causes of hyponatraemia (see Box 16.12)
- Appropriate clinical context (above)

With hypervolemia: in this situation, excess water retention is associated with sodium retention and volume expansion, as in heart failure, liver disease or kidney disease.

Classification of symptoms:

- All symptoms that can be signs of cerebral edema should be considered as severe or moderate symptoms that can be caused by hyponatremia

Moderately Severe

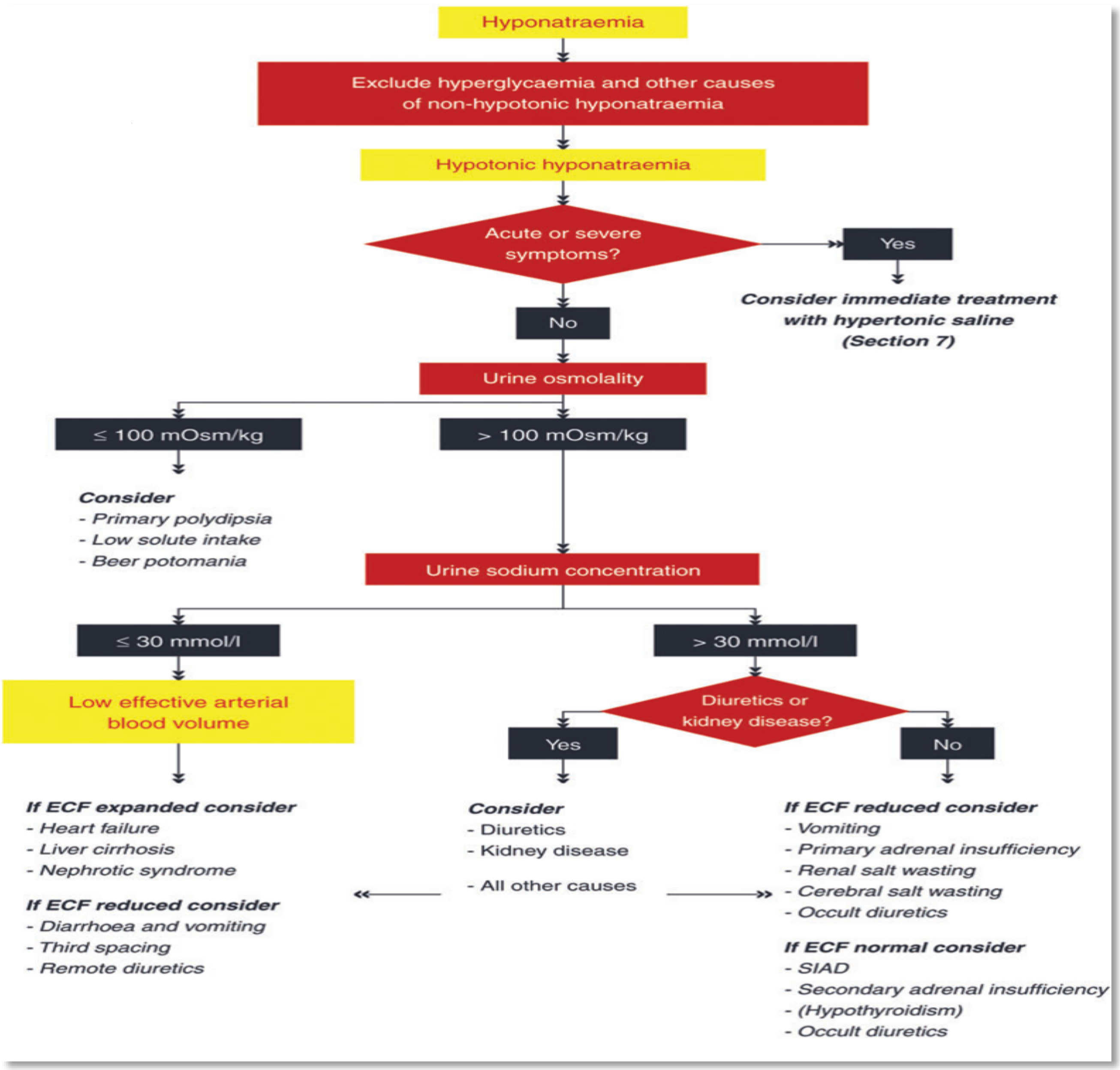
- Nausea without vomiting
- Confusion
- Headache

- Patient has symptoms of hyponatremia → fix it! Don't wait! Otherwise pt will die.

Severe

- Vomiting
- Cardiorespiratory distress
- Abnormal and deep somnolence
- Seizures

- Coma (Glasgow Coma Scale ≤8)



Investigation: ***Davidson*** - Plasma and urine electrolytes and osmolality *(see the pic in next page)* are usually the only tests required to classify the hyponatraemia. Doubt about clinical signs of ECF volume may be resolved with measurement of plasma renin activity. Measurement of ADH is not generally helpful in distinguishing between these categories of hyponatraemia. This is because ADH is activated both in hypovolaemic states and in most chronic hypervolaemic states, as the impaired circulation in those disorders activates ADH release through non-osmotic mechanisms. Indeed, these disorders may have higher circulating ADH levels than patients with SIADH. The only disorders in which ADH is suppressed are primary polydipsia and iatrogenic water intoxication, where the hypo-osmolar state inhibits ADH release from the pituitary.

Urine Na (mmol/L)	Urine osmolality (mmol/kg)	Possible diagnoses
Low (< 30)	Low (< 100)	Primary polydipsia Malnutrition Beer excess
Low	High (> 150)	Salt depletion Hypovolaemia
High (> 40)	Low	Diuretic action (acute phase)
High	High	SIADH Cerebral salt-wasting Adrenal insufficiency

*Urine analysis may give results of indeterminate significance, and in this case the diagnosis depends on a comprehensive clinical assessment.

Management of Hyponatremia: (important)

Tables from davidson

According to the rate of development	
Rapidly (within hours to days)	**Slowly (within weeks to months)**
Usually associated with signs of cerebral edema (e.g., convulsions) ◦ Sodium levels should be restored to normal rapidly by infusion of hypertonic (3%) sodium chloride. *A common approach is to give an initial bolus of 100 mL, which may be repeated once or twice over the initial hours of observation, depending on the neurological response and rise in plasma sodium*	*Rapid correction can be hazardous, since brain cells **adapt** to slowly developing hypo-osmolality by reducing the intracellular osmolality, thus maintaining normal cell volume. Under these conditions, an abrupt increase in extracellular osmolality can lead to water shifting out of neurons, abruptly reducing their volume and causing them to detach from their myelin sheaths. The resulting 'myelinolysis' can produce permanent structural and functional damage to mid-brain structures, and is generally fatal.* 1) rate of correction of the plasma Na concentration in chronic asymptomatic hyponatraemia should not exceed 10 mmol/L/day 2) *The underlying cause should be treated.*

According to the type of hyponatremia		
Hypovolemic pt	**Euvolemic pt**	**Hypervolemic pt**
controlling the source of sodium loss, and administering intravenous saline if clinically warranted	1) fluid restriction in the range of 600–1000 mL/day, accompanied 2) withdrawal of the precipitating stimulus (such as drugs) 3) If the response of plasma sodium is inadequate, treatment with demeclocycline (600–900 mg/day) (increase water excretion) 4) persistent hyponatraemia due to prolonged SIADH → oral urea therapy (promote water excretion)	1) treatment of the underlying condition, 2) cautious use of diuretics in conjunction with strict fluid restriction. *Potassium-sparing diuretics may be particularly useful in this context where there is significant secondary hyperaldosteronism.*

oral vasopressin receptor antagonists such as tolvaptan may be used to block the ADH-mediated component of water retention in a range of hyponatraemic conditions.

From the slides

Symptoms & Signs:

- Volume Status - When you give fluid, keep checking the levels in case of any change.

Serum:

- Osmolality
- TSH, FT4, Cortisol
- Albumin, Total Proteins
- Uric Acid

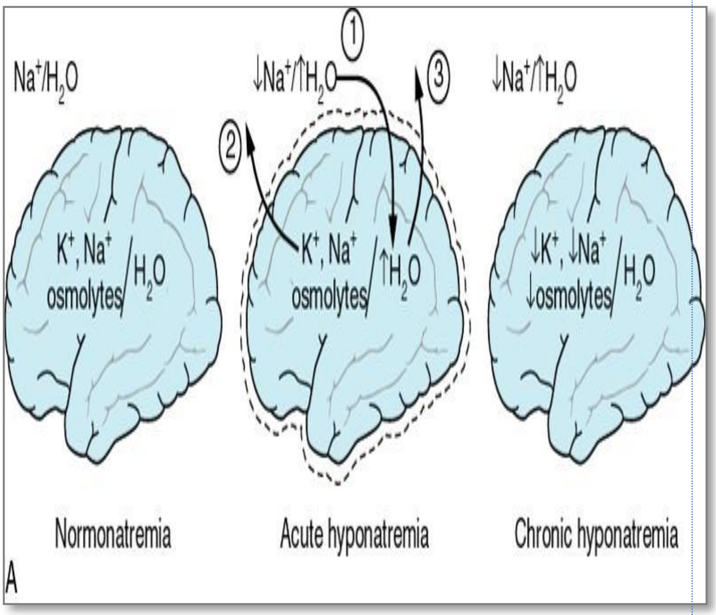
Urine:

- Electrolytes (Na/K/Cl/Urea/Creatinine)
- Osmolality
- Urinalysis

Rate of correction:

- 0.5 mmol/L/h ~ 10-12 mmol/L/d

Symptoms usually begin when the Na+ Level falls to <120 mEq/L.
As ECF osmolality decreases, water shifts into brain cells, further increasing ICP
Resulting in a swollen brain causing Seizures and coma.
In chronic hyponatremia(>48 h) the brain release some osmolytes. No sowllening happen.



Diagnostic Criteria for SIADH:

excessive release of ADH result in dilutional hyponatremia in which the sodium remains normal but total body fluid increases.

- Essential criteria
  1. Effective serum osmolality <275 mOsm/kg (Na decrease in serum)
  2. Urine osmolality >100 mOsm/kg (Na increase in urine)
  3. Clinical euvolema (normal volume)
  4. Urine sodium concentration >30 mmol/l with normal dietary salt and water intake
  5. Absence of adrenal, thyroid, pituitary or renal insufficiency
  6. No recent use of diuretic agents

- Supplemental criteria
  - A. Serum uric acid <0.24 mmol/l (<4 mg/dl)
  - B. Serum urea <3.6 mmol/l (<21.6 mg/dl)
  - C. Failure to correct hyponatremia after 0.9% saline infusion
  - D. Fractional sodium excretion >0.5%
  - E. Fractional urea excretion >55%
  - F. Fractional uric acid excretion >12%
  - G. Correction of hyponatremia through fluid restriction

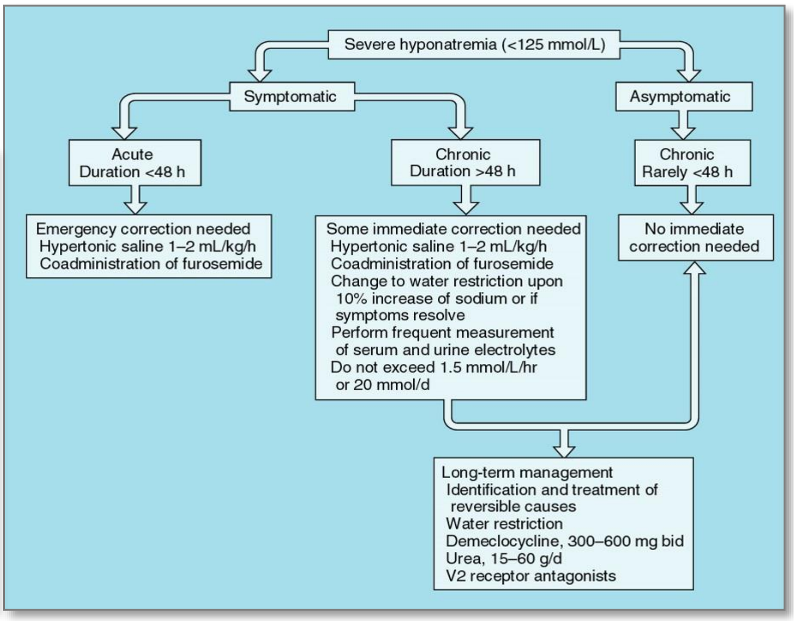
SIADH: "HIVE"

- **H:** Hypoosmolar Hyponatremia (Posm <275 mOsm/Kg H2O)
- **I:** Inappropriate urine concentration (Uosm >100 mOsm/Kg H2O)
- **V:** Euvolemia, No diuretic use
- **E:** Endocrine = normal Thyroid, adrenal and renal function
- Hypouricemia (<238 mcmol/L) and low Urea (<3.5 mmol/L)

Hyponatremia: Treatment

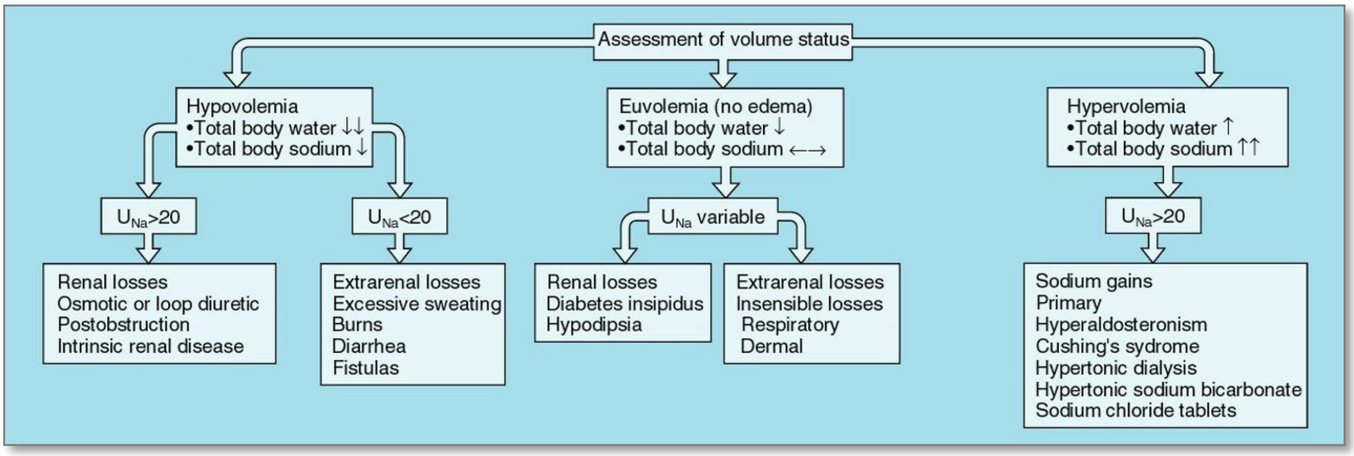
Question from the doctor: If you have a patient with heart failure edema , serum Na = 140 mmol\L should you write: decrease Na intake in his diet or, decrease water intake?

Answer: I will restrict Na but not water unless the he become hyponatremia (Na <135 mmol\L)

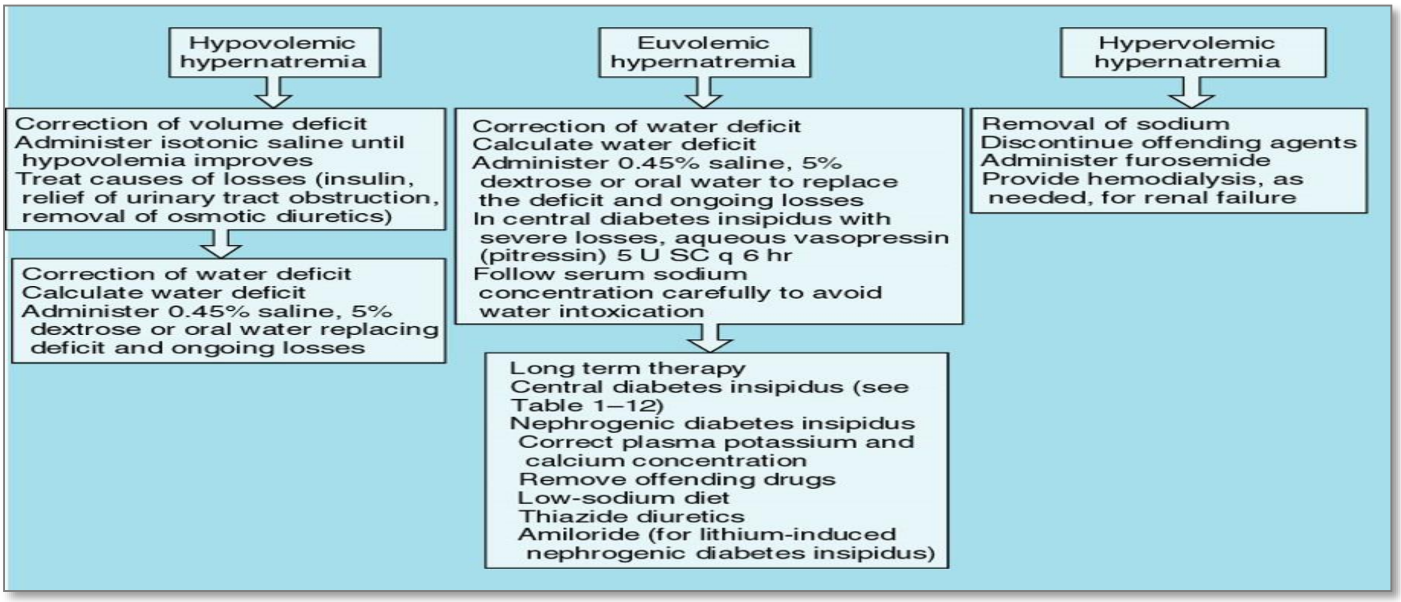


Hypernatremia:

Hypernatremia: Causes



Hypernatremia: Treatment



Water Deficit Calculation:

- Current Total Body Water = 0.6 x Current Body Weight
- Current TBW x Current [Na+] = Target TBW x Target [Na+]
- Target TBW – Current TBW = Water Deficit
- Ongoing loss
- IVF: type and rate
- Reassessment

SUMMARY (covering the objectives)

1. Na conc. and water controlling mechanism:
   Osmolality and volume: ADH and osmoreceptors
   Volume alone by: baroreceptor, RAS, natreuritic peptide, kinine and prostaglandine

2. IV fluid types :

D_5W, $D_{10}W$, Normal saline, Half normal saline, 2/3-1/3 (2/3 D5W + 1/3 NS)

3. Management of hyponatremia
   - According to the rate
   - According to the ECF volume

4. How to calculate water deficit

Target TBW – Current TBW

5. Na volume disturbaces → hypovolemia, hypervolemia

6. Water volume disturbances → hyponatremia, hypernatremia

432 Medicine Team Leaders

Raghad Al Mutlaq & Abdulrahman Al Zahrani
For mistakes or feedback: medicine341@gmail.com